DEPARTMENT OF AGRICULTURE.

FORESTRY DIVISION.

BULLETIN No. 2.

REPORT

ON THE

FOREST CONDITIONS OF THE ROCKY MOUNTAINS,

AND

OTHER PAPERS;

WITH A MAP SHOWING THE LOCATION OF FOREST AREAS ON THE ROCKY MOUNTAIN RANGE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
FORESTRY DIVISION,
Washington, D. C., January 6, 1888.

SIR: I have the honor to submit for publication as a special bulletin, prepared under your instructions, a collection of reports illustrating the forest conditions of the Rocky Mountains, together with such information as may serve for a basis in formulating needed forest legislation with reference to the timber lands of the region which are still held in the hands of the General Government.

Respectfully,

B. E. FERNOW,
Chief of Forestry Division.

HON. NORMAN J. COLMAN,
Commissioner.

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INTRODUCTORY.

The following report and papers are designed as a basis for an intelligent conception of the possibilities and requirements of legislative action on the part of the General Government in regard to some of its property. They will also, it is hoped, be welcome to the student of the climatic, floral, and economic conditions of the region to which they refer, and serve as a historic reference book in the times when the folly of present days will be judged by those who will suffer its consequences.

The pioneering days are rapidly disappearing before the energetic push and advancement of railroad building and settlements; and with the changed conditions of life, in communities instead of in isolated log huts, a change in the manner of life and its adjustment to the demands of civilized existence is called for.

The development of the Rocky Mountain region during the last seventeen years is indicated by the growth of its population. The population has increased from 263,236 in 1870 to 900,000 in 1886, while the assessed valuation, exclusive of mining property, has risen from \$96,507,000 in 1870 to \$330,000,000 in 1886. This growth has been obtained, no doubt, partly through the liberal policy which the Government has pursued in regard to railroad grants, to mineral claims, to land entries, etc.

Of the enormous amount of public lands given free or at nominal prices to settlers, miners, and to encourage development, amounting to about 630,000,000 acres, a proportionate share has fallen to the region in question. For educational purposes it received 22,963,403 acres or 34 per cent. of the total grant. Of the 50,000,000 acres or so of railroad grants, outside of the rights of way, 4,500,000 acres at least must be debited to the region for its 2,060 miles of land-grant roads. Under the desert-land act 1,193,548 acres were given up at \$1 per acre. Under the timber-culture act, 389,991 acres have been entered in the region under consideration.

In addition to these grants a liberal use of the timber on the public domain, for all legitimate purposes which would aid the settler in building up and improving his settlement and the railroad companies in building their roads, has been permitted.

But whether the continuance of such lavish liberality after the pioneer existence is passed has not already been, and may not become still more in future, detrimental to the best interests of the region in question, as well as of the Pacific coast region, which should have been included in this discussion; whether a change from the present policy in regard to the remaining public domain would not better answer the purposes of the community at large—these questions now call for deliberate investigation.

That this need of a change of policy exists, especially in regard to the timber lands occupying the mountain regions of the Rocky Mountains and the Pacific slope, has been claimed and urged for many years by competent officers as well as by well-informed citizens.

The reasons brought forward for such a change in regard to the Government timber lands are partly of an organic, partly of a moral character.

In the present classification of lands, special regard to the existence of timber on the land is only given in California, Oregon, Nevada, and Washington Territory, where timber land not fit for cultivation may be sold in tracts of 160 acres, to any one person, at $2.50 per acre (act June 3, 1878), forbidding, however, the purchase for purposes of speculation, the land only to apply to the exclusive use and benefit of the purchaser, and the title not to inure to a third person. It is well known that this act has not been of much practical value, and does not furnish relief to the settlers for whom it was designed. Under this act nearly 1,000,000 (986,158) acres have been sold and are held by large corporations mostly.

The valuable timber lands in the Southern States have been mostly disposed of at private sales for $1.25 per acre, under the act of June 22, 1876, by which the public land policy, which had been stated to be that of holding the land for actual settlers, was repudiated. In Alabama this avowed policy sustained another blow from the act of March 3, 1883, by which the distinction of mineral lands was wiped out; and thus the door was opened for speculators, who have not failed to take advantage of the chance, and have bought many millions of acres of valuable timber for a small price.

In the Rocky Mountain States and Territories, as well as in all other parts of the United States, all bona fide residents are permitted (act June 3, 1878) to fell and remove for building, agriculture, mining, or other domestic purposes, timber or other trees on the public lands which are mineral and subject to mineral entry only, and on the land entered under homestead acts, and they are also allowed to clear for the purpose of cultivation and improvements only, not for sale, before the patent accrues to them, any timber on their entries.

In addition to the grants of right of way and the land grants of alternate sections under the general right of way act and other acts to aid in construction of railroads, the railroad companies are allowed "to take from the public lands adjacent to the line of said road the timber necessary for the construction thereof," this right to cease at the expiration of five years after location, and, of course, after construction.

This permission has in practice been construed by the railroad companies into a license to cut timber wherever, whenever, and for whatever purpose they saw fit, before and after construction.

That the timber on the public domain had a special value, and also that it needed, like all movable property, to be looked after and protected, was recognized by the act of March 2, 1831, under which, for the care and custody of the timber on the public domain, a system of agencies under the supervision of the Solicitor of the Treasury was established. When, in 1854, the management of the timber interest was transferred to the General Land Office, and the registers and receivers were expected to act as timber agents without additional pay, an exceedingly loose construction as to the right to take timber, and naturally a lax enforcement of any laws, prevailed until 1877. In fact, until 1876 the collection of stumpage, when found out, was the only penalty for timber stealing, and a regular revenue, payable quarterly at the discretion of the receivers, was attempted to be collected from the saw-mill men without any sanction of law. From the year 1872 until 1877 annual appropriations were made for this service, amounting in the aggregate to $48,000 ($45,624.76 expended).

In 1877 the Commissioner of the Land Office instituted a service of special agents, and in 1878 a special appropriation of $25,000 was made "to meet the expenses of suppressing depredations upon timber on the public lands." The system of special agents was gradually enlarged and the appropriations increased, with the results during the last seven years as exhibited in the table below.

Depredations on the public timber during seven years.

Year.	Estimated value of timber reported stolen.		Amounts actually recovered, partly by compromise.	Appropriations for protection service.	Agents employed.	
	Market.	Stumpage.			Number.	Months employed.
1881	$891, 888	$225, 472	$41, 680	$40, 000	17	(?)
1882	2, 044, 278	511, 069	77, 365	40, 000	31	(?)
1883	8, 144, 658	1, 709, 824	27, 741	75, 000	25 / *13	12
1884	7, 289, 854	1, 093, 178	52, 108	75, 000	26 / *44	12
1885	2, 862, 530	489, 255	49, 451	75, 000	23 / *41	8
1886	9, 339, 679	1, 726, 516	101, 086	75, 000	21 / *50	12
1887	6, 146, 935	1, 138, 320	128, 642	75, 000	26	12
Total	36, 719, 852	6, 893, 634	478, 073	455, 000	27	

* Actual number of agents employed for shorter periods.

With more and more urgency have the Commissioners of the Land Office, the officers to whose care, under the Secretary of State, this prop-

NOTE.—During the thirty-three years from 1855 to 1888 the sums recovered from trespassers amounted in the aggregate to $491,172.

erty is intrusted, insisted that under existing laws and conditions not only is it impossible to protect the property of the people against theft and devastation, but the need of the settler and the requirements of the industrial pursuits being disregarded by the law, the users of timber are by necessity forced to become depredators if they wish to satisfy their needs. That such must be the case may be inferred from the fact that within the last seven years, since 1881, over $36,000,000 worth of timber has been reported as stolen, not to speak of the large amount of depredations which must have been left undiscovered.

While the Government might have donated this timber, or timber and land, to those who have needed it—although the need of home consumption has presumably had a less share in these spoils than the greed of lumbering monopolists—it must be a matter of shame and reproach to us to have in this manner allowed the spoliation of the public property; certainly a state of affairs, which allows such robbing of its partners from year to year, does not speak well for either the wisdom of the laws or the morality of the community.

In addition to these spoliations of its direct material value, the public timber domain has suffered untold damage by reckless, willful, or careless firing, and in every respect the management of this part of our national inheritance reflects discredit on our much-praised business capacity.

It has been claimed that the fault lies with the existing laws, and this charge has no doubt good foundation. The charity which the Government has extended, in allowing free use of its property under certain conditions, the settled community now would gladly exchange for a fair bargain, in which the consumer pays for what he uses, and gains a right as against a mere privilege.

Any one who will take the trouble to trace, year by year, the expressions in regard to this interest of the nation, in the reports of the Secretary of the Interior and the Commissioners of the Land Office, will be astounded that no hearing has been accorded to them which would lead to a proper management of this interest.

Recommendations for a change occur from year to year, dating back earlier than 1880, but they have become more and more urgent since then as the need has become more urgent. Extracts from the reports of the Commissioners of the Land Office will be found further on.

The Secretary of the Interior, in 1880, after devoting over six pages to the subject of forestry, says:

I regret to say that in spite of the repeated recommendation of the passage of a law to facilitate the prevention of the wasteful devastation of the public timber lands, and to enable the Government to dispose of timber to settlers and miners, as well as for legitimate mercantile purposes under such regulations as would prevent the indiscriminate and permanent destruction of our forests, almost all the legislation that has been had upon this subject consisted in acts relieving those who had committed depredations in the past of their responsibility and protecting them against the legal consequences of their trespasses, etc.

And Secretary Lamar, in 1885, repeating his recommendations in 1886 and 1887:

The subject of the preservation of timber on the Government lands has been suggested to Congress repeatedly in the reports of my predecessors. Perhaps its frequent repetition has rendered it commonplace, until it has come to be recognized as a part of routine report. Its importance justifies its repetition. That the timber is rapidly disappearing is an indisputable fact. Much is wasted and destroyed. Its effect on rain-falls, the flow of our rivers, and the healthful character of climate are subjects worthy of consideration. Its importance and necessity for agricultural, domestic, and mechanical uses requires no portrayal. Good government, while not forgetful of the present, should use some care for the future. Both on account of its present importance and its future necessity, this subject is worthy of your thought.

And further, speaking of the timber act of 1878:

Its enactment was suggested, doubtless, by the fact that settters in a new country, surrounded by woodland, could not and would not suffer in a rigorous climate for want of fuel and shelter; that the necessary industries of a frontier would not submit to the pinchings of a famine in the midst of abundance. But while it was necessary to recognize the inevitable, the recognition was not properly guarded, and waste and greedy speculation seems to have resulted from the law.

Any timber for the uses named in the statute may be cut, under its provisions, by any resident of the Territory on any mineral lands of the Government, in the Territory of his residence, without compensation. Individual avarice and corporate greed, thus invited, with hasty eagerness, vie in accepting the bounty, and unless checked by wholesome modifications of the law, will soon cause all the mineral lands to be stripped of their forests. Railroads pass through many of the Territories; along their routes wealthy companies have been organized, mills erected, and the most valuable timber accessible is being rapidly cut off. That which is "every one's property is no one's care," and waste and extravagance are the natural consequence of negligent legislation.

The last report of the Commissioner of the Land Office (1887) contains a chapter illustrative of the manner in which a small minority has been for a long time defrauding the nation unchecked. Any citizen who feels himself a part of the great government "of the people, for the people, by the people" will do well to ponder over these pages of disgrace.

Such is the moral aspect of our present conditions in regard to the land laws and to the reasons for a change in our forest policy. The organic reasons are those which compel us to consider the forest cover of the mountains as of more importance than merely to supply material for the present.

Under existing conditions not only is it made difficult for the resident population to supply itself with the needed lumber in an honest way, but the danger of doing so in contravention of the law entails an enormous needless waste. Acres of timber are felled in anticipation of possible use, and rot on the ground, because their haulage may become too risky, or the depredator finds it difficult to dispose of the property, and so it is left to furnish food to the ever-recurring annual fires, which destroy also not acres but miles of standing timber, and no legal disposition of the burnt timber may be made.

That those who may cut timber legally on mineral lands, or homesteads, or timber entries on the Pacific slope have no interest except to satisfy a present momentary need, and clear the land regardless of any consequences to future supply, or proper management, or forest conditions, utilizing only whatever part of the trees they may readily use or require, leaving the balance in the most wasteful manner on the ground, is attested by those acquainted with the manner of timber-cutting in those regions. Any sign of intelligent and systematic management which would insure a full utilization and continuity of the same is, of course, absent and is not encouraged by present regulations under the existing laws, and local supplies are waning in many parts. While in view of the needs of local supply for mining operations, especially in mines yielding low-grade ores, which can not bear the burden of heavy charges for the importation of their timbering, this is an undesirable prospect, a much more serious danger is threatening the community at large in and around these mountain regions.

The climate, as will be seen from the paper of Mr. Parsons included in this report, is, in many parts of the region, not favorable to tree growth; at least not to the germination of seeds of coniferous trees, which form there the natural growth, except under specially favorable conditions, while broad-leaved trees of economic importance are not naturally found in the region, or only in small quantity. These unfavorable conditions are, by the act of man, made still more unfavorable. The wholesale clearing which is practiced lays bare the thin soil to the influence of drying sun and wind; fires that sweep over the ground without hindrance destroy the thin mold and whatever seedlings may have been on it, and thus natural recuperation of the forest is made impossible, and any attempt at artificial reforesting is almost precluded. Barrenness and desolation is, as a rule, the result, except that in more favorable situations the quaking aspen, of little economic use, may find a foothold, covering the nakedness of which nature has become ashamed.

If, in view of so much graver consequences, it were permissible to allude to it, I would impress upon those who take a delight and a pride in the charms with which nature has endowed our country, vying with the finest scenery of Europe, that the beauty of the once verdant mountain sides is being ruthlessly and needlessly destroyed, and with such general equanimity is this devastation considered that we may soon substitute in our dictionaries the word "Americanism" for "vandalism."

What the graver consequences are can be readily understood by those who have studied the history of deforestation and forest devastation in southern France, Switzerland, Spain, Italy, and those far eastern countries which compare somewhat in climatic aspects with the region in question.

Not only is the forest cover of the mountain crests destroyed when it might have yielded continuous supplies, but at the same time agriculture in the valleys below is first endangered and then made impossible.

In a region which, like most of the plains of Idaho, Montana, Wyoming, Colorado, Utah, New Mexico, Arizona, and southern California, requires for agricultural purposes the aid of irrigation, regularity of water-supplies is all-important. This is being tampered with when the ground is laid bare on the mountain sides, allowing the rains to run off as from a roof and permitting the snows to melt and their waters to pour down in torrents at a time when more than enough water is on hand and the husbanding of the supplies for a later season is highly desirable.

Other consequences, such as an increase of snow-slides and land-slides and the washing of débris into the valley have begun to make themselves felt and it can only be a question of time when we must reach such a state of things as was brought upon the mountain districts of France, Switzerland, and the Tyrol, and which is too well-known to be rehearsed again. I will only mention that after entire communities had been impoverished by the action of torrents due to deforestation the Governments found it necessary to interfere, or rather, interference coming too late, to assume or aid in the work of reforestation. Thus in France it was found that 783,000 acres needed to be restocked for reasons of public utility, besides the securing of 1,900 miles of torrents. One hundred and three thousand one hundred and thirty-eight acres of mountain land are reported already as put in condition by the Government at a cost of $4,365,750, outside of the cost of expropriations, etc. To this must be added $1,116,643, which have been given to communities and private owners in aid of similar works, and a further expenditure of round $34,000,000 is expected to be necessary. Altogether it is estimated that $30,000,000 have been expended to correct the evils brought on by foolish disregard of nature's laws. For the year 1887 the appropriation for these purposes amounts to $794,000, the total appropriation for the forest department of France being in round numbers $5,000,000.

The public land commission in 1883, recommending necessary changes in existing land laws, says: "The timber lands should be sold. Will not private ownership, self-interest, best protect this class of lands?"

If the history of the countries just cited, if the forest lands in the older settled parts of our own country, have not shown that this is a fallacy, we may never expect to learn from experience.

While the existing system of espionage and police may be "unpopular and un-American," as it undoubtedly is, it exists, not because there is no other choice than sale, but because there are no adequate provisions made to satisfy the requirements of lumber for actual and commercial use, thus forcing the population to depredations. Settlers and consumers of wood can not be expected to go to the woods and cut their sticks when wanted, as in the pioneer days. They must have an opportunity to supply their wants in a business manner, as they do in all other needs of civilized life, through the agency of a middle-man—in this case the lumberman or the saw-mill man—nor, with the absence of stability in our population, can more than a temporary or an ephemeral interest attach to forest property for the individual.

It is not the forest that is valuable and would appear worth his protection to the individual, but the timber which the forest yields. As soon as that is gone the value and the interest is gone for the individual. The interest which the community has in the forest is transcendant. The continuation, reproduction, and protection of the forest cover is of importance to the continued welfare of the community, especially in the mountain forests, and they will therefore be in safer hands with the community at large, with the state.

Let it not be overlooked that the state is not only the representative of communal interests as against individual interests, but also of future interests as against the present; that the forest is a kind of trust, of which the usufruct belongs to the present, and that to draw upon its capital is a perversion of the trust and can only be excused by direst necessity. Every other civilized country has found out after severe punishment that private interest is not sufficient to protect this class of lands; that state ownership or, what is more objectionable and less effective, state supervision of private forest lands, is indispensable in those regions where the forest subserves other functions than that of mere material supply.

Whether or not interference of the state in the management of one of the most potent factors of national welfare is un-American has been fully discussed in the paper contributed by Prof. E. J. James, well known as a writer on economic subjects.

The report of Colonel Ensign, the facts for which were gathered under many difficulties for lack of more liberal funds than could be allowed for this work, will present a clear and tolerably exhaustive picture of the present conditions (1887) of the region in its economic development and other aspects, so far as they bear upon the consideration of our question and of the forest areas as distributed through its different parts.

It was impossible to include in this investigation the Territory of Utah, and although the writer of this, at his own expense, visited the Territory and obtained considerable information which would show that, if anything, the forest interests of Utah are in a more precarious condition than those of the other parts of the region, this information was not deemed complete enough to appear as a separate chapter. A short résumé, however, has been appended to the report of Colonel Ensign.

The map accompanying this report was compiled from the returns which appear under the description of forest conditions by counties. It of course makes no pretense at exactness as to boundaries, but simply gives to the eye an idea of the relative position of wooded areas and of the principal irrigation ditches.

The question of what constitutes timber land is a perplexing one. As one or other view predominates, it denotes land stocked with trees ready for the saw-mill or merely land upon which there is a wood growth. If to "what is" we add the conception of "what ought to be," timber land would include also, in a mountainous region at least, all that treeless area which, not fit for agriculture or not needed in the development of mines, etc., can and should bear a tree growth and produce a timber crop.

In this connection the report of Mr. Abbot Kinney on the forest condition of the southern counties of California will be read with interest, showing that the timber lands in which the state should be concerned do not always contain "timber" of the kind in which the lumberman or other private owner would interest himself. For the preservation of favorable hydrologic and agricultural conditions even care of the "chaparral" may be of service.

To the student of the forest botany of the region the careful compilation by Mr. George B. Sudworth, of the division, will be welcome. The main effort has been to so arrange and describe all the woody plants of the region that the layman may be enabled, without much unnecessary technical terminology, to get acquainted with them; but at the same time the scientific botanist will find much aid in such a compilation, for which all authorities have been carefully consulted and, after due sifting, a truthful statement of facts attempted.

As it is the object of this bulletin to aid in forming a basis for intelligent forestry legislation, it seemed desirable to note what action had been attempted in the national legislature looking toward a better administration of the timber lands of the nation.

Mr. Egleston, of the division, has, for this purpose, compiled a complete reference table to this kind of legislation, from which it appears that attempts to effect a change have not been unfrequent, although unsuccessful. No doubt the more pressing interests of the day have excluded from the halls of Congress proper consideration of the vital interests of the future.

Since there does exist in the region a Government reserve of timbered country—though not by any means created with a view to the needs of forestry—it was desirable to give special information as to its conditions and its further needs at the hand of Government. No more competent writer for this task could have been found than Mr. Arnold Hague, for several years geologist-in-charge of the National Park; a man thoroughly acquainted with the ground, of broad views, and alive to the important interests depending on such timber reservations. The letter which he kindly consented to contribute, will, it is hoped, stir up an interest in those who, while in sympathy with the idea of the National Park, can not rise to the broader conception of national forestry.

A chapter on snow-slides, prepared by the writer, will give an imperfect intimation of what direct dangers may be expected from forest devastation in the mountains, and how to meet them.

The concluding pages, kindly contributed by Mr. Parsons, will be read with interest by those who, in the plains of the region in question, have begun to ameliorate their climatic conditions by the planting of trees and groves.

Fully aware that defects in a report like the following must become apparent to any one who peruses it with interest and finds one or the other important question imperfectly answered or altogether overlooked —defects which are due to many different causes, too many to recount— I still hope that they will not prove such as to overshadow the value of the work as a whole for the purpose for which it has been done. Love and zeal, at least, have been brought by all the contributors to their work in behalf of the great national interest which is connected with the "backbone" of this continent.

B. E. Fernow.

EXTRACTS FROM REPORTS OF THE COMMISSIONERS OF THE LAND OFFICE.

Commissioner Williamson, in his reports, deals at length and in detail with the depredations, the deficiency of funds to counteract them, the feeling of the law-abiding citizens in regard to them, and proposed changes.

Commissioner McFarland says, in 1881:

The existing provisions of law permitting citizens to fell and remove timber on the public lands for mining and domestic purposes, as found in act of June 3, 1878, are, in my opinion, very defective. The only lands from which such cutting is authorized are the mineral lands.

(1) The mineral lands are to a great extent undefined and necessarily must so remain.

(2) Large quantities of timber are absolutely necessary for the development of mines, while the said act authorizes the cutting thereon of the timber for other purposes. The purchaser of a mining claim has as much (if not a greater) need for the timber thereon as the agriculturist; and the transportation of timber to the mines from a distance is very expensive.

(3) The law furnishes no relief to such as reside at a distance from such lands. The situation is practically this: The settlers on lands devoid of timber need timber for fuel, building, etc. Very frequently they can not get it, except from the public lands. If they can not get it legally still they will take it, and when taken solely for said purposes it is under circumstances which largely mitigate the technical legal offense.

While parties who steal the public timber for speculation and profit deserve severe punishment, those who use it solely for home purposes, under the imperative necessities above mentioned, should have their privileges accurately and reasonably defined. I deem the enactment of some law which will accomplish this end to be very desirable and in the public interest.

In 1882:

Proceedings for the protection of the public timber are now had under several different statutes, some of a general and others of a more local character. Much embarrassment grows out of this diverse legislation, portions of which are also conflicting.

It is my opinion that a general law should be enacted clearly defining the rights of citizens to take timber from the public lands for prescribed purposes, and providing penalties for unlawful cutting, removal, destruction, or waste.

Of the various classes of cases of trespass with which this office has to deal, the most numerous are those committed under cover of homestead entries, fraudulently made for the purpose of securing the timber on the land. This class of entries does not seem confined to any one locality, but the fraud is perpetrated wherever there are public timber lands subject to entry under the homestead laws.

In 1883:

The present increasing value of timber is an inducement to individuals and companies to make large investments with a view to the control of the timber product and the further enhancement of prices resulting from such control.

It would, perhaps, be of little moment how soon the public title to lands should pass to private holders, since that is the ultimate purpose of the laws, if the further purpose of the laws that public lands should in the original instance be widely distributed among the people could be secured.

Public notices relative to forest fires have been prepared to be posted, have been of beneficial effect, but no funds are on hand to do enough in this direction.

In regard to the timber and stone act of 1878, he says:

The restrictions and limitations are flagrantly violated.

Evidence is cumulative that the act is made use of by corporations and wealthy individual operators to secure fraudulently, for the purpose of manufacturing into lumber or to hold for speculation, the accessible forests yet remaining in the States and Territories, thus to be lost to those who would enter and make use of them.

Fraudulent removal of timber on mineral lands, under cover of this act, is also reported:

Information is in my possession that much of the most valuable timber is being taken up by home and foreign companies and capitalists through the medium of entries made by persons hired for that purpose. I have found it necessary to suspend all entries of this class. * * *

In 1884, in regard to the same act:

The developments of the past year emphasize the foregoing statements relative to the prevalently illegal character of this class of entries. The result of the operation of the act is the transfer of the title of the United States to timber lands practically in bulk to a few large operators.

The preventive measures at the command of this office have proven wholly inadequate to counteract this result.

Public interest would be served by its repeal.

Speaking of the necessity of some measure by which natural forests may be preserved at the headwaters of important rivers, the Commissioner says:

The importance of the subject can not perhaps be overestimated, and it is apparent to me that if anything is to be done in this direction it should be done quickly. The forest areas of the country are rapidly diminishing, and the timbered lands of the United States will, under existing laws, soon be exhausted. To a great extent such lands are now appropriated by pre-emption and commuted homestead entries, made without settlement except that of lumber camps, and without improvement except the cutting and removal of the timber for commercial purposes. The United States receives only the minimum agricultural price of the land, irrespective of its real value, which is usually largely in excess of the Government price.

The low price at which such lands are now obtained stimulates fraud in acquiring titles and holdings for future speculative purposes, while as soon as reduced to private ownership such lands have their proper market value, and the cost of timber products to consumers is naturally predicated upon that value and not upon the Government price at which the lands were primarily obtained.

Commissioner Sparks expresses himself as follows, in 1885:

Depredations upon the public timber are universal, flagrant, and limitless. Whole ranges of townships covered with pine timber, the forests at headwaters of streams, and timber land along water-courses and railroad lines have been cut over by lumber companies, under pretense of titles derived through pre-emption and homestead entries made by their employés and afterward assigned to the companies. Steam saw-mills are established promiscuously on public lands for the manufacture of lumber procured from the public domain by miscellaneous trespassers. Large operators employ hundreds, and in some cases thousands, of men cutting Government timber and sawing it up into lumber and shingles, which, when needed and purchased by local citizens, can only be obtained by them at prices governed by the market value of timber brought over expensive transportation routes from points of legitimate supply.

Under cover of the privilege of obtaining timber and other material for the construction of "right-of-way" and land-grant railroads, large quantities of timber have been cut and removed for export and sale. Immense damage is also inflicted by the destruction of small growing trees and the spread of forest fires, resulting from a failure to clear up the land and dispose of the brush from felled trees, even in the cases of authorized cutting.

And in regard to the timber-land act of June 3, 1878:

It has operated simply to promote the premature destruction of forests, the shipment of their products out of the country, or for holding lands and the lumber needed by the citizens at the speculative prices demanded by foreign and domestic corporations acquiring a monopoly of the timber lands of the Government at nominal rates through easy evasion of the terms of the law.

Why, as a mere business proposition, timber lands worth at lowest averages from $10 to $25 per acre for the standing trees or, according to accessibility and class and quality of timber, worth $25 to $100 per acre should be sold by the Government for $2.50 per acre it is not easy to perceive.

The evils developed in its practical operation are inherent in the system and can be cured only by a repeal of the law by which they are propagated.

And, further, in enlarging upon the importance of forest preservation in the mountains, he says:

The Government is now expending large sums of money in attempts to substitute by artificial means the regulation of the flow of the Mississippi River which nature had provided in the dense woods originally surrounding the sources of its numerous tributaries.

That wise and speedy measures should be adopted for the preservation of forests on the public domain is in my opinion an incontrovertible proposition. To this end I recommend the immediate withdrawal from appropriation, sale, or disposal of all the public forests and of lands valuable chiefly for timber, subject to future legislation for the permanent reservation of designated areas and a more economically-governed disposal of such timber lands or timber as it may not be necessary indefinitely to reserve.

In 1886:

Depredations upon the public timber by powerful corporations, wealthy mill-men, lumber companies, and unscrupulous monopolists are still being committed to an alarming extent and to the great detriment of the public at large.

An immense pressure is brought to bear upon the legislative and executive branches of the Government to the end of securing immunity for past and unlimited privileges for future spoliations of public timber lands, all ostensibly urged in the interest of bona fide "agriculturists" or "miners," but notoriously in fact to forward gigantic schemes of speculation and monopoly in the remaining forests of the United States.

Replying to a request for a change of construction, so as to permit mill-owners to cut timber for their mills on land that might be mineral, the Commissioner writes:

The act itself is injudicious and entirely too broad, and its repeal or modification has been recommended by you (the Secretary) for the reason that its provisions ignore the importance of the preservation of the timber, and invite, in a measure, great waste and greedy speculation by individuals and corporations. It is impolitic and unjust in not preserving timber for the use of future settlers and inhabitants, and permitting it to be taken in large quantities without consideration and proper restrictions. It, however, is still the law, and so long as it remains on the statute book it can be enforced.

The act of June 3, 1878, gives the timber to the miner and settler, but if the saw-mill men can come in and cut and sell it, they, and not the settlers, will get the benefit of the timber. The interest of the settlers and lumbermen in this matter are not identical.

But a later circular (August 5, 1886) permits the sale of timber or lumber to bona fide residents for the legitimate use of the purchasers in compliance with the provisions of the act, which means for actual personal consumption. In this circular the right of existence of saw-mills using timber cut on Government land is recognized, and while it is imposed upon the saw-mill men to keep such records as will show where the timber they manufacture comes from, and to obtain an agreement from the purchaser that he will use the timber legitimately according to the spirit of the act, the door is opened to circumvent the law.

It is also stated that "there exists no authority of law for granting the privilege of cutting timber on the public lands and paying stumpage therefor;" that "there is no authority to dispose of burned timber separately from the land."

In 1887:

Such a record of crime as that shown by investigations made by special agents during the last two years is rarely to be found. Bold, reckless, and gigantic schemes to rob the Government of its lands have been discovered and exposed in every State and Territory containing public lands.

The unavoidable continuance, on account of the early exhaustion of the appropriation to pay witnesses in United States courts, of the important cases against the Sierra Lumber Company, in California, involving over $2,000,000, and in which two special agents of this office devoted nearly their entire time for a year in securing evidence and preparing for a successful prosecution, and of the cases against the Montana Improvement Company and Northern Pacific Railroad Company, in Montana and Idaho Territories, involving an equal, if not greater, amount, is greatly to be regretted. The delay in these cases can not fail to be exceedingly detrimental to the public interests. The Government, so far as the office is concerned, was fully prepared, and had every reason to expect that had said cases come to trial judgments would have been secured for nearly the entire amounts sued for.

During the delay in the prosecution of the above and other important pending cases the defendants are by no means idle. They not only continue their unlawful depredations on public timber in defiance of all efforts of this office to prevent that course, but they avail themselves of every such opportunity to destroy the evidence of their past transgressions and to nullify the efforts of this office.

By the time these cases can again be brought to trial many of the witnesses will have disappeared and much of the evidence depended upon by the Government will have been destroyed, necessitating a re-investigation and the securing of additional evidence in nearly every case, thereby duplicating the expenses of the special agents in preparing the cases for trial, exhausting the appropriation, and rendering it impossible for this office to cause the investigation of the many new and flagrant cases of trespass which are brought to its attention. The appropriation for this branch of the public service is *altogether inadequate for the purpose.*

The wholesale destruction of public timber on odd sections of public lands within the granted limits of unconstructed railroads, or of roads which failed to comply with the provisions of their grants, continues to an alarming extent. The delay of Congress in declaring the forfeiture of said grants is, in this particular alone, of great detriment to the public interests. Irresponsible parties are rapidly denuding such lands of their valuable timber, rendering the lands, in many instances, barren wastes and utterly worthless.

To secure proper enforcement of the laws and punish willful and persistent violators a force of at least fifty special timber agents, at an annual expense of $150,000, ought to be employed. I have, however, estimated for $125,000 as a minimum, below which a reasonable efficiency in the service can not be obtained. Vastly more can be accomplished in one year with a sufficient appropriation than can be accomplished in several years with smaller annual appropriations aggregating a larger sum.

The area of timbered lands in the United States is disappearing at a ratio that excites grave apprehension, while timbered agricultural lands in the public States and Territories generally may be regarded as practically exhausted. The necessity for clearing land of its timber preliminary to making a farm is exceptional. It is want of timber and not its surplusage that afflicts settlers on the public domain. The struggle to accumulate great private fortunes from the forests of the country has reduced forest areas to a minimum. What is left at the heads of rivers and streams and on mountain sides should be preserved as of infinite importance and value for climatic effect, the natural regulation of the flow of waters, and to prevent the relapse of large agricultural districts to a desert condition.

When timber had to be cut and burned as a necessity in clearing land for cultivation there was no cause for increasing the price of land because there was timber upon it. This is not the present situation. The remaining timber lands, as a rule, are worth little or nothing except for the timber, and their value for timber is being rapidly enhanced as transportation facilities increase and timber areas decrease.

The appropriation of $75,000 for the prevention of depredations on the public timber is TOTALLY INADEQUATE. The vast fields to be covered, stretching from Florida to Alaska, can not be supervised by twenty-five special agents, nor can the determined efforts of timber depredators, many of them corporations with millions of dollars at their command, to despoil the forests of the country, be met by puny attempts to check their unlawful and disastrous acts. The service is more than self-supporting, and draws no money from the Treasury that is not more than returned to it by fines and recoveries. It is no part of an intelligent or defensible policy to make timber depredations a source of revenue. The object to be attained is to save the forest lands from unlawful destruction, and if this can be accomplished by appropriating the whole of the receipts derived from trespass prosecutions there should be no hesitancy in allowing the administrative department the aid, at least, of the amount it recovers. My estimate for the next fiscal year is $100,000 for this purpose, a modicum only, I must say, of the amount that could be beneficially and profitably expended.

Three years ago my predecessor recommended an appropriation of $400,000 to protect the public lands from unlawful and fraudulent appropriation. Since that period the need of such protection has increased with the intensified demand for public land holdings for monopolistic and speculative purposes. Yet Congress at the last session allowed but one-fourth of the sum regarded as requisite under the preceding administration of the Government.

Both Congress and the Executive, not less than political parties, annually assert an intention that the public lands shall be preserved for actual settlement. No public demand is greater than that land monopoly shall not be fostered by the Government. Yet at the vital point where these words are to be put into action, Congress fails to place in the hands of the executive branch the means to redeem these public promises and to prevent the indiscriminate waste and misappropriation which has for years dishonored the public-land system, and through which great areas of lands needed for actual settlement pass into the hands of speculators, syndicates, and corporations.

THE GOVERNMENT IN ITS RELATION TO THE FORESTS.

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The forests of any large country bear a peculiar relation to national prosperity. They not only constitute a large proportion of the natural wealth of a nation, but they form the indispensable basis of a flourishing agricultural, manufacturing, and commercial industry. They are, moreover, one of the most important elements in determining the climatic conditions of any given region and, through these, the distribution of population, of industrial pursuits, and of disease and health.

According to the census report of 1880 the value of the forest crop of the United States for that year exceeded $700,000,000. To obtain an adequate idea of the relative importance of this product it will only be necessary to institute a brief comparison with other branches of industry or wealth. The value of the forest products was equal to one-third of that of all farm products whatsoever sold, consumed, or on hand in the year 1879. It exceeded by over $100,000,000 the total assessed value of all the farming property in the six New England States, and by a somewhat smaller figure that of the farms of Virginia, North and South Carolina, Georgia, Alabama, and Mississippi. It would have purchased, at its assessed valuation for the purpose of taxation, the entire property, personal and real, of all the citizens of the States of Vermont, Delaware, Florida, Arkansas, Nebraska, Colorado, Nevada, and Oregon, and of all the Territories besides, and still have left a balance nearly equal to the same kind of property rated in the District of Columbia.

If to the value of the total output of all our veins of gold, silver, coal, iron, copper, lead, and zinc were added the value of the stone quarries and petroleum obtained, and this sum were increased by the estimated value of all the steam-boats, sailing vessels, canal-boats, flatboats and barges plying in American waters and belonging to citizens of the United States, it would still be less than the value of the forest crop by a sum sufficient to purchase at cost of construction all the canals, buy up at par all the stock of the telegraph companies, pay their bonded debts, and construct and equip all the telephone lines in the United

States. This sum of $700,000,000 exceeds the gross income of all the railroad and transportation companies in the United States, and, if we leave out New York and Pennsylvania, it would suffice to pay the public indebtedness of all the other States in the Union, including that of all the counties, townships, school districts, and cities within those States. In a word, we have to do here with an interest ranking third in the line of importance, even from the mere view of dollars and cents, counting manufacturing of all kinds first and agriculture second.

If forests, therefore, were of no more consequence than as the source of the wealth which their annual yield represents, they would be worthy of special attention and care on the part of every community which would be considered thrifty and far-sighted.

From the very inception of government on this continent down to the present time our towns, counties, cities, States, and, since its establishment, the National Government, have devoted much attention and put forth great efforts in various forms to promote the development of agricultural and manufacturing industry.

By offering lands on easy terms, by giving premiums for excellence of products, by encouraging the importation of improved breeds of live stock, by promoting the use of fertilizers, by free distribution of seed, by the establishment of experimental stations, of model farms, of agricultural schools, and of fairs, by exempting land from taxation for a certain length of time, and by many other means, the endeavor has been made to enlarge and improve agriculture.

By the establishment of a so-called protective tariff, by bounties, by exemption from taxation, by direct grants from the public treasury or by subscriptions of private parties, by a system of patent rights, by premiums, by expositions and exhibitions, and by the establishment of technical schools and similar means in many directions, we have labored to diversify and enlarge our manufacturing industry.

More especially have we tried to secure that fundamental condition of a highly civilized state, general and rapid means of transportation and communication. We have expended untold sums in the improvement of our highways and water-ways. Country roads, turnpikes of many different kinds, railroads, canals, we have practically constructed at the expense of the public Treasury. We have laid out large sums in the improvement of our rivers and harbors in order to faciliate our commerce. We have established and maintained at a large cost to the general Treasury a Federal post-office, which performs many of the functions of an express company.

But not only for transportation, agriculture, and manufacturing has the Government actively engaged in a promoting and fostering way. It has passed laws for the preservation and increase of various forms of our natural wealth. Most, if not all, of the States have undertaken to protect game and fish from the ravages of private individuals. They have enacted laws which have for their object the limitation of what was until recently an unrestricted right to kill as much game and to catch as many fish as any one could. The General Government has gone even further; it investigates the habits and history of the clam, the oyster, and the lobster, with the purpose of supplying information which will promote their successful and profitable cultivation. It has undertaken the business of stocking the rivers and lakes, even the shore waters of the ocean, with fish. By these and other means it seeks to preserve the sources of natural wealth from the devastations of selfish persons or to render them more valuable.

Our forests, on the other hand, from which we are drawing a larger amount in natural wealth than from any other source of supply, or indeed from all other sources together, we have so far done practically nothing either to protect or to cultivate. While this seems strange when we contemplate the forests, as we have done, merely as a source of raw material for our mechanical industries, it will seem the more remarkable when we consider how much more important the forests are on other and widely different accounts. Although they are the chief source from which we draw all our building materials, yet even if they should cease to yield sufficient to satisfy our wants in this direction, we could perhaps secure enough for this purpose for generations to come from the untold and untouched wealth of other countries, though at a vastly increased cost. We would resort, morever, in the face of a growing scarcity of timber, to other materials for our building, such as brick, stone, iron, and other metals. The value of the product of lumber was, for the census year, $233,268,000. This would be transferred, of course, to foreign countries, if the supply of lumber should give out in this country, but it might at least be possible to get as much lumber as we desired from outside sources by restricting our demands within narrow bounds.

The fuel supply of the country would, of course, be very much diminished if our forests were cut off and none others should take their place. In the census year, three-fifths of the people of the United States used wood as the ordinary domestic fuel, and the total value of wood used for fuel purposes amounted to nearly $325,000,000. At the same time, if wood should get scarce other material could be found to take its place as fuel. Coal and peat, natural gas, petroleum, and many other and perhaps some now unknown substances, might be substituted in place of the forest products for fuel.

Other articles for which wood is in demand, among which as most important may be mentioned fence posts and fencing material, handles, wheel-stock, wood pulp, baskets, boxes, etc., might all be supplied by other material, though at a considerable sacrifice in cheapness and, in some cases, convenience.

It is to be said, however, in this connection, that in spite of the inventions or application of substitutes for wood, the demand for the latter shows no tendency to decrease in an advancing community, since the growth of population and the ever-multiplying wants of an expanding industry more than keep pace with the substitution of other materials, and a rising price of wood is likely to be the result.

But forests occupy an entirely different position from all other forms of natural wealth, and a far more fundamental one. They determine, to a very large extent, climatic and hygienic conditions, and, through these, the prosperity of industry and the distribution of disease and health. The functions of forests in modifying climate and soil are so fully and ably presented in the various reports and bulletins of the Department of Agriculture, and in the proceedings of the various Forestry Associations, that the merest summary of the important facts will suffice for our present purpose.

Whether the presence of forests actually increases the total amount of rain-fall within any great region may still be a subject for dispute, but all authorities agree that forests produce a much more equable distribution of moisture throughout the year than exists where they are not found. In a treeless district, particularly if it be hilly, the rain glides off into the rivulets and into the rivers, scarcely moistening the ground below its surface. The burning rays of the sun, or the sweeping blasts of air, cause the rapid evaporation of what may remain here and there on the surface or may have penetrated a little way into the soil. A few hours after the rain there are almost no signs that rain has fallen at all. On the contrary, where there are forests the interlaced roots of the trees and the mass of leaves above them act as a sponge, which absorbs the water and holds it long enough to enable it to perform its service of quickening animal and vegetable life. The water oozes and trickles down through this spongy substance, and flows slowly away to feed the springs and streams. The modifying action of great forests on the distribution of moisture is both direct on the immediate region lying about them, and indirect on distant localities, owing to their influence on the character of the streams and rivers which drain their areas.

Where streams are not thus protected and modified at their sources by forests they may become the cause of almost as much injury as benefit. Owing to the fact that the water flows off so rapidly, the streams become at one time raging torrents, sweeping everything before them and inflicting an amount of damage which it requires much of the time elapsing between floods to make good, while at another they dwindle into insignificance, scarcely furnishing water enough for the flocks and herds along their banks. Where the forests have been cleared from the sources and banks of historic rivers the result has been an entire change in the character of the streams. The history of the Rhine, Rhone and Danube, in this respect, is full of instruction for us, and if alternating periods of drought and disastrous floods can not always be directly traced to the removal of the forests, their aggravation and frequency has been shown, even in this country, to be due to such removal.

This influence of forests on the character of our streams is a much more important subject than it seems to a careless observer. It affects navigation, and through that the whole transportation system of the country. A river which is navigable only at high water, or for a part of the season, is of little value as a channel of commerce, and can scarcely be considered an active competitor with such an agency as the railroad. And yet to such a condition are many of our great streams being brought, and we are now called upon to spend large sums of money, on the one hand in dredging and cutting in order to utilize a decreasing amount of water in the dry season, and, on the other, in building dykes and embankments against ever-increasing floods from the melting snows of spring-time or as the effect of protracted rains.

The character of the streams has an important if not a controlling influence upon our manufactures. A system of factories and mills, which would spring up spontaneously along a water-course regularly and equally supplied with water, is rendered impossible if this stream becomes a mountain torrent during one quarter of the year, and an all but dry bed during another, even if in the two cases the same quantity of water falls during the year and flows off through this channel in the course of a twelvemonth. Such a state of things necessitates a resort to more expensive means of water supply, or to auxiliary power of another kind, which again means increased cost of production and a rise in the cost of living for every member of society.

Irregularity of streams also affects agriculture, and not only indirectly, through the industries above-mentioned, but directly as well. The decreased volume of water during the period when the least rain falls diminishes the humidity of the atmosphere and affects powerfully the quality and variety of crops which may be raised, while the increased volume at high water cuts into and carries away enormous quantities of the soil from the farms lying along the banks of the streams, even when it does not by its overflow spread ruin and devastation through the adjacent valleys.

A striking illustration of the extent to which a stream may be changed by the deforesting of its headwaters and shores is afforded by the river Schuylkill, from which Philadelphia draws its water supply. The current has become for a large part of the year so shallow and sluggish that it is no longer able to rid itself, as it once did with ease, of the impurities which are poured into it, and the quality of the water is deteriorating at a more rapid rate than the stream of impurity is increasing. This result can be due only to a change in the character of the stream itself.

The fundamental importance of forests is, if possible, still more evident in mountainous and hilly districts. Their existence in such situations is the absolutely essential condition, we will not say of obtaining the necessary rain-fall, or preserving the necessary moisture, but even of maintaining the soil itself. Without forests a soil can not be made, or preserved, on our mountain-sides. The action of frost and of rain easily sweeps away every vestige of soil and leaves only the bare rocks as the basis of agriculture and the sources of streams. The soil thus carried away chokes up the streams and finishes the work of destroying their navigable character, which was so surely begun when the disappearance of the forests changed their broad and equable currents into mountain torrents.

Forests, moreover, have a powerful influence upon the sanitary conditions of life, owing partly to their effect on temperature and moisture, and partly to their effect on the purity of the atmosphere. Careful observations have proved that if the moisture of the atmosphere rises above or falls below a given degree certain diseases become more prevalent and fatal. Forests act as regulators to diminish excessive and to increase insufficient moisture. The beneficial influence of pine forests on pulmonary diseases is universally recognized.

In a word, then, the forests are an absolute necessity. If we would have the advantages referred to, with many others not discussed, we must have the forests near us. Mild winds, humid atmosphere, equable climate, regular rivers, a flourishing agriculture, an expanding industry, are things we can not import, and they are all things which depend for the very possibility of their existence on the presence of forests, and extensive forests, within the bounds of our own country and distributed where they will do most good.

The experience of the race and the investigations of science agree in testifying that there is a certain ratio which the forest land of any given country (varying of course with the country and even with different parts of it) should bear to its other lands, and that if the forested region is allowed to sink below that ratio, either through carelessness or a selfish desire to get all the advantage out of the resources of a country for the present generation, regardless of the interests of posterity, the result can be only an impaired industry and declining prosperity.

Even if all the land of a country were good agricultural land, the plan of clearing it entirely off in order to put it under cultivation would be strikingly like the old folly of killing the goose that laid the golden egg; for not only would no increased yield of agriculture occur as the result of such a policy, but a greatly-decreased return would probably be the result, diminished to the lowest point and ending in the utter destruction of agriculture and all other industry in one common ruin.

The importance of forests then for the national welfare being admitted, the question remains to be considered, What is the condition of our forests, and what action should be taken in their behalf? It must suffice in regard to this to refer to the facts contained in the various census reports, the bulletins of the Department of Agriculture, and the numerous other publications in which the past condition, present state and future prospects of our forests are discussed. The evidence is ample and conclusive that we are making fearful inroads on our forest stores. We are cutting off a much larger crop than can possibly be replaced by natural growth within the period when, at the present rate, we shall have cleared the original forest off the ground. We are doing almost nothing in the direction of cultivating forests; nay, we are not even protecting from devastation the young trees which might replace the forests if they had a fair chance for growth.

It is not the farmer—who only clears the forest in order to sow his crops, nor the lumberman—who fells the trees for the purpose of sending the lumber to market, nor the railroad—which calls for our forest trees for its ties, nor even the settler—who wants fuel to keep him warm, who are the enemies of our forests. All these at least obtain from this moderate destruction some return for themselves and society which is great and visible, though not always commensurate with the damage they inflict by their careless and wasteful methods. Fire, however, and browsing animals of all sorts inflict a damage on the growing forests for which there is either no return at all or one so insignificant as not to be worth mentioning. These two agencies, between them, keep millions of acres free from trees which would soon be covered with dense forests if they could be protected from such spoilers for a few years.

It is estimated on good authority that within fifty years, at the present rate of cutting, and with the present wasteful methods of management, the great bulk of our valuable forests will be gone, with almost no prospect of seeing them replaced by a new growth possessing anything like the value of the present one. To put it mildly, we are using up our forests at a much more rapid rate than we are replacing them. We are already beginning to experience some of the most serious evils of such a policy in a growing scarcity of valuable timber and in the changing character of our streams, soil and local climate. And these evils are bound to increase with every year of continuance in this line of action.

Such being the case, the question as to efficient remedies becomes all-important.

Before mentioning the various measures of relief to which I believe that it would be wise to have recourse, and which I think will in their main outlines have to be adopted before long, if we are to avoid the losses which will inevitably accompany our present policy, I wish to call attention to some important distinctions in terms. I would emphasize the fact that *tree-planting* is not *forest-culture.* The two are quite distinct in their methods, in the persons who manage them, and to a large extent in the purposes which they subserve. The term tree-planting I shall apply to the system of planting trees which a farmer may carry on in connection with his agricultural operations from a variety of motives, such as beautifying his farm and house yard, shading his cattle in the fields, protecting them or his fields from the blasts of winter by cultivating wind-breaks, planting them along the water-courses to keep the soil from being carried away by sudden freshets, etc. Forest-culture I shall apply to the regular system of cultivating extensive tracts of country with a view to securing as large and valuable a stand of trees as possible. This also may be done from a variety of motives, as when done by government or corporations with a view of affecting the climate and preserving the rivers and soil of the mountains, etc. The difference consists chiefly in the fact that in the one case tree-planting is done as a mere incident with a view of enhancing the value of other forms of property with which it is intimately connected, while in the other case it is the chief business, and the ground is given up entirely to this one crop and is managed with reference to its prosperity. The former can be done, of course, by every farmer or owner of a lot which he devotes chiefly to other uses, while the latter can be done only by those who give up their whole land to this one purpose. Tree-planting, however extensive it may become, can never take the place of forest cultivation. The former would, of course, be done only by people in places where they live and cultivate the fields, while the forests must be kept up often on sterile and, for agricultural purposes, good-for-nothing soil, where no farmer could make a living. To secure, moreover, the meteorological advantages of forests and the indirect industrial benefits which flow from their regular maintenance, it is absolutely necessary in certain conditions that they should cover a large extent of contiguous ground, stretching often for miles. It is evident that such work can not be done by a small farmer in the time and with the means usually at his command.

Another point must be insisted upon, and that is that forest preservation does not at all mean that trees shall not be cut down, but simply that they shall be cultivated just like any other crop, and not wasted; that they shall not be taken away before they are ripe for use, except for some special reasons, and that the conditions necessary for reproduction shall be steadily maintained from year to year. This means, oftentimes, that care must be exercised not to allow the stand of trees to be cut off entirely or all at once, since this sometimes so changes the whole character of the soil and climate as to make it impossible to recover the ground with any reasonable expenditure of effort. It is from this wholesale and inconsiderate cutting that such immense damage is being done in all mountainous regions by the clearing of the forests from the hill-sides. The soil is left exposed to the free action of the frost and rain and is carried off in such quantities as to leave only the bare rocks, on which nothing can take root. Even if the soil should not be carried off, the beating rain and driving storm, the scorching sun and biting frosts will dry up, freeze out, drown out, or sweep away whatever seedlings might spring up there. The judicious cutting of a forest in a climate like that of the Atlantic or Pacific coast regions, says Dr. Sargent, entails no serious or permanent loss. A crop ready for the harvest is gathered for the benefit of the community. Trees which have reached their prime are cut instead of being allowed to perish naturally, and others take their place. In this way the permanence of forests is secured while their fruitfulness is kept at the maximum, if we consider, say, a century as the unit of time.

Now, I believe that our own brief experience confirms that of the various European countries and is in full harmony with the *a priori* deduction drawn from a study of the problem, viz, that a wide and intensive care on the part of the Government is indispensable to insure the preservation of the necessary forests. As already shown, our Government has never taken it for granted that any branch of industry would flourish to the desirable extent if left to itself. Much less likely is forestry to flourish, if left to itself, than other branches. A very short glance at the history of our forests is sufficient to show why they have been disappearing so rapidly.

The farmer has cleared off, perhaps, as many acres as the lumberman, it may be more; but he has cleared the ground for the purpose of cultivating it, and though it is undoubtedly true that in some localities he has pursued a short-sighted policy and cut off an excessive amount of the forest, yet on the whole most of the clearing he has done has been of a character that has contributed to increase the total wealth, present and prospective, of the community. This can not be said to the same extent of the lumberman, who has often cleared the forests from ground which was really good for nothing but to grow forests. Until a very recent period it was possible to get possession of forest lands for a mere song. A company having once put up its mills, found it for its interest to use up the supply of material as soon as possible and then to change the location of its works. Such enterprises had little interest in the welfare of the region within which the mills were situated, for they did not expect to stay longer than was necessary to make use of the wood which was suitable for their purposes. They cared still less for the interests of the dwellers in the valleys of the water-courses which their policy was converting into entirely different sorts of streams. They hoped to make more money by cutting down the trees as rapidly as possible and then moving on than in any other way, and as it was money alone which they were after they did what promised to give them the biggest and quickest returns. From their stand-point it was all right, and just what everybody else in society would have done if he had had the chance, but it was none the less ruinous to the interests of those who were affected by it. The feeling of the injured had little chance, however, to concentrate itself against any one, as the aggressors were often far removed from the scene of operations which affected them, and the injured were, moreover, ignorant of the true cause of their losses. In a word, it is to the pecuniary interest of the lumberman to cut as fast as he can, since the more he cuts the more money he makes, and if the supply gives out he can move on to where there is plenty of it. What does he care even if the supply will come to an end in twenty or twenty five or fifty years? That is a long way off, and after him the deluge. Now, I think that no one can doubt that it was a short-sighted policy for our States and the nation to be so free with their timber resources as to hand them over without control of any sort into the hands of private parties to do with them as they chose. The nation never thought of doing anything of the sort with its streams. They were looked upon from the very first as things in which all had an interest and which the Government should protect in the interest of the whole. But with that curious inconsistency which characterizes all men more or less in their political and social relations, but especially the Anglo-Saxon, while we prescribed punishments for all who polluted or filled up or diverted our streams, no matter how convenient it was for them to do so, no matter how much they may have saved or made by so doing—we have had nothing to say to him who was slowly drying up the very sources of the streams by cutting away by wholesale the trees that protected them.

It must seem to a disinterested student of human affairs a strange thing that a Government will protect the farmer by its police force against the thief who would take a bushel of corn, but will do nothing with him who steals away the fertility of his field by drying up his water supply; or, indeed, will prevent a brother farmer from turning aside a portion of the stream which has always flowed through his farm, but will say nothing to him who causes the whole stream to dry up and disappear at one time, and reappear at another as a raging torrent threatening to sweep away his most valuable acres; or will protect him against the assault of a bodily aggressor, but do nothing with the man who steals away his health by altering the whole character of his air and climate.

Strange it would seem to be that a Government will establish an agricultural school where the scientific side of agriculture can be studied, experiments made on crops and soil, etc., and spread abroad at public expense the results of such experiments, and yet make it no part of the duty of such a school, nor offer any inducement to any one to undertake the investigation of forestry, which underlies and conditions the very possibilities of a flourishing agriculture. Strange that it will spend large sums of money in growing and distributing freely to farmers seeds of various kinds of plants, while it has as yet done little or nothing toward the same kind of thing in regard to trees, the growing of which under some sets of conditions would be as profitable as that of any of the new kinds of crops which it would introduce. Strange that it will establish agricultural fairs and offer premiums for excellence in all branches of agricultural work and yet not notice a work which is of vital and fundamental importance to the whole industry of the country.

All this however is spilt milk. What has been done has been done and can not be helped. Its consequences may perhaps be obviated somewhat. What has been left undone has been left undone, and we can not remedy the evil except by inaugurating a different policy.

The first step is for the Federal and State governments to remove the timber lands which still belong to them from the list of lands for entry or sale, and, after a thorough examination as to what forests are of climatic and industrial importance, to keep them under the control of the Government. There are in the older States perhaps few such lands of any considerable extent, but such as there are should be retained in public possession and managed in the interest of the whole.

As to the lands which have passed into private possession it is more difficult to do anything, and I think that better results can be achieved by adopting a line of action, which I shall outline presently, than in trying to restrict or control lands which have finally passed over into private possession.

To insure the most complete success in this work of protecting and promoting the growth of forests it will be necessary to have hearty co-operation between the State and national governments. A word, therefore, may not be out of place in this connection as to what the State governments may properly do in this direction, though they can accomplish but little unless the Federal Government does its part.

One of the first and most important measures which the individual States may wisely adopt is to take some steps which will attract public attention to the vast importance of the matter, and which will interest the great mass of the people in some active work of their own in connection with the subject. This can be done, I think, by some general plan of encouraging tree planting on the part of our farmers. To do this in any satisfactory way it is necessary to devise some method of reaching the great mass of people and fixing their attention, if it be only for a short time. This, I think, can be secured by the establishment in the proper manner of a State holiday, to be called Arbor Day, and insisting, so far as possible, on its general observance by all the people in the State. But this of itself would not be enough. Men must be provided whose business it should be to make a thorough study of the subject of forestry in general and the business of tree planting in particular; as to the kind of trees it would pay best to plant in each locality, the methods of culture, the influence of trees on the farm, etc., and who should go to agricultural fairs and farmers' meetings, and impart the instruction which the average farmer is wofully in need of. They should also go into the teachers' institutes, especially in the rural districts, and try to interest the teachers in a matter which they would have rare opportunities to urge upon their pupils, who will shortly be the controlling element in the State. Means of publication should, of course, be amply provided, so that they could reach with their publications and lectures every farmer in the State. These lecturers should make it a special point to show how a wood-lot or even isolated trees may be utilized so as to return the largest yield to the farmer.

The State would find it for its interest, also, to establish nurseries where seeds of trees or young trees could be obtained at a nominal price, or for nothing, as experience might demonstrate to be the best plan. Premiums also should be offered for the best groves or groups, or samples of trees of various kinds, for the best utilization of tree pro ducts, etc. For, in the long run, this element would determine how large a per cent. of the farmers would really go into the matter.

It may be objected to this plan that it is not necessary, since farmers are alive to their own interests, to lead them to take up any such thing of themselves. This, I think, is entirely a mistaken notion. In the first place, under present conditions it is very questionable whether it would pay farmers to take up tree planting on a large scale as a mere matter of dollars and cents. They know very little of the subject. It would cost entirely too much to get the education necessary to make such a thing profitable for any farmer to undertake it on his own account. On the other hand, if the necessary information was brought home to him by a skilled expert in such a form as to be thoroughly intelligible to him, it might pay him well to engage in it. Moreover, it is a well-known fact that if a custom once creeps into a farming community and naturalizes itself, so to speak, among a few of the best farmers, it oftentimes takes root and grows, when if it had not come so recommended and pushed by strong public influence it might never have come at all. The introduction of nearly all public improvements amply proves this. It is as well established, for instance, as anything can be in agriculture, that at a certain period in the development of the industry of the country the introduction of improved breeds of live stock will result in enormous profit. But the larger part of the agricultural regions of this country, although they have long reached that period, still worry along with the old style of spindle-shanked draught horse, the long-nosed swine, and the scrub cow. Nearly every good thing is the result of the determined effort of public-spirited citizens, or of the Government, or the pushing commercial spirit of the manufacturer or merchant who has made or bought something which he wants to sell. Of these means the Government offers, so far as forestry is concerned, in the long run, the only sure and permanent one, as in nearly every other sphere of education.

But this knowledge itself which is to be distributed must first be acquired; for it is safe to say that it is not now in existence. To acquire it will cost considerable money and many years of effort if the private individual is to do it alone and at his own expense. It can be obtained only as the result of careful experimentation on the growth and cultivation of all the different kinds of trees which will grow in this climate, and which are of any considerable value. This can be best done in connection with a regular school of forestry, where all the problems relating to kinds and values of trees, growth and cultivation, management of stretches of woodland, the effect of forests on climate and health, their economic aspects, and the other countless elements of this great subject of forestry are thoroughly studied. Such a school of forestry might and should be established in connection with the several agricultural colleges and experiment stations which have been so liberally endowed in all the States by the Federal Government, and which will be undeserving of their name if they fail to give instruction on a subject so vitally connected with agriculture and the general interests of the country as is forestry.

At such a school as this could be trained the men who could manage extensive tracts of forest lands in the ownership either of private individuals or of the State. But all these measures, important and valuable as they are, would not be sufficient by any means to insure satisfactory results at the present juncture. In order to make them of any permanent value they must be accompanied by a radical and far-reaching policy of governmental encouragement and management.

The States and the nation should encourage the planting and cultivation of large forests. Mere tree planting will never meet the requirements of the case. Large tracts of contiguous forest land must be maintained, if we are to get the industrial and climatic advantages which flow from a well-wooded country. The time has come when it may be profitable for private citizens as a mere means of acquiring wealth to plant and cultivate forests; profitable, I mean, if they have the knowledge in regard to local conditions which it should be the duty of the State to furnish through such forestry schools. To manage such forests so as to make them profitable requires a high degree of administrative talent and trained technical skill such as is rarely acquired by any great number of men except in connection with a regularly equipped school. If the trained men are at hand, and can be obtained, and the evidence is forthcoming that the cultivation of forests is likely to prove profitable, we may expect to find many corporations or individual men going into the business from purely pecuniary considerations, and thus we should enlist private interest in the cause of public welfare, as we do in other branches of industry.

But though I believe, judging from the experience of foreign countries and from the probabilities of the case, that we should thus get many men interested in extending and maintaining our forests, I do not think that this will be sufficient. We shall never have a thoroughly or even an approximately adequate remedy for the evils which beset us in this matter until the States and the nation undertake the planting and cultivation of forests on a large scale.

In the first place it is evident that in the case of the large percentage of forests which, on account of meteorological considerations, must be maintained under unfavorable conditions, such as those remote from large streams and railroads, which would facilitate transportation, there can be no sufficient inducement for private capital to seek such an investment. If the enterprise will not pay good returns we can not expect private parties to take it up, and much of the reforesting or new afforesting which is most necessary for climatic reasons is of this character. It is, moreover, unsafe to have forests of this kind in private hands, since there is no foretelling at what moment private interest might lead to the cutting off of the forest from localities where they could be replaced only with difficulty, if at all.

Moreover forestry, at the best, is an industry of such peculiar character that it is very doubtful indeed whether, even under the most favorable conditions, it can ever attract the investment of private capital to such an extent as to furnish forests of the necessary size and quality. It requires, in the first place, a large capital, which of course cuts off most individuals from any hope of engaging in it. It requires, moreover, the use of capital for a long time with no return at all, and as most people prefer to risk their money where there is hope of large and quick profits rather than where there is certainty of no return for years to come (no matter how sure it may be in the long run), this still further limits the number of those who are willing to go into the business. It requires, moreover, a regular supply of highly trained labor for the efficient working of the forests, which it is difficult to get unless there are such schools as before mentioned and a reasonably certain career for those who prepare themselves for such work.

Another peculiarity of the business, viz, the great value of the stock on hand after the forest is fairly started, is a constant temptation to spendthrift owners to clear the ground at once, in order to realize immediately, and where land changes hands so rapidly as in this country there is of course great probability that it will sooner or later fall into the hands of such a man, who can do more damage in five years than a successor can make good in fifty.

All these considerations justify, on theoretical grounds, the conclusion to which our own experience points and which that of Europe absolutely demonstrates, viz, that we can not rely on private enterprise to conserve the interests of the public in this regard. On the other hand, there are comparatively few objections to Government ownership and management of forests on the ground of efficiency. The characteristics of the business coincide very closely with those which modern economists have enumerated as necessary to any business which Government should undertake. European experience, moreover, has fully demonstrated that Government management may be quite as efficient as the best private management. Indeed the state forests have become the models which private owners imitate, and they count themselves happy if they can equal them.* European Governments, after having to a very large

* From recent reports in regard to the German forests it appears that in 1884 Baden, with a forest area of only 234,000 acres, had a net income of $578,000. Wurtemburg, with 476,000 acres, had a net income of $1,237,600. Saxony from her 408,000 acres of timber lands derived a net revenue of $1,588,325, while Prussia, with a large part of her forest area unproductive and undeveloped, shows a gross income from the State timber lands of more than $2 per acre. The net income from year to year of all the German forests—equal in area to the forests of New England, New York, and Pennsylvania—is estimated at $57,000,000. This it must be understood is derived under the most conservative management, which harvests only what yearly grows and spends considerable sums for improvement of the crop and recuperation of waste areas.

extent followed the advice of the orthodox English economists and gotten rid of the forest lands which from time immemorial have belonged to the state, are now trying to get back large tracts of them into the possession of the state. The attempt to control private owners in the use of their forests has broken down in Europe nearly as completely as it would do here. There is a reason in our society why the state should undertake this branch of business which does not exist to the same extent in Europe. We have no old families with vast landed estates handed down unimpaired from father to son which offer a good basis for forest management. The only person, natural or artificial, in our society fit to do this is the state. I would not be understood as arguing for state monopoly of forests. On the contrary, I think the state should encourage private individuals to engage in forest culture on a large scale, but I think that it will never succeed in getting them to do so to such an extent as to do away with the necessity of planting and maintaining forests on its own account, which it will need to do, partly because many of the forests most required will offer slight inducements or no inducements at all to private capitalists, and partly for the sake of conducting model forests in connection with its schools of forestry. The best if not the only way to secure the development of private forests, even to the extent which is possible under the best conditions, is to have the state take the initiative in planting and caring for forests. The function of state forestry is not merely to secure the existence of certain public forests, but also, and perhaps quite as much, to encourage private forests by showing the proper methods of cultivation and utilization of forest products. Men do not like to put their money into an entirely new branch of business. They like to know that somebody has entered the field, if only as a pioneer, and has achieved satisfactory results.

It may be said that we have already experience enough to show that forestry may become a profitable branch of business of private parties. The trouble is that our experience on that subject is exceedingly small, that it moves very few to enter the business, and our forests disappear much more rapidly than such favorable experience accumulates.

It is superfluous to say that the State and the United States Governments should establish and enforce laws which would put an end to the criminal destruction of our forests by fire and browsing animals.

The whole subject, then, may be summed up as follows:

We are wasting our forests—by the ax, by fire, by pasturage, by neglect. They are rapidly falling below the amount required by industrial needs, by our water supply, by our rivers, by our climate, by our navigation and agriculture. It is high time to call a halt. The devastation of the ax will probably go on in the forests owned by private parties. Other forms of devastation can and should be stopped by rigorous measures on the part of the Government.

Our only hope is to save what forests we have still in the public possession, so far as they are necessary to the prosperity of the country, by not allowing them to be cut except under such conditions as will keep the forests in good condition; to encourage tree-planting and forest-planting on the part of individuals, corporations, and communities; and above all, as forming the condition on which the rest will be of any avail, to insist that the States shall undertake the systematic cultivation of forests in those places where it may be necessary to preserve our streams and climate.

Some one may ask where the Government is to get the authority for this purpose. In the case of the Federal Government, the answer is easy. It still owns millions of acres of forest lands, which should instantly be withdrawn from entry and subjected to a searching examination, by experts, as to its character, reserving permanently to the Government those portions which are of fundamental importance to the climate, soil, and streams. In the case of the States much of the very land needed falls into their possession for non-payment of taxes. Let the States keep it. Much of the land needed can be obtained at private sale for a mere song. Let the States buy it. More, if necessary, can be obtained by the exercise of the right of eminent domain—let the States take it. Shall we allow a railway to take land, no matter how insignificant the line it proposes to construct or how few people it will benefit, and refuse to the States the right to take land for such a purpose as this, on which hangs the welfare of our whole people?

In all this we ask nothing more than that the State shall do for forestry what it has already done for mining, agriculture, trade, and transportation, and we ask it not so much in the interest of forestry itself as a separate branch of industry as in the interest of other industries whose prosperity depends on the continued existence of forests.

It will be noticed that in the preceding discussion we have not attempted to distinguish particularly between what the National Government and the various State governments should do, but have indicated rather what they should all do, taken as a whole. The particular part which each should do follows almost as a matter of course from a study of the relations of the different parts of our governmental system. Some of the things we have mentioned, most of them, perhaps, should be done by the States individually. But the Federal Government should certainly go on with the work it has begun in connection with the Department of Agriculture at Washington.

It should continue the work of acquiring and disseminating information, and for this purpose should establish experimental forests in different parts of the country, which should be well equipped and placed under the most skillful direction. It should certainly place a check on the exploitation of forests on Government lands, and withdraw what remains of our national timber lands from the clutch of the devastators and insist on some regard being paid to general interests by those who wish to utilize them. If there be no way to get the States to look after the matter themselves the Federal Government should take some steps toward reforesting the headwaters of our great navigable streams where they have been cleared off, and nothing is being done to protect them. Surely it is as legitimate to expend Federal money to keep the soil from flowing down our mountain sides and filling up our rivers as it is to expend money in clearing out their channels when once filled. It is surely permissible to expend Federal money to protect the stream itself if it be proper to stock and restock it with fish.

Our State governments should do the rest, and should begin soon. The expense of such a system, properly organized and carried out, will be defrayed ten thousand times by the great increase in national wealth and national health which will ensue, while the loss incident to a persistence in our present policy will be simply incalculable.

REPORT

ON THE

FOREST CONDITIONS OF THE ROCKY MOUNTAINS,

ESPECIALLY IN THE

STATE OF COLORADO, THE TERRITORIES OF IDAHO, MONTANA, WYOMING, AND NEW MEXICO,

BY

EDGAR T. ENSIGN,
Forest Commissioner of Colorado,
SPECIAL AGENT OF THE DEPARTMENT OF AGRICULTURE.

CONTENTS.

LETTER OF TRANSMITTAL.

COLORADO SPRINGS, COLO., May 14, 1887.

SIR: Under dates of April 1 and September 27, 1886, respectively, commissions were issued to me from your Department, authorizing an investigation of the forest conditions and resources of the State of Colorado and the Territories of New Mexico, Wyoming, Montana, and Idaho, and an examination of the relations existing between the forests, water-courses, and irrigating systems of the region, with special consideration of the Government timber lands.

I have the honor to submit the accompanying report.

Upon receiving authority to conduct the investigation, correspondence was instituted with civil engineers and other well-informed persons in the several counties of the region, and printed circulars were sent out embracing the following questions:

CIRCULAR A.

(1) What is the extent of forest land in your county, giving approximate number of square miles; and in what part of the county is it mainly situated?

(2) What proportion of it is fully stocked; good for timber? What part of it brush, of promising growth? What part of it made waste by burning over?

(3) What is the proportion of forest to other lands?

(4) What is the character of the forest growth now remaining, in the size and kinds of trees?

(5) What species of trees predominate?

(6) Name, in the order of their importance, the principal uses to which each kind of timber is applied.

(7) What special dangers threaten the forests in your county, as lumbering, consumption by railroads, fires, etc.

(8) What are the chances for renewal after the forests have been destroyed?

(9) Of what species of trees is the second-growth usually?

(10) What kinds, if any, follow after the timber has been destroyed by fire?

(11) Is any planting done? And to what extent, and with or without irrigation?

(12) Have you noticed any changes in the volume of water in the streams, as the trees in their vicinity have been cut off or burned? Is there less water in the streams than formerly? Have floods and droughts become more frequent? Is the flow of water in the streams more intermittent?

(13) Are any observations on rain-fall kept in your locality? If so, by whom (giving name and post-office address)?

(14) Have any avalanches occurred in your section? If so, please give the particulars; when, where, and what, if any, loss of life and property?

(15) What measures would you suggest for more adequate protection of forest growth?

(16) Give any other information, upon the same general subject, which may occur to you. So far as possible, give definite and particular answers to the foregoing questions, and known facts rather than general statements. If there is insufficient space on this sheet for your answers, supplementary sheets may be used, care being taken to refer to the numbers on this sheet, so as to prevent uncertainty or confusion.

CIRCULAR B.

(1) Please give a brief and general topographical description of your county.

(2) What is the approximate total number of acres of land in your county, suitable for agricultural purposes, requiring irrigation?

(3) Is there a sufficient water supply to irrigate that amount? If not, what proportionate amount short?

(4) What is the approximate number of acres already under ditch?

(5) What is the approximate number of acres already irrigated?

(6) In your county, what is the approximate total length of: (*a*) Irrigating ditches? Main; secondary; small. (*b*) Mining and milling ditches? (*c*) City water-works (and capacity in gallons)? together with total capacity of each, in statutory inches or cubic feet, per second.

(7) Has the volume of water in the streams of your county increased or diminished, to your knowledge? Is the flow of water in such streams any more or less intermittent than was formerly the case? If you have noticed any such changes, please state the causes, so far as known to you.

(8) What effect, if any, in your opinion, do the forests have on the water supply?

(9) What, in a general way, is the extent, character, and location of timber in your county?

(10) Please note on sketch (to the best of your knowledge) the situation of the timber, irrigating and other canals, and city water-works in your county; giving the timber in black and canals and water-works in red.

(11) What are the principal causes of the destruction of forests in your county, and what measures would you suggest for their more adequate protection?

(12) Please give any other suggestions upon the same general subject which may occur to you. If there is insufficient space on this sheet for your answers, supplementary sheets may be used, care being taken to refer to the numbers on this sheet, so as to prevent uncertainty or confusion.

It also became necessary to conduct an extensive written correspondence, which extended through a period of about one year. Considerable interest was manifested in the general subject, and much valuable information was obtained concerning local forest conditions. The facts collected with respect to the numerous irrigation systems of the region were not so full and explicit as was desirable, but served a useful purpose in the preparation of my report.

Between the months of April and December, 1886, I visited many of the principal points in Colorado and the several Territories included in this examination. By personal investigation and inquiry in the various localities, I was enabled to obtain much useful information relating to the subject, and to verify statements derived from other sources.

For most timely and valuable assistance rendered me in this connection grateful acknowledgment is due to ex-Governor Benjamin H. Eaton, George G. Merrick, esq., Hon. William N. Byers, Capt. Edward L. Berthoud, C. E., Prof. A. E. Beardsley and Blair Burwell, C. E., of Colorado; Samuel Ellison, esq., General H. M. Atkinson, H. Hartman, C.

E., and Prof. Ad. F. Bandelier, of New Mexico; Governor E. A. Stevenson and Hon. Milton Kelly, of Idaho; W. L. DeLacy, C. E., Hon. Granville Stuart and Prof. O. C. Mortson, of Montana; Franklin O. Sawin, C. E., Hon. M. N. Grant and Frank Bond, esq., of Wyoming. Many others, who most generously and efficiently aided me in this behalf, can not here be mentioned by name.

In conclusion, permit me to say that this work has been one in which I have taken great pleasure, and though not unmindful of its imperfections and deficiencies, I trust it will in fair measure meet your expectations and be of service to the general public.

I remain, very respectfully, your obedient servant,

EDGAR T. ENSIGN,
Special Agent of Department of Agriculture.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture, Washington, D. C.

FOREST CONDITIONS OF THE ROCKY MOUNTAINS.

I.—GENERAL VIEW.

The forests of the Rocky Mountain region sustain an important relation to the western half of the United States, if indeed their influence is not more widely extended. In the past their value has been wholly measured by their yield of timber and other useful products, but a more enlightened estimate is now gaining ground. It is gratifying to note that a more just comprehension of their value and importance prevails, and that the indifference with which their partial destruction has been viewed is yielding to a desire for their preservation.

These forests are mainly situated upon the lands of the General Government, and are not subject to State or Territorial control. The measures in force for their maintenance and protection are extremely ineffectual.

GEOGRAPHY OF THE REGION.

In order to understand the existing forest conditions of this region it will be necessary first to consider its leading physical features.

The term "Rocky Mountains" (originally "Stony Mountains"), in its widest sense, includes all the mountains of North America between the Great Plains and the Pacific Ocean, extending to the Arctic Ocean on the north and to Mexico on the south. It is the opinion of many that the same system includes the mountains of Mexico and Central America. Exclusive of Mexico, the chain traverses the entire region embraced between the thirty-second and seventieth parallels of north latitude. Its greatest expanse is between the thirty-eighth and forty-second degrees of north latitude, where the system has a breadth of about 1,000 miles. Its highest peak is Mount Saint Elias, in Alaska, which rises to an altitude of 19,500 feet above the sea.

THE MOUNTAIN SYSTEM.

For the purpose of the present investigation, the term "Rocky Mountains" will usually be confined to those portions of the system which are comprised within the State of Colorado and the Territories of Idaho, Montana, Wyoming, Utah, and New Mexico.

The mountain system under consideration is situated midway between the Mississippi River and the Pacific Ocean, and running nearly parallel with these has a general course from northwest to southeast. It extends through seventeen degrees of latitude, reaching from the British Possessions to the Mexican boundary. Springing from elevated plains and plateaus, which range in altitude from 3,000 to 7,000 feet, the mountains of this system attain their greatest elevation in Colorado, reaching there an extreme height of 14,460 feet above the sea.

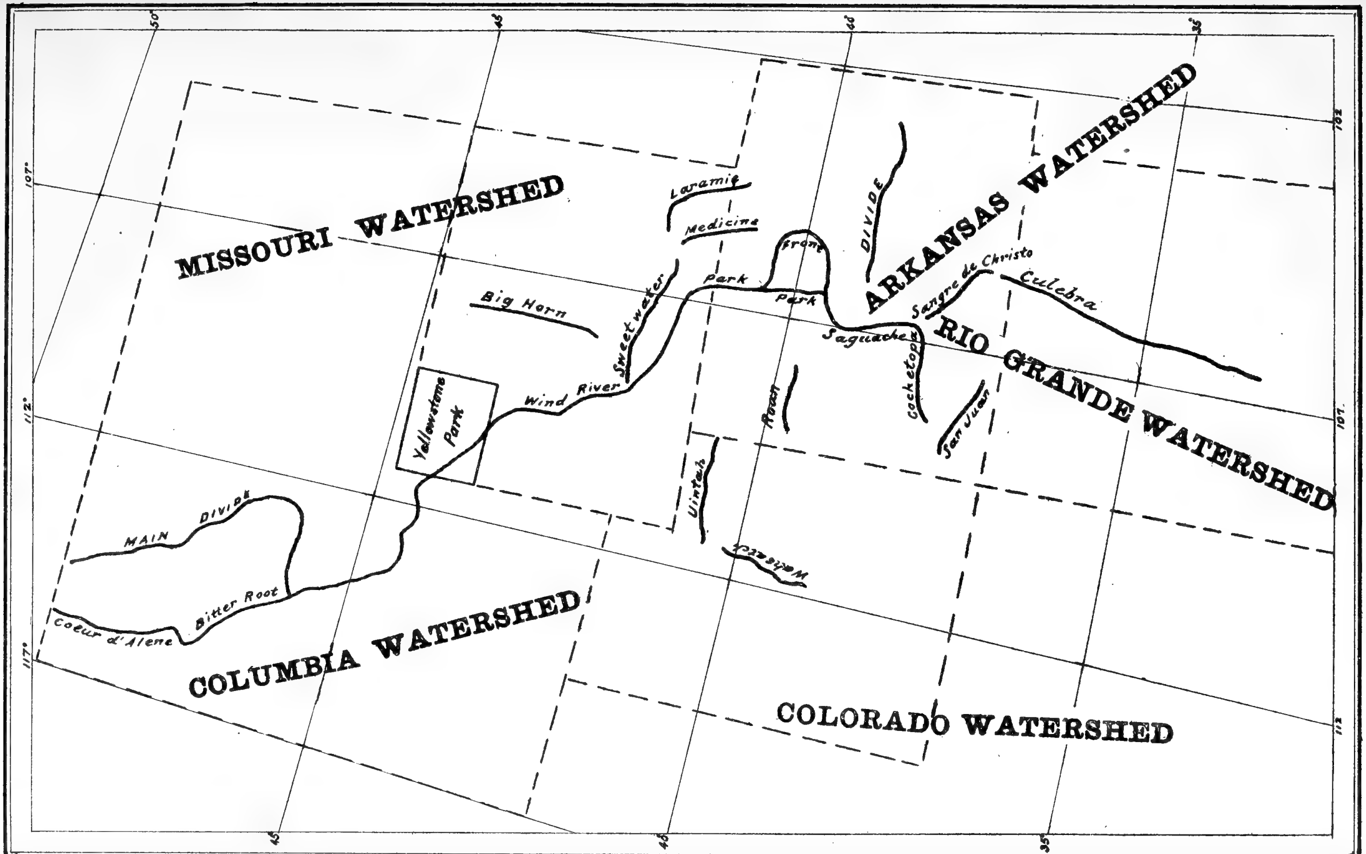
The several parts of the system may be described briefly as follows:

Commencing at the boundary line between British America and Montana, in the western part of the last-named Territory, the Main Range there takes a southeasterly course for a distance of about 200 miles; then it turns sharply to the west and at the boundary of Idaho is joined by the Bitter Root chain of mountains, which run in a southeasterly direction and form the middle portion of the dividing line between Montana and Idaho. The Coeur d'Alene Mountains, in northern Idaho, constitute the northwest extension of the Bitter Root Mountains.

The Main Range, from the point where it is joined by the last-named mountains, continues in a southeasterly course on the line between the two Territories and enters northwestern Wyoming near the southwestern corner of the Yellowstone National Park. Continuing in the same direction, the Wind River Mountains form an important link in the great chain. At their southeastern extremity they meet the Sweetwater Mountains, a comparatively short range, trending eastward. The crest, or dividing line, there turns to the southeast and passes over an open country or high table-land for a distance of 75 to 100 miles; it then strikes the Sierra Madre Mountains, the northern extension of the Park Range of Colorado, which form a portion of the Main Range. In North and Central Wyoming, the Big Horn, the Laramie and Medicine Bow Mountains are the most notable adjacent ranges.

The Colorado system commences on the north with the Park Range, which forms the western boundary of North Park. At the southwestern angle of the park the main divide turns directly eastward, separating North and Middle Parks, and is joined by the Medicine Bow Range at the northeast corner of the last-named park. The Main Range then bears to the southeast for a short distance, then turns southwestward and continues in that direction until it crosses the Park Range a few miles north of Leadville. The northern extremity of the Saguache Range is here reached. This range takes a course a little east of south, and terminates about 40 miles southeast of the town of Gunnison, in southwestern Colorado. A range called in part the "Cochetopa Hills," and running in a southwesterly direction, connects the Saguache with the San Juan Mountains. The latter, bearing southeastward, terminate near the southern line of the State.

The principal secondary range in Colorado is the Park Range, which constitutes the western boundaries of North, Middle, and South Parks, and is crossed, as before stated, by the Continental Divide. Other im-


MISSOURI WATERSHED
ARKANSAS WATERSHED
RIO GRANDE WATERSHED
COLUMBIA WATERSHED
COLORADO WATERSHED
Laramie
Medicine
Front
Park
Park
DIVIDE
Sangre de Christo
Culebra
Big Horn
Sweetwater
Saguache
Cochetopa
Wind River
Yellowstone Park
Roan
San Juan
Uintah
Wahsatch
MAIN DIVIDE
Bitter Root
Coeur d'Alene
50°
45°
40°
35°
107°
112°
117°
102
45
40
35
107
112

portant ranges in Colorado, upon the eastern water-shed, are the Medicine Bow Range at the north, the Pike's Peak Range in the central section, and the Sangre de Christo, the Culebra, and Raton Mountains at the south. Upon the western slope the Elk and San Miguel, or La Plata Mountains, are the most prominent.

Thus far and until near the southern limit of Colorado, the Continental Divide has consisted almost wholly of high and rugged mountains. It here loses that character, and entering New Mexico bears southwestward through an open and broken country interspersed with detached mountain ranges.

Returning to the northern boundary of New Mexico, to a point some distance east of the central portion, it is found that the Culebra Range is prolonged southward for about 100 miles, or until it reaches the neighborhood of Santa Fé. There the bold continuous mountains give way to lesser ranges scattered at intervals throughout the Territory, but usually conforming to the normal trend of the general system. Including the mountains of Utah in the general system, the Uintah and Wahsatch Mountains are to be mentioned as important branches. The former are especially noticeable on account of their exceptional eastward and westward trend.

CONFIGURATION.

The Rocky Mountain region is of such great extent and its topography so extremely varied, that an adequate description of it would far exceed the limits of this report. Its leading characteristics only can be considered. The subject may be conveniently treated under the headings—Mountains, Plains, Plateaus, Water-courses.

Mountains.—The mountains of this region are generally massive and rugged. In their midst are vast solitudes, snow-clad peaks, precipices, rapid streams, and deep cañons.* At some points, however, the mountains rise so gradually from the plains at their base that the traveler easily ascends and passes over them, hardly realizing that he is crossing divides which separate great water systems. In still other localities, lovely mountain parks, wooded heights, and sheltered valleys beautify and soften the harsher features of the landscape. While the Main Range pursues, generally, a course from northwest to southeast, the system as a whole is much involved. The comparatively low mountains and minor ranges of western Montana, and the more rugged mountains separating Idaho from Montana and Wyoming, culminate in the magnificent peaks and ranges of the Yellowstone Park region. Here lofty mountains, cañons, water-falls, geysers, boiling springs, fantastic rocks, and other of nature's strange works combine to make this region the "wonderland" of America. In the near distance, at the southwest,

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* Cañon or canyon (Spanish—a tube or hollow); a deep gorge, ravine, or gulch between high and steep banks worn by water-courses; a term in common use in the United States in the States and Territories bordering upon Mexico. (Fremont.)

the "Three Tetons," prominent snow-clad peaks, rise above the surrounding country.

In Wyoming the principal range follows a tortuous line from the northwest to the southeast. There is a break in its southern extremity, and other ranges flank it at various angles upon the right and left, separated from each other and from the Main Range by high plateaus, sandy plains, grazing lands, and fertile valleys.

In Colorado the system is complex in the extreme. The course of the Main Range is very irregular; other high ridges abut upon or cross it, and detached groups appear upon either hand. Natural parks of great magnitude, surrounded by high mountains and each containing the head waters of an important river, here constitute a marked and agreeable feature. The mountains, as well as the general level, are higher here than elsewhere, and the ranges more massive. From almost any of the snowy summits scores of others may be seen.

The Culebra Range of northern New Mexico is a continuation of the general system, and is similar in character to the Colorado Mountains. Many of the mountains in Montana have smooth slopes and rounded outlines. In other parts of the range they are generally rugged, many having serrated crests and angular peaks. The sides are often rocky and precipitous, and the summits, of naked rock, extend far above the limits of vegetable life.

The "ground plan" of this mountain system is so irregular and of such great extent that, in the absence of surveys, it is impossible to determine its area with any degree of certainty. A conservative and approximate estimate would give it a length of 1,500 miles and an average breadth of 200, or a total area of 300,000 square miles.

Although the general course of the system is in one direction, the ranges, spurs, and groups lie at many and varying angles, and present the utmost diversity of form and exposure.

At the base of the mountains, on the east, are foot-hills and high mesas,* and these merge into wide, rolling plains. On the west the mountains are bounded by foot-hills, mesas, elevated plateaus, and wastes of sand and lava. In many places appear water-courses, canyons, and valleys.

Plains.—Second only in importance to the mountains are the Great Plains, which bound the mountains on the east for almost their entire length and extend hundreds of miles to meet the prairies of the Central Basin.

The western border of this region, adjacent to the range, varies in altitude from 3,000 to 6,000 feet above the sea, the greatest elevations being in Wyoming, Colorado, and northern New Mexico; thence sloping to the north, east, and south, coincidently with the direction of the principal water-courses.

* *Mesa* (Sp.), the common name for the table lands (which are usually quite arid) in central and western North America.

The surface of the Great Plains is usually gently rolling, but in some localities buttes,* headlands, and detached masses of rock vary its otherwise monotonous aspect. The soil is generally a light mold, from 10 to 15 inches in depth, resting on a bed of sand, gravel, and bowlders. In some places there is considerable clay mixed with the surface soil.

In their natural condition the plains, mesas, and foot-hills are generally covered with a short but succulent grass. Some portions produce sage brush, among which nutritious grasses are interspersed. In other parts sage brush is the only growth. A comparatively small proportion is wholly barren.

Plateaus.—The great plateaus upon the western flank of the mountain system have a mean elevation of about 7,000 feet above the level of the sea. They extend from southern Wyoming through western Colorado and eastern Utah into Arizona and New Mexico, and are there lost in low desert plains.

By faults in the geologic structure, and by lines of cliffs and deep canyons, the various plateaus are separated one from another. Their general level is broken by mountains—single and in groups—buttes and towering escarpments of rock. Some thirty mountain peaks, ranging in altitude from 10,000 to 12,000 feet above the sea, have here been noted. The few streams of the region find their way through canyons, the walls of which are of immense height. Aridity is the prevailing condition, and vegetation is dwarfed and scanty.

Water-courses.—That the main crest of the Rocky Mountains constitutes the "Continental Divide" or line separating the eastern and western water systems is known to all; that there is also a great Transverse Divide, forming northern and southern water systems, is not so generally understood. Commencing in the northwestern part of Nebraska, the divide last named runs westward through central Wyoming to the southern border of Yellowstone Park; thence southwestward to the northwestern corner of Nevada.

Hence there are four great basins; one sloping to the northeast, drained by the waters of the Upper Missouri; one at the northwest, drained by the Columbia River; one at the southwest, which is double and discharges its waters into the Great Salt Lake Basin and the Colorado River; and one at the southeast, which is drained by the Arkansas and Rio Grande Rivers and their affluents. These several systems radiate from a common center, and have their sources in the high and snowy mountains of Wyoming and Colorado. The fact, however, should not be overlooked, that other and surrounding parts of the Rocky Mountain region largely contribute to the volume of water in the principal streams.

In considering further the several systems here outlined, it appears that at the northeast the South Platte rises in South Park and the

* Butte (Fr., pronounced *bute*), an isolated peak or elevation of land in the central and western parts of North America (too high to be called a hill or ridge, and not high enough to be called a mountain).—(Webster.)

North Platte in North Park, Colorado, the two rivers flowing eastward and uniting in Nebraska.

At the northwest the Big Horn, Yellowstone, and Upper Missouri Rivers rise within or near the Yellowstone Park, and find outlet through the channel of the Missouri. Crossing the Continental Divide westward, it is found that Clark's Fork of the Columbia, the Salmon River, and Lewis or Snake River, also rise in the same region, but, as tributaries of the Columbia, send their waters to the Pacific Ocean.

In the southwest the principal streams flowing into the lakes of the Great Salt Lake Basin are the Bear, Weber, and Sevier. The Green River, which has its source in the Wind River Mountains, Wyoming; the Grand River, which drains Middle Park, Colorado, and the San Juan River, which rises in the southern part of the same State, unite in southern Utah and form the Colorado River of the West.

The Rio Grande and Arkansas Rivers drain the southeastern portion of the Rocky Mountain region. They have a common origin in the mountains of Colorado, but the first seeks an outlet directly in the Gulf of Mexico, while the latter, at a point some 800 miles northeastward, unites with the Mississippi river.

The Rio Grande, Arkansas, North and South Platte, and their main affluents, debouch upon high planes which slope rapidly to the south and east; and while the most of these streams pass through deep canyons in emerging from the mountains, they flow with a rapid current (descending from 5 to 8 feet to the mile) in shallow channels. Therefore it is not difficult to utilize their waters for irrigation and other purposes.

In Montana the plains have much less elevation than in the region southward, and the principal streams, the Upper Missouri and the Yellowstone, following a long and devious course to the junction of the two, have a gradual descent and sluggish flow; hence it is not easy to bring their waters to the level of the adjacent country. What can be done there by a system of reservoirs which will save the flood waters of spring and early summer, is a question for the future.

In Idaho, upon the western slope of the range, the principal streams flow rapidly, through arable valleys, and the waters can be easily utilized.

Southward, in western Colorado, the streams, in descending from the mountains, have a swift current and pass through valleys of much natural fertility. As they approach the plateau region, farther south and west, some of them enter profound canyons, and thus are lost for irrigating purposes.

ALTITUDES.

The altitudes of the Rocky Mountain region, inclusive of the valleys, plains, and plateaus, vary from 680 feet above sea level at Lewiston, Idaho, to an extreme height of 14,460 feet in the mountains of Colorado.

The average or mean elevation of the several political divisions is given by good authorities as follows: Montana, 3,000 feet; Idaho, 4,700 feet; Wyoming, 6,000 feet; Colorado, 7,000 feet; New Mexico, 5,600 feet.

The approximate mean elevation of the Idaho and Montana ranges is 8,000 feet; of the Wyoming ranges, 9,000 feet. The mean height of the Colorado and New Mexico system, south to the latitude of Santa Fé, is about 10,500 feet.

In Montana two mountains reach an elevation of 8,355 and 10,629 feet respectively. Eleven peaks in Idaho range in height from 9,100 to 13,691 feet. In Wyoming fifteen of the principal peaks range in altitude from 9,273 to 13,790 feet. The best known and named peaks of the Colorado system, sixty-seven in number, vary in height from 10,906 to 14,464 feet. Seventy-two other peaks in the same State, between 13,500 and 14,300 feet in height, are unnamed. Two prominent mountains in New Mexico have an elevation, one of 11,200 feet and the other of 12,202 feet; while Utah boasts of seventy-five peaks above 10,000 and fourteen above 12,000 feet, the highest being Mount Emmons, with 13,694 feet.

*Elevation of timber-line on some of the mountains in the Rocky Mountain region.**

[Taken from Dictionary of Altitudes, U. S. Geological Survey.]

Mountain.	Timber-line.	Mountain.	Timber-line.
COLORADO.	*Feet.*	COLORADO—continued.	*Feet.*
Arapahoe Peak	11, 100	Long's Peak	11, 100
Mount Audubon	11, 325	Massive Mountain	11, 607
Bald Mountain	11, 100	Park View Peak	11, 100
Buffalo Peak	12, 041	Pike's Peak	11, 720
Mount Byers	11, 400	Mount Powell	11, 600
Crestone	12, 107	Mount Princeton	11, 500
Cunningham Pass	11, 500	Red Mountain	11, 746
Mount Elbert	11, 871	Mount Rito Alto	11, 817
Mount Engelmann	11, 578	Sierra Blanca	10, 410
Mount Evans	11, 723	Mount Silverheels	11, 549
Mount Evans	11, 300	White Rock Mountain	11, 919
Gray's Peak	11, 100		
Grizzly Peak	11, 758	MONTANA.	
Mount Guyot	11, 811		
Hamilton Pass	10, 840	Mount Blackmore	9, 550
Mount Harvard	12, 117	Mount Delano	8, 784
James' Peak	11, 100	Electric Peak	9, 442
La Plata Mountain	12, 080		
Lillie's Mountain	11, 100	UTAH.	
Mount Lincoln	12, 051	Gilbert's Peak	11, 100

*Capt. E. L. Berthoud, a civil engineer, of Golden, Colo., and a good authority, referring to a mountain range about 8 miles southwest of Georgetown, Colo., says: "Across the narrow valley north of McClellan Mountain, and upon another high peak, the limit of tree growth exceeds 12,400 feet elevation on the south slope of that peak. Here can be seen *Pinus aristata*, some of the trees 2 feet in diameter and 30 feet high, that retain their hold and slowly increase in size, thus maintaining themselves in respectable numbers in spite of furious gales of snow and wind, and an extreme arctic cold."

SURROUNDINGS.

The "Great Plains" lie contiguous to and eastward of the Rocky Mountains, but how far to the east they extend—at what point the "plains" (so long a synonym for sterility) end, and the prairie, or fruitful country, begins, is not easily determined. It is safe to say, however, that the western portions of Dakota, Nebraska, Kansas, the Indian Territory, and Texas, partake of the semi-arid condition of the region of the plains and indeed constitute a part of it, and have identical interests. Their grazing and farming industries are conducted upon principles similar to those which govern the like operations of their neighbors westward, and dependence upon the streams flowing from the mountains is as marked in one instance as in the other.

Oregon and Washington lie at the northwest. They, also, in their eastern portions, require water for irrigation. Their great river, the Columbia, is kept at a navigable stage by the large tributary streams which flow from the mountains.

At the west and southwest, the contiguous Territories of Utah and Arizona fall within the Arid Belt. The needs of their increasing population and rapidly developing industries require that the timber and water supplies of the mountains shall be maintained in perpetuity.

CLIMATE.

The atmospheric conditions of the Rocky Mountain region, as affecting the life and health of those who are living under their influence, have been a subject of quite general interest, and thus the leading characteristics of the region in this respect are known to many.

A concise statement of the climatic conditions of the region is given in the official report for 1885 of Hon. Francis E. Warren, governor of Wyoming, to the Secretary of the Interior. I take the liberty of quoting as follows:

> Were it not for the heat of the tropical regions, which is distributed over the continent by atmospheric currents as well as by the thermal ocean and Gulf currents, the high elevations of the Rocky Mountain regions would be too rigorously cold for habitation. But through these tempering influences they are not only habitable, but delightful and healthful portions of the continent, far more so than the Atlantic coast, or the great river valleys which approximate the sea-level on either side of the great continental divide. The humid tropical winds and the equatorial warm Japanese currents of the North Pacific Ocean—which are similar to the Gulf Stream of the Southern Atlantic—reaching the western and southern shores of the continent, produce the mild and even temperature of these coasts and, with climatic modifications, extend to the elevated Rocky Mountain regions of the interior.
>
> These modifications are mainly produced by the high snow-capped and almost unbroken mountain ranges of the western coast—the Cascade and the Sierra Nevada, the latter of which is covered with dense forests to an elevation of some 8,000 feet, while still above this lies perpetual snow. These, to some degree, are barriers against the extension of the warm atmospheric currents of the ocean over the interior Rocky Mountain elevations. Hence, as these mild winds, heated by the tropical ocean currents, sweep over the snow-capped mountain ranges, and around their extremities, and thus pass over vast arid regions in their course to the great Rocky Mountain elevations, they become somewhat tempered, and give to them their salubrious climate. The moisture that comes upon the mountain ranges, in the way of rain, during the rainy seasons of the Pacific coast, is slight from January to May.

It may be said further, that the superior elevation of this great central plateau, its remoteness from the sea or other large bodies of water, the comparative absence of fogs and rain, and the prevalence of sunshine, have conduced to render the atmosphere of this region dry, rarefied, and wonderfully clear. Through its medium distant objects are seen with surprising distinctness. Its curative properties have made it a famous resort for health-seekers and tourists.

Again, it should be noted that the climatic conditions of different parts of the mountain region, though having common characteristics, vary in degree one from another. The great extent of the region, its varying altitudes, its irregular outlines and configuration, combine to produce in the various sections diverse atmospheric conditions. Hence the flora of the country is varied, and in connection with differing soils the productive capacities of its several parts vary in kind and degree.

A friend notes the difference between the climatic and forest conditions of the eastern and those of the western slopes of the Rocky Mountains, as follows:

One of the principal effects of the main mountain range is to cause a much greater precipitation of moisture, in the form of snow or rain, upon the western than upon the eastern slope. Within such areas of greater precipitation the forest growth is denser and the trees larger and better developed than upon the eastern side. The streams are larger, the water-flow more evenly distributed throughout the year, vegetation more luxurious, and the natural pasture of native grasses is maintained until late in the year or until snow falls. Upon the eastern side there is greater necessity for a rigorous enforcement of the laws to save the few remaining forests.

The following communication, lately received from Mr. George Cornwall, of Gunnison, Colo., is of interest, as showing the comparatively humid conditions which prevail in some localities upon the western slope of the mountains:

I send you a tabulated statement of the number of days on which we had rain or snow for the years 1882, 1883, 1884, 1885, and 1886 to June 1. This statement is taken from the diary kept on my ranch, in the valley of Ohio Creek, 7 miles north of Gunnison, elevation 8,000 feet above sea level. The rains and snows come mostly in showers—very few all-day or all-night storms. We are not in a stormy belt. Please remember that any report from any portion of Colorado, except the plains, is a local report, and another report of no more than 5 or 10 miles away might be very different.

Castleton's or Baldwin's, 10 miles higher up our valley, would show, I think, double the amount of rain or snow we have here, and still higher in the mountains the amount of rain and snow would again be doubled.

The climate of this western slope is moist. The prevailing winds are from the west, starting perhaps from the Pacific Ocean, and, passing over a vast extent of country, when they reach the western slope of the Rocky Mountains they precipitate their moisture. Evaporation at our elevation is of course rapid, but on our bottom-lands we grow all vegetables and grains without irrigation. For grasses we irrigate thoroughly. Mesa land we have to irrigate.

The preservation of timber as affecting the rain-fall is not an important question with us. We have almost too much moisture.

Table showing the number of rain and snow falls at a point near Gunnison, Colo., from August, 1882, to May, 1886, inclusive.

Month.	1882.		1883.		1884.		1885.		1886.	
	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.
January				7		5		4		12
February				2		6		4		3
March				6		8		5		3
April				3		7	4	4		2
May			4	2	4	3	5		3	
June			6		14		3			
July			14		2		15			
August	8		10		11		12			
September	6		12		6		5			
October	1		3	2						
November		4		2				2		
December		5		11				4		

The following table, kindly prepared by Sergeant Hall, the officer in charge of the U. S. Signal Service station at the summit of Pike's Peak, shows the total precipitation and relative humidity at that point from the year 1875 to 1885, inclusive:

Date.	Total precipitation.	Relative humidity.	Date.	Total precipitation.	Relative humidity.
	Inches.			*Inches.*	
1875	24. 74	78. 4	1881	44. 49	66. 7
1876	23. 87	67. 1	1882	28. 99	78. 4
1877	25. 58	68. 7	1883	18. 17	80. 1
1878	42. 99	61. 2	1884	9. 28	77. 4
1879	39. 82	49. 4	1885	30. 48	82. 3
1880	40. 65	55. 3			

Yearly and seasonal averages at Denver, Colo.

[Compiled from thirteen years' observations.]

Season.	Temperature.	Maximum temperature.	Minimum temperature.	Relative humidity.	Rain-fall or melted snow.	Number of days on which rain or snow fell.	Number of clear days.	Number of fair days.	Number of cloudy days.	Number of sunny days.	Cloudiness (in tenths).	Wind direction.	Hourly wind velocity.
				Per ct.	*In.*								
Spring average	47. 2	77. 9	19. 2	49. 1	5. 86	25	33	39	20	81	3. 0	S.	7. 3
Summer average	69. 8	95. 9	47. 1	44. 9	4. 91	26	37	42	13	89	2. 4	S.	6. 1
Autumn average	49. 6	80. 6	19. 8	45. 5	2. 34	15	49	29	13	86	2. 2	S.	5. 6
Winter average	29. 8	62. 2	—7. 3	54. 3	1. 84	15	44	36	10	84	2. 1	S.	6. 2
Yearly average	49. 1	79. 2	19. 7	48. 4	14. 95	81	163	146	56	340	2. 6	S.	6. 3

JOSEPH J. GILLIGAN,
Observer Signal Service, U. S. Army.

Yearly and seasonal averages at Santa Fé, N. Mex.

[Compiled from thirteen years' observation of the U. S. Signal Service.]

Season.	Temperature.	Relative humidity.	Rain-fall or melted snow.	Number of clear days.	Number of fair days.	Number of cloudy days.	Cloudiness (in tenths).	Wind direction.	Hourly wind velocity.
		Per ct.	*In.*						
Spring average	46.9	36.3	1.93	36.5	43.6	11.9	3.9	SW.	8.5
Summer average	66.4	42.8	7.56	28.3	50.3	13.4	4.5	E.	6.8
Autumn average	48.4	46.4	3.18	49.1	33.5	8.4	2.9	Var.	6.3
Winter average	30.2	53.3	1.90	41.8	34.4	14.0	3.5	N.	6.8
Yearly average	48.0	44.7	14.57	155.7	161.8	47.7	3.7		7.1

The following meteorological data are from observations taken at the U. S. Signal Service station, Santa Fé, N. Mex. The data for 1881 do not include the month of December for that year. During the years 1883 and 1884 the station was closed:

Year.	Mean Barometer.	Mean temperature.	Mean humidity.	Direction of wind.	Rain-fall.
1872	23.292	47.9	41.8	N.	9.89
1873	23.272	48.6	37.0	N.	9.73
1874	23.211	48.0	48.0	E.	19.83
1875	23.209	48.0	42.0	SW.	18.79
1876	23.256	47.6	52.9	E.	15.07
1877	23.266	47.6	43.3	E.	13.15
1878	23.251	47.5	42.1	N.	19.55
1879	23.299	50.2	39.8	E.	11.44
1880	23.269	45.4	44.6	SW.	9.89
1881	23.268	49.7	51.9	SW.	21.75
1882	23.238	48.3	44.8	E.	10.37
1885	23.297	47.7	53.4	N.	14.89

For the subjoined tables I am indebted to the courtesy of General A. W. Greely, Chief Signal Officer, U. S. Army.

Annual and mean annual temperature (in degrees Fahrenheit) at stations of the Signal Service, U. S. Army.

Stations.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	Number of years.	Mean annual.
Northern Plateau:														
Boisé City, Idaho	....	....	....	....	....	52.4	51.4	48.9	50.0	48.6	[1]	50.0	6	50.2
Lewiston, Idaho	....	....	....	....	....	....	....	49.5	51.1	51.6	50.3	49.4	5	50.4
Northern Slope:														
Assinniboine, Ft., Mont	....	....	....	....	....	....	....	....	....	42.7	39.2	39.1	3	40.3
Benton, Fort, Mont	42.5	43.3	42.1	[1]	[2]	[2]	[2]	40.3	43.6	44.8	43.0	41.5	8	42.6
Custer, Fort, Mont	....	....	....	....	....	....	....	43.0	45.3	45.2	[1]	40.9	4	43.6
Helena, Mont	....	....	....	....	....	....	....	....	43.8	43.8	42.7	40.2	4	42.6
Maginnis, Fort, Mont	....	....	....	....	....	....	....	....	....	....	39.5	38.1	2	38.8
Shaw, Fort, Mont	....	....	....	....	....	....	....	....	42.1	42.5	40.6	39.8	4	41.2
Deadwood, Dak	....	....	....	....	....	....	....	40.8	[1]	42.9	40.5	40.5	4	41.2
Cheyenne, Wyo	44.8	45.5	42.5	44.3	44.2	44.2	46.5	42.9	45.8	43.9	42.4	42.6	12	44.1
Middle Slope:														
Denver, Colo	48.1	49.8	48.6	49.5	48.8	49.5	50.8	47.4	50.8	50.3	48.8	49.5	12	49.3
Pike's Peak, Colo	....	18.9	18.2	19.0	18.4	19.4	21.9	17.9	20.7	18.8	18.7	18.3	11	19.1
West Las Animas, Colo	....	....	....	....	....	....	....	....	....	....	49.6	48.7	2	49.2
Southern Plateau:														
Santa Fé, N. Mex	48.6	48.0	48.0	47.5	47.6	47.5	50.2	45.4	[1]	48.3	[1]	[1]	9	47.9

[1] Record incomplete. [2] No record.

Annual and mean annual precipitation at stations of the Signal Service, U. S. Army, compiled from the commencement of observations to 1884, inclusive.

Stations.	Established.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.
Northern Plateau:		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Boisé City, Idaho	July 1, 1877	....	....	....	....	....	....	....	10.21
Lewiston, Idaho	July 1, 1879	....	....	....	....	....	....	....	....
Northern Slope:									
Assinniboine Fort, Mont	Oct. 6, 1879	....	....	....	....	....	....	....	....
Benton, Fort Mont	Oct. 11, 1879	....	12.32	11.95	10.45	12.75	([1])	([1])	([1])
Custer, Fort Mont	Dec. 5, 1878	....	....	....	....	....	....	....	....
Helena, Mont	Oct. 15, 1879	....	....	....	....	....	....	....	....
Maginnis, Fort, Mont	July 14, 1882	....	....	....	....	....	....	....	....
Poplar River, Mont	May 1, 1882	....	....	....	....	....	....	....	....
Shaw, Fort, Mont.	April 1, 1880	....	....	....	....	....	....	....	....
Cheyenne, Wyo.	Nov. 1, 1870	9.23	13.48	10.01	9.71	12.10	5.03	11.71	12.64
Middle Slope:									
Denver, Colo	Nov. 19, 1871	....	18.05	11.81	13.46	17.25	20.12	16.38	15.51
Pike's Peak, Colo.	Nov. 1, 1873	....	....	....	26.86	24.74	23.87	25.58	42.87
West Las Animas, Colo	Oct. 1, 1881	....	....	....	....	....	....	....	....

Stations.	Established.	1879.	1880.	1881.	1882.	1883.	1884.	Mean annual.	
								Years.	Inches.
Northern Plateau:		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		
Boisé City, Idaho.	July 1, 1877	17.63	10.66	13.56	14.43	([1])	21.05	6	14.59
Lewiston, Idaho.	July 1, 1879	....	17.41	20.56	14.74	15.83	21.71	5	18.05
Northern Slope:									
Assinniboine, Fort, Mont	Oct. 6, 1879	....	....	....	12.76	15.10	25.67	3	17.84
Benton, Fort, Mont	Oct. 11, 1879	([1])	([1])	16.81	10.18	13.01	([1])	7	12.50
Custer, Fort, Mont	Dec. 5, 1878	....	19.65	11.88	12.05	13.84	16.60	5	14.80
Helena, Mont	Oct 15, 1879	....	....	19.94	10.32	([1])	19.18	3	16.48
Maginnis, Fort, Mont	July 14, 1882	....	....	....	....	13.29	9.00	2	11.14
Poplar River, Mont	May 1, 1882	....	....	....	....	6.22	10.25	2	8.24
Shaw, Fort, Mont.	April 1, 1880	....	....	14.77	14.21	12.64	13.64	4	13.82
Cheyenne, Wyo.	Nov. 1, 1870	7.34	8.38	11.88	8.64	19.24	15.54	14	11.07
Middle Slope:									
Denver, Colo	Nov. 19, 1871	10.86	9.58	12.78	14.49	19.49	15.07	13	14.99
Pike's Peak, Colo.	Nov. 1, 1873	39.82	40.65	44.57	28.82	18.17	9.28	11	29.57
West Las Animas, Colo	Oct. 1, 1881	....	....	....	....	11.12	15.70	2	13.41

[1] Record incomplete.

AGRICULTURAL CONDITIONS.

A well-known writer speaks of the agricultural resources of the Rocky Mountain region as follows:

Generally speaking, those best acquainted with the West make the largest estimates of its resources and have the most faith in its future. Land, on first sight, often appears worthless, which experiment afterwards proves to be fertile. I instance the "Great Columbia Plains" of eastern Washington, where the soil, which varies from 1 foot to 20 in depth, is, except in the bottom-lands, a very light-colored loam, containing an unusually large percentage of alkalies and fixed acids. A few years ago sowing wheat on the soil would have been deemed throwing it away; but the experiment resulted in a revelation, viz, that these 14,000,000 acres of peculiar soil are probably the best wheat fields in all the world. Other illustrations equally striking might be given. * * * "

The arable lands of the Rocky Mountains are mainly in the valleys, which, like basins, have gathered the detritus of the mountains for ages. The soil is therefore very deep and fertile, yielding much more than the same area in the East; and in the southwest two crops a year from the same soil are very common, so that this land is equal to twice or three times the same area in the East.

Another writes:

Nothing is more surprising than the material for supporting a population which continues to be developed in all this region of mountain and plain, which twenty years ago was considered an inhospitable desert, capable of supporting nothing but Indians.

The State of Colorado, and the Territories of New Mexico, Wyoming, Montana, and Idaho, have collectively an area of 553,654 square miles, which is more than three times the area of the Middle and New England States.

The extraordinary mining development of this region and its immense grazing resources are widely known and appreciated, but its agricultural possibilities are, as yet, but little known to the general public. In some localities in the mountains, farming operations are carried on to a limited extent without the aid of irrigation, but such instances are exceptions to the general rule. For the growing of crops recourse must usually be had to artificial water-supply. The extensive irrigation systems, fully inaugurated in Colorado, and partially so in the adjacent territories, have already reclaimed for agricultural uses millions of acres once deemed barren and worthless. The only limit to progress in that direction will be the amount of available water. Could the sources of water supply be adequately protected, and storage reservoirs constructed in suitable places, thousands of square miles in this region could be gained to agriculture, homes provided for multitudes of people, and the aggregate wealth of the country greatly enhanced. The capacity of the land to produce crops and the fitness of the seasons to mature them are no longer unsettled questions.

NOTE.—More particular statements in regard to irrigation, as practiced in the Rocky Mountain region, are given in the descriptions of the several divisions as they occur in this report. The following summary will bring the whole matter into view at one glance, and on that account it has been inserted here. It will be understood of course that minute accuracy in such a case is impossible. Approximate estimates only can be made. But it is believed that the estimates are in no case exaggerated.

Colorado has from 930 to 1,000 miles of main irrigating canals, 3,500 miles of second class canals, and 40,000 miles of ditches, constructed at a cost of $11,000,000. More than 1,000,000 acres of otherwise useless land have thus been brought under successful and profitable cultivation.

Wyoming, in 1884, had seventeen incorporated irrigation companies, chiefly in two counties. One of these had under its control 60,000 acres of land, and has constructed a canal 66 miles in length. Another company has begun the construction of a canal calculated to irrigate 270,000 acres.

Utah, in 1885, had 2,810 miles of main and 7,750 miles of tributary canals, and 656,000 acres under cultivation by this means.

New Mexico is estimated to have irrigating canals and ditches equal in extent to those of Utah. Two canals are now projected capable together of watering from 3,000,000 to 4,000,000 acres.

In Idaho there are sixty-five land and water companies reported and there are many hundred miles of canals and ditches, but particulars are not published.

In Montana there is a considerable but indefinite amount of irrigation by means of the smaller mountain streams. One company in Yellowstone County has constructed a main canal 40 miles long and ditches capable of irrigating 60,000 acres, and another has a main canal 75 miles in length.

The intimate relation of the forests to the water supply necessary for irrigation will soon force itself upon the consideration of those living in the Rocky Mountain region, and it is well set forth in a recent statement of Mr. Nettleton, State engineer of Colorado, who says:

"It is estimated that 60 inches of water fall annually on the eastern slope of the Rocky Mountains in the form of snow and rain; 80 per cent. of this falls during the winter and spring months. That which falls late in the autumn and early in winter is most available for irrigation, as it becomes solid, almost like ice, and melts slowly under the summer's sun, affording a steady flow through the irrigating season. Snows falling in late spring melt rapidly, and the waters run down the rivers unused. Although about fifty mountain peaks in Colorado reach an elevation of over 14,000 feet, yet the snow nearly all disappears every season, small quantities only remaining in small patches here and there. On this account there are at present no glaciers in the Rocky Mountains. The cold mountains condense the moisture in the country adjacent, thereby robbing the plains of their quota of moisture.

"Hence the necessity for irrigation. It is quite easy to foretell the probable amount of water for irrigation purposes for the coming season by watching the amount of snow-fall in the mountains.

"Farmers living from 20 to 30 miles from the mountains, or where they can watch the snow-fall on the main range of the mountains, have learned to gauge their crops by the time the snow falls and the quantity. If the snow falls early, they expect water for late crops. If the snow falls principally in the spring months, they fear short water in summer and fall, and plant or sow accordingly.

"There can be no doubt about the influence that cutting or burning the timber on the mountains has on the flow of our streams. They will on this account become more intermittent in their flow, which is a drawback to the irrigation interests of the State. The preservation of the mountain forests should be encouraged."

INDUSTRIES.

AGRICULTURE.

Agriculture is making rapid progress in this region, and is likely to have greater proportionate development than other industries. Utah was the first of the mountain Territories to show adequately what could be done in the way of systematic farming, and the first to adopt proper methods of irrigation. Her example has been extensively followed, whenever practicable, throughout the region of the mountain and the plains. During the last year or two western Kansas and Nebraska and eastern Colorado have received large accessions of settlers who have opened new farms and grown crops without the aid of irrigation.

Except upon the plains, broad areas adapted to a single crop are not found. Great diversity of production exists by reason of differences in soil, elevation, and climate. Colorado Springs, the home of the writer, has an elevation of 6,000 feet above the sea. The spring seasons of the year are backward, and early vegetables, small fruits, and other supplies of a like nature are obtained in part from the warm valleys only a few miles distant but 1,500 or 2,000 feet lower in altitude. As the season advances nearly the same products are grown at higher elevations. Upon the farms of this region are raised wheat, oats, alfalfa, timothy, red and white clover, and other grains and grasses. In the orchards and gardens are found the hardier and smaller fruits, including many varieties of grapes. At elevations 1,000 or 2,000 feet higher in the mountain parks and valleys, or upon the Arkansas-Platte Divide, oats, rye, barley, buckwheat, potatoes, turnips, timothy, and other grasses, tame and native, are successfully cultivated; usually without the aid of irrigation. The foregoing is only an illustration of what is being done in many parts of the mountain region.

MINING.

The yield of precious metals for the year 1886 is officially reported as follows:

State or Territory.	Gold.	Silver.
Idaho	$1,800,000	$3,600,000
Montana	4,425,000	12,400,000
Colorado	4,450,000	16,000,000
Utah	216,000	6,500,000
New Mexico	400,000	2,300,000
Wyoming	(*)	(*)
Total in Rocky Mountain region	11,291,000	40,800,000
Percentage of total product in United States	32.4	79.5

* No report.

The copper product of the Rocky Mountain region is given in pounds as follows by Mr. Kirchhoff, jr., in the report of the mining statistics compiled by Mr. D. T. Day, of the U. S. Geological Survey:

State or Territory.	1882.	1883.	1884.	1885.	1886.
Idaho	....	....	46,667	40,381	....
Montana	9,058,284	24,664,346	43,093,054	67,797,864	57,611,621
Wyoming	100,000	962,468	....	....	....
Colorado	1,494,000	1,152,652	2,013,125	1,146,460	409,306
Utah	605,880	341,885	265,526	126,199	500,000
New Mexico	869,498	823,511	59,450	79,839	558,385
Total	12,127,662	27,944,862	45,477,822	69,190,743	*69,079,312
Total of United States	90,646,232	115,526,053	144,946,000	165,875,000	156,735,000
Percentage from Rocky Mountain region	13.3	24.2	31.3	41.7	44

* The decrease of production in 1886 was due partly to labor troubles and partly to unfavorable market conditions.

The lead product in 1886 for the region may be estimated as follows:

	Short tons.
Utah	20,000
Colorado	59,000
Idaho	16,000
Total	95,000

or about 75 per cent. of the total lead product of the United States.

Coal.—Statistics relating to the production of coal will be found in another part of this report.

STOCK-GROWING.

This industry has been not only a very important but a very profitable one. During the last year or two, owing to a variety of causes—mismanagement being a principal one—the leading branch of the business, cattle-raising, has not yielded much profit. The "range" system of raising cattle and horses, with its attendant cruelties and losses, is gradually giving way to more humane and thrifty methods. Improved breeds are being introduced, and no doubt in the near future the business will be placed upon a much better footing than heretofore. In fact, the immense grazing resources of the region are likely to be more fully utilized in the future than in the past.

The estimated number of cattle in the Rocky Mountain region at the beginning of the present year (1887) was 4,919,113, and the value of the same $104,981,067.

WOOL-GROWING.

This is a branch of the live-stock industry which should not be overlooked. In Colorado and New Mexico it has long occupied a prominent place, and it is gradually gaining ground in the surrounding Territories. Growing the mutton breeds of sheep is also receiving attention.

The number of sheep in the region now under review was estimated to be, on the 1st of January, 1887, 7,353,326, and their value $12,477,725.

MANUFACTURES.

Some of the leading manufactures are those connected with the mining industry, such as the reduction of ores, manufacture of coke, charcoal, machinery, and castings. Iron furnaces, steel and nail works, rolling mills, foundries, etc., are mainly centered at Denver and Pueblo.

The following is the product of the works of the Colorado Coal and Iron Company, at Pueblo, for the year 1886:

	Tons.
Coal	615,360
Coke	112,200
Pig-iron (five months' run only)	9,323
Spiegeleisen	982
Steel rails (four months only)	5,872
Merchant bar iron	4,240
Castings (for their own use only)	621
Cast-iron pipe	995
Nails, kegs of 100 pounds each	53,250
Track spikes, kegs of 150 pounds each	3,370

Smelting and reduction works are in operation in all of the principal mining districts. The many minor manufactures and productions of this country can not here be described. When one considers the extensive water-power afforded by the mountain streams, the inexhaustible coal measures, and the amount and variety of raw material at hand, it seems more than probable that the manufactures of the region will rapidly increase in number and importance. In view of the great production of wool here, it is difficult to understand why cloth and woolen factories have not already been established.

STONE AND MARBLE.

Extensive and valuable stone quarries have been developed and worked wherever building operations have created a demand for stone. The existence of many elegant and substantial public buildings, business blocks and residences, constructed of this material, attest the extent and value of this industry. Fine marble quarries of great extent have also been discovered at various points, and are receiving due attention and development.

POPULATION AND VALUES.

An estimate, based mainly upon official reports, of the present population of Colorado and the Territories under consideration is, in round numbers, as follows:

Idaho, 97,250; Montana, 130,000; Wyoming, 85,000; Colorado, 250,000; New Mexico, 148,000; Utah, 196,600; total, 906,850. The principal towns and their population are as follows:

Idaho.—Boisé City, 3,000; Hailey, 2,500; Ketchum, 2,000; Paris, 1,000.

Montana.—Helena, 10,000; Butte City, 15,000; Missoula, 2,500; Bozeman, 2,500; Fort Benton, Billings, and Miles City, about 1,500 each.

Wyoming.—Cheyenne, 7,700; Laramie, 5,100; Rawlins, 1,500; Evanston, 1,800; Rock Springs, 1,200; Douglas, 1,200; Carbon, 1,000.

Colorado.—Denver, 62,000; Pueblo, 12,500; Leadville, 11,000; Colorado Springs, 5,800.

New Mexico.—Santa Fé, 7,000; Albuquerque, 10,000.

Utah.—Salt Lake City, 20,768.

The following are the assessed valuations for the year 1887 of real and personal property, exclusive of mines:

Idaho	$20,741,192.00
Montana	60,200,000.00
Wyoming	32,089,613.00
Colorado	136,322,313.00
New Mexico	63,000,000.00
Utah	35,865,000.00

More detailed statements can be given as follows:

NOTE.—For the purpose of comparison, the estimates of the numbers and value of farm animals, January 1, 1887, made by the Statistician of the Department of Agriculture, are appended to the assessed valuations.

Assessed valuation of the Territory of Idaho for the year 1887.

Description of property.	Territorial estimate.	Estimate of Department of Agriculture.	
	Number.	Number.	Value.
Horses	132, 922	48, 750	$2, 681, 250
Mules	....	2, 436	210, 714
Cattle	442, 363	339, 453	7, 298, 240
Swine	60, 411	28, 100	147, 525
Grain (bushels)	2, 374, 325	....	....
Hay (tons)	342, 914	....	....
Railroads (miles)	900	....	....

Total taxable property, $20,741,192.

Assessed valuation of the Territory of Montana for the year 1886.

Description of property.	Territorial estimate.		Estimate of Department of Agriculture.	
	Number.	Value.	Number.	Value.
Acres of land and improvements	4, 115, 457	$9, 898, 470	....	....
Town lots and improvements	33, 954	8, 997, 460	....	....
Horses	127, 748	4, 333, 595	129, 203	$6, 535, 088
Mules and asses	2, 121	116, 145	9, 229	662, 181
Sheep	968, 298	1, 952, 728	754, 681	1, 762, 197
Cattle	663, 716	13, 347, 815	812, 784	18, 775, 310
Swine	18. 837	75, 713	20, 263	119, 168
Wagons and carriages	10, 406	493, 716	....	....
Watches and clocks	3, 619	90, 113	....	....
Pieces of jewelry and plate	299	54, 646	....	....
Musical instruments	1, 123	103, 971	....	....
Shares of stock	....	288, 020	....	....
Merchandise	....	3, 493, 976	....	....
Capital and manufactures	....	296, 700	....	....
Moneys and credits	....	5, 660, 843	....	....
Household furniture	....	135, 827	....	....
All other property	....	5, 737, 131	....	....
Total	....	55, 076, 871	....	....

Assessed valuation of the Territory of Wyoming for the year 1887.

Description of property.	Territorial estimate.		Estimate of Department of Agriculture.	
	Number.	Value.	Number.	Value.
Horses	66, 658	$2, 310, 712	82, 500	$3, 678, 675
Mules	2, 590	118, 300	2, 850	198, 887
Cattle	753, 648	10, 186, 360	1, 255, 298	28, 815, 365
Sheep	421, 688	637, 433	534, 020	1, 047, 480
Swine	1, 144	6, 010	2, 750	17, 596
Railroads (miles)	670	....	....	....
Capital in manufactures and trade	....	1, 502, 700	....	....

Total assessment, $32,089,613.

Assessed valuation of the State of Colorado for the year 1886.

Description of property.	State estimate.		Estimate of Department of Agriculture.	
	Number.	Value.	Number.	Value.
Acres of land with improvements	4, 534, 938	$24, 211, 001. 24		
Miles of railroad	2, 969. 03	23, 508, 367. 59		
Average of merchandise		6, 087, 084. 00		
Capital in manufactures		475, 926. 00		
Town and city lots		43, 779, 068. 00		
Horses	124, 032	4, 663, 327. 00	123, 770	$7, 178. 918
Mules	6, 247	385, 529. 00	8, 165	685, 224
Cattle	845, 038	12, 425, 061. 00	1, 070, 768	23, 768, 479
Sheep	777, 494	832, 121. 00	1, 149, 178	1, 845, 579
Swine	22, 260	67, 205. 00	21, 290	146, 424
Asses	2, 230	28, 203. 00		
Goats	10, 713	10, 639. 00		
All other animals	3, 421	26, 968. 00		
Musical instruments		339, 301. 00		
Clocks and watches		200, 391. 00		
Jewelry and plate		56, 612. 00		
Money and credits		2, 689, 646. 00		
Carriages and vehicles		900. 798. 00		
Household property		510, 985. 00		
Bank and other shares		1, 269, 836. 00		
All other property		1, 801, 640. 00		
Total valuation		124, 269, 710. 00		

To this may be added the mineral production, which is not taxable, as follows:

Gold	$4, 447, 077
Silver	14, 083, 190
Copper	43, 507
Lead	5, 143, 566
Total	23, 717, 340

More recent returns give the total assessed valuation of Colorado for 1887, as $136,322,313.36.

The changes from 1886 are mainly in the following items:

Description of property.	Number.	Value.
Miles of railroad	3, 650	$28, 988, 300
Horses	148, 027	5, 042, 480
Mules	7, 560	544, 865
Cattle	1, 500, 000	22, 500, 000
Sheep	1, 422, 900	3, 311, 652
Swine	63, 332	206, 292

Assessed valuation of the Territory of New Mexico for the year 1887.

Description of property.	Territorial estimate.		Estimate of Department of Agriculture.	
	Number.	Value.	Number.	Value.
Horses			20, 786	$745, 944
Mules			10, 912	520, 501
Cattle	916, 287	$11, 003, 280	1, 220, 968	21, 824, 801
Sheep	1, 702, 287		4, 025, 742	5, 958, 098
Swine			20, 990	131, 555
Coal (tons)	384, 762			
Railroads (miles)	1, 050			

Total assessment, $63,000,000.

Assessed valuation of the Territory of Utah for the year 1887.

Description of property.	Territorial estimate.		Estimate of Department of Agriculture.	
	Number.	Value.	Number.	Value.
Horses	250, 000	$10, 000, 000	56, 136	$2, 466, 490
Mules			3, 597	215, 082
Cattle	500, 000	11, 500, 000	219, 812	4, 498, 871
Sheep	2, 400, 000	7, 000, 000	658, 285	1, 343, 692
Swine	100, 000	500, 000	28, 656	237, 052
Railroads (miles)	1, 141			

Total valuation, $35,865,000.

II.—THE FORESTS OF THE REGION.

LOCATION.

The forests of the Rocky Mountains, mainly coniferous, are usually located upon the mountain slopes, at altitudes varying from 4,500 to 12,000 feet above the sea; in some cases the timber line extends to a height of 12,500 feet. The foot-hills and mesas often have a scattering, inferior forest growth, and many of the streams which flow from the mountains are bordered with a sparse growth of cottonwood and a few other deciduous species native to the region.

AREA.

The forest areas, though large in themselves, are not large as compared with the area of the entire region, which amounts to 640,155 square miles, nor are they to any considerable extent contiguous. There are at present no means of determining accurately their bounds and extent. Approximate estimates only can be given, based mainly upon statements received from residents of the several localities, or from persons having special knowledge of particular portions of the region.*

According to the best data obtainable, and including in the estimate all kinds of forest growth, light and heavy, valuable and inferior, the approximate forest areas, in square miles, of the several divisions are as follows: Idaho, 15,990; Montana, 26,285; Wyoming, 12,060; Colorado, 16,625; New Mexico, 12,500; Utah, 6,000; or a total in round numbers of 90,000 square miles or 57,000,000 acres, being 14 per cent. of the total land area.

OWNERSHIP.

The bulk of the forest land of the Rocky Mountain region is still owned by the General Government. In New Mexico, through the means of old Spanish grants, the titles to large tracts of woodland are held by private

* It is one of the most difficult undertakings, as every one who has attempted it knows, to ascertain with accuracy the timber areas, especially in the great mountain region of the West. In all of the Territories I found a disposition among the people to overestimate the timber area, and to call all lands timber lands that had once been covered with forest growth. Lumber dealers and producers do not like to give figures to a Government agent, and when they do, are not likely to exaggerate them. There is no common and recognized standard by which to estimate forest areas.—E. T. E.

parties. In Colorado, although the greater portion of the timber lands have been surveyed, comparatively a small part have become subject to private ownership. The lands selected from time to time by the State, under various grants from the United States, have usually been farming lands, including but little timber. The school sections, and a few other tracts owned by the State, embrace some timber land. It is difficult to determine the ownership of the forest lands in this State, to decide which belong respectively to the General Government, to the State, and to individuals. Although public surveys have been made, the field-notes and official plats give very limited information respecting the timber or forest growth; and since the surveys were made forest fires and operations incidental to lumbering, mining, and charcoal burning have effected very material changes in the timbered region.

In Wyoming, Montana, and Idaho, in all of which large forests exist, hardly any of the timber lands have been surveyed. It is gratifying to know that the present policy of the General Land Office is to discourage or forbid the making of such surveys. The precedent is a good one, as tending to prevent encroachment upon the forests.

FOREST CONDITIONS.

The Rocky Mountain region embraces a wide expanse of wooded ranges, foot-hills, valleys, parks, and plateaus. Naked and often snow-clad crests and peaks, rocky slopes, barren surfaces, deep defiles, and swift-rushing streams still further diversify a landscape wonderful in the extent and variety of its natural features.

Upon the mountain ranges are irregular masses of coniferous forest, separated by wide spaces—the latter treeless, or sometimes clothed with a growth of Aspen. Bordering the streams are Cottonwood, Willow, Alder, and other deciduous growths of minor importance. The "parks" (by which are meant mountain valleys bare of timber or nearly so) are usually covered with wild grasses or sage-brush. Scrub-oak and Cedar, Sage-brush, and other shrubs—in rare cases a scattering growth of timber—are found in the foot-hills, mesas, and plateaus.

This region, though nearly surrounded by arid or semi-arid plains and plateaus, and subject, more or less, to conditions of aridity, heat and cold inimical to forest growth, receives in many parts a comparatively large precipitation of moisture, and is favored through large portions of the year with abundant sunshine. To these last-named causes may be ascribed the existence here of relatively extensive forests. It is believed that but for the scourge of fire, these forests would be at least one-third greater in extent.

Upon the western slope of the main range the annual rain and snow-fall are greater than upon the eastern side; hence the larger and more important forests are found there. Furthermore, the forests of that portion have suffered less from fire and depredation than those in other sections. In all parts of the mountain region, northern slopes are the most favorable to forest growth, as affording maximum conditions of moisture and minimum evaporation.

The soil in which these forests grow consists, for the most part, of decomposed rock (or gravel) mingled with sand. A thin surface layer of humus aids, ordinarily, in the retention of moisture, but in dry seasons it is a source of danger, promoting the spread of fire.

The surface is usually quite sloping—in many cases extremely so—and the soil, deficient in clay or other coherent substances, is easily moved by the action of water. When, therefore, the slopes have been stripped of their natural covering, the violent rain storms of the region have a powerful and disastrous effect upon them. The light surface mold is carried downward to the valleys, more or less remote, and is soon followed by masses of sand and gravel. The mountain side, which was formerly clothed with a noble forest, now seamed and furrowed by the torrents, has become a barren waste—beyond reclamation. Conditions identical with these are very apparent along the front range in Colorado, and in many parts of the mining districts throughout the mountain region.

Even in the most favored districts, where the forests have been removed their renewal is extremely difficult. Nature does much in such cases, however, and though the original species may not be reproduced, an inferior growth often appears. The extent of natural reforestation varies greatly in different localities. In New Mexico, with greater degrees of heat and aridity than prevail farther north, the second growth is proportionately less vigorous. Where fierce forest fires have scorched the ground and destroyed the vegetable mold, the difficulty of reforestation is usually greatly enhanced. On the other hand, it is alleged that in some instances the action of fire serves to open the cones or outer coverings of certain tree seeds, and thus affords them a chance to take root and grow. It has been said, also, that the ashes produced by a forest fire enriches the soil, and to that extent promotes the reproduction of trees. But these are at best only mitigating facts, if they are facts, attending the almost inestimable loss resulting from forest fires.*

In what has been said above concerning reforestation, reference has been made to spontaneous growth. While the necessity is great for restoring to the denuded slopes of the Rocky Mountains their once useful and beautiful forest covering the expediency of attempting the artifi-

* These are facts only in the imagination of those who wish to find an excuse for the unmitigated nuisance of forest fires. No cones need the action of fire to be opened; a sufficient quantity would be opened by the heat of the sun, without destroying the seeds, as the fire does. No trees need the enriching quality of the ashes, but their seeds do need very much the vegetable mold, as a bed in which to germinate and to be supplied with the needful moisture which the mold provides, but which the ashes are not capable of storing up.

The fires, not only of this year, but those of years back, have destroyed the chances of natural reforestation by seed in many places, because they have destroyed the proper seed-bed.—B. E. F.

cial planting of large tracts in that section is doubtful. If men will cease their destructive operations and extend a protecting hand over the forest regions, nature will repair in a measure the injuries of the past. In truth, most kindly healing processes are already begun. The ubiquitous Aspen, with its light summer foliage and brilliant autumn hues, gives grateful shade and moisture to wide areas which otherwise would be barren and desolate. Some abler pen than mine should apostrophize the Aspen! It is nature's restorative—the balm poured upon grievous wounds! No soil, apparently, is too poor and inhospitable to provide for it. It has, however, its limitations. It is a denizen of the mountains, and succumbs to excessive degrees of heat and aridity. The Dwarf Maple, Creeping Juniper, Wild Rose, and other hardy shrubs are also helpful in the restoration of denuded surfaces. In the midst of these minor growths the seeds of the Pine, Spruce, and other timber trees gain lodgment and find necessary protection.

In all situations where the existing conditions of soil and climate are favorable the planting of forest trees should be encouraged to the utmost extent. In valleys, among the foot-hills, upon the mesas and plains where water is available, and along the streams, irrigating canals and ditches, this important work should be carried on.

There is no longer doubt that with the aid of irrigation, trees can be made to grow at any point upon the western plains. Nay, with a proper selection of species and judicious treatment, it is probable that plantations and forests can be established even without the aid of irrigation.

FOREST FLORA.

The forests of the Rocky Mountain region are mainly coniferous, with scattering groves of Aspen in the mountains, Scrub-oak and Cedar upon the foot-hills and mesas, and Cottonwood, Box-elder, Dwarf Maple, Birch, Willow, and other minor deciduous species along the canyons and streams.

A full account of the woody plants prepared by Mr. George B. Sudworth will be found on page 153 of this report. The more important forest trees occurring in each Territory are also enumerated in the special part of this report.

LOCAL DEMANDS ON FOREST SUPPLIES.

By numerous letters of inquiry sent to lumbermen and others, in various localities, efforts have been made to obtain statistics relative to the consumption of timber in this region. The results, however, have not been commensurate with the efforts, and the information so obtained has been quite meager, and shows mostly how little thought or intelligent estimation has been so far given to this important branch of economics; how little its importance is as yet appreciated.

One of the questions contained in the letters of inquiry was as follows:

Is there danger of the timber supply failing?

To this, twelve replies in the affirmative were received and nine in the negative. Five correspondents stated there was no danger of the supply failing unless the timber was destroyed by fire, and that the undergrowth would make good the loss by consumption, and one stated that the timber would last for a hundred years.

With respect to remedies for failing lumber supply, the following suggestions were offered:

Import from Oregon.
Ship more lumber from the East.
Protect from fire.
Post notices to prevent setting of fires.
Encourage tree planting.
Plant Oak, Walnut, and Hickory.
Impose heavy penalties for cutting small timber.
Timber should be owned by private parties.

The principal uses made of timber in this region are the manufacture of lumber, railway ties and timber, mining timber, telegraph poles, charcoal, fencing, and fuel.

LUMBER.

Yellow Pine (No. 7),* White Pine (No. 2), and Black Pine (No. 9), White (Engelmann) Spruce (No. 11), and Red or Yellow Fir (No. 19), are the principal timber trees of the region. They furnish most of the common and a portion of the finishing lumber. Considerable White Pine (*Pinus strobus*) from the lake region, Redwood (*Sequoia sempervirens*) from the Pacific coast, many of the hard woods also, and Southern Pine are imported for the finer kinds of work.

Approximate estimates, based upon reports received from some of the principal lumber dealers of the region, make the consumption of lumber for the year 1886 as follows: Native, 46,000,000 feet, B. M.; imported, 18,000,000 feet.

NOTE.—These figures can hardly be used to convey an idea of the quantities of lumber manufactured at home or imported into the region, and unless the large but quite uncertain quantity of unsawn lumber used in the mines is deducted, they seem to be far below the actual amounts used, as will appear from the following results of an independent canvass among saw-mill men and statements of railroad companies.

From these an estimate of between 150,000,000 and 200,000,000 feet of native timber and of 40,000,000 to 50,000,000 feet imported would appear to represent more nearly the amount of lumber consumed in the region.

Idaho.—Five mills out of six report an aggregate cut of 4,550,000 feet, while an estimate places the whole amount of native timber used in the Territory at 17,000,000 to 19,000,000 feet. (See also page 93.)

Montana.—Nine mills out of eleven report an aggregate cut of 19,592,000 feet, mainly for mine timber, but exclusive of railroad ties and cord-wood, of which large quantities are cut.

Wyoming.—Only one mill out of five reports cutting 500,000 feet, and estimating the cut for the Territory at 8,000,000 feet outside of railroad and mine timber.

* The numbers refer to those used in the account by Mr. Sudworth in this report.

Utah.—Out of five mills replies were received from two, with an aggregate cut of 1,350,000 feet; one estimates the cut for the Territory at 10,000,000 cubic feet of mine timber and 60,000 cords of fuel and fencing.

This estimate assumes that the cut in Wahsatch and Summit Counties, which is placed at 2,000,000 feet B. M. lumber, 300,000 cubic feet mine timber, and 12,000 cords fuel and fence material, represents 20 per cent. of the total cut of the Territory.

Colorado.—Out of some eighty mills written to, of which several have gone out of business, thirty have replied, reporting an aggregate cut of 18,820,000 feet for the year 1886. From various estimates by counties, the total cut of mill timber can not be short of 75,000,000 to 100,000,000 feet, of which 25,000,000 are used in Lake County (Leadville) alone.

No replies from New Mexico. (Estimation, see page 141.)—B. E. Fernow.

NOTE.—We are indebted to the kindness of Mr. E. R. Murphy, auditor of the Denver and Rio Grande Railroad, and of Mr. J. A. Munroe, general freight agent of the Union Pacific Railroad, for the following interesting statements regarding the movement of lumber and other wood from outside points to the Rocky Mountain region.

Union Pacific Railroad.—The total amount of lumber hauled into the Rocky Mountain region from points on the line of this road was, in 1886, 53,786 tons (33,616,250 feet, B. M.), and during nine months of 1887, 65,437 tons (40,898,125 feet, B. M.). Of this amount 24,595 tons (15,371,880 feet), or 45 per cent., were from Oregon in 1886, and 40,918 tons (25,573,750 feet), or 60 per cent., from Oregon in 1887.

Denver and Rio Grande Railroad.—As appears from the following detailed statement, this road during the same period imported 1,075 tons (672,422 feet, B. M.) in 1886, and 625 tons (390,000 feet, B. M.) during nine months of 1887.

Shipments of lumber and wood over Denver and Rio Grande Railroad to Rocky Mountain region from points outside.

From	1882.	1883.	1884.	1885.	1886.	1887 to August 31.	Total, 1882 to August 31, 1887.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Denver	2, 844, 300	2, 934, 340	802, 900	808, 075	787, 090	961, 240	9, 137, 945
Colorado Springs	20, 000	17, 000	....	....	....	....	37, 000
Pueblo	648, 000	280, 055	550, 090	277, 635	506, 545	88, 390	2, 350, 715
Florence	14, 800	16, 000	....	20, 000	20, 000	....	70, 800
Canon	82, 000	48, 000	32, 000	17, 300	37, 055	....	216, 355
Barnes	....	....	....	....	....	40, 000	40, 000
Apishapa	149, 475	108, 000	124, 700	300, 000	645, 710	160, 000	1, 487, 885
El Moro	....	53, 300	....	....	....	....	53, 300
Santa Clara	....	....	....	101, 650	....	....	101, 650
La Veta	235, 000	232, 000	320, 000	....	155, 350	....	942, 350
	3, 993, 575	3, 688, 695	1, 829, 690	1, 524, 660	2, 151, 750	1, 249, 630	*14, 438, 000

* Or 4,512,000 feet.

RAILWAYS.

With the exception of forest fires, it is conceded that no one agency consumes the forests of the country so rapidly as do the railways. Their lines, of vast extent, stretching in every direction, make enormous and unceasing demands upon the forests, and it is quite time for the railroad corporations, as well as for the public, which must suffer by any impediments to cheap railroad transportation, to interest themselves in a better management of forest supplies.*

While it is true that railroad companies legitimately require large quantities of timber, it is not less true that in many cases they use the timber resources of the country in a most wasteful and destructive

* See Bulletin No. 1, Department of Agriculture, 1887, Forestry Division, on the relation of railroads to forest supplies, with appendices.

manner. Perhaps the most constant and serious drain on their part is in connection with the demand for cross-ties. For this use it is customary to cut the smaller and rapidly growing trees, which results in a wasteful consumption of the trees themselves and a great diminution of the source of future supply; or else much valuable timber is left in the woods, the tie cutter taking only such parts of trees as will most easily yield him ties of the required size.

The information collected with respect to the railway mileage of this region, and the amount and kinds of native timber used by the several roads, is not sufficiently complete to warrant the presentation of the same in tabular form, and is therefore embodied in the condensed statements following.

By the courtesy of Messrs. Poor, publishers of Poor's Manual of Railroads, we are enabled to give, in advance of publication in the usual way, the following estimate of the railroad mileage in the Rocky Mountain region at the present time. In a letter received from them they say:

From careful examination of the data now in our office, our estimate is as follows

	Miles.
Idaho	850
Montana	1,575
Wyoming	850
Colorado	3,650
New Mexico	1,238
Utah	1,145

It is possible that before the end of this year there will have been added to the mileage of the six St ates and Territories named an additional 300 miles of new railroad, making the total increase for the year about 1,650 miles of railroad, to which will be added at least 400 miles of sidings and other auxiliary tracks, or a total of over 2,000 miles of track within the year.

Assuming this estimate to be correct, there will be in the Rocky Mountain region at the close of the year 1887, 10,008 miles of railroad track. This would bring the demand upon the forests up to the present time for construction to not less than 200,000,000 cubic feet, and the annual demand for renewal and maintenance to 25,500,000 cubic feet.

Union Pacific Railway.—Consumption of native timber. Statements from S. T. Smith, general superintendent, Omaha. (Length of road in Colorado, 965 miles.)

August 20, 1886. We have used during the last twelve months in Colorado about 200,000 cross-ties, about 5,000 posts, 2,700 cords of slabs for fuel purposes, and 1,500,000 feet of mountain pine for various purposes.

February 1, 1887. Number of cross-ties and feet of dimension lumber used in the year 1886 on the following divisions:

State or Territory.	Number of cross-ties.	Square feet of dimension timber.
Idaho	9,180	1,084,827
Montana	41,844	401,221
Wyoming	355,930	1,800,282
Colorado	279,827	5,164,639
Total	686,827	8,450,969

Denver and Rio Grande Railway.—Mileage of road and consumption of native timber. Statement from C. M. Hobbs, purchasing agent. (Length of road, main line, in Colorado, 1,161.8 miles; New Mexico, 155.2 miles; Utah, 368 miles.)

Approximate amount of timber required for annual renewals and repairs:

Cross-ties	number..	1,023,376
Sawed timber (B. M.)	feet..	5,625,000

Kinds of timber preferred for the several purposes:

For cross-ties, Red Spruce (local name for White Spruce) and Yellow Pine—the former very much preferred; for bridge timbers and cars, Yellow Pine; for buildings, Yellow Pine or Red Spruce.

Native timber used in Colorado and New Mexico in the year 1886:

Number of broad-gauge cross-ties	60,000
Number of narrow-gauge cross-ties	740,000
Feet of dimension lumber (B. M.)	3,000,000

In my opinion there is an ample supply of timber in our State for a hundred years to come; but the increasing cost of securing it will soon make necessary the use of some wood-preserving process, at least on the part of railroad companies.

Colorado Midland Railway.—Mileage of road and consumption of native timber. Statement of H. D. Fisher, president of Colorado Midland Construction Company.

January 27, 1887. The present mileage of the Colorado Midland Railway, now under construction, and which we expect to finish and operate before the close of the year, is 250 miles.

The number of cross-ties required for the above main track and the sidings requisite for the same will be about 900,000.

The amount of timber to be used in bridges and other construction work is estimated at between 6,000,000 and 7,000,000 feet.

The timber generally used for bridge purposes is Yellow Pine or Red Spruce (local name for White Spruce); and the same may be said with regard to ties, except that we endeavor to obtain all the Red Spruce that can be had.

Burlington and Missouri River Railroad.—Statement from G. W. Holdrege, general manager, of date January 22, 1887. (Length of road in Colorado, 175 miles.)

No Rocky Mountain timber used in 1886.

Atlantic and Pacific Railroad Company.—Consumption of native timber during the year 1885. Statement from D. B. Robinson, general manager.

During the year 1885 we consumed in New Mexico 937,240 feet, and in Arizona 2,028,959 feet (B. M.) of native pine. Our principal source of supply is from the Ayer Lumber Company, at Flagstaff, Ariz. Pine lumber is about the only kind of lumber we use, and is the only kind that grows either in Arizona or New Mexico to any extent.

Mileage of road in New Mexico and consumption of native timber during the year 1886. Statement from T. R. Gabel, general superintendent. (Length of road in New Mexico, 191 miles.)

Number of cross-ties (native pine) used in New Mexico in the year 1886, 47,456.

Number of feet of dimension lumber (native pine) used in New Mexico in the year 1886, 298,755.

On the western division of this road extensive use has been made of Redwood for cross-ties and telegraph poles; these ties last about twelve years.

TELEGRAPH POLES, ETC.

The consumption of native timber, especially the White Spruce, for telegraph and telephone poles, amounts in the aggregate to considerable. In a recent communication received from the superintendent of the Western Union Telegraph Company, at Omaha, Nebr., he says:

We are not now using any native poles, but, for what renewals are made and new lines built white Cedar poles are shipped from the East—obtained mainly in Michigan and Ohio. In the lines built several years ago pine was used.

The superintendent of the Colorado Telephone Company at Denver states that telegraph and telephone poles should be cut in winter, when the trees are not full of sap. Experiments in applying preserving processes for poles, tarring, charring, etc., have not been satisfactory. The nature of the soil greatly affects durability. There exists also this practical objection, that as contracts provide that poles shall be delivered "at the stake," for lines of considerable length preserving processes are not feasible.

MINING.

In connection with the mining industry in this region, a great amount of timber is annually consumed, of which it is impossible to give even an approximate estimate. But it is larger in the aggregate than one unacquainted with the facts would suppose. One mining camp in Montana, Butte City, established only a few years, it is estimated requires at its present state of development not less than 40,000,000 feet, B. M., per year, of round and square timber of large size, not to speak of the countless number of small trees used for "lagging." Much of the timber used in Utah and Montana is now imported from the Pacific slope, as the home supply of good-sized or accessible timber, especially in the former Territory, has been exhausted, or timber can be produced more cheaply by rail from a distance. Much timber is required for fuel and charcoal, especially the latter, which is used extensively in smelting operations. The before-mentioned mining camp with its reduction works consume, it is estimated, 1,000 cords of fire-wood a day, or about 30,000,000 cubic feet of solid wood per year.

CHARCOAL MANUFACTURE.

From the best information obtainable, it is believed that the charcoal burners of the Rocky Mountain region are doing immense injury to the forests. They draw their supplies of wood almost wholly from the public domain, and although they profess to make large use of dead timber, there is no doubt that the growing forests are largely encroached upon by them. A person well informed upon this subject recently expressed himself thus:

The charcoal burner is the most conscienceless violator of law that we have, cutting everything down to poles 2 inches in diameter. He leaves behind him barrenness and desolation. The traffic in charcoal is so exhaustive upon the forests, and so injurious to the best interests of the State, that wherever permitted it should be done under a license only, by the giving of a bond, and by the rigid enforcement of conditions and penalties. There are no reasons why the charcoal burner should longer be allowed to prey upon the timber and young forest growth. On the contrary, many strong and urgent reasons exist for limiting his operations.

Efforts were made to obtain statistics relative to the consumption of timber for the manufacture of charcoal, but, as in the case of lumber manufacture, the returns were quite unsatisfactory.

In response to the question, "What is your principal source of timber supply for the manufacture of charcoal?" replies were received (mostly from persons in Colorado and New Mexico) as follows:

In the foot-hills; plenty of pine and piñon.
Foot-hills and ranches.
Purchase from parties who deliver at kiln.
All around the city (Breckenridge, Colo.).
Patented lands and pre-emptions.
Mineral ground.
Abundance of timber, chiefly on grants (N. Mex.).

To the questions, "What kinds of timber do you mainly use? What proportion of green timber and what proportion of dry?" the following replies were received:

Pine and piñon.
All dry wood—it takes too long to burn green.
One-fifth dry; piñon the best for charcoal.
Piñon; mostly dry—killed by fire.
Pine; 90 per cent. dry, 10 per cent. green.
Aspen; three-fourths green, one-fourth dry.
Pine; one-half green, one-half dry.
Piñon; equal parts of green and dry.
Scrub timber; half dry and half green.
Dead timber and dry; green too expensive.
Piñon, pine, and cedar; one-third green, two-thirds dry.
Pine; 75 per cent. green.

Concerning the yearly product of charcoal (in bushels) reports were received as follows:

Colorado:	
Lake County	2,000,000
Conejos County	150,000
Custer County	150,000
Rio Grande County	150,000
Park County	800,000
Dolores County	75,000
Chaffee County	380,000
La Plata County	75,000
New Mexico:	
Santa Fé County	200,000

No means are at hand for verifying the above statements; and besides, it will be seen that the figures cover but a small territory. The Philadelphia smelter at Ketchum, Idaho, has thirty kilns for burning charcoal; the annual product is not reported.

At least nine-tenths of the charcoal manufactured is used by the smelters; the remainder is used mostly by blacksmiths and tinsmiths.

A Colorado manufacturer writes as follows upon the subject:

The largest amount of charcoal is made and used in Lake County; the Leadville smelters there use daily about 10,000 bushels. Charcoal is made of both dry and green timber. About three-fourths is made from dead timber, one-half of which is down. One cord of wood will yield about 50 bushels of coal. Dry or dead timber, if sound, will yield more than green, but the quality of the coal will be about the same.*

Concerning the extensive use of charcoal by smelting companies, and the consequent heavy draft upon the forests, it is reliably stated that the use of charcoal in smelting is a convenience but not a necessity. There is in many parts of this region an abundant supply of mineral coal, of good quality, including dry, bituminous, or coking, and anthracite, and its use by smelting companies would simply involve the employment of more skillful furnace men than are used under the present system.

FENCING.

Although barbed wire is largely superseding the use of boards for fencing, there is a continued demand for timber for fence posts, rails, etc., and as farms and ranches are rapidly increasing in number, the demand for fencing material is likely to grow in proportion. Much dead timber is utilized in this way. In the mountains, Aspen is often used for fence rails. For posts, Yellow Pine (here called Pitch Pine), Cedar (*Juniperus*), White and Black Spruce, etc., are used. In a few instances posts for wire fences have been made of bar iron.

With the data available, it is impossible to state the amount of timber that is annually consumed in this region for fencing purposes. It is a varying and probably an increasing quantity.

FUEL.

In the mountains, except in the immediate vicinity of coal mines, wood is the principal fuel, and for this dead and fallen timber is largely used. Except in the case of Piñon, it is unlikely that growing timber will suffer greatly from this use, and the greater portion of the Piñon meets its fate at the hands of the charcoal burners. In most of the towns, and in the plains region, mineral coal is furnished of good quality and at reasonable prices.

Note.—Since the fuel question is a most important one in connection with forest preservation, the statistics of the supply of mineral coal are of great interest in this place. The following notes, therefore, taken from the reports of the Division of Mining Statistics and Technology, U. S. Geological Survey, are here inserted.

In the Rocky Mountain district coal beds are found in a number of geological formations, from the Carboniferous up to and including the Cretaceous.

No detailed information of the entire coal area of the Rocky Mountain region, similar to that which has been determined by State geological surveys of the coal basins

*From imperfect returns to a separate canvass, it would appear that the total consumption of charcoal for smelting purposes in the region must be placed at round 4,000,000 bushels, of which the three Leadville smelters take 2,364,000 bushels.—B. E. F.

east of the Rocky Mountains is available, and no reliable estimates have been made of the areas underlaid by workable coal beds. It has been surmised that the total area of the coal-fields of this district is between 200,000 and 300,000 square miles, but this estimate is little more than a guess.

The total production, exclusive of colliery consumption, in each State and Territory, and corresponding value at the mines in 1886, are shown in the following tables:

States and Territories.	Total production not including colliery consumption.	Value of coal at mines.
	Short tons.	*Dollars.*
Colorado	1,368,338	3,215,524
Wyoming	829,355	2,488,065
New Mexico	271,285	813,855
Utah	200,000	420,000
Montana	41,846	174,460
Idaho	1,500	6,000
Total	2,720,324	7,117,974

In the Rocky Mountain region the production of coal is dependent exclusively upon the demand of the local trade. This varies not only on account of the growth and decline of the local industries, but upon the variable freight tariffs which have permitted the importation to Rocky Mountain points of more distant and superior coals at prices advantageous to the consumer.

Colorado.—The general prosperity of Colorado in 1886 has in no way been better shown than in the great development of the coal-fields of the State, although this development was begun too late to show a very great increase in the production for 1886 over 1885. While the mines in the northeastern portion of the State have only held their own, those of southeastern Colorado have materially increased their output in response to the steadily increasing demand from points in western Kansas and Nebraska. The greatest amount of new work has been done, however, west of Pitkin and the Continental Divide, in what is known as the Glenwood field.

Noteworthy discoveries of coking coal have also been made in Gunnison County, on Ohio Creek, and of anthracite of good quality, in a region where its existence has only been suspected—the basalt-covered tract southwest of Hahn's Peak, in Routt County. The more remote coal-fields, although known to produce excellent coals of varying qualities, have been hitherto neglected, because of the remote prospect of railway communication, which is necessary to bring their product into competition with that from well-opened mines.

The great activity in railway building in the direction of Garfield, Routt, and Pitkin Counties has spurred on the work of opening the coal beds in these counties, in order to meet the demand which the completion of the three railways now being built in that direction will bring. The superior quality of the coke made from the coal from the mines in Pitkin and Garfield Counties, and the accessibility, low altitude, and thickness of the beds in the anthracite districts of Routt County will meet a commercial demand from the smelting and manufacturing centers of Colorado, and also from those in the adjoining States and Territories.

Total product of mines operated in the interest of railways in Colorado for 1886 was 1,115,267 tons; increase of 0.7 per cent. over 1885. The increase in railway production is very slight indeed. The coal area has been variously estimated at from 20,000 to 50,000 square miles. The known and partially developed coal-fields cover about 1,000 square miles, while the area of the Laramie, Fox Hills, and Colorado cretaceous formations, which are coal-bearing, comprises about one-third of the surface of the State, or approximately 35,000 square miles.

The coal production of Colorado in 1876 was 117,666 short tons, as against 1,368,338 short tons for 1886 and 1,791,735 tons in 1887.

The average number of men employed, directly or indirectly, in the coal mines of Colorado is estimated at 3,500.

The State inspector estimates that the average thickness of the coal beds worked in Colorado is 5 feet 3$\frac{7}{9}$ inches. He also states that the thickest bed worked is 9 feet and the thinnest is 2 feet.

The average price paid for mining and loading the coal and doing the necessary timbering is 89 cents per ton of 2,000 pounds of screened coal.

The average cost of the coal delivered on the cars is $1.74 per ton.

The average value of the coal is estimated at $2.35 per ton, making the total product of the State worth $3,215,594.30.

Idaho.—Large areas exist in the Territory underlaid by bituminous coal and lignites. Mines have been opened at Smith's Fork and on Twin Creek, and what is known as the Mammoth bed shows local thickness of 70 feet.

A good quality of lignite has been found near Boisé; also on the Snake River, between Payette and Weiser City. A good blacksmithing coal is also reported on Sucker River, 22 miles north of Silver City; also several deposits near Lewiston, in the northern part of Idaho.

Montana.—Much interest has been taken of late years in the coal-fields of Montana and the development of the coal and lignite beds.

Although the occurrence of good fuel in Montana is a matter of great importance to the development of the Territory, there has been no great activity displayed in coal mining in Montana during 1886. The greatest production had been at the Timberline mines, between Bozeman and Livingston, but the production there was seriously interfered with by labor troubles, as a result of which the mines were closed in July, and no coal was produced during the last six months of the year.

The value of the Territory's output in 1886, at $3.50 per ton, was $174,460. The number of men employed can not well be estimated.

New Mexico.—There were no special developments in the coal-mining industry of New Mexico in 1886. The field of the largest operations has shifted from Raton to Gallup and other points near by on the line of the Atlantic and Pacific Railroad in Bernalillo County, and near the Arizona border.

No new mines have been opened. The production of the Raton district fell from 135,833 tons in 1885, to 87,706 tons in 1886. This fall in production was due mainly to the increased production of better coal at the Starkville and Rockvale mines in Colorado, which furnished the Atchison, Topeka and Santa Fé Railroad with coal for shipment and for railway uses. The coal from Raton is used almost exclusively for fuel by the Santa Fé Railroad. The mines are located within the Maxwell land grant, and it is understood that a royalty is paid.

A large amount of the San Pedro coal is coked, the coke being used by smelting works in New Mexico and Arizona.

Wyoming.—The coal-fields of Wyoming are of great extent and value. They have been known since 1850, but remained undeveloped until the completion of the Union Pacific Railroad to Carbon, 100 miles west of Laramie, in 1868. The Coal Measures are estimated to cover at least 20,000 square miles of the surface of Wyoming, and the beds are found for nearly 350 miles along the line of the Union Pacific Railroad, in every case, where developed, cropping boldly on the surface. In quality, the coal is a lignite of superior grade, and suitable for all heating and domestic purposes, but non-coking and useless for gas making.

The entire coal-fields of Wyoming are practically controlled by the Union Pacific Railroad. The capacity of these beds is indefinite. They would doubtless be able to supply the whole demand of the far West with a uniformly good coal.

The total amount of coal mined in that region in 1875 was 300,808 short tons, and in 1885 it was 807,328 short tons.—B. E. Fernow.

DESTRUCTIVE AGENCIES.

FOREST FIRES.

In nearly all portions of our country fire is the most destructive agency affecting the forests. It does immense harm in the Rocky Mountain region. Annually, during the dry seasons, forest fires break out, spread with great rapidity, and destroy in a few days the growth of many years. The aridity of the climate, the resinous nature of the timber, the prevailing high winds, and the sparseness of population render forest fires in this region almost uncontrollable. They are doubly disastrous here, for when the mountain slopes are denuded of their natural covering, restoration is extremely difficult, if not impossible.

The following is taken from the recent report (1886) of Hon. S. T. Houser, governor of Montana, to the Secretary of the Interior:

> Another loss that has been greatly increased this year by the extended drought is the fearful destruction of our mountain forests by fires. These fires occur every summer. They originate generally from carelessness of hunters and campers (white or Indian), sometimes from lightning. In former years the destruction has been comparatively limited. This season they have prevailed generally, covering immense districts. More timber has been destroyed in the past six months by fire than would supply the wants of our people for fifty years, and more than will be renewed by growth in a generation.

By the enactment of laws prescribing penalties for the willful or careless setting of fires, and requiring the local authorities to post notices warning persons against violation of the law, some good has been accomplished. It is evident, however, that effective measures for the prevention of forest fires will not be adopted until the people and law-making powers become fully alive to their necessity. And then the object can be effected only by a carefully devised system of forest protection which will include the active co-operation of local officers.

Acres burned and values destroyed in Rocky Mountain region in 1880.

States and Territories.	Acres.	Value.
Montana	88, 020	$1, 128, 000
Idaho	21, 000	202, 000
Wyoming	83, 780	3, 255, 000
Utah	42, 865	1, 042, 800
Colorado	113, 820	935, 500
New Mexico	64, 034	142, 075
Total	413, 519	6, 705, 375

WASTE.

The wasteful methods now practiced in dealing with our timber supplies deserve earnest condemnation and, by the enactment of proper laws, should be visited with severe penalties.

In some instances lumbermen will set mills near large bodies of fine timber, and with unrestrained greed cut down vastly more timber than they can use. Again, it is the common practice to use the butts or larger portions of the trees for sawlogs, while the limbs and smaller parts of the trunk are left to waste and to furnish food for forest fires. In districts where large-sized trees abound it is not unusual, on the other hand, for tie choppers to cut ties from the upper and smaller portions only, and leave the butts on the ground to decay.

Any laws or customs which allow the cutting of trees and the utilization of a portion only, or permit the cutting of partly-grown trees (except in forest reserves or plantations, for necessary thinning) are pernicious, as authorizing wasteful and improvident methods.

SNOW AND LAND SLIDES.

Snow-slides are frequent in the Rocky Mountain region, more especially among the higher Colorado ranges. They usually occur in the late winter and early spring months, when heavy falls of snow are succeeded by sunshine, causing the partial melting of the snow, and giving it also great weight. The slides or avalanches destroy both life and property. In some instances entire mining camps have been engulfed. Slides often start near the crests of the mountains, above the timber line, and gaining momentum as they descend, carry every thing before them. Large trees are swept away, rocks of many tons weight are torn from their beds, and human beings who are in their path are entombed in the snow, which packs like ice, yielding only to the axe and pick. Again, the impacted snow, after reaching the bottom of a deep gulch, will be forced sometimes far up the opposite side, carrying with it buildings, people, and whatever may be in its way.

Land slides, though not frequent, some times occur. Through the action of frost, melting snows, or rain-fall—or all combined—masses of earth and rock are precipitated down the mountain side, overwhelming all beneath. To a beholder, the mass, with its accompanying roar, smoke, and fire, would seem to have evoked the lightnings and thunder to aid it in its destructive course. The path of the slide is usually marked by a strip of naked rock—of greater or less breadth—called, in mountain parlance, a "gouge," and upon which soil or vegetation is not likely to appear again. What means, if any, can be devised for the prevention of these disasters it is hard to say. Stripping the timber from the slopes, if not an original cause, contributes largely to the evil effect. Land-slides would hardly be possible in localities where the soil is sustained by the interlacing roots of a vigorous forest growth. It has been stated that in some of the Alpine regions stakes are driven upon the upper slopes of bare mountains to prevent the inception of snow-slides. Such a plan would hardly be feasible here, as the higher slopes of our mountains present steep and rocky surfaces of immense area.

NOTE.—It is a well-known fact that in Europe, not only torrents but land-slides as well as snow-slides are induced and aggravated by the removal of the forest cover, but also that their formation has been prevented by reforesting and returfing the denuded mountain slopes. If in the Rocky Mountains the occurrence of these dangers is not so frequent and disastrous as it has proved to be in Switzerland, Tyrol, and other European mountain regions, this may be partly due to differences of climate and geologic conditions. The presumption, however, is that the frequency and effects of such slides will be duly recorded in our mountain regions with the increase of settlements and decrease of forest cover. As a proper protection against snowslides is even now called for, a chapter on their formation and prevention has been appended to this report.—B. E. F.

LOSS OF FOLIAGE.

In the early part of the year 1885 extensive belts of conifers along the Pike's Peak and Front ranges, in Colorado, suffered a loss of blighting of foliage, which many supposed would result in the death of the trees.

Inquiry developed the fact that such occurrences, though rare in this region, were not without precedent, and were probably caused by sudden and extreme atmospheric changes. The trees so affected usually regain their foliage, although it is believed their vitality is impaired.

RELATIONS OF FOREST PRESERVATION TO AGRICULTURE.

In all countries the relations between forests and agriculture are more or less intimate. The forests receive moisture from the atmosphere, store it in their recesses, and through springs and running streams send it forth to water the land. Forests in proper proportion meliorate the severities of climate, rendering a country habitable for man and adapted to the growth of fruits and grains suited to his needs. Floods and droughts seldom occur in a region of forests. Forest products enter into all human activities, and it may be said that the race could not exist in the absence of forests.

In the Rocky Mountain region, where arid or semi-arid conditions prevail, the most important office performed by the forests is the conservation and distribution of moisture. The countries at the base of the mountains, and surrounding them, would be uninhabitable were it not for the forests which partially clothe the latter. Were the mountains wholly stripped of that covering which nature has so wisely bestowed upon them, but little moisture would be gathered from the atmosphere, violent storms would often occur, and torrents and seasons of drought would take the place of existing conditions.

In this region the direct dependence of agriculture upon the forests is more plainly seen than elsewhere. Except in a few localities, field crops, orchards, and gardens are cultivated with the aid of irrigation systems, the water for which is taken from the mountain streams. Should the forests be destroyed, the streams, irrigation systems, and crops would meet a similar fate.

The relation existing between the Colorado mountain system with its forests, and the water supplies for agricultural purposes, is strongly stated by Prof. Cyrus Thomas, of the Hayden Survey, as follows:

This eastern mountain group appears to have two culminating points or radiating centers; the northern, and principal one, lies immediately around the North and Middle Parks, and forms the rim of these elevated basins; the other lies immediately southwest of South Park. In the first of these, Blue River, White River, Yampah River, and North Platte take their rise. In the other, Grand River, the Rio Grande, Arkansas, and main branch of the South Platte have their sources. The parks act as huge cisterns for the reception of the numerous little mountain rivulets that flow down from the surrounding rim, collecting them together and discharging them at one outlet. Thus, the North Park collects the various streams which form the North Platte; the Middle Park those that form Blue River; South Park those that form the South Platte; the San Luis Park those that form the Rio Grande; and the upper Arkansas Valley, which is a true park, those which form the Arkansas River. Here, then, we see that five of the great rivers of this vast central region have their sources close together in this mountain area. Upon the peaks, ranges, parks, and forests embraced between the one hundred and fifth and one hundred and seventh meridians and the thirty-eighth and forty-first parallels, an area not exceeding 18,000 square miles, depend, in a great measure, the agricultural resources of an area of more than 100,000 square miles.

IRRIGATION SYSTEMS.

It may be safely predicted that, within a comparatively few years, the Rocky Mountain region and adjacent portions of the Pacific slope will have irrigation systems equal to any the world has ever known. The discovery that vast areas of land, once deemed sterile and worthless, are reclaimable by the application of water has given wonderful impetus to irrigation projects. Favorable legislation has been obtained, and various plans to effect the desired object have been well advanced.

By legislative act, in 1881, the State of Colorado created the office of State hydraulic engineer, and adopted a carefully devised code of irrigation laws. Since then numerous irrigation enterprises have been begun and successfully prosecuted in that State. In many cases incorporated companies have been formed for the construction of canals and reservoirs, and the distribution of water over wide tracts of land. In numberless other instances, individuals, under the rule of priority of use, have made smaller canals and ditches, appropriating water in accordance with their needs and the existing rights of others.

In the adjoining Territories, especially in Utah, systems more or less perfect have been introduced, and will be enlarged and improved as the necessities of the people may require.

The data that have been collected with regard to the location and extent of the irrigating canals and ditches of this region, changes in the volume and flow of streams, etc., are given in the tables and maps accompanying this report and in the descriptions of the several political divisions.*

* See note on irrigation, page 61.

FOREST POLICY.

In the State of Colorado, and in the Territories of New Mexico, Montana, Idaho, and Utah, there are in round numbers 90,000 square miles of forest land. It is estimated that four-fifths of it still belongs to the public domain, equal to not less than 45,000,000 acres. To speak of a management of this domain would convey the erroneous idea that there exists such a thing as forest management in these mountains. While private owners may, perhaps, be somewhat careful in the cutting of their timber, and possibly may take measures to protect it against spoliation or fire, nothing of the kind can be said of the people's property.

Under existing laws and regulations with respect to this vast body of woodlands, it would appear that forest fires have almost undisputed sway; railway corporations freely use and waste the public timber; unscrupulous lumbermen fell more trees than they can use; while poor men, struggling to establish homes, often find it difficult legally to obtain timber enough for their personal use. The few special agents of the General Land Office, scattered through this wide region, from lack of numbers and proper system, are powerless to avert forest destruction. Alleged trespassers are often prosecuted, but rarely convicted. No forests are saved from fire, and few, if any, from the ax. The policy of withholding from survey the public timber lands in certain of the Territories is worthy of commendation, and is likely to prevent, for the time being, the entry or sale of such lands, but not the spoliation of the timber on the same.

That the present condition of affairs is, and has been for some time, noxious and detrimental to the best interests, present and future, of this region, has been recognized by every honest settler along the mountain range. While all are agreed that the existing policy is injurious, undesirable, and should be changed, the proposed remedies differ, often very widely.

The present administration of the Land Office has exerted itself to the utmost, with absolutely inadequate means, to guard the people's property, and the reports of the Commissioner in the strongest language make clear the necessity, and at the same time the impossibility, of protecting from depredation this part of the domain. The impossibility of dealing adequately under the present system often necessitates dealing unfairly, or seemingly so.*

The following extracts from letters received from representative men, in reply to inquiries as to the character of the present laws for the disposal of the public lands and the necessity for their amendment, will be of interest:

> The laws are not sufficiently strict to prevent denudation of the forest lands, fraudulent appropriation of timber supplies, and leaving of rubbish to cause forest fires.
>
> There is too liberal construction of the law allowing the cutting of timber for domestic purposes; under it many abuses are perpetrated.

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* See summary on page —.

It is difficult in a thinly-settled country to get proof that will convict of setting forest fires.

In discussing the question of forest management, European examples are not always valuable to us; the conditions are very different and our difficulties are greater.

The Government should take care of the forests on forest principles.

In portions of the mountain region every alternate section should be reserved for forestry purposes, including the planting of forest trees.

All timber lands at the heads of streams capable of furnishing sufficient water for irrigation should be withdrawn from market, and religiously preserved, protected and, when necessary, replanted.

One-half of the public forest lands should be sold to settlers, and the other portions placed under the care of experienced foresters and held by the Government forever.

Local forest officers should be appointed, with power to quell fires, make arrests, etc.

All timber lands should be sold, or else donated to the State, to be disposed of or protected under the State laws.

In the arid regions timber lands should be donated to the respective States.

The entire control of the forest growth (not the land) should be conferred upon the State. The State, being more directly interested in the subject-matter, would be better able to adopt such measures as would conserve its forest resources.

There should be State reserves, with foresters who live in the forests and guard them from fires and depredation. The timber should be disposed of under regulation, and for the use only of the people of the State, regard being had always for the preservation of the forest, so that it be not denuded.

Timber on public lands should be free to settlers, and no restrictions placed upon lumbermen who cut timber only for home consumption.

Settlers upon the public domain should be allowed to use timber from the public lands for their homes and farms before and after perfecting their titles under the homestead or pre-emption laws, regardless of the fact that the timber land may be designated as "mineral" or "non-mineral." This distinction is generally imaginary and fictitious and has no value in point of fact.

Land should be granted to actual settlers only under the homestead law. All other laws for the settling or disposal of the public domain, including the act relating to placer-mining claims, should be repealed.

Every settler upon the public domain, when he shall have perfected his title to a pre-emption or homestead entry, should be allowed to enter at Government price not more than 40 acres of timber land in the same district, provided his pre-emption or homestead entry shall not have a natural growth of timber upon it sufficient for its necessities.

Repeal the pre-emption law, and make it a misdemeanor for a homesteader to sell timber, or suffer it to be cut, more than is absolutely necessary for domestic purposes.

A system of leasing the public timber lands within clearly-defined boundaries, with specific rights and liabilities, under penalties, guarantied by bonds of forfeiture in case of non-compliance with the terms of lease, will prove the most efficient means of promoting the interests of American citizens seeking homes in the Rocky Mountain region.

Persons cutting Government timber should be required to obtain a permit from the local land office, with safeguards and restrictions to prevent waste or trespass.

It would be better to allow charcoal-burners and the cutters of mine timbers to take living timber from the public domain under proper restrictions, than to encourage the destruction of the forests by fire, in order that they may cut the deadened timber as they please.

Railroads should be required to use dead timber if possible; no question of mere convenience should be considered. Some method of chemical preservation should be required where ties and bridge timbers are obtained from the public lands.

The timber-culture act is inoperative, and offers facilities for fraud.

The good results of the timber-culture law overbalance all objections to it. An inspection of each claim before a patent issues would insure compliance with the law and prevent fraud.

The following extracts give valuable hints on one side of the question:

[Extract from a recent report (1886) of Hon. S. T. Houser, governor of Montana Territory, to the Secretary of the Interior.]

There seems, at least in one branch of Congress, a purpose to set aside a large portion of the forest-clad sections of our Territory for permanent forest reservations, with a view to protect the fountain heads of the great continental rivers. Under proper regulations and provisions for needed care such reservations might be of great use and value. But it must be remembered that there is no timber in this region save that which grows in the mountains where these rivers rise. If this country is to be occupied and developed, these forests will, to some extent, have to be put under tribute for various domestic and mining purposes and uses. It must be further remembered that this entire region is metalliferous, and it would not be wise to exclude from these forest reservations all explorations for mines.

Owing, no doubt, to a want of knowledge of our peculiar situation and the purposes of the laws of Congress, adopted in 1878, in reference to the cutting of timber on mineral lands in the Rocky Mountain States and Territories, there have been many seizures for violation of law during the past summer, and many instructions and interpretations and applications of the law that have generally been regarded by our people as unwarranted and fatal to their interests. Under the regulations since prescribed by your Department it is believed that all conflict and irritation will disappear, unless too restrictive an interpretation or construction is attached to the words of the law confining its operations to mineral lands.

[Extract from the report, for the year 1886, of Hon. E. A. Stevenson, governor of Idaho Territory, to the Secretary of the Interior.]

The thanks of the people of Idaho Territory are due to the Department of the Interior for the modification of rules 2 and 3 concerning the felling of timber, as secured by the circular of August 5, 1886. The modification was well-timed and is gratefully received; but there are still some regulations in force in the Department that work great injury in the Territories of the Far West. Idaho is blessed with limitless forests of timber, which are of incalculable value in this western country—a great portion of whose area consists of barren and treeless plains. To enable settlers to cultivate and redeem these desert plains lumber must be readily accessible, else their efforts to build homes would be unsuccessful. Many of the settlers are poor, having expended their all in securing their land and in improvements. Under the rules and regulations of the Interior Department the purchaser must enter into a certain written agreement with the lumberman, and must, further, file with the mill-owner a certificate, under oath, that he purchases such lumber exclusively for his own use. This formality must be gone through with every time a settler desires a little lumber. It is a great inconvenience. Then, again, it is a matter of expense, for the oath must be taken before some magistrate qualified to administer oaths, and fees must be paid therefor. To the poor settler this extra expense is a matter of some consequence. Such magistrates are not often, in this new country, in close proximity to the saw-mills. The natural obstacles encountered by settlers on this desert land are severe enough without additional ones being put upon them by the Government. It is a source of great benefit to our country that this land be settled up, and to this end the policy of the Government should be to remove obstacles from the path of the honest settler, not seek to retard his efforts by impracticable regulations. There are in this Territory great forests, sufficient to supply the home consumption without any apparent effect on their extent.

From personal observation it is safe to say that the entire local consumption of timber in this Territory does not equal the growth of the forests. Let the Government afford sufficient protection against forest fires, which, through carelessness, annually consume immense quantities of timber, and protect our forests against the inroads of scavengers and consumers from other States and Territories, and no fear need be entertained as to the preservation of the timber.

In conclusion, I may be permitted to say that in my opinion a general policy with respect to the public timber lands should embrace the following features:

(1) The withdrawal from sale, entry, or disposal under existing laws of all such lands.

(2) The creation by law of a forest commission, to be composed of three competent persons, and to hold office for a period of five years. This commission should be authorized and required (*a*) to adopt tentative measures for the protection and preservation of the public forests; (*b*) to examine and classify the public timber lands and determine what portions should be held permanently as forest reserves, and what portions, if any, should be disposed of; (*c*) to devise and submit for the action of Congress a proper system of forest management and extension, and a plan for the establishment and endowment of a national school of forestry. Congress to make due provision for the necessary expenses of the commission.

(3) The enactment of laws for the protection of forests and the planting and cultivation of forest trees should be encouraged in the several Territories.

(4) When any Territory shall become a State and shall have instituted good and sufficient forest laws, there should be conveyed to such State, in trust, the public forest lands within its borders, for the perpetuation of the forests thereon.

III.—FOREST CONDITIONS OF THE SEVERAL POLITICAL DIVISIONS.

NOTE.—For the purpose of obtaining information with respect to the forest conditions of the several parts of the Rocky Mountain region, circular letters of inquiry, embracing the following questions, were sent to persons in each county:

(1) What is the extent of forest land in your county, giving approximate number of square miles?

(2) What proportion of it is fully stocked, good for timber? What part of it is made waste by burning over? What part of it brush, of promising growth?

(3) What is the proportion of forest to other lands?

(4) What is the character of the forest growth now remaining, in the size and kinds of trees?

(5) What species of trees predominate?

(6) Name, in the order of their importance, the principal uses to which each kind of timber is applied?

(7) What special dangers threaten the forests in your county, as lumbering, consumption by railroads, fires, etc.?

(8) What are the chances for renewal, after the forests have been destroyed?

(9) Of what species of trees is the second growth usually?

(10) What kinds, if any, follow after the timber has been destroyed by fire?

(11) Is any planting done and to what extent, and with or without irrigation?

(12) Have you noticed any changes in the volume of water in the streams, as the trees in their vicinity have been cut off or burned? Is there less water in the streams than formerly? Have floods and droughts become more frequent? Is the flow of water in the streams more intermittent?

(13) Are any observations on rain-fall kept in your locality? If so, by whom, giving name and post-office address.

(14) Have any avalanches occurred in your section? If so, please give the particulars, when, where, and what, if any, loss of life and property.

(15) What measures would you suggest for the more adequate protection of forest growth?

(16) Give any other information upon the same general subject which may occur to you. So far as possible give definite and particular answers to the foregoing questions and known facts rather than general statements. If there is insufficient space on this sheet for your answers supplementary sheets may be used, care being taken to refer to the numbers on this sheet so as to prevent uncertainty or confusion.

Responses to the above were in many instance so long delayed and often so incomplete that a laborious and protracted correspondence became necessary. Although but few correspondents could identify and name, according to their botanical relations, the several species comprising the forests of their locality, nearly all could give common names, location, uses, and other descriptive matter.

To obtain further details concerning the forests of the region and their relation to agriculture and systems of irrigation, letters of inquiry, embracing the subjoined questions and a plat of the particular county, were sent to county surveyors and other civil engineers:

(1) Please give a brief and general topographical description of your county?

(2) What is the approximate total number of acres of land in your county suitable for agricultural purposes requiring irrigation?

(3) Is there a sufficient water supply to irrigate that amount? If not, what proportionate amount short?

(4) What is the approximate number of acres already under ditch?

(5) What is the approximate number of acres already irrigated?

(6) In your county what is the approximate total length of (*a*) irrigating ditches—main, secondary, small; (*b*) mining and milling ditches; (*c*) city water-works (and capacity in gallons), together with total capacity of each, in statutory inches or cubic feet per second?

(7) Has the volume of water in the streams of your county increased or diminished, to your knowledge? Is the flow of water in such streams any more or less intermittent than was formerly the case? If you have noticed any such changes, please state the causes, so far as known to you.

(8) What effect, if any, in your opinion, do the forests have on the water supply?

(9) What, in a general way, is the extent, character, and location of timber in your county?

(10) Please send sketch, noting (to the best of your knowledge) the situation of the timber, irrigating and other canals, and city water-works in your county; giving the timber in green and canals and water-works in blue. To assist you in answering this question, a miniature map of your county is inclosed herewith.

(11) What are the principal causes of the destruction of forests in your county, and what measures would you suggest for their more adequate protection?

(12) Please give any other suggestions upon the same general subject which may occur to you. If there is insufficient space on this sheet for your answers, supplementary sheets may be used, care being taken to refer to the numbers on this sheet so as to prevent uncertainty or confusion.

Answers to a portion of the above questions were quite generally returned. The estimates of forest areas, acreage of lands suitable for irrigation, etc., were, of necessity, approximate rather than exact.

IDAHO.

Idaho Territory is situated in the northwestern portion of the United States, and near enough to the Pacific to share in the climatic influence of the warm ocean currents which sweep northward along the western shores of the continent.

The Territory has an area of 86,400 square miles. It is a vast wedge-shaped plateau, traversed by numerous streams, which find outlet at the northwest through the channel of the Columbia. High and rugged mountains cover large areas in the northern and eastern parts; innumerable ranges span the interior, while in the west and south-central portions are broad table-lands and arable valleys. The Bitter Root and Cœur d'Alene are the most rugged and precipitous of the mountain ranges. Their summits are snow-clad throughout the year, as are also those of the three Tetons, noted peaks in southeastern Idaho. The highest elevations in the Territory range from 9,000 to 13,000 feet. The lowest point is at Lewiston, where the Snake and Clearwater Rivers unite at an elevation of 680 feet.

The published maps fail to convey an idea of the almost numberless ranges of this region. In a distance of 300 to 500 miles, from east to west, it is said "there is a range of mountains, on an average, every 10 to 20 miles. Sometimes the distance across the range in a straight line, from the bed of a stream in one valley to the bed of the stream in the valley beyond the range, is not more than 5 to 8 miles, while it is seldom more than 20 miles."

The many streams of the Territory, fed by perpetual snows, are of good volume. Their flow is quite regular and constant, reaching its maximum at midsummer, and shrinking to its minimum in midwinter. The principal river is the Snake. It rises in the mountains of northwestern Wyoming, flows through southern Idaho, and thence northward along the western border of the Territory to its junction with the Columbia. The Snake is a magnificent river, of nearly 1,000 miles in length; the greater part of the drainage system of the Territory is tributary to it. Other important rivers are the Salmon and Clearwater, affluents of the Snake.

From a comparatively small portion of southeastern Idado the drainage flows into the basin of the Great Salt Lake.

The northern part of the Territory is mainly a region of mountains and forests, with small prairies and narrow valleys available for agriculture. Here also are situated lakes Pend d'Oreille, Cœur d'Alene, and Kaniska, which vary in length from 20 to 60 miles, and are wide and deep in proportion.

Other well known lakes of the territory are the Cocolalla, Payette, and Bear. In southern Idaho are lava fields covering probably 1,000 square miles, extending east and west nearly across the Territory, and southward to Snake River. To the southwestward of these are extensive sage-brush plains, reaching to the mountains of Northern Nevada. It is estimated that within the Territory there are 6,000 square miles of "mountain, desert, and volcanic formation, entirely unfit for any use except that designed by nature, being utterly destitute of mineral, timber, or vegetation."

The climate of the Territory, modified and softened by warm winds from the western coast and by the prevalent sunshine, is mild and delightful, notwithstanding the northern latitude.

Though arid conditions prevail to a degree that often render agricultural operations dependent upon irrigation, there is in the mountain region sufficient moisture to secure a vigorous forest growth.

The finest timber in the Territory is found in the central portion, on the Payette River and its tributaries. In the swamps, at the junction of Lolo Fork and Clearwater River, in Shoshone and Nez Perces Counties, is found Cedar timber (probably *Thuya gigantea*), the largest trees of which are 300 feet high, with trunks 6 to 9 feet in diameter. The wood makes handsome and valuable finishing lumber.

Yellow or Bull Pine is the principal timber tree. It grows on the lower mountains. The Black Pine or Tamarack is of small size and is found at elevations of 7,000 to 10,000 feet.

The Red or Yellow Fir grows on both the low and high mountains; the heart of the wood is quite red in color. The Mountain Mahogany is common in the Owyhee Mountains (southwestern Idaho). It is a small tree, rarely exceeding 20 feet in height, of irregular growth; has a hard, brittle wood and handsome grain. It is a favorite wood for canes and is much used for fuel.

Pine and Fir are largely used in the manufacture of charcoal.

There are saw-mills at Lewiston, Coeur d'Alene Lake, Spokane, and other points in the Territory. It is estimated that the amount of lumber manufactured during the year 1886 was 50,000,000 square feet, and that an equal amount of timber was used for fencing and fuel. Much of the lumber was exported. The importations of lumber, estimated at 9,000,000 square feet during the year 1886, were mostly cross-ties and timber for railway uses, which consisted mainly of Fir from Oregon and Washington.

The bulk of the shingles used are of native Pine. Some Redwood shingles are brought from the west, but iron and other kinds of prepared roofing are largely supplanting wooden shingles.

Territorial laws have recently been enacted imposing penalties for the willful or careless setting of forest fires, or failure to extinguish camp fires, etc. Also by legal enactment an annual "Arbor Day" has been designated for the planting of trees throughout the Territory.

Except in a small portion of the Territory north of Salmon River, irrigation is necessary in the cultivation of crops. The conservation of the mountain streams is of great importance. Millions of acres of land suitable for agricultural purposes can be made productive only by systems of irrigation, and these should be encouraged and promoted by a liberal policy on the part of the Government.

The people of the Territory earnestly desire the continuance of the desert-land act, under which vast tracts of arid land may be reclaimed and made valuable. In many of the counties irrigation companies have been organized and large canals and auxiliary ditches constructed.

ADA COUNTY.

Total area, 3,500 square miles; estimated forest area, 50 square miles.

This county, in which is Boisé City, the Territorial capital, is situated near the southwest corner of the Territory. Snake River forms its boundary line at the southwest. The Boisé River divides the county into two nearly equal parts. The southern portion consists of rolling lands, too high for irrigation. The northern part is divided by the Payette River, and has many narrow and fertile valleys.

The only timber in the county is a narrow belt of Pine and Fir on the mountains of its eastern border, and a growth of Cotton-wood and Willow along the Boisé River.

ALTURAS COUNTY.

(Total area, 16,700 square miles; estimated forest area, 2,500 square miles.)

This county is bounded on the south by the Snake River, and is drained by its tributaries. The northern portion is mountainous, while the valley of the Snake is rolling and consists of sage-brush plains and almost impassable lava beds. The bulk of the timber is found in the northwest part of the county, and consists of Yellow and Black Pine, Fir, and Spruce. Red Fir and Black Pine are the predominant species. They do not grow large, nor are they very abundant. Aspen is found in the mountains, and Cottonwood along the streams.

A little planting is done, with the aid of irrigation.

BEAR LAKE COUNTY.

(Total area, 1,200 square miles; estimated forest area, 40 square miles.)

This county is situated in the southeast corner of the Territory, and is divided into two unequal portions by the Bear River and Bear Lake. Streams tributary to the river and lake rise in the mountain ranges which traverse the eastern and western portions of the county.

About one-half the area of the county is agricultural land. The remainder is broken and mountainous and composed of timber or grazing lands.

The average altitude is 5,900 feet. The rain-fall is chiefly in spring and autumn. Crops are cultivated mainly by means of irrigation.

The timber is mostly situated along the ravines near the crest of the high range which forms the western border of the county.

There is also some scattering timber on the slopes of the range in the eastern part. About one-third of the timber is fully stocked, one-third brush, and the remainder burned over.

The forest growth consists of White and Yellow Pine, White Fir, Mountain Mahogany, White Cedar, Cottonwood, and Aspen. Pine and Fir predominate.

Very little tree planting is done except on a few timber-culture claims, with the aid of irrigation. Small fruits are grown to some extent, and also some of the hardier large fruits.

BINGHAM COUNTY.

(Total area, 13,600 square miles; estimated forest area, 150 square miles.)

This county is also in the southeastern part of the Territory. It is well watered, the Snake and Bear being the most important rivers. The surface is greatly varied, and includes mountains, table lands, sage plains, valleys, and swamps. There is a large proportion of agricultural and grazing lands.

The little timber there is in the county is situated mainly in the northeastern part, and in canyons and narrow valleys. It is estimated that one-half is well grown, and the larger portion of the remainder is thrifty young Fir (red) and Cottonwood. No forest fires have occurred for a number of years. On a few timber-culture claims trees are grown with the aid of irrigation.

BOISÉ COUNTY.

(Total area, 2,500 square miles; estimated forest area, 1,100 square miles.)

Boisé county is situated in the central southwestern portion of the Territory. It has a rolling surface, and is watered by tributaries of the Payette and Boisé Rivers. Long Valley, about 75 by 15 miles in extent, and Garden Valley, also of large size, contain rich farming lands. There are wide tracts of grazing land in different parts of the county.

Some of the finest timber in the Territory grows here, covering from one-half to two-thirds of the area of the county. The predominant species are Yellow and Black Pine, Red Fir, and Balsam.

CASSIA COUNTY.

(Total area, 4,300 square miles; estimated forest area, 100 square miles.)

This county occupies a central position upon the southern border of the Territory. Snake River bounds it on the north, and it is watered by tributaries of the same stream. The surface of the county gradually rises from the Snake River south to the Utah line, where it becomes rough and mountainous, but interspersed with numerous valleys of greater or less extent. It is essentially a stock-growing county, and as such ranks among the first in the Territory.

The winter climate is cold and changeable. The amount of snow-fall in the valleys is not very heavy, but immense quantities accumulate in the mountains, which afford vast stores of moisture for the growing crops when the hot days of summer come. There is a great deal of rain in the valleys during the winter season, or from about the 1st of November to the middle of April. During the remainder of the year rain seldom falls, except occasionally a shower about the 1st of July. Consequently no crops can ordinarily be raised without irrigation.

The forest area is very limited and confined almost wholly to the mountains of the southern portion. Yellow and Black Pine and Balsam Fir are the principal timber trees. Good sawing timber, however, is getting scarce, although there is plenty of an inferior quality to furnish the county with rough lumber for a long time to come. The supply for fuel is inexhaustible. Cedar grows abundantly on the low mountains, and there are large bodies of Pine of small growth farther up on the mountains and in the canyons. There is some Mountain Mahogany and Nut or Piñon Pine, both of which make superior fuel.

CUSTER COUNTY.

(Total area, 5,800 square miles; estimated forest area, 1,900 square miles.

This county is centrally located in the Territory. It is broken by many low mountain ranges. The Salmon River, pursuing a zigzag course in a northeasterly direction through the county, receives the waters of eleven large affluents. Lost River and its tributaries water the southeastern part of the county. The topography of the region is greatly varied, and agricultural, grazing, and timber lands cover nearly the entire area. In the western part of the county are a number of small lakes.

Nearly one-half of the county is forest land. Very little, if any, has been made waste by burning. Pine, Fir, and Cottonwood are the predominant trees. The timber is inferior, the trees rarely exceeding two feet in diameter of trunk. Cottonwood is used mostly for fuel.

With the exception of a few fruit trees no tree planting is reported.

IDAHO COUNTY.

(Total area, 9,200 square miles; estimated forest area, 1,950 square miles.)

Idaho County is essentially a mountainous region, the principal portion of the Salmon River Mountains being included within its boundaries. These mountains are in no well-defined range, but are a vast collection of irregularly scattered peaks, overtopping a wilderness of lesser peaks, all of a rugged and forbidding aspect. The average altitude is about 6,000 feet, though many peaks have an elevation of nearly double that height.

The county is watered principally by the Salmon River and its tributaries. The northern portion is drained by some of the forks of the Clearwater. Salmon River cuts a deep chasm through the county from east to west. Its valley is from 3,000 to 4,000 feet lower than the average altitude of the mining camps scattered through the adjacent mountains, causing a marked difference in climate. In the winter snow rarely falls before February, and frequently the ground is not whitened during the year, while in the surrounding mining camps the snow covers the mountain sides from 4 to 8 feet in depth.

Camas Prairie, comprising an area of six to ten townships on the western border, is the only agricultural portion of the county.

The forests cover the outer portions of the county. Three-fourths of the timber-lands are well stocked, one-eighth is young growth, and one-eighth made waste by recent fires. The principal species of trees are Cedar, White Pine, Tamarack, and Red and Yellow Fir. Some of the timber is very large and fine, growing from 1 to 6 feet in diameter. In the open country considerable tree-planting is done without the aid of irrigation.

KOOTENAI COUNTY.

(Total area, 4,830 square miles; estimated forest area, 2,400 square miles.)

This county is in the extreme northern or "pan-handle" portion of Idaho. The high and rugged Cœur d'Alene Mountains extend through the central part from east to west. Flanking this range are lakes Pend d'Oreille, Kaniska, Cœur d'Alene, and others of lesser note. Clark's Fork of the Columbia and the Spokane are the principal rivers.

The forest growth, which is pretty well distributed over the county, consists mainly of Yellow and Black Pine, Fir, Cedar, Cottonwood, Yew, Alder, and Willow; Pine predominating. A small portion has been burned over and made waste. The finest timber of the territory is found in this county on the waters of the Cœur d'Alene, St. Joseph, and St. Mary's Rivers. One authority states that on the banks of the first named thousands of immense trees can be seen, the trunks of which will measure from 1 to 13 feet in diameter. This has long been known as the best timbered section of Northern Idaho, and is second only in importance to that on Puget Sound.

On the banks of Kootenai Lake there is a large body of fine saw-timber. For miles on either side of Pack River there are bodies of good timber along its course.

The line of the Union Pacific Railroad passes directly through this region, and a heavy draft is likely to be made upon its timber resources.

A little tree-planting is done in Kootenai County on timber-culture claims without the aid of irrigation.

LEMHI COUNTY.

(Total area, 3,870 square miles; estimated forest area, 2,100 square miles.)

This county has for its northeastern boundary a portion of the main Rocky Mountain range. It is watered by the Salmon River, its main affluent, the Lemhi, and numerous smaller streams tributary to the two named. Two great valleys, the Lemhi and Pahsamari, and a few lesser ones, afford some 300,000 acres of land suitable for cultivation.

The heaviest timber is found along the north fork of Salmon River, and within 35 miles of Salmon City. Pine trees with trunks 3 and 4 feet in diameter, and attaining a height of 60 and 70 feet, are common. Timber also extends along the mountains on either side of the valleys occupying the central portion of the county. White and Black Pine and Fir are the predominant forest trees.

NEZ PERCES COUNTY.

(Total area, 3,100 square miles; estimated forest area, 450 square miles.)

The Salmon River, extending through the county from east to west, divides it nearly equally.

The average elevation is about 3,000 feet; the lowest altitude in the Territory (680 feet above sea level) is at Lewiston, in this county. The climate is mild, and the rain-fall sufficient for the growth of crops. Agriculture and stock-raising are the chief industries.

The timber, which is mostly situated in the mountains along the eastern border of the county, consists of Yellow and Black Pine, Red and

White Fir, Cedar, and Larch. Much of the timber is large, reaching a diameter of 3 to 5 feet.

A few forest trees are cultivated on timber-culture claims without the aid of irrigation.

ONEIDA COUNTY.

(Total area, 2,500 square miles; estimated forest area, 150 square miles.)

This county is situated in the southeast corner of the Territory and is an agricultural region. There is but little timber, and that is found in the central and southeastern portions.

Red Fir, Cedar, and Aspen are the predominant forest trees.

OWYHEE COUNTY.

(Total area, 7,430 square miles; estimated forest area, 300 square miles.)

This large county occupies the southwestern corner of the Territory. Snake River forms its northern boundary. In the eastern part are extensive sage-brush plains. As a whole the county is mainly adapted to stock-raising.

The only timber reported is a body covering the South Mountain range, in the west central part.

SHOSHONE COUNTY.

(Total area, 5,200 square miles; estimated forest area, 1,900 square miles.)

This county is situated in the northern part of the Territory. The Bitter Root and Cœur d'Alene Mountains, which form a part of the Rocky Mountain chain, constitute its northeastern boundary. Its principal streams are the Lolo Fork and North Fork of the Clearwater River.

The greater portion of the county is mountainous, and includes large bodies of timber. The forest growth consists of Red and White Fir, Yellow and White Pine, White Spruce, Hemlock, Tamarack, Cedar, Yew, and several minor species. The timber grows of medium size on the mountains, and larger on the bottom lands; portions of it on the high ridges have been destroyed by fire.

WASHINGTON COUNTY.

(Total area, 2,500 square miles; estimated forest area, 900 square miles.)

This county, situated in west central Idaho, is bounded on the west by Snake River. The Weiser River and other streams water the interior of the county.

Black and White Pine, Red and White Fir, Hemlock and Balsam, are the principal species of forest trees. Pine predominates. The heaviest bodies of timber are found in the northern and eastern parts of the county. The trees composing the forest vary greatly in size, the trunks measuring from 1 to 6 feet in diameter. There is not much brush, and but little timber has been destroyed by fire.

MONTANA.

The Territory of Montana, having the form of an immense parallelogram, and embracing a superficial area of 145,776 square miles, occupies a large space upon the map of the United States. It is situated in the extreme northern tier of Territories, bordering upon the British Possessions. The Rocky Mountain chain, constituting the Continental Divide, passes through the western portion. About four-fifths of the entire area belongs to the Atlantic slope, being drained by the Missouri River and its tributaries, and one-fifth to the Pacific slope, being drained by the headwaters of the Columbia. The mountain range separating so unequally the two parts of the Territory is comparatively low, and the contiguity of the region to the Pacific Ocean renders it, to a degree, subject to the climatic influences governing the western coast.

Three-fifths of Montana, comprising the eastern and central portions, is a rolling plateau, having an average elevation of 3,000 feet, broken by mountain spurs, buttes, and headlands, and watered by numerous streams. It is pre-eminently a grazing country, and is largely covered with the nutritious bunch grass. In this eastern part, north of the Missouri River, are vast plains. The western two-fifths of the Territory is mountainous.

As a general thing the mountains of this section are less rugged than in the Colorado group; although here and there are sharp angular peaks, yet as a general rule, instead of the rocky, jagged sides and serrated crests, there are smooth slopes and rounded outlines. The height of both mountains and valleys, as will be seen from the list of elevations presented below, is much less than that of the great mountain belt of Colorado and Wyoming, and even that of New Mexico, Utah, and Nevada.

Elevations in Montana, chiefly along a line running east and west near the middle of the Territory:

	Feet.
Fort Union, at the mouth of the Yellowstone	2,022
Trading Post, on Milk River	2,388
Fort Benton	2,780
Forks of Sun River	4,114
Lewis and Clark's Pass	6,519
Blackfoot Fork, near the mouth of Salmon Trout Creek	3,966
Blackfoot Fork, near its junction with Hell Gate River	3,247
Missoula River, near the mouth of St. Regis de Borgia	2,897
Summit of Cœur d'Aléne Mountains, at Cœur d'Aléne Pass	5,089
Fort Owen, in Bitter Root Valley	3,284
Deer Lodge City, in Deer Lodge Valley	4,768
Prickly Pear Valley, near Helena	4,000
Little Blackfoot, or Mullen's Pass	6,283

From this list we see that the western or intermontane basin has a depression less than 3,000 feet above the level of the sea; and that the least altitudes of the eastern slope range from 4,000 to 2,022 feet above the level of the sea. Comparing these with the altitudes of the other Territories, we find the difference much greater than would be anticipated. For this purpose I give here the elevations of a few points:

	Feet.
Albuquerque, N. Mex	5,032
Santa Fé, N. Mex	6,840
Denver, Colo	5,300
Green River, at the railroad crossing, Wyoming	6,140
Salt Lake City, Utah	4,350
The Humbolt Sink, Utah	4,017
Fort Laramie, Wyo	4,519
Sweet Water River, at Independence Rock, Wyo	5,998
South Pass City, Wyo	7,857

From this we see that even the lowest point of the Great Basin near the "Humboldt Sink" is 1,126 feet above the mouth of the St. Regis de Borgia, and 733 feet above Fort Owen. This very important fact in regard to the physical geography of this Territory will serve as an explanation of its comparatively mild climate, notwithstanding its northern latitude.

Probably none of the southern and central ranges reach the line of perpetual snow. Those in the extreme north are unexplored. It is said that glaciers flow from some of them.

The western or mountainous portion of Montana is interspersed with many fine valleys well adapted to agriculture and stock raising. The principal forests of the Territory are in this section.

The most dense and continuous bodies of timber are found on the western flanks of the main range, and on the Cabinet, Cœur d'Aléne, and Bitter Root Mountains, which are contiguous to it, or form the boundary line between Montana and Idaho. These forests, which extend to eastern and northern Idaho, are the most extensive and valuable of any in the Rocky Mountain region. They guard the sources of many important streams, and furnish timber supplies for an adjacent treeless territory of wide extent. Their careful conservation is of the greatest consequence.

The forests of Montana are composed mainly of Yellow Pine (*Pinus ponderosa*); White Pine (*Pinus flexilis, Pinus albicaulis* and *Pinus monticola*), Lodge-Pole or Tamarack Pine (*Pinus Murrayana*); Red or Yellow Fir (*Pseudotsuga Douglasii*); White or Balsam Fir (*Abies grandis*); Cedar (*Thuya gigantea* and *Juniperus Virginiana*); and Yew (*Taxus brevifolia*). The Yellow Pine and Red Fir predominate, forming the bulk of the forests at the lower altitudes. At higher elevations are found the White Spruce, Tamarack, and Balsam.

The deciduous species most worthy of mention are the Cottonwood (*Populus monilifera* and *P. angustifolia*); Balsam Poplar (*P. balsamifera*); Aspen (*P. tremuloides*); Box-Elder (*Negundo aceroides*); and Mountain Mahogany (*Cerco-carpus ledifolius*).

Yellow and White Pine, and White Spruce are the principal timber trees. The first named is the largest and most useful, and furnishes most of the building lumber, both common and finishing. In favorable situations the trees of this species attain a height of 100 feet and the trunks a diameter of 6 or 7 feet.

The White Pine is of smaller growth than the Yellow, the wood is softer and more subject to decay. The two kinds are, however, used for many similar purposes.

Lodge-pole Pine seems to be a stunted variety of *Pinus Murrayana*. It is a slender tree which covers large areas upon the mountains. It grows to a height varying from 20 to 100 feet, with trunks from 2 to 10 inches in diameter, often forming masses so nearly impenetrable that trails must be made with the ax. A section from the trunk of one of these trees measures 2½ inches in diameter and has fourteen layers of annual growth. A lumberman of experience states that good saw-timber can be had from the same kind of pine where the growth is less dense and crowded. The smallest kinds are extensively used for fencing, "logging" for mines, and by the Indians in the construction of their lodges. A similar growth is found in portions of Wyoming and Colorado.

Cottonwood and Box-Elder border the streams at comparatively low elevations. The Aspen covers large surfaces which have been denuded of the original forest growth. It prefers northern slopes and narrow moist valleys.

Although the forest area of the Territory is large, it is being rapidly reduced. The destruction by forest fires is almost beyond computation; railroads use and transport immense quantities of timber; lumbering operations cause a large and steady drain upon the forests; while the consumption of timber for mining purposes is of equal magnitude.

The Territorial laws prescribe penalties for the willful or careless setting of fires, or failure to extinguish them; and county commissioners are required to post notices annually in conspicuous places, calling attention to the provisions of the law. Notwithstanding these precautions, forest fires are frequent and destructive in the extreme.

A recent legislative act provides for rebatements in taxation to persons planting and cultivating forest trees, under certain conditions named in the law.

Irrigation is practicable at different points upon all streams near the mountains, and it is stated that by this means crops are cultivated in every county of the Territory.

East of Great Falls the Missouri River has cut a channel 600 to 900 feet deep, through the table-lands to the Dakota line. This gives to its tributaries a very swift current, although their channels are quite deeply sunken below the adjacent plains. In the Yellowstone system the waters flow somewhat nearer the general level.

A number of great irrigation enterprises have been undertaken. The canal of the Minnesota and Montana Land and Improvement Company, in Yellowstone County, is about 40 miles long by 35 feet wide, and 5 feet deep. Another large canal, in Choteau County, is 75 miles in length. Others of similar character are in process of construction. Irrigation systems are greatly needed for the reclamation, under the desert-land act, of sterile tracts. The repeal of that act, as proposed, might be a serious mistake.

The numerous valleys of the Territory are remarkably fertile, and, with proper facilities for irrigation, yield large returns in wheat, oats, barley, and all kinds of vegetables unsurpassed in quality.

BEAVER HEAD COUNTY.

(Total area, 2,800 square miles; estimated forest area, 1,100 square miles.)

This county is situated in the extreme southwestern corner of the Territory. It is bordered on the north, west, and south by the main Rocky Mountain range. Beaver Head and Big Hole Rivers are its principal streams. They flow through a long reach of country and find outlet at the northeast, through the Jefferson River, into the Missouri.

The surface of the county is much broken, and includes many detached ranges and spurs, which, in some instances, are comparatively high and rugged. There are a number of arable valleys, and quite an extent of rolling, open country suitable for grazing.

Upon all the mountains, except at the highest elevations, there is a forest growth, but usually not dense nor of great value for lumber. The forests, however, afford timber supplies for the ordinary local uses, and serve to protect the head-waters of the streams.

Red Fir, Black Pine, or Tamarack, White Pine, and White Spruce are the predominant species. Black Cottonwood (*Populus angustifolia*), which here grows large and tall, borders many of the streams.

Forest fires have destroyed much timber in the county, but as the winter snows are heavy and the climate not extremely arid, a new growth of the same species soon appears.

CHOTEAU COUNTY.

(Total area, 26,000 square miles; estimated forest area, 350 square miles.)

The greater part of this immense county, nearly all of which is in the plains region, is held as an Indian reservation. It is situated in the north-central part of the Territory, and is watered by the Missouri River, the Milk, Marias, and other tributary streams.

The small amount of timber the county contains is found upon the Sweet Grass Hills in the north, the Bear Paw and Little Rocky Mountains at the northeast, the Highwood Mountains in the southern portion, and on the foot-hills of the main range in the extreme western part.

The forests are composed almost wholly of an inferior growth of Red Fir and White Pine, not more than 5 or 10 per cent. of which is good saw-timber. A scanty growth of Cottonwood lines the streams.

It is stated that forest fires have not been frequent. When they do occur, the second growth is usually of the same species as the original.

CUSTER COUNTY.

(Total area, 20,000 square miles; estimated forest area, 200 square miles.)

Custer County, situated in the southeastern corner of the Territory, is another of the "plains counties." It is an agricultural and grazing region, and is watered by the Yellowstone, Powder, Tongue, and Rosebud Rivers and their affluents.

There is but little timber in the county, and that is found in the southwestern part.

DAWSON COUNTY.

(Total area, 2,700 square miles; estimated forest area, 200 square miles.)

This, one of the largest counties of the Territory, is situated in its northeastern corner. More than one-half of its area, at the north, is still held as an Indian reservation. It is wholly in the plains region. The Missouri River flows through the central part and the Yellowstone crosses the southeast corner. The only timber of any importance—and that very limited in extent—is situated in the piney buttes, in the southwestern portion of the county.

DEER LODGE COUNTY.

(Total area, 5,000 square miles; estimated forest area, 2,400 square miles.)

This county lies upon the western slope of the Continental Divide. The main Rocky Mountain range forms its northern, eastern, and, in part, its southern boundaries. The area of this county is quite equally divided between mountains and valleys, the most notable of the latter being Deer Lodge Valley, which is 30 miles long and from 3 to 10 miles wide.

Numerous streams afford a plentiful water supply for irrigation and other purposes.

All of the mountains are more or less timbered, the heaviest growth being found in the northern and southwestern parts of the county. Red Fir, White and Yellow Pine and Cedar, are the principal species of forest trees. Fir and "Lodge-pole Pine" (a variety of the White Pine) predominate.

One-half of the timber lands is covered with Lodge-pole Pine, one-fourth has trees of large growth, and one-fourth is brush and burned over. The trunks of the larger species attain a diameter of 4 to 5 feet.

FERGUS COUNTY.

(Total area, 7,500 square miles; estimated forest area, 700 square miles.)

This county is situated in the central part of the Territory. The Muscle Shell River, a tributary of the Missouri, bounds it on the south and east. Its average elevation is about 3,500 feet above sea-level. One-third of the area is mountainous, and covered with a scanty growth of timber. The remaining portion consists of long, narrow plateaus, with deep valleys and ravines at the sides. The bottom-lands, bordering the streams, are of small extent, and in some parts are too stony for cultivation. To a great extent the soil is gravelly. This, in connection with the broken configuration, and prevailing arid conditions, will greatly limit agricultural operations.

The timber lands are situated in the central and western portions of the county. The greater part are thinly wooded, the forest growth appearing on rocky ridges, buttes, and the sheltered sides of plateaus. The predominant species are Yellow and White Pine and Fir. Only the first two grow large enough for lumber. The White Pine is small, and is much used for fencing poles. A scattering growth of Cottonwood and Box-elder along the streams furnishes more or less fuel.

About one twenty-fifth of the timber area is fully stocked, and one-fiftieth is brush.

Forest fires have been very destructive. A correspondent, under date of August, 1886, describes one then prevailing on the Fort Maginnis military reservation. He recounts the unavailing efforts of citizens to subdue it, and the utter indifference with which the matter was viewed by the commandant of the post, who refused to extend any aid in the premises.

Tree-planting, either with or without the aid of irrigation, is deemed impracticable. The atmosphere contains so little moisture that trees sunburn in summer and freeze dry in winter.

GALLATIN COUNTY.

(Total area, 7,100 square miles; estimated forest area, 1,600 square miles.)

Situated upon the southern border of the Territory at a moderate elevation, and abundantly watered by streams flowing from Yellowstone Park, this county ranks among the first in Montana for fertility and productiveness. Its surface is greatly varied, and includes mountains, foot-hills, and valleys.

Most of the mountain slopes are covered with timber; the trees, however, do not grow large. Yellow and White Pine and Fir are the predominant species. Lodge-pole Pine is the most common variety, and occupies large areas. Cottonwood grows along the streams. About 40 per cent. of the timber land has been burned over.

JEFFERSON COUNTY.

(Total area, 2,200 square miles; estimated forest area, 350 square miles.)

This county lies upon the eastern slope of the main range and is centrally situated in the western or timbered portion of the Territory. The

Jefferson and Missouri Rivers, respectively, form its southern and eastern boundaries. It is well watered by numerous tributary creeks.

The timber, confined mostly to the mountain slopes, is neither very heavy nor dense. Yellow and White Pine and Spruce (variety not named) are the principal species of forest trees. Cottonwood borders the streams.

Complaint is made that lumbermen cut large quantities of timber which they fail to use, leaving it on the ground to decay.

With the aid of irrigation, a few forest trees are cultivated for ornamental purposes.

LEWIS AND CLARKE COUNTY.

(Total area, 2,100 square miles; estimated forest area, 400 square miles.)

This county lies directly north of Jefferson and, in common with the latter, is bounded on the west by the main Rocky Mountain range. The Missouri and Sun Rivers, respectively, constitute its eastern and northern boundaries.

One-half or more of the county is mountainous and more or less timbered. On the sheltered slopes of the mountains, the trees are tall and straight, varying in diameter of trunk from 4 inches to 2 feet. In situations where the southwest winds have unobstructed sweep, the forest growth is scanty and dwarfed. Yellow and White Pine and Red Fir are the predominant trees and constitute the principal timber. As in most other parts of this region, Cottonwood borders the streams.

Some claims have been taken under the timber-culture act, trees being cultivated with the aid of irrigation.

MADISON COUNTY.

(Total area, 4,500 square miles, estimated forest area, 900 square miles.)

Madison County is situated near the southwest corner of the Territory. Its area embraces mountains, valley and grazing land in almost equal proportions. The Jefferson and Madison are its principal rivers.

The forests, composed chiefly of Red Fir and White Pine, grow upon the mountain ranges, which have quite general distribution throughout the county. The Fir reaches a size of 10 to 40 inches in diameter of trunk, while the Pine is much smaller, rarely exceeding 12 inches in diameter. Cottonwood fringes the streams. About one-fourth of the forest growth is good timber, one-fourth young trees and brush, and the remainder made waste by burning.

It is said that forest fires occur every fall in the dry season.

Trees are grown to a limited extent, and with indifferent success, on timber-culture claims, with the aid of irrigation.

Some loss of life and property by avalanches is reported.

MEAGHER COUNTY.

(Total area, 5,700 square miles; estimated forest area, 1,100 square miles.)

This county is situated near the center of the Territory. The Missouri River forms its western boundary. Other important streams are the Muscle Shell and Smith Rivers. Mountains, valleys, and foot-hills, or grazing lands, further vary the surface of the county.

The forests are mostly situated on the mountain slopes, the main sources of timber supply being the Big and Little Belt, Snowy and Elk Mountains, and portions of the Highwood and Crazy ranges. The best timber is usually in the least accessible districts It is estimated that one-tenth of the forest area is good timber and three-tenths promising second growth. The remainder is brush and lands made waste by fire.

Yellow and White Pine and Spruce are the principal timber trees. Cottonwood is used to some extent for fuel.

The following list includes the names and location of the different species native to this county:

Yellow Pine (*Pinus ponderosa*), Smith River and elsewhere.
White Pine (*P. albicaulis*), Little Belt Mountains.
Lodge-pole Pine, wrongly called Tamarack (*P. Murrayana*), Little Belt Mountains.
Blue (or White) Spruce (*Picea pungens*), all mountain ranges.
Cottonwood (*Populus monilifera*), widely distributed.
Black Cottonwood (*P. angustifolia*), all large streams.
Balsam Poplar (*P. balsamifera*), Belt Creek.
Aspen (*P. tremuloides*), mountain ranges.
Box-elder (*Negundo aceroides*), margins of streams.
Dwarf Maple (*Acer glabrum*), Little Belt Mountains.
Mountain Mahogany (*Cercocarpus ledifolius*), Little Belt Mountains.
Wild Cherry (*Prunus demissa* and *P. Pennsylvanica*), creek valleys.
Black Birch (*Betula occidentalis*), borders of streams.

MISSOULA COUNTY.

(Total area, 24,500 square miles; estimated forest area, 16,200 square miles.)

This county, of such great extent, is situated in the northwest corner of the Territory, and upon the western slope of the continental divide.

The Cabinet, Cœur d'Alene, and Bitter Root Mountains and their outlying spurs occupy a large portion of the western half of the county, It is watered by the Kootenai, Clarke's Fork of the Columbia, Missoula. Bitter Root, Pend d'Oreille and other streams. Flathead Lake, a sheet of water 30 miles in length by 10 in width, is situated in the northeastern portion. A few other small lakes are found in the same region. The surface of the county is about one-third mountains and hills, and the remaining part consists of valleys and plateaus. Agriculture and fruit-raising are leading industries; many fine orchards have been grown.

The mountains are not rugged and are comparatively low, rarely exceeding 8,000 feet in altitude. They, as well as the foot-hills, are usually covered with timber. Some of the low, Rocky Mountain spurs at the eastward, however, are quite bare. About three-eighths of the forest growth is good timber; as much more is promising young growth, while the remainder has been made waste by fire.

The leading species of forest trees are Yellow and White Pine, Red and White Fir, White Spruce, Tamarack, Cedar (*Thuya gigantea*), Larch, and Balsam. In the bottoms and along the streams are found Balm of Gilead, Birch, Alder, Willow, etc. The Pines, Firs, and Tamarack furnish most of the lumber supplies. The Yellow Pine grows large, and is the predominant forest tree.

At higher elevations the White Spruce is the leading species.

SILVER BOW COUNTY.

(Total area, 576 square miles; estimated forest area, 60 square miles.)

The county of Silver Bow, situated upon the crest of the main Rocky Mountain range, is one of the principal mining centers of the region.

Mining interests have greatly flourished here, but the forests have suffered in a corresponding degree. The demand for mining timbers and wood for charcoal manufacture has been so great, that the once valuable forest lands of the county have been almost wholly stripped. There is but little, if any, chance for reproduction of the forest growth. A little timber still remains in the western part of the county, but is likely to be consumed during the next three years.

Yellow and White Pine, Red Fir, and White Spruce are the predominant species. The Fir grows to a size of 6 to 15 inches in diameter of trunk, and the Spruce reaches an average diameter of 15 inches. Lodgepole Pine grows from 2 to 6 inches in diameter. A small growth of Cottonwood and Willow is found along the streams. A correspondent writes:

> The timber question is a serious one for this part of the Territory. The consumption of timber is so great that the forests of western Montana will be cut off within the next ten years.

YELLOWSTONE COUNTY.

(Total area, 3,600 square miles; estimated forest area, 25 square miles.)

There are no mountains in this county, and no forests of importance. The Yellowstone River forms its southern boundary.

Upon the bottom lands and hills, skirting this river and its tributary creeks, is found a little timber, consisting of Pine, Cedar, and Cottonwood; none of which, unless the latter, attains large size. About one-eighth of the forest growth is said to be good timber.

CROW INDIAN RESERVATION.

(Total area, 7,200 square miles; estimated forest area, 700 square miles.)

This reservation is in the south-central part of Montana, bordering on the Territory of Wyoming. The Yellowstone River bounds it on the north; and the entire area is fairly well watered by the two Big Horn Rivers, the Nez Perce and Rosebud Rivers and their affluents, all of which are tributary to the Yellowstone.

In the southern part of the reservation are outlying spurs and foot-hills of the Wyoming ranges. These are covered to some extent with Pine, Fir, and Spruce timber. The foot-hills of the Snow Mountains, which encroach upon the western border of the reservation, also bear a forest growth, but no report concerning the same has been received.

WYOMING.

The Territory of Wyoming, in situation, exterior form, area, and configuration, has much in common with her southern neighbor, the State of Colorado. Both lie in the northern temperate zone, and cover portions of the great interior plateau where the open country and mountains meet. In both are high and rugged mountain ranges, wide plains, valleys, and powerful streams. One contains the distribution or radiating center of the water system of the Northwest; in the other is the distributive center of the water system of the Southwest.

The surface area of the Territory is 100,375 square miles and its mean altitude about 6,000 feet above the sea. The main Rocky Mountain range crosses it in a direction from northwest to southeast. This is flanked upon either side by minor ranges, groups, and spurs, the most prominent of which are the Big Horn Mountains in the north, the Laramie and Medicine Bow ranges in the south, and the Bear, Salt River, and Teton Mountains at the west.

In the southwestern part, and following the trend of the main range from northwest to southeast is an area of barren country, about 200 miles in length and from 50 to 90 in breadth. Its northern part comprises the "Colorado Desert," or Green River Basin; the central portion is mostly sage-brush and sand, and the southeastern part is known as the "Red Desert." The surface of this desolate region—which extends southward into western Colorado and eastern Utah—is broken by hills, sand dunes, and buttes.

As an offset to this, in the northwestern corner of the Territory is the Yellowstone National Park, a region remarkable for its grand and wonderful scenery. Here, amid snowy peaks and vast forests, are the sources of the Big Horn, Yellowstone, Madison, Green, and Snake Rivers; the first three finding outlet through the Missouri and Mississippi to the Gulf of Mexico, the next through the Colorado of the West to the Gulf of California, and the last through the Columbia to the Pacific Ocean. In this part of Wyoming are also a number of beautiful lakes, of which the Yellowstone is the best known.

The North Platte, Green, Big Horn, and Powder are the principal rivers. Numerous other streams, of greater or less importance, water the different portions of the Territory.

The climate, though cool and bracing, as befits a high altitude, is not rigorous except in the higher mountains. But slight falls of rain or snow occur during the year, so that the aggregate of sunny days is very great. The mean annual rain-fall, including snow, varies from 12 to 15 inches. The greatest humidity is from the middle of autumn to the middle of spring. Irrigation is depended upon for raising farm products, the rain-fall being insufficient to mature crops, except grass for grazing purposes.

Stock-raising is as yet the chief industry, though the natural resources of the Territory are extremely varied. It is estimated that one-eighth of its entire area is suitable for cultivation.

The forests of Wyoming are confined mainly to the mountain ranges. Some of them are of wide extent, and the timber quite dense and heavy; but, as a rule, they are not equal to those of the Territories farther north and west. The best timber is found on the southern part of the Big Horn Mountains, the central portion of the Laramie Range, Medicine Bow, and Sierra Madre Mountains, and the northern spurs of the Uintah Range, which extend from Utah into southern Wyoming. Upon nearly all of these mountains the snows are heavy, and remain, in part, throughout the year. The Shoshone, Teton, and Snake River ranges also bear quite heavy forests. The timber upon the eastern extension of the Sweetwater range and western portion of the Rattlesnake Mountains is light and scattering. The widest timbered area is in the northwestern part of the Territory, covering the Wind River, Shoshone, and other mountains of the main range, including the groups of Yellowstone Park.

There is considerable timber mostly Yellow Pine, upon the Black Hills near the Dakota line.

Measurements of the timber limits of various mountains have been made, which show the heights, in their respective latitudes, above which coniferous trees—the hardiest of any species—will not grow. The timber line of Mount Washburn is 9,900 feet above sea level, while the altitude of that mountain is 10,388 feet; the timber line of Mount Hayden, of the Teton range, is 11,000 feet, while its altitude is 13,858 feet above the sea; the timber line of the Wind River range is 10,160 feet, while its general altitude is 11,500 feet above the sea.

Yellow and White Pine and White Spruce are the principal timber trees. Many regard the Yellow Pine as the best and most useful tree, while others think the White Spruce furnishes the best timber for all purposes.

Lodge-pole Pine (*Pinus Murrayana*) is the prevailing forest tree in a wide area along the mountain range north and south of Laramie. It is also common in the northwestern and other portions of the Territory. It often replaces the original growth after fires, etc.

Red Cedar (*Juniperus Virginiana*) has a scattering growth upon the foot-hills and low elevations in many parts of the Territory.

The Cottonwood (*Populus monilifera* and *P. angustifolia*) fringes many of the streams.

The entire forest area of the Territory is estimated at 12,060 square miles. Large portions, however, are thinly stocked and other parts have been overrun by fire.

The several species, comprising, so far as known, the forest flora of the Territory, are named in the following list:

Yellow Pine (*Pinus ponderosa*, Dougl.).
White Pine (*Pinus flexilis*, James).
Black, or Lodge-pole Pine (*P. Murrayana*, Balfour).
Piñon, or Nut Pine (*Pinus edulis*, Engelm.).
White Spruce (*Picea Engelmanni*, Engelm.).
Blue (or White) Spruce (*Picea pungens*, Engelm.).
Black Spruce (*Picea nigra*, Link).
Red Fir (*Pseudotsuga Douglasii*, Carr).
Balsam (*Abies subalpina*, Engelm.).
Balsam Fir (*Abies balsamea*, Mill).
Red Cedar (*Juniperus Virginiana*, L.).
Cottonwood (*Populus Monilifera*, Ait.)
Cottonwood (*Populus angustifolia*, James)
Aspen (*Populus tremuloides*, Michx.).
Willow (*Salix longifolia*, Muhl.).
Green Ash (*Fraxinus viridis*, Michx.).
Box-Elder (*Negundo aceroides*, Moench).
Scrub Oak (*Quercus undulata*, Torr).
Mountain Mahogany *Cercocarpus ledifolius*, Nutt).
Mountain Mahogany (*Cercocarpus parvifolius*, Nutt).
Wild Plum (*Prunus Americana*, Marsh).
Wild Cherry (*Prunus Pennsylvanica*, L. f.).
Black Birch (*Betula occidentalis*, Hook).

A small tree, not included in the above, is known locally as "Iron Wood." It grows along the streams in bunches or clusters, the bark resembling that of the Red Cherry. It has long, slender stems, which are often used for fishing-rods. No complete description of this species has been obtained.

The principal demands upon the forest are for railway timbers and cross-ties, the manufacture of lumber—for local uses—and timber for fencing and fuel. But little if any timber is exported.

Common lumber, used in building, is mostly of the native wood. Laramie and Evanston are principal points of production of native lumber. Hard woods and Southern Pine for finishing and flooring are brought from the East; White Cedar shingles are obtained from the Pacific region. It is estimated that 40 per cent. of the lumber used in the Territory is imported.

The statutory laws prescribe a penalty of fine and imprisonment for the willful or careless firing of woods, marshes, or prairies, and satisfaction in damages to any person injured. Forest fires, nevertheless, are frequent and destructive.

No officers are specially charged with the enforcement of the forest laws, and although there may be violations of the same, the guilty parties are rarely if ever apprehended.

Wyoming is within the "arid belt," and irrigation is depended upon for the raising of crops. The tillable area of the Territory is estimated at 12,000 square miles. The land is easily broken and cultivated, being generally free from stones and other obstructions. In exceptional seasons the natural rain-fall is sufficient to produce a growth of grain and vegetables, but irrigation ditches and a reliable supply of water are necessary to insure the success of farming operations. During the last few years many companies have been incorporated in the Territory for the purpose of constructing irrigating canals and ditches. Many of these enterprises are now in successful operation. In a period of four months during the year 1886, within the district comprising the southeastern portion of Laramie County, there were recorded the articles of incorporation of over five hundred canals and ditches, extending over 1,000 miles in length and covering at least 100,000 acres of land. The works of the Wyoming Development Company, in the same county, include two canals, 29 and 37 miles long, respectively, and from 20 to 25 feet wide; 19 miles of lateral ditches, from 6 to 12 feet wide, and a rock tunnel three-fourths of a mile long, with a flow of 1,500 cubic feet per second. This system, built at a cost of $500,000, reclaims 60,000 acres of desert land.

ALBANY COUNTY.

(Total area, 6,922 square miles; estimated forest area, 840 square miles.)

This is a long and narrow county, in the southeastern part of the Territory. The Laramie and Medicine Bow ranges occupy large areas in the north central, eastern, and southern portions.

The North Platte and Big Laramie Rivers are the principal watercourses. These, together with numerous tributary streams having their sources in the snowy mountains of the region, furnish an abundance of water for irrigating purposes.

The forest growth consists mainly of Yellow and White Pine, Tamarack or Lodge-pole Pine, Red Cedar, and Aspen. It is mostly confined to the mountain slopes and foot-hills. The heaviest bodies of timber are found in the central and southwestern parts of the county.

Between Fort Fetterman and Laramie Peak on the La Bonte and Horseshoe Creeks, and on the Caspar Mountain, 50 miles west of Fort Fetterman, are large tracts of good saw timber. Along the North Platte and its tributary creeks are fine growths of Cottonwood and Box Elder.

Lodge-pole Pine (*Pinus Murrayana*) is the predominant forest tree along the range east of Laramie. Yellow Pine is common along the lower mountains, but does not have a dense growth. It is the largest and most valuable of the pines. White Pine (*Pinus flexilis*) grows near the timber line. A scattering growth of Red Cedar is found on the foot-hills. Of the two varieties of Cottonwood native to this region (*Populus monilifera* and *Populus angustifolia*) the latter is the most prevalent. It is estimated that one-quarter of the entire forest area is good timber. Upon northern slopes, after the original stock has been cut or destroyed, a second growth soon follows, consisting of Lodge-pole Pine, or species similar to the first growth. Forest trees are planted and cultivated to a very limited extent, with the aid of irrigation.

CARBON COUNTY.

(Total area, 13,526 square miles; estimated forest area, 1,360 square miles.)

This county is in the south central portion of the Territory. Its area is quite equally divided between mountains and plains. The Laramie Plains extend across its eastern border, and westward to the North Platte River. The principal mountain ranges are the Medicine Bow at the southeast, Sierra Madre at the southwest, and the Seminole and Rattlesnake in the west central portion. Spurs of the Big Horn and Laramie ranges penetrate the county at the northeast and north. The North Platte River, for a distance of about 200 miles, flows through the interior of the county. Many other streams tributary to the Platte, and the Powder River at the north, have their sources here. Upon all the mountains are coniferous forests, of greater or less extent, the most important being upon the snowy ranges of the Medicine Bow and Sierra Madre. The forest growth appears at altitudes ranging from 8,000 to 12,000 feet above sea-level, and consists, for the most part, of Yellow and White Pine, Tamarack or Lodge-pole Pine, White Spruce, and Aspen. Lodge-pole Pine is the predominant species. It grows from 2 to 14 inches in diameter. At high elevations in the Medicine Bow Mountains the White Spruce attains great size, the trunks of that species sometimes reaching a diameter of 6 feet. In sheltered places along French Creek, on the western slope of the same range, the Aspen grows very large, the bodies of the trees often being 2 feet in diameter. About one-half of the forest area is good timber, though not large, the trees having a tall and slender habit. Immense coal fields exist in this region and have been partially developed—a condition which ought to lessen the drain upon the forests for fuel.

CROOK COUNTY.

(Total area, 10,709 square miles; estimated forest area, 400 square miles.)

This county, which occupies the northeastern corner of the Territory, is in form an exact square, its sides being a little more than 100 miles in length. Its general surface features are rolling plains, the Black Hills and other minor ranges and hills occupying but a small portion of the county. It is fairly well watered for a plains region. The lands are adapted to grazing and limited farming operations, if irrigated.

The forest growth is scanty, consisting principally of Yellow Pine, Red Cedar, Oak, and Cottonwood. The Pine is found on the Black Hills, in the eastern part of the county, and on detached spurs in the southwestern portion. The Cedar and Oak have a scattering growth on the low hills, and the Cottonwood borders the streams.

About one-third of the timbered area is fully stocked. Forest fires have been very destructive, and after a fire a second growth rarely appears. As yet there are only five saw-mills in the county.

FREMONT COUNTY.

(Total area, 20,957 square miles; estimated forest area, 3,300 square miles.)

This is the largest county in Wyoming. It is situated in the northwestern part of the Territory and extends to both the eastern and western slopes of the main Rocky Mountain range.

The topography of the region is greatly varied; mountains, plains, valleys, and swift-running streams are leading features. "The Shoshone and Wind River Mountain ranges extend from the north along the west limit of the county to the Sweetwater and Rattlesnake Ranges in its southeastern corner. The Wind and Sweetwater Rivers and tributaries of the Green run through it, and the Big Horn River forms a part of its eastern boundary." In the northeastern part of the county there is a broken and open country. At the southwest the Colorado Desert occupies a considerable area.

The most extensive (though not the heaviest) bodies of timber in the Territory are found in this and the adjoining county of Uinta.

From one-third to one-half of the forest area is fully stocked, good for timber. Yellow and White Pine, Lodge-pole Pine, Red Cedar, and Cottonwood are the predominant species. The best timber grows on the higher elevations. An open growth of Pine and Cedar covers the foot-hills. Dense groves of Cottonwood are found on the bottoms, along the Grey Bull and Big Horn Rivers and their tributaries.

JOHNSON COUNTY.

(Total area, 11,121 square miles; estimated forest area, 1,800 square miles.)

Johnson County is in the north central portion of Wyoming, bordering on the Montana line.

The Big Horn range of mountains, which is about 100 miles long by 40 to 50 wide, enters at the northwest and extends nearly through the county to its southern border.

These mountains are quite high and rugged, and carry snow upon their summits most of the year. The Big Horn River, which forms the western boundary of the county, and the Powder River, flowing near its eastern margin, are the most important streams. Many tributary creeks traverse the county in other directions. The surface of the eastern and southwestern parts is rough and broken. The country lying at the eastern base of the mountains is undulating and susceptible of irrigation. The bottoms along many of the streams are from one-fourth of a mile to a mile in breadth and are well adapted to agriculture.

The forest area, which is comparatively large, is confined to the Big Horn Mountains. The principal species of trees are the Yellow and White Pine, White Spruce, Aspen, Oak, Cottonwood, Box Elder, and Willow. The last three grow on the narrow bottoms bordering the streams. White Pine is the predominant coniferous species. There are from ten to twelve saw-mills in the county, and the timber is being rapidly cut. The annual lumber product is about 8,000,000 feet, besides 2,000,000 shingles and 300,000 laths; all of which is for local use.

LARAMIE COUNTY.

(Total area, 11,200 square miles; estimated forest area, 80 square miles.)

This county occupies the southeastern corner of Wyoming and is the seat of the Territorial capital, Cheyenne. About three-fourths of its area is a rolling plain, and, excepting some of the bottom lands along the streams, it is a grazing region. At the western side the spurs and foot-hills of the Laramie range of mountains cover a small portion of this county. The North Platte River flows in a diagonal course through the central part, and is the principal stream. A number of smaller rivers and creeks traverse the county.

The timbered area is extremely limited. Some scattering Pine is found on the foot-hills in the western part, and narrow belts of the Cottonwood along the North Platte, Laramie, Chugwater, and other streams. There is no timber of sufficient size for the manufacture of lumber.

SWEETWATER COUNTY.

(Total area, 10,550 square miles; estimated forest area, 40 square miles.)

This county is situated in the southwestern part of the Territory and is, to a large extent, barren and worthless for agricultural purposes. The northwestern corner includes a portion of the Colorado Desert, the central portion is mostly sandy and abounding with sage brush, while at the southeast is the Red Desert. The southern part, bordering on Colorado and Utah, is broken and sterile. The Green River flows through the western part of the county. Small streams start from the mountains at the northeast, but are soon lost in sandy wastes. The county is rich in coal, iron, and other minerals, and parts of it afford good grazing for stock.

There are no forests in the county. A little Pine and Spruce upon the northern and southern borders, an open and scattering growth of Cedar and Aspen on some of the ridges, and a fringe of Cottonwood along a portion of Green River, comprise the timber supply.

UINTA COUNTY.

(Total area, 12,140 square miles; estimated forest area, 2,400 square miles.)

Exclusive of Yellowstone Park at the north, Uinta County extends across the entire western border of the Territory. Three-fourths of its area is mountainous. The principal ranges are the Wind River, at the northeast, and the Teton, Snake River, Salt River, and Bear River ranges along the west line. The county has some fertile valleys, and is well watered by numerous small streams flowing from the mountains.

The forest area is large, but the timber is inferior in size and quality. White and Lodge pole Pine are the predominant species. They grow tall and slender, the trunks of the largest trees rarely exceeding 15 inches in diameter. A scattering growth of Red Cedar appears upon many of the low hills.

Lumber and charcoal are manufactured here to some extent. Large deposits of mineral coal are being worked in the southern part of the county.

YELLOWSTONE NATIONAL PARK.

(Total area, 3,250 square miles; estimated forest area, 1,840 square miles.)

This Government reservation is situated in the northwestern corner of Wyoming, and embraces a section of the main Rocky Mountain range nearly 60 miles square. The region is noted for its magnificent scenery. Its snow-clad ranges and peaks are partially clothed with pine forests, and overlook a number of beautiful lakes of great depth and clearness. Here are found the sources of rivers tributary to the Missouri, the Columbia, and the Colorado of the West—great waterways which seek the sea in opposite directions.

The predominant forest trees are White and Lodge-pole Pine. Occasionally, upon the lower slopes of the mountains, the Yellow Pine appears. Scattering growths of Red Cedar and Aspen are also found upon the foot-hills, and Cottonwood along the streams.

As this reservation is under the special supervision of officers of the General Government, it is presumed the forests, as well as other natural features of the region, will be preserved.

COLORADO.

The State of Colorado occupies a central and commanding position upon the great interior plateau, and within its borders are grouped the highest and most rugged of the Rocky Ranges. It has been justly termed "The Crest of the Continent." Amid its snowy summits and forest-clad mountains rise many of the great streams constituting the water systems of the West and South. Its average or mean elevation (7,000 feet above sea level) is greater than that of any other portion of North America. The neighboring Territories have a mean elevation as follows: New Mexico, 5,600 feet; Wyoming, 6,000 feet; Utah, 5,700 feet; Idaho, 4,700 feet; Montana, 3,000 feet.

The State is regular in outline, nearly square, and embraces a superficial area of 100,200 square miles. Its two great natural subdivisions, plains and mountains, are separated by a north and south line nearly coincident with the one hundred and fifth meridian. Three-sevenths of the entire area lies east of that line, within the plains region, and is a high, rolling, semi-arid country, almost wholly devoid of timber, and insufficiently watered by the South Platte and Arkansas Rivers and their tributaries. At the base of the mountains it has an elevation of 5,000 to 6,000 feet; thence sloping gradually to the eastern border, where the altitude is 1,000 to 1,500 feet less. The western and larger division of the State includes in its eastern part the Main Range, or Continental Divide, and almost numberless minor ranges, spurs, and groups. Between these and the Utah line is a more open country, broken by extensive plateaus and mesas, detached mountain groups, isolated peaks, hills, and buttes. Large rivers traverse the region, bordered in places by broad and fertile valleys, and at other points confined within deep and narrow canyons.

"The parks of Colorado are a distinctive and remarkable feature of the mountain region, apparently the basins of former lakes upheaved and deprived of their waters by volcanic agency, with their original shape and situation at the foot of high mountains undisturbed, while their lowest depths are from 6,000 to 9,000 feet above the level of the sea. Many of these parks are small, being little valleys at the sources of single streams, or the beds of small lakes into which several streams from the surrounding mountains are emptied; yet there are four of these elevated valleys, the smallest of which extends 20 by 50 miles, and the largest 100 by 200, equal in size to some of the most important of the New England States. These are called the North Park, Middle Park, South Park, and San Luis Park."

In all these parks are rich grazing lands, and in many of them are large and productive agricultural areas.

The principal rivers of the State are the Arkansas and South Platte on the eastern side, which find outlet through the Missouri and Mississippi to the Gulf of Mexico; the Yampah, White, Grand, Gunnison, and Rio Dolores upon the Pacific slope, tributary to the Colorado River of the West; and the Rio Grande, flowing southward to the Gulf of Mexico. All of these rivers have their sources in, and are dependent upon, the central snowy ranges. It is instructive to note the preponderance of streams upon the western slope, where the forests are most dense, and where occurs the greatest precipitation of moisture.

The forests of Colorado are situated mostly in the western mountainous divisions at the higher elevations. A tongue of timbered land invades the mid-eastern portion for a distance of about 30 miles along the crest of the Arkansas-Platte divide; and another tract of wooded country extends for a short distance into Las Animas County at the southeast. The heaviest forest growth is in the north central, central, and southwestern parts of the State. Some of the finest timber is found at the southwest, in La Plata and Archuleta Counties. Much of it grows on high, rolling plateaus; the trees are tall and straight; but little undergrowth exists; and should the land ever be cleared, it is unlikely to revert to forest, and would be suitable for agriculture or pasturage.

The forest flora of the State is embraced in the following list:

Yellow Pine (*Pinus ponderosa* var. *scopulorum*).
White Pine (*P. flexilis*).
Black or Lodge-pole Pine (*P. Murrayana*).
Fox-tail Pine (*P. Balfouriana* var. *aristata*).
Piñon or Nut Pine (*P. edulis*).
White Spruce (*Picea Engelmanni*).
Black Spruce (*P. nigra*).
Silver or Blue Spruce (*P. pungens*).
Red or Yellow Fir (*Pseudotsuga Douglasii*).
White Fir (*Abies concolor*).
Balsam (*A. Subalpina*).
Red Cedar (*Juniperus Virginiana*).
Juniper (*J. occidentalis* var. *monosperma*).
Juniper (*J. communis* var. *alpina*).
Cottonwood (*Populus monilifera*).
Black Cottonwood (*P. angustifolia*).
White Cottonwood (*P. Fremontii*).
Balm of Gilead (*P. balsamifera*).
Aspen (*P. tremuloides*).
Box Elder (*Negundo aceroides*).
Dwarf Maple (*Acer glabrum*).
Locust (*Robinia Neo-Mexicana*).
Mesquit or Honey Locust (*Prosopis juliflora*).
White Oak (*Quercus grisea*).
Scrub Oak (*Q. undulata* var. *Gambelii*).
Wild Plum (*Prunus Americana*).
Chickasaw or Hog Plum (*P. angustifolia*).
Wild Cherry (*P. Pennsylvanica*).
Mountain Mahogany (*Cercocarpus parvifolius*).
Black Thorn (*Cratægus tomentosa*).
Willow (*Salix lasiandra*).
Sand-bar Willow (*S. longifolia*).
Black Birch (*Betula occidentalis*).
Black or Speckled Alder (*Alnus incana*).

Yellow and White Pine and White Spruce are the predominant species, and are the most useful for general purposes. The Spruce (known locally as "Red Spruce," from the color of its wood) grows at higher elevations than the Pines and is not so plentiful or so easily obtained as the latter. Its wood is superior to that of the others. Piñon, though not forming extensive forests, has quite a wide range in the State, and is largely used for fuel and the manufacture of charcoal.

The consumption of lumber in the State during the last twelve months is estimated at 120,000,000 feet, B. M., two-thirds being native timber and one-third imported. For building purposes native Yellow and White Pine and White Spruce, and White Pine from Michigan and Wisconsin are largely used. For finishing and cabinet-work the

White Pine and hard woods of the central, western, and eastern States are preferred. Southern Pine is extensively used for flooring. Redwood from the Pacific coast is used to a limited extent for some purposes. Red Cedar shingles are shipped to Colorado from both the east and west. Long timbers for bridges, railway construction, etc., are not easily obtained here, nor are they equal in strength and durability to those procured at outside points. The Colorado Midland Railway Company has recently made purchases as follows:

Oregon Pine, 3,000,000 feet, B. M.; Texas Pine, 500,000 feet, B. M.; New Mexico Pine, 2,500,000 feet, B. M.

It is hoped that when more direct railway communication is established between this region and the heavily timbered portions of the Pacific coast the lumber supplies of the latter will be more freely drawn upon, lessening to that extent the demands upon the scantily timbered districts of the mountains.

The agricultural interests of the State are rapidly increasing, and have become of the first importance. The dependence of farming operations upon irrigation systems, and the important relations existing between them and the streams and forests of the mountains, are nowhere more apparent than in Colorado. It is estimated that the entire canal system of the State embraces something over 800 miles of large canals completed, about 200 miles projected, and about 4,000 miles of canals of smaller size. The Del Norte Canal, in the San Luis Valley, is the largest irrigating canal in the United States. "It is 65 feet wide on the bottom at the head-gate, carrying water 5½ feet deep, with side slopes 3 to 1, making the top width at water-line 98 feet. Four miles from the head it is divided, the larger branch being 42 feet wide on the bottom, and the smaller branch 38 feet wide. There are about 50 miles of main channel. It carries something over 2,400 cubic feet of water per second and is calculated to irrigate over 200,000 acres. The extent of territory in the State covered by the entire distributive system is, approximately, 40,000 square miles, constituting the bulk of the arable land. The system has cost in construction about $12,000,000.

In mileage of canals and acreage irrigated, Colorado more than doubles any other State; its works are the greatest, the most permanent, and the most rapidly extending.

This State is the only one which has a constitutional clause requiring the enactment of laws to prevent the destruction of forests and to keep them in good preservation. Until within the last three years, however, but little heed has been paid to that provision. In the summer and autumn of 1884, by a series of published articles, the attention of the people was drawn to the urgent need of protecting the forests of the State and enlarging their area. In November of that year a State forestry association was formed, which has done a good work and is still in active existence. In the winter of 1884–'85, by legislative enactment, the office of State forest commissioner was created, the duties of the office defined, and the county commissioners and road overseers throughout the State constituted forest officers in their respective localities, with special duties relating to the protection of forests. At the same time acts were passed imposing penalties for the willful or careless setting of forest fires, for failure to extinguish camp fires, etc., and requiring the posting of notices in public places warning persons against the violation of the law. At the recent session of the legislature (1886–'87) the law was made more stringent in some respects, the State forest commissioner was given a salary and traveling allowances, and Congress was memorialized upon the subject of transferring to the State the custody or control of the public forest lands within her limits. Altogether, Colorado has made very substantial and gratifying progress in forest matters.

ARAPAHOE COUNTY.

(Area, 4,700 square miles.)

This county is in the northeastern part of the State. It has no forest land. Its area consists mainly of gently rolling prairie. The western half of the county is quite well watered by the South Platte River and its tributaries. An extensive system of irrigation renders productive large bodies of land.

ARCHULETA COUNTY.

(Area, 1,026 square miles; estimated forest area, 450 square miles.)

This county is situated on the southern line of the State, and near its western border. Its surface is mountainous, but includes fertile valleys. The forest land is well distributed; every square mile is said to have timber enough for needed purposes.

The timber is chiefly Pine, of good quality; 12 per cent. is brush of promising growth; very little has been made waste by burning. The principal species are Pine, Cedar, Spruce, Cotton-wood, Piñon, Oak, Aspen, and Willow; Yellow Pine predominates.

After the destruction of the forests, the chances of their renewal are slight. On mountain ranges sloping to the north, Aspen usually follows fires as a second growth.

No changes are noticed as yet in the volume and flow of water in streams; springs and running streams abound.

Indians start fires to drive the game from some places; they also strip the bark from standing Pine trees to obtain a pulp of sweetish taste that accumulates between the bark and the wood. It is stated that they cause more destruction of timber than all other agencies combined.

The water for irrigation purposes is deemed insufficient.

BENT COUNTY.

(Area, 9,070 square miles.)

Bent County lies upon the eastern border of the State, and is wholly within the plains region. It is inadequately watered by the Arkansas

River and its tributaries. There are no forests in the county. Considerable land is being brought under cultivation, with the aid of irrigation.

BOULDER COUNTY.

(Area, 768 square miles; estimated forest area, 275 square miles.)

This county is situated in the north-central part of the State. It is bordered on the west by the main Rocky Mountain range, and is well watered by streams tributary to the South Platte River. The western half is mountainous and timbered; about one-third of the timber is good, and one-fourth burned over, with a young growth following. The principal arborescent species are, Yellow and White Pine, Spruce, and Fir. The timber is scattered over nearly all of the mountainous portions of the county, while along the foot of the range it is quite dense. After forest fires, the second growth usually consists of wild Maple, Alder, and shrubs.

The eastern third of the county is rolling and valley-land, most of which is suitable for farming purposes.

CHAFFEE COUNTY.

(Area, 900 square miles; estimated forest area, 500 square miles.)

This county, which occupies a central position in the State, is almost surrounded by mountain ranges. It contains a large proportion of farming and grazing land, and is abundantly watered by the Arkansas River and its tributaries.

About two-thirds of the county is timbered. Near the summits of the mountains is Spruce, below them Yellow Pine, and in the foot-hills and mesas Piñon and Scrub Pine; along the streams are Willow—(Black or Narrow-leafed), Cotton-wood, and Aspen. The timber land is mainly situated along the eastern slope of the Continental Divide, which forms the western boundary of the county, and in the range of hills between the South Park and the Arkansas River. The timber in the more open valleys of the river is largely Piñon, great quantities of which have been cut and converted into charcoal for the use of the smelters of Leadville, Pueblo, and Denver. There are a number of saw-mills, and a great many railway cross-ties are being cut. This consumes the best part of the timber.

CLEAR CREEK COUNTY.

(Area, 450 square miles; estimated forest area, 200 square miles.)

This is pre-eminently a mountainous county. The main snowy range, with an altitude of 14,000 feet and more, extends along the entire western boundary. It sends off lofty spurs, many of the peaks rising far above the timber line, and these, in parallel ranges, traverse the county from west to east. The surface of the county, therefore, is almost wholly covered with lofty mountains, with narrow valleys between.

The county was originally well timbered, the valleys and mountain sides, up to the timber line, being generally covered with a fine growth of Pine, Balsam, and Spruce. Much of this has been cut off, and more has been destroyed by forest fires, but the supply is thought sufficient for some years to come, if carefully husbanded. It is believed that the careless and willful destruction of timber might be prevented by speedily and surely punishing offenders.

The amount of water carried by the streams varies somewhat from year to year, being dependent upon the snow-fall. The average amount for a given period of years would remain about the same. Owing to the cutting of timber on the mountains the snow melts more rapidly than formerly, thus causing a greater flow of water in the early summer and less later.

CONEJOS COUNTY.

(Area, 1,320 square miles; estimated forest area, 300 square miles.)

This county is in southern Colorado, bordering on the Territory of New Mexico. The western half of the county is mountainous; the eastern half lies in the San Luis Park, the surface having a gradual descent to the Rio Grande River. About three-eighths of the county is forest land, located in the range in the western part. Not more than one-eighth of the forest land is well stocked with timber; one-eighth is covered with Aspen and one-fifth is made waste by burning. The forest growth remaining is mostly Pine, with some Spruce and Aspen. Along the streams in the valleys are found Cottonwood and Willow.

Fire destroys more timber in one year than would be consumed by other causes in ten. After the forests have been destroyed there is very little chance for their renewal.

As the trees are cut off or burned there is less water in the streams, the snows melting earlier in the spring. It is suggested that the supply of water might be materially increased by the beaver. This little animal, by a system of dams and canals, stores immense quantities of water in the early summer, which comes down later in the season. Could the beaver be protected by law on many streams there would be no need of artificial storage.

COSTILLA COUNTY.

(Area, 1,450 square miles; estimated forest area, 450 square miles.)

This county is also on the southern border of the State. Its eastern boundary is formed by the Sangre de Christo and Culebra ranges. The Rio Grande River borders it on the west. The San Luis Park extends through a large portion of the county.

The forests are situated in the northern and eastern parts, on the mountains and foot-hills. About one-half of the timber is Piñon and

Cedar, one-fourth Pine and Spruce, and the remainder consists of burned tracts and belts of Cottonwood along the streams. The trees are generally inferior in size, only a small proportion being suitable for lumber.

Fire is the most destructive agent threatening the forests; railroads next. Some lumber is made, but most of the saw-timber has been consumed. After the forests have been destroyed by fire it is only on the northern hill-sides that the original growth starts again. Aspen generally follows after fire. Only in favorable situations do Spruce and Pine grow again.

During the last twenty years the forest growth in this county has not been sufficiently disturbed to affect the volume and flow of the stream.

CUSTER COUNTY.

(Area, 750 square miles; estimated forest area, 200 square miles.)

This county, which lies in the south central part of the State, is bordered on the west and south by the Sangre de Christo and Greenhorn ranges, respectively.

The forests are situated mainly at the west and south, in the mountains. Some timber is also found on the north and east sides. In the western part of the county, at the foot of the range, there is an open valley, about 9 miles wide, running the whole length of the county. The only timber there consists of a few Cottonwoods and Willows along the streams. Pine, Piñon, and Cedar are found on the low hills; at higher elevations are Spruce, Balsam, and Aspen. Very little has been made waste by burning. The best timber has been cut off for use at the mills. The special dangers threatening the forests are fires and lumbering. On the range a second growth will start, usually of the same kind as the first. On the low hills, especially after fires, there is no second growth.

No changes have been observed in the flow and volume of streams at their headwaters. In the lower lands floods are now frequent from cloud-bursts or sudden rains.

DELTA COUNTY.

(Area, 1,150 square miles; estimated forest area, 500 square miles.)

This county is situated in the western part of the State, in a region of plateaus and mesas. The Gunnison and Uncompahgre are its principal rivers.

The timber consists of Pine, Piñon, Cedar, and Spruce, the several kinds being about equally distributed over the slopes of the Grand and other high mesas along the western, northern, and eastern borders of the county. There are about 10,000 acres of Cottonwood along the Gunnison River and its tributaries.

The average rain-fall is thought to be increasing. The danger of forests being destroyed by fire is not considered imminent, as they are situated at a high altitude, and where there is considerable humidity.

DOLORES COUNTY.

(Area, 800 square miles; estimated forest area, 150 square miles.)

The surface of this county is much broken. It includes mountain ranges, high mesas or table-lands, and narrow valleys bounded by box canyons, or gently sloping hill-sides. It is well watered by the Dolores River and its tributaries.

The forest lands are situated chiefly in the eastern half of the county. About two-thirds of the timber is Yellow Pine and Spruce; the remainder is Piñon and Aspen. Only a small percentage of the timber is suitable for lumber, the trees being small and stunted. Fires and the consumption for mining purposes are the special dangers threatening the forests. It is said that after the forests have been destroyed Nature speedily reproduces them, the high altitude and moist atmosphere contributing to that end.

DOUGLAS COUNTY.

(Area, 850 square miles; estimated forest area, 300 square miles.)

About two-fifths of the area of this county has a scattering growth of timber, situated mainly on the north side of the Arkansas-Platte Divide and in the mountains to the west. The timber on the divide has been cut, but considerable young timber is now growing. In the mountains fully one-half of the timber has been burned. The forest growth remaining, principally small, rarely exceeds 15 inches in diameter. Pine and spruce are the predominant species. Lumbering has been the greatest destroyer of timber. A new growth is appearing on some of the old burned tracts. This growth is usually Pine on the south side of the mountains and Spruce on the north side.

The volume and flow of water in the streams have been affected by various means; such as forest fires, or cutting off the timber at the head-waters of the streams, or of dense growths of timber and underbrush elsewhere. Wherever the forests have been cleared off, the snow melts rapidly, giving a heavy flow of water in early spring, and an insufficient flow in the summer.

EAGLE COUNTY.

(Area, 1,750 square miles; estimated forest area, 300 square miles.)

This county is situated in the northwestern part of the State. The surface is mountainous, and includes fertile valleys suited for many kinds of grain and vegetables, especially those that mature in a short season. Mining and stock-raising are the chief industries.

The forests are found in the eastern part of the county. Two-fifths are said to be good timber, one-fifth brush, and two-fifths made waste by burning. The forest trees are of straight and thrifty growth, of medium size, but mostly too small for lumbering purposes. The White Pine and White Spruce predominate.

Fire is the special danger threatening the forests. When the forest is destroyed by fire the ground is usually burned so deeply that all fertility is destroyed. The second growth is usually the same as the first, when the land has been burned. After fire, Aspen grows first, then White Pine, and later Spruce.

ELBERT COUNTY.

(Area, 5,800 square miles; estimated forest area, 100 square miles.)

The county is situated in the eastern part of the State, in the Plains region. The western portion is broken, and is fairly well watered by tributaries of the South Platte River.

The limited amount of forest land in this county is found mostly in the northwestern part. Lumbermen have cut all the good timber, and the present forest growth is small and scattering. Pine is the predominant species.

It is stated that floods have become more frequent since the destruction of the timber.

EL PASO COUNTY.

(Area, 2,650 square miles; estimated forest area, 500 square miles.)

This county occupies a central position in the State. The eastern half (south of the Arkansas-Platte Divide) consists of undulating plains, with no timber and very little water. The elevation at the east line is 4,500 feet, reaching to 6,000 feet in the center, at the base of the Pike's Peak range. The western portion, and also that lying north of a line between townships 12 and 13, south, is very mountainous, reaching an elevation of 14,167 feet at the summit of Pike's Peak, 9,250 feet at the crest of the Hayden Divide, and 8,500 feet at the highest point of the Arkansas-Platte Divide. The western and northern parts of the county, above an elevation of 5,500 feet, are in most parts well timbered with Pine, Spruce, Fir, etc. The heaviest timber is found at an altitude of 6,000 to 10,000 feet; that below 6,000 feet is mostly Yellow Pine, Piñon, Scrub Oak, and Cottonwood.

FREMONT COUNTY.

(Area, 1,450 square miles; estimated forest area, 450 square miles.)

About three-fourths of the area of this county is mountainous. The county is drained by numerous streams, all of which flow into the Arkansas River. The forest land is situated mainly in the northern and western portions. There is very little available timber large enough for lumber, and no brush of promising growth. The forest growth is Piñon and Pine, White Spruce, Cottonwood (on margins of streams) Aspen, Scrub Oak, Box-Elder and Wild Maple. Piñon and Pine predominate. The Piñon and Oak make excellent fuel; the former is also used extensively in the manufacture of charcoal.

Charcoal burning is the principal danger threatening the forests. The prospects of renewal after the forests have been destroyed are very poor. In the mountains the second growth is usually Aspen.

GARFIELD COUNTY.

(Area, 7,250 square miles; estimated forest area, 800 square miles.)

This large county is situated in the plateau region of western Colorado. It is watered by the White and Grand Rivers and their numerous tributaries.

From the Great Hogback west to the head-waters of Roan and Douglas Creeks, are low sandstone hills, covered with stunted Piñon and Cedar. The divide between Grand and White Rivers bears scattering bunches of Spruce and Aspen, the latter predominating. East of the great Hogback are large forests of Fir, White Spruce, and Pine; also, in the immediate vicinity of White River are groves of very large Aspen. Dwarf Piñon and Cedar are found near Carbonate and west to the great Hogback, on the divide between Grand and White Rivers. The finest timber is said to be situated in the northeast part of the county, on the White Pine Plateau. In the higher altitudes there are some large bodies of timber, mainly White Spruce.

Fire is the principal cause of the destruction of timber in this county. The law requiring the extinguishment of camp-fires should be strictly enforced. The statement is made that the Ute Indians, who roam at large and make their summer headquarters in the best timber, are responsible for some of the forest fires. The chances for renewal, after the forests have been destroyed by fire, are few. Aspen, if anything, springs up after fire.

GILPIN COUNTY.

(Area, 140 square miles; estimated forest area, 50 square miles.)

This county is situated in the north-central part of the State, upon the eastern slope of the main range. The eastern portion is rugged and mountainous, embracing Bear Mountains, South Hill, etc. In the central and northern part are low foot-hills: the western part rises to the summit of the range; and the southern part rises from North Clear Creek 2,000 to 3,000 feet to the summit of the ridge between the two forks of Clear Creek, which forms the southern boundary of the county.

There is but little timber of importance in the county; it has nearly all been cut off for mining purposes and fuel. That which is now used is brought from the extreme western part of the county, at the head of North Clear Creek. The principal green timber is in the vicinity of Bear Mountains, but it will not much exceed 1 square mile in area. A new growth, however, is rapidly springing up over about one third of the county. Of the forest trees now remaining, White Pine predominates.

There are no irrigating ditches in the county, and no farming land except small areas along the creeks and gulches, which in general require no irrigation. The volume of water in the streams has diminished to a considerable extent and become more irregular in flow, partly on account of the failure of springs, resulting from deep mining, but mainly because of the clearing off the forests. As the bare slopes can not absorb and retain the rain-fall, heavy floods occur at some seasons (summer) and there is excessive dryness at others.

GRAND COUNTY.

(Area, 1,800 square miles; estimated forest area, 700 square miles.)

This county is situated in north-central Colorado. A large portion of its area is covered by Middle Park, in which are found the sources of the Grand River. These streams furnish an abundant water supply. The forests of the county are situated upon the surrounding ranges and upon the mountain spurs projecting into the Park. About three-fifths of the timber is good for lumbering purposes; one-fifth is brush and saplings of promising growth, and the remainder has been made waste by fire. A peculiarity of this district is that burned areas are soon retimbered with the original species. Sometimes the second growth is Aspen.

The timber here is better than the average of Rocky Mountain timber, the trees running from 8 inches to 4 feet in diameter of trunk, from 25 to 75 feet in length, and suitable for lumber, shingles, etc. The principal species are Pine, Spruce (three varieties), Fir (two varieties), and Aspen; Pine predominates. Most of the timber is at present used as logs and poles, but little having been sawed into lumber.

"At the high altitude of the forests in this county, 8,000 to 11,000 feet above sea-level, timber growth is necessarily slow. In some parts of the forests snow lies until June, and in many portions until July. I can point out areas that had been burned over a few years previous to 1863, and upon which the new pine growth was then just started, or but a few feet high, which are now thickly covered with trees 10 or 12 inches in diameter and from 30 to 50 feet in height. These are in the middle of the Park. The spruce forests at high altitudes are seldom burned, and I can not speak so confidently of their reproduction. We have had no extensive fires for several years."

There are no irrigating ditches in the county, except a few very small and short ones belonging to individual ranchmen.

GUNNISON COUNTY.

(Area, 4,000 square miles; estimated forest area, 1,200 square miles.)

This county is irregular in outline, and covers a large area upon the western slope of the main range. It is bordered on the north by the Elk Mountains. The Gunnison River and its numerous tributaries constitute the water system.

The forests are situated mainly on the mountain slopes at the north and east. The principal trees are Pine, Spruce, Cedar, and Aspen. About one-fourth is brush, and as much more has been burned over. No portion is fully stocked. The trees are usually 3 to 18 inches in diameter. Pine and Spruce predominate. Cottonwood and Alder grow along the streams.

Fire is the principal destroyer of the forests. The renewal is slow but steady. The second growth is usually the same as the first, except after fire, when Aspen follows.

No particular change has been observed in the flow and volume of water in the streams. The entire county is well watered. There is a heavy fall of snow in the winter, and copious rain-fall in the summer.

HINSDALE COUNTY.

(Area, 1,440 square miles; estimated forest area, 450 square miles.)

This county is situated in the southwestern part of the State. It is drained in the northern portion by the head-waters of the Lake Fork of the Gunnison River and Henson Creek; in the middle part by the head-waters of the Rio Grande River; and in the southern portion by some of the tributaries of the San Juan River. The main range, or Continental Divide, crosses the county twice, in an east and west direction.

Timber grows in all of the valleys (which lie at an altitude of about 7,000 feet) and on the hillsides and mountain slopes, to a height of 11,000 feet. White Spruce, White and Yellow Pine, and Aspen are the principal species. Spruce and Aspen predominate. Only a small proportion of the forest trees are large enough for lumber.

No changes are observed in the streams, although without doubt the forests have a beneficial effect on the water supply. The difference here between high and low water is considerable, and the rise and fall is quite gradual. Heavy snows have occurred during the last three winters, resulting in plenty of water in the streams through the spring and summer months.

HUERFANO COUNTY.

(Area, 1,160 square miles; estimated forest area, 250 square miles.)

This county is situated in southeastern Colorado. Upon its northwestern, western, and southern borders are mountains and foot-hills covered, to a greater or less extent, with Pine, Spruce, Fir, Cedar, and

Aspen. These portions also include fertile valleys and fine grazing lands. In the central parts of the county are low hills, covered with Piñon and Cedar; also table-lands and valleys suitable for agriculture. In the eastern and northeastern portions are plains, on which are found scattering Piñon and Cedar. It is estimated that one-fourth of the forest land is fully stocked—good for timber; one-eighth brush of promising growth, and one-eighth made waste by burning.

Pine, Piñon, and Cedar are the leading species. Brush and dwarf trees (mainly Cedar) are scattered in clumps over the whole county, but the heavy timber is mostly in the north and west, on the Greenhorn and Sangre de Christo Mountains. It is stated that less than one-hundredth part of the forest area is stocked with trees fit for timber.

Forest fires are frequent in the mountains of this county, destroying great quantities of timber.

JEFFERSON COUNTY.

(Area, 760 square miles; estimated forest area, 175 square miles.)

This county lies in the north-central part of the State, to the eastward of and at an average distance of 25 miles from the main Rocky Mountain range. In the eastern half of the county are plains and low foot-hills; the remainder is mountainous, and includes the narrow valleys of Coal, Clear, Bear, Elk, Cub, and Turkey Creeks, and the South Platte River.

"About 400 square miles in the mountains are two-thirds clad with forest. Not over 150 square miles abound in good timber. About 40 square miles is burned, dead, or wasted timber land; the rest is cleared or covered with young Poplar, Pine, or Spruce. The proportion of forest to other lands is about one-fifth."

The principal species of forest trees are Yellow, Fox-tail, and Scrub Pine, White Fir, Douglas Fir, Piñon, Cottonwood, Aspen, Hackberry, and Box-elder.

" Fires have destroyed in twenty years more timber than has been used in that time for lumber and fuel. The only protection possible is by a skillful body of forest police, to be established by the State, either alone, or in co operation with the General Government. Such a police force should not only prevent destructive fires, but should have rigid supervision of mills sawing lumber on public lands. There should be penalties for the careless use of fire by hunters, mill-men, and others. There is a feeling of general indifference, unless aroused by self-interest, concerning such fires. No one should be allowed to waste the forests any more than other public property.

The chances for the renewal of forests are good, if fires are prevented from burning the waste and remnants of lumbering and clearing. The second growth is Aspen, the two kinds of Pine common everywhere, and Douglas and White Fir. After fires follow Aspen, with low Vine Maples and Willows; then common Pine.

For several years after 1860 I noticed changes in the volume of water in the streams. Since 1870 I have observed that a large growth of Pine and Poplar clothes the burned surface of the mountains on Bear and Clear Creeks, thus rendering sudden floods less violent than formerly. Since 1879 Clear Creek has had a more steady flow. I gauged that creek very closely from 1860 to 1872. I think the water supply in the months of August, September, and October of those years decreased. This was due, I think, to mining and the clearing of timber. Since that time a slight increase is perceived.

LAKE COUNTY.

(Area, 420 square miles; estimated forest area, 200 square miles.)

This county, of which Leadville is the county seat, is situated at a high elevation in the mountain ranges of central Colorado. Within its borders are a number of small lakes; and here also are the sources of the Arkansas River.

The forest lands of the county are mainly on the mountains forming its eastern and western borders. About one-fourth of the forest land is fully stocked, good for timber; one-fourth is brush of promising growth, and the remainder has been made waste by burning. Pine and Spruce are the predominant trees.

Very destructive forest fires have occurred in this county. After the destruction of the forests there is but little chance for their renewal.

LA PLATA COUNTY.

(Area, 4,000 square miles; estimated forest area, 1,500 square miles.)

This county, in southwestern Colorado, is 95 miles in extent from east to west, by 42 from north to south, and is situated on the southern slope of the San Juan Mountains. Its streams flow southward from fertile valleys, the principal ones being the Piedra, Los Pinos, Florida, Animas, La Plata, Mancos, Montezuma, and Dolores. The elevations are from 4,800 to 14,056 feet above the sea. The general altitude of the agricultural belt is 6,500 feet. The northern part of the county is rugged and broken, but the southern slope, dropping into long mesas and broad valleys, is well adapted to grazing and agriculture.

The northern and western portions of the county are well timbered. About 65 per cent. of the same is fully stocked; 25 per cent. is brush of promising growth, and the remainder made waste by burning.

The forest growth is Spruce and Fir, large and abundant, in the mountains; excellent Pine in the middle belt; and Cedar and Piñon in the south, interspersed with broad stretches of sage brush. After the destruction of forests, especially when caused by fire, their renewal is very slow.

The volume of water in the streams of the county has not changed, but high water is higher and low water is lower than formerly, due perhaps to loss of timber, causing less absorption and a more rapid flowing off of rain-fall. The forests cause a greater rain-fall, and absorb and more evenly discharge the water supply.

The snow-fall at Durango is often 6 feet in depth, beginning about the 1st of December and lasting until the 1st of April. In the mountains the fall in 1882-'83 was 45 feet, beginning on the 1st of October and lasting until the 1st of May.

LARIMER COUNTY.

(Area, 4,000 square miles; estimated forest area, 700 square miles.)

This county, lying immediately east of the main Rocky Mountain range, upon the northern border of the State, includes within its limits North Park. Its surface is greatly varied, embracing plains, mountains, and valleys. From range lines 69 and 70, in the eastern part of the county, the country rises rapidly to the summit of the Medicine Bow range, thence falls to the center of North Park, and rises again to the crest of the main range or Continental Divide. The prominent streams are the Little Thompson, Big Thompson, Cache la Poudre, Big Laramie, and the North Fork of Platte River.

The heaviest timber in the county runs through the central part, covering the Medicine Bow range and the northern and eastern slopes of the Continental Divide. Of the entire forest area about 300 square miles is fully stocked—good for timber, although the timber would not be considered first-class for commercial purposes, it ranging from saplings to trees 2 feet in diameter. White and Black Pine, White Spruce, and Hemlock are the predominant species. Cottonwood is found along the streams in the valleys, and Aspen in places on the mountain slopes.

Forest fires and the consumption and waste for railway purposes are the greatest dangers threatening the forests. There is very little chance for renewal after the forests have been destroyed. It is stated that 60 sections of forest land were burned over in the summer of 1886.

LAS ANIMAS COUNTY.

(Area, 6,500 square miles; estimated forest area, 500 square miles.)

This county, situated in the southeastern corner of the State, embraces four distinct topographical regions, viz:

First, the Park Plateau, which includes about 800 square miles in the extreme western part of the county, sloping from the Culebra Mountains eastward to Trinidad. Its elevation is 6,500 to 10,000 feet, and it consists of a sloping plain, broken by numerous canyons into narrow and rocky ridges.

Second, the Raton Hills, embracing a strip of basalt-covered Mesa, from 6 to 15 miles wide, and 120 miles long, extending along the southern boundary of the State, from Trinidad eastward. Elevation 6,000 to 9,000 feet; area, 1,000 square miles.

Third, the "Plains," comprising an area of 3,000 square miles, including nearly the entire eastern half of the county. This is a flat, nearly level country, sloping to the east. About 95 per cent. of its area has a rich, loamy soil; the remaining 5 per cent. is sandy. There is no water for irrigation. Elevation, 4,500 to 5,000 feet.

Fourth, the west-central division, or Purgatoire region, embraces an area of about 2,400 square miles, mostly of rough, broken prairie. Elevation, 5,000 to 6,300 feet. The drainage is to the northeast, by the Purgatoire and Apishipa Rivers, through deep, narrow canyons.

The forest lands are situated mainly in the western part of the county.

There are small forest areas in the Raton Hills, and along the canyon of the Purgatoire River. But a small proportion of the forest is fully stocked—good for timber, and probably one-sixth has been made waste by fire.

The principal species of trees are: On the southern slopes, at about 9,500 feet elevation, Aspen; from 8,000 to 9,000 feet, Yellow Pine and White Spruce; from 5,000 to 7,000 feet, Piñon and Cedar. On northern slopes, the range of each species is 1,000 feet lower. Along the streams are found Box Elder, Cottonwood, and Willow at various elevations; in the higher altitudes Pine and Spruce predominate.

Lumbering and fires are the special dangers threatening the forests. Fully one-third of all the Pine timber in the county has been cut and removed. Destructive forest fires are likely to occur from the dead tops and lops of trees cut for lumber and left scattered on the ground, although during the last few years such fires have been infrequent. After the forests have been destroyed, the chances for their renewal are very slight, except in comparatively moist situations above 9,000 feet elevation. The second growth is usually Aspen or Scrub Oak.

LOGAN COUNTY.

(Area, 3,000 square miles.)

This is a newly organized county, and is situated in the Plains region, in the northeastern corner of the State. The South Platte River flows through it. It has no forests. The county is being rapidly settled by a good class of farmers, and the subject of tree-planting is likely to receive due attention.

MESA COUNTY.

(Area, 3,850 square miles; estimated forest area, 275 square miles.)

This county is situated upon the western border of the State. It is watered by the Grand, Gunnison, and Rio Dolores Rivers, and their tributaries. The valley of the Grand River, which is here from 8 to 10 miles long and 30 miles wide, constitutes the main body of arable land in the county. East of Grand Junction, the Grand Mesa, 9,000 to 10,000 feet above the sea, and Plateau Creek Valley, 6,000 to 8,000 feet elevation, are covered mostly with Grass, Cedar, and Piñon. The county is broken by deep canyons, but affords good range for stock.

The main body of timber is on Piñon Mesa, the head waters of East and West and Rio Dominguez Creeks. South of the Grand and Gunnison Rivers, Yellow Pine and Spruce abound. A great part of the county, outside of Grand Valley, is covered with a scattering growth of Pine and Piñon. There is but little good timber. Along some of the streams are found Cottonwood and Box Elder. Aspen is plentiful in some localities.

MONTROSE COUNTY.

(Area, 2,040 square miles; estimated forest area, 640 square miles.)

This county adjoins Mesa County at the south and east. The Gunnison, Uncompahgre, San Miguel, and Rio Dolores are its principal rivers.

The forest land is situated mainly in the central part of the county. About one fifth of its area includes good timber. There is no brush of promising growth, and no portion made waste by fire. The trees are mostly Pine and Spruce of good size and quality. Aspen, Cottonwood, and Oak are small.

Lumbering is the special danger threatening the forests. If they are destroyed it is doubtful if they will ever be renewed.

OURAY COUNTY.

(Area, 190 square miles; estimated forest area, 110 square miles.)

This county is situated in southwestern Colorado, upon the western slope of the Main Range. The timber is pretty well distributed; it is said the best is found in the vicinity of Ouray, and in the northwestern part of the county. The forest growth consists of Yellow Pine, Fir, Piñon, Cedar, Cottonwood, Box Elder, Aspen, and Oak. Spruce and Aspen predominate in the mountains; on the hill sides, Cedar and Piñon.

After the forests have been destroyed the second growth, if any, is usually Cedar and Piñon. It is difficult for trees of any kind to start after fire has run over the ground.

PARK COUNTY.

(Area, 21,000 square miles; estimated forest area, 600 square miles.)

This county is in the geographical center of the State. A magnificent mountain park, called South Park, covers a large part of its area. On the west it is bordered by the Main Range. The principal streams which find outlet at the northeast are Tarryall Creek and the North and Middle Forks of the South Platte River.

The forest land of the county lies chiefly upon its western and northern borders. The timber consists largely of Pine and Spruce, the latter predominating. Of the forest area about one-fourth is good timber, and about one eighth made waste by fire. The remainder is composed of small growth and brush.

Concerning the effect of forests upon the water supply, it is stated that many of the small streams which were never known to fail in 1873–'84, and prior to that time, now fail about the last of July or the the first of August. It is believed by some that the snow-fall is lighter than in former years.

PITKIN COUNTY.

(Area, 1,090 square miles; estimated forest area, 540 square miles.)

This county is situated in west-central Colorado. It is bordered upon the east and southwest by the Saguache and Elk Ranges, respectively. It is abundantly watered by the Roaring Fork River and its tributaries.

The forests are well distributed over the county, the heaviest timber being found in the mountains. Pine, Spruce, Piñon, and Cedar are the principal species. They vary greatly in size; Pine predominates.

Fire, lumbering, and snow slides have been destructive to the forests; as yet railroads have caused little injury. The chances for renewal after the forests have been destroyed are poor. Scrub Oak, Aspen, Cottonwood, and various other small trees and shrubs constitute the second growth.

No changes have been observed in the volume of water in the streams. That is largely influenced by the fall of snow in the mountains.

PUEBLO COUNTY.

(Area, 2,350 square miles; estimated forest area, 125 square miles.)

This county, which borders the Plains Region in southeastern Colorado, is drained by the Arkansas River. About four townships in the southwestern corner are mountainous; the remainder of the county consists of plains much broken by bluffs or buttes, and deep, rocky ravines. Most of the county east, southeast, and north of the city of Pueblo lies in fair shape for cultivation.

The forest lands are mostly situated in the valleys of the Arkansas, Huerfano, Saint Charles, Fontaine qui Bouille, and in the western and southern parts of the county. A small portion, perhaps one-tenth, is fully stocked; good for timber.

Cottonwood is found in the valleys, Pine, Piñon, Cedar and Spruce in the high lands. The estimated area of forest lands includes the Cedar Bluffs, which are properly timber lands, and probably more valuable than any other, as the wood is used extensively for fencing. The Cottonwood timber is but little used. In the southwestern part of the county there are Pine and Spruce, but limited in amount; also some Oak and Aspen. That portion of the county has furnished the inhabitants with timber and lumber for more than twenty years.

The prospects for renewal of the forests after they have been destroyed are not promising, especially on the Cedar and Piñon lands. The second growth is usually the same as the original.

The flow of water in the streams is more intermittent than formerly

RIO GRANDE COUNTY.

(Area 1,300 square miles; estimated forest area, 275 square miles.)

This county is situated in the southwestern part of the State. The river Rio Grande del Norte enters near the northwest corner and flows through the county in a southeasterly direction. The valleys of the Rio Grande and its tributaries include good agricultural land, and the most easterly tier of townships are of like character. The remainder, and especially the western portion, is mountainous and covered with Spruce, Aspen, Pine, Piñon, and Cedar timber. The narrow-leafed Cottonwood grows abundantly and luxuriantly in the Rio Grande Valley, east of the South Fork.

Some years ago the Ute Indians destroyed many forest trees by removing the bark; they also caused many forest fires. Of late years lumbermen have taken more or less of the timber, and mining operations have been very destructive to forest growth.

The flow of water in the streams early in the spring is greater than formerly, probably owing to destruction of the forests, which occasions early melting of the snows.

ROUTT COUNTY.

(Area, 6,200 square miles; estimated forest area, 1,050 square miles.)

This county is situated in the northwest corner of the State. It is traversed from east to west by the Yampah River. This, with its tributary streams, constitutes its water system. The surface of the county is mountainous; the valleys for the most part are deep, and from one-half to one and a half miles wide. Several large parks are included within its boundaries.

The forests are found mostly in the eastern part and in the northwestern corner. The heaviest timber grows in the main range, extending along the eastern border of the county. About 25 per cent. of the forest area is good growing timber; 25 per cent. Aspen and Oak-brush, good mainly for fuel; and the remainder has been killed by fire.

The timber consists of Pine, Spruce, Balsam, Aspen, and, along the streams, Cottonwood. There are some fine trees, but of medium size. Pine and Spruce predominate.

SAGUACHE COUNTY.

(Area, 3,150 square miles; estimated forest area, 1,175 square miles.)

This county is situated in south-central Colorado. The Sangre de Christo Range forms its eastern boundary, and the Main Range passes diagonally through the western portion. The San Luis and Saguache Rivers and Cochetopa Creek are its principal streams.

The timber lands are mainly on the mountain ranges at the north and east. The forest growth consists of medium-size Pine, Spruce, Piñon, and Cedar, with Cottonwood in the valleys along the streams. About one-tenth of the forest area is fully stocked; good for timber.

Railroads and fires are the principal dangers threatening the forests. The replacement of forest growth is very slow. The second growth is usually the same as the original. The adoption of measures for the prevention of forest fires is strongly urged.

No particular changes in the flow and volume of water have been observed. High water has prevailed during the past three seasons.

SAN JUAN COUNTY.

(Area, 450 square miles; estimated forest area, 100 square miles.)

This county is situated in southwestern Colorado, in the San Juan Mountains, which form a part of the Main Range. Nearly one-half of the area of this county is above the timber line. Its elevation is from 8,400 to 14,000 feet above sea level. It is drained by the Animas River and tributaries, excepting a small portion on the east, which is drained by the headwaters of the Rio Grande.

Timber is found on nearly two-thirds of the area below the timber line, which equals about one-third the total area of the county.

The forest growth consists principally of Pine, Spruce, Balsam, and Aspen, and is situated in the valleys and on the lower parts of the mountains. Fifty to 75 per cent. of the forest is said to be good timber, the trees having an average diameter of 12 to 24 inches. About 20 per cent. has been made waste by burning. There is very little brush or new growth.

The second growth, if any, is Aspen. Much of the timber is inaccessible. That which can be reached is likely to be used, as at present, for mining purposes and fuel. Lumber for building is now obtained from the adjoining county of La Plata.

The county lies at so high an altitude that there is scarcely any agriculture. The land in cultivation embraces about one and a half acres.

SAN MIGUEL COUNTY.

(Area, 1,375 square miles; estimated forest area, 260 square miles.)

This county lies in southwestern Colorado, its western extremity reaching the Utah line. Its surface descends toward the northwest. The principal streams are the Dolores River and tributaries, most of which flow through cañons, with precipitous banks. The San Miguel Mountains, a high range, form the east and southeastern boundaries of the county.

In the eastern part of the county is a dense growth of Spruce and Aspen, about 10 per cent. of the first named being good saw-timber.

The western part of the county is mostly mesa land, with scattering Piñon and Cedar, and in some parts a heavy undergrowth of Oak-brush. White Spruce is the predominant wood in the county.

The timber line varies from 10,500 to 11,000 feet. From the timber line down to about 9,000 feet the timber is chiefly Spruce and Fir; from 9,000 to 8,000, Aspen; 8,000 to 7,000, Aspen and Pine; 7,000 to 6,000, Aspen, Piñon, Scrub Oak, and Cottonwood. The mesas are mostly devoid of timber, except occasional groves of Aspen on the higher ones.

SUMMIT COUNTY.

(Area, 750 square miles; estimated forest area, 275 square miles.)

This county is situated in the north-central part of the State, on the western slope of the main range. The forests are located mainly on the mountain slopes at the east and south, and along the streams. The best timber is found in the mountain region. The forest growth consists of White Spruce, Balsam, Pine, Hemlock, Cedar, Piñon, Aspen, Narrow-leafed Cottonwood, Black Birch, Alder, and Willow. The Spruce, Pine, Hemlock, and Balsam grow large enough for lumber.

The special dangers threatening the forests are lumbering, railroads, and the careless use of fire by campers and mill employés. Quite a large part of the forest on the northeast side of Blue River has been burned over; also that on the Snake River, a tributary of the former. It is stated that before the settlement of the county forest fires destroyed 60 square miles of timber. There are in some places promising second growths, which are usually Pine, Spruce, and Aspen. After fire, Aspen usually follows, although in many places, on southern exposures, Pine is the most abundant.

As yet there is no noticeable change in the flow of water in the streams. The existing forest affords ample protection to the snow from solar heat, while the high altitude also prevents rapid melting. The lowest elevation in the county, near Blue River bridge at Green Mountain, is 7,600 feet.

For the more adequate protection of forests, it is said the people should be taught the importance of preventing forest fires, and that notices relating to the extinguishment of camp fires, etc., should be posted in all prominent places. People are more careless than malicious in allowing fires to spread.

"Keep up the cry, 'Preserve the forests,' and the people will heed it after awhile; you can not coerce, but it is possible to teach."

There is no land in the county suitable for agriculture, and there are no irrigating ditches.

WASHINGTON COUNTY.

(Area 2,220 square miles.)

This is a newly organized county, in the plains region of northeast Colorado. It has no native timber, unless it is a slight growth of Cottonwood along some of the streams.

WELD COUNTY.

(Area, 5,300 square miles.)

This county is situated in the northeastern part of the State. Its surface is mostly rolling plains, intersected by the South Platte, Cache la Poudre, Big and Little Thompson, and St. Vrain Rivers, and numerous small creeks. There is but little timber in the county except a scattering growth of Cottonwood along the Platte River, which extends through the county from west to east. There are small groves of Cottonwood and fruit and ornamental trees in union colony, Greeley.

NEW MEXICO.

The Territory of New Mexico extends from the thirty-second to the thirty-seventh degree of latitude, and from the one hundred and third to the one hundred and ninth parallel of longitude—embracing a superficial area of 122,500 square miles. It has the form of a parallelogram, with sides 350 miles in length. It is situated upon the southeastern border of the Rocky Mountain plateaus, and has an average or mean elevation of 5,600 feet above the level of the sea. The principal surface features of the country are extensive table-lands, or mesas, wide and sandy plains, mountains, foot-hills, and valleys.

The mountain system, which in Colorado is so intricate, including scores of rugged ranges and lofty peaks, becomes in New Mexico more simple. The ranges here are not so massive, are less in number and elevation, and more widely separated one from another. The mountain chains, diverging at the northern border, spread fan like over the Territory, and in broken lines flank upon either side the valley of the Rio Grande, which traverses the entire region from north to south. Detached groups and solitary mountains are seen at many points. Though all belong to the Rocky Mountain system, they are each distinguished by local names.

In the southeastern part of the Territory is the Llano Estacado, or Staked Plain, an elevated, arid region, which also extends into the adjoining State of Texas. The soil here is apparently barren, but produces abundantly the Mesquit (*Prosopis juliflora*), a small but deep-rooted and valuable tree or shrub. The land would yield good crops if water could be had for irrigation.

The general surface of the Territory has an elevation of about 5,000 feet in the northwestern portion, and thence descends toward the southeast, where at the lowest point it is only about 3,000 feet above sea-level.

"The fall of the Rio Grande, from the northern border of the Territory to the point where it cuts the New Mexico, Texas, and Chihuahua boundaries, is about 3,500 feet. The ranges generally rise from 2,000 to 5,000 feet above the mesas and high table-lands. Mount Baldy, 18 miles from Santa Fé, is 12,202 feet high; Mount Taylor, in the Sierra Mateo, is 11,200 feet high.

The Rio Grande, Rio Pecos, Canadian, and San Juan are the principal rivers of the Territory. The first rises in the mountains of southern Colorado, crosses the northern border of New Mexico at a central point, and follows a nearly direct course through the Territory to its southern boundary. This stream is not navigable at any point within the Territory. The valley of the Rio Grande, having an average width of 8 or 9 miles and a length of about 400, includes large areas of most excellent farming and fruit lands. The Rio Pecos, a large affluent of the Rio Grande, drains the mideastern and southeastern portions of the Territory, and the Canadian River and its tributaries the northeastern portion. The western part is drained by the San Juan, Zuñi, Gila, and other affluents of the Colorado River of the West. No lakes of considerable size have as yet been discovered in the Territory.

The water-courses of New Mexico, compared with those of her northern neighbor, Colorado, are few and of small volume. In the last-named State at least ten large and powerful rivers rise in the central mountain region, and, re-enforced by numerous tributaries, pass to and beyond the borders of the State. In New Mexico but two rivers, the Rio Grande and Rio Pecos, flow for a considerable distance within the limits of the Territory. The two other important streams, the Rio San Juan and Canadian, flow, respectively, through the northwestern and northeastern corners of the Territory. The San Juan River, as well as the Rio Grande, rises in southern Colorado.

"It is not uncommon for a river to be considerably larger toward its source than at its mouth. Many of the important streams that flow from the Black Hills into the Missouri are lost on their way through the plains; this is especially the case with rivers in the arid regions of New Mexico and Arizona."

The high mountains of the Main Range extend southward into New Mexico for a distance of about 100 miles, reaching the neighborhood of Santa Fé. South of this there is a semi-tropical region. "There is of necessity a wide difference in the extremes of temperature, but with the exceptions of the cold seasons of the higher lands at the north, the climate is temperate and equable. The summer days in the lower valley are sometimes quite warm, but as the dry atmosphere rapidly absorbs the perspiration of the body, it prevents the debilitating effect experienced where the air is heavier and more saturated with moisture. The nights are cool and refreshing. The winters, except in the mountains at the north, are moderate, but the difference between the northern and southern sections during this season is greater than during the summer. The snow-fall is small in amount, and seldom remains on the ground longer than a few hours. The rains fall principally during the months of July, August, and September, but their annual amount is small, seldom exceeding a few inches. When there are heavy snows in the mountains during the winter there will be good crops the following summer, the supply of water being more abundant, and the quantity of sediment carried down greater than when the snows are light."

As a general statement, it may be said that the semi-arid conditions which prevail in Colorado and the northern Territories of the Rocky Mountain region, are intensified in New Mexico. The more southern situation, and the comparative absence of high mountain ranges, forests and streams all contribute to the aridity of this region. Hon. Edmund G. Ross, governor of New Mexico, in his annual reports for 1885 and 1886 to the Secretary of the Interior, very justly urges the pressing need of constructing, in or adjacent to the mountains of that Territory, reservoirs for the storage of water. He refers to the droughts and floods with which this, in common with other parts of the West, has been afflicted, and suggests that a system of storage basins, near the head-waters of the various streams, would not only prevent destructive floods, insure supplies of water for irrigation and reclaim millions of acres now barren, but that the resulting increase in vegetable growth and conservation of moisture would also greatly modify the climatic conditions; that an increased degree of evaporation would be established, and the annual rain-fall regulated and equalized. In this connection the aid of the General Government is invoked. I most earnestly concur in the foregoing. There is urgent necessity for the systematic storage of water in most parts of the Rocky Mountain region, and especially in the southwestern Territories. Had the mountain forests been maintained the need of artificial reservoirs would not now be so great.

" The average rain-fall from 1870 to 1885, inclusive, has been as follows, at the points named, to wit:

	Inches.
Fort Bayard, in the southwest	15.30
Fort Union, in the north	16.74
Fort Wingate, in the west	15.52

"At Fort Stanton, in the southeast, the average has been about the same."

Although the principal forests of New Mexico are confined to the mountain chains, other parts of the Territory are more or less wooded. Upon the wide mesas, which form so prominent a feature of the southwest and western portions, are found scattering growths of Cedar,

NOTE.—It is estimated that New Mexico has irrigating canals and ditches equal in extent to those of Utah, irrigation having been practiced in a rude way in this Territory long before it came into the possession of the United States. Two large irrigating canals are now projected, one on each side of the Rio Grande, capable of watering from 3,000,000 to 4,000,000 acres.

Juniper, and Piñon; while the *arroyos*, or depressions in the mesas, contain fine groves of Mesquit. In the mountain valleys, gulches and canyons, are Yellow Pine, Piñon, Dwarf Maple, and Scrub Oak. On the higher ranges, at the north, in addition to the Pines, are found the White Spruce and Red Fir. Juniper is common on the foot-hills of this section. The river valleys are lined with Cottonwood, Box-Elder, several varieties of Willow, Alder, Ash, Sycamores, Cherries, and Mulberries. On the southern plains, or wide sandy valleys, the prevailing growths are Yucca, Madroña, and Palo Verde (acacia). On mountain slopes the second growth is often Aspen. The elevated plain, which occupies the eastern portion of the Territory, has no forests, and is practically treeless. The finest timbered region in New Mexico is in the southwestern part, and includes the Magdalena, Mogollon, Sierra Diablo, and other high ranges. Large bodies of Pine, Spruce, and Fir, suitable for lumber, are found here. In the northern mountains, at the headwaters of the Rio Pecos, there is some excellent timber.

Viewing the Territory as a whole, the Yellow Pine is the most important and useful tree, and furnishes a large proportion of the native lumber.

The following is a list of the forest trees of New Mexico:

Yellow Pine (*Pinus ponderosa*, Dougl.).
White Pine (*P. reflexa* and *P. flexilis*, Engelm.).
Black Pine, or Tamarack (*P. Murrayana*, Balfour).
Pinus Chihuahuana, Engelm.
Piñon, or Nut Pine (*P. edulis*, Engelm.).
White Spruce (*Picea Engelmanni*, Engelm.).
Red, or Yellow Fir (*Pseudotsuga Douglasii*, Carr.).
White, or Balsam Fir (*Abies concolor*, Lindl. and Gordon).
Juniper (*Juniperus pachyphloea*, Torr.).
Juniper (*Juniperus occidentalis*, Hook. var *monosperma*, Engl.).
Red Cedar (*Juniperus Virginiana*, L.).
Cypress (*Cupressus Guadalupensis*, Watson).
Sycamore (*Platanus Wrightii*, Watson).
Box Elder (*Negundo aceroides*, Moench).
Dwarf Maple (*Acer glabrum*, Torr.).
Dwarf Maple (*Acer grandidentatum*, Nutt).
Ash (*Fraxinus pistaciæfolia*, Torr.).
Walnut (*Juglans rupestris*, Engelm).
Black Oak (*Quercus Emoryi*, Torr.).
Locust (*Robinia Neo-Mexicana*, Gray).
Mesquit (*Prosopis juliflora*, D. C.).
Cottonwood (*Populus monilifera*, Ait.).
Cottonwood (*P. angustifolia*, James).
Cottonwood (*P. Fremontii var. Wislizeni*, Watson).

NOTE.—Estimates of forest areas differ widely for the same region. This results from the difference in the competency and carefulness of the observers, and from the fact that there is no accepted standard of estimate. Some include in forest lands not only those tracts which are densely or mainly covered with trees, but also grazing lands on which may be found only a few scattering piñons or cedars. The estimates here given of the forest areas of New Mexico, as indeed all the estimates of forest areas embodied in this report, are designed to embrace only those which are strictly forest clad. The constant endeavor has been not to overestimate in this respect.

Aspen (*P. tremuloides*, Mich.).
Willow (*Salix flavescens*, Nutt).
Willow (*S. lasiandra*, Benth.).
Desert Willow (*Chilopsis saligna*, D. Don).
Alder (*Alnus oblongifolia*, Torr.).
Wild Cherry (*Prunus Capuli*, Cav.).
Mountain Mahogany (*Cercocarpus ledifolius*).
Mountain Mahogany (*C. parvifolius*, Nutt).
Black Thorn (*Cratægus tomentosa*, L.).
Spanish Buckeye (*Ungnadia speciosa*, Endl.).
Wild China or Soap' erry (*Sapindus marginatus*, Willd).
Spanish Bayonet (*Yucca baccata*, Torr.).
Madroña (*Arbutus Xalapensis*, H. B. K.).
Palo Verde or Greenbarked Acacia (*Parkinsonia Torreyana*, Watson).
Mexican Mulberry (*Morus mycrophilla*, Buckley).

It has been estimated that the amount of native lumber used in the Territory in the year 1886 was 5,000,000 feet. About 1,000,000 feet were imported from Arizona, and used for all purposes, including finishing. Of high grade Eastern and California lumber, about 50,000 feet of each kind were consumed during that year. Some 200,000 feet of different grades were brought into southern New Mexico from northern Texas during the period named. The consumption of lumber for that year was comparatively light.

Farming and fruit-growing are carried on quite extensively in different parts of the Territory generally with the aid of irrigation. Most of the ditches, however, are small. In some of the mountain districts crops are grown without the aid of irrigation.

The Territorial law provides for the punishment of persons who shall willfully or maliciously set on fire any woods, marshes, prairies, or other grounds not their own, or who shall intentionally or by neglect permit the spread of fire from their own grounds to those of another; also, that satisfaction in damages may be recovered by parties injured by such fires.

New Mexico is subdivided into fourteen counties, the relative situation of which, upon the map, is about as follows:

San Juan.	Rio Arriba.	Taos.	Colfax.
Bernalillo.	Santa Fé.		Mora.
Valencia.			San Miguel.
Socorro.			
Sierra.			Lincoln.
Grant. Dona Ana.			

BERNALILLO COUNTY.

(Area, 8,350 square miles; estimated forest area, 1,450 square miles.)

The Rio Grande River traverses the eastern part of Bernalillo County from north to south. Its principal tributaries are the Rio Galisteo on the east, and the Rio Jemez and Rio Puerco Rivers at the west. In addition to the above, there are numerous springs, and a few small streams of more or less permanence. The Rio Grande is the most important valley, and includes a large area of agricultural land. To the westward of this valley the county is rolling and broken by hills and canyons. It has grass lands and some timber, and is well adapted for grazing purposes. The Sandia Mountains occupy the eastern and the Jemez Mountains the central portions of the county.

Upon the mountains named above are situated most of the forests. About one-fourth of the forest area has good timber, and as much more has a promising young growth. Open forests of Yellow and White Pine and Red Cedar extend from the northeastern corner of the county westward to the Jemez River. The principal species of trees, in addition to those named above, are Scrub Oak and Piñon, the latter predominating.

But little change, if any, has been observed in the volume of water in the streams of this county; the flow is more intermittent than in former years, and floods have become more frequent.

COLFAX COUNTY.

(Area, 7,000 square miles; estimated forest area, 1,275 square miles.)

This county is situated in the extreme northeastern corner of the Territory. It is bordered on the west by the Main Rocky Mountain range, and its surface, as a whole, is greatly varied. Mountains, single and in groups, hills, buttes, rolling lands, mesas, and valleys are embraced within its limits. Numerous streams, the most important of which are the Cimarron and Canadian Rivers, traverse the region. This, with the fine growth of grass, makes it one of the best grazing districts of the west.

The forest lands are situated principally in the western part of the county and constitute about one-fifth of the entire area. Nearly 10 per cent. of the timber is Pine and Spruce of medium size. The remainder is mostly Aspen, Scrub-Oak, Piñon, and Dwarf Cedar. Cottonwood grows along the streams.

There is less water in the streams in summer than there was fifteen years ago. Floods and droughts have become more frequent.

DONA ANA COUNTY.

(Area, 10,260 square miles; estimated forest area, 75 square miles.)

Dona Ana is the central county of the southern tier bordering on Texas and Mexico. It is, in general terms, a strip of table land about

4,000 feet above the sea level, from which rise a number of mountain ranges. These ranges are from 20 to 50 miles long, and seldom exceed 10 miles in width. Between them are great plains, from 20 to 80 miles wide, treeless and almost waterless, but generally covered with grass and affording pasturage for stock. The Rio Grande del Norte flows through the center of this region, forming a rich alluvial valley about 5 miles in width and sunken some 200 feet below the surrounding plains. It includes the famed "Mesilla Valley," a district noted for its fine fruits and immense crops of cereals. Between the valley of the Rio Grande and the Organ and San Andres Mountains at the eastward is a desolate region known as the "*Journanda del Muerto*" (Journey of Death). With the exception of the valley of the Rio Grande, which includes some 300 square miles of alluvial land that may be irrigated, but a small portion of the county is adapted to the production of crops.

There is but little timber in this county, and it is mostly confined to the higher portions of the Organ and Sacramento Mountains. Pine, Fir, Cedar, and Juniper are the principal species growing in the mountains, and forming forests. The first two are used to a limited extent in the manufacture of lumber. Piñon, Oak, Ash, Mesquit, Cottonwood, and Willow are also native to this region. Oak and Ash are used in wagon and carriage work.

When the forests are destroyed, there is absolutely no chance for their natural reproduction, and the denuded tracts become barren wastes.

GRANT COUNTY.

(Area, 10,090 square miles; estimated forest area, 800 square miles.)

Grant county is in the southwestern corner of the Territory, bordering on Mexico. The northern portion is mountainous, and includes the sources of the principal streams, the Rio Mimbres and Gila River. The southern half of the county consists mainly of plain and mesas, and has an average or mean elevation of about 5,000 feet. The great plateau of the Sierra Madre extends into the southeastern portion of the county. A little farming is carried on in the large valleys, but stock-raising and mining are the chief industries.

The largest bodies of timber are situated in the Black Range, Mimbres, Pinos Altos, and other mountains in the northern part of the county. The Florida Mountains upon the eastern border, and the Hades and Peloncillo Mountains in the southwestern portion, are also wooded to some extent. About one-tenth of the forest area is well stocked. Pine and Juniper are the predominant species of forest trees and attain a good size. A scattering growth of Scrub Oak is found on the mesas and Cottonwood fringes the streams in some places. The forests proper are rarely dense; there is but little undergrowth, and the loss incurred from forest fires is inconsiderable. In fact, fires in this section are more destructive to the stock ranges than they are to timber.

The demand for lumber causes the consumption of the Pine timber as fast as it can be reached. Much of the best Pine is situated at points in the mountains not now accessible, and for the present it is likely to be spared. After the forests have been destroyed their reproduction can hardly be hoped for; the region is too arid to favor a new coniferous growth.

LINCOLN COUNTY.

(Area, 24,450 square miles; estimated forest area, 920 square miles.)

This county is situated in the southeast corner of New Mexico. Along its western border are the Sierra Blanca, Sacramento, Guadalupe, and other mountain ranges; the central and eastern portions extend into the plains region. The Rio Pecos River flows through the entire county from north to south, and midway in its course is joined by its main affluent, the Rio Honda River, which enters it from the west. That part of the county east of the Rio Pecos is very scantily watered, a few springs and wells being the only source of supply. Stock-raising is the chief industry, for which the county is well adapted. A large body of tillable land lies along the valley of the Pecos for a distance of about 200 miles, and along the tributaries of the river for a distance of some 300 miles.

The forests of the county are confined mostly to the mountains of the western portion. About one-fourth of the forest area includes good timber; the remainder has a small growth suitable only for fencing and fuel. Forest fires have, as yet, done but little damage. Pine, Spruce, Piñon, and Cedar constitute the bulk of the forests. The first two are used in the manufacture of lumber. Spruce is found at the greater elevations; it grows large and often forms dense forests. Piñon, "Scrub Pine," and Cedar are the most prevalent trees. Other trees native to this county are Oak, Yucca, and Madroña.

Settlers who have taken timber-culture claims, generally plant Cottonwood, cultivating them in all cases with the aid of irrigation.

MORA COUNTY.

(Area, 3,830 square miles; estimated forest area, 720 square miles.)

The altitude of this county varies from 4,000 feet in the extreme eastern portion to 7,000 feet at the base of the Rocky Mountain range in the west, and some of the high peaks attain an elevation of 11,000 to 12,500 feet. About one-fourth of the surface of the county in the western part is mountainous; the remaining three-fourths extends into the Plains Region, and is an open rolling country, varied to some extent by hills and buttes. The Canadian River, passing from north to south through the central portion, is the principal stream. A number of creeks and arroyos water other portions.

The heaviest bodies of timber, consisting of Yellow and White Pine and Spruce, are found in the mountains. Here, also, are large tracts covered with Aspen. The trees of this species grow very straight, are from 10 to 40 feet in height, and are much used for fence poles. Upon the lower slopes and foot-hills the predominating species are Piñon, Cedar, and Scrub Oak; the latter sometimes growing to a height of 30 feet. The central portion of the county has scattered groves of Piñon and Cedar, with patches of Scrub Oak. The bluffs overhanging the streams are covered, to a limited extent, with Piñon, Cedar, Scrub Oak, Mesquit, and a few Pines. Cotton-wood, Box Elder, Hackberry, Mulberry, Wild Plum, and Wild Cherry line many of the water courses. The streams of the eastern portion are nearly bare of trees, the groves that once existed there having been destroyed by the early settlers.

RIO ARRIBA COUNTY.

(Area, 7,500 square miles; estimated forest area, 175 square miles.)

The eastern and central portions of Rio Arriba County are mountainous and well watered. The western portion is occupied by high mesas and plains, which here constitute the Continental Divide. The Rio Chama is the principal river traversing the county for any considerable distance. This and a few smaller streams discharge their waters into the Rio Grande, which flows through the southeastern part of the county. The valleys of the streams are fertile, producing fine crops of grain and vegetables, and yielding different kinds of fruit.

The forests, found mainly in the mountainous districts, consist chiefly of Yellow and Black Pine, with some Spruce at the higher altitudes. The timber is not dense, nor are the trees of large size. Cedar, Piñon, Scrub-Oak, Cottonwood, Willow, and Wild Cherry are also native to this county.

About one-fourth of the forest area has been made waste by fire, and as much more is brush of promising growth. After the destruction of the forests from any cause their renewal is extremely difficult.

Floods and droughts are more frequent than in former years.

SAN JUAN COUNTY.

(Area, 7,200 square miles; estimated forest area, 250 square miles).

This county has an elevation above sea-level of 7,000 feet. The San Juan Mountains border it at the north and the Chusca Mountains at the west. In the central and eastern portions are wide plains and mesas. The San Juan and Chusca Rivers and their affluents constitute the water system of the county.

The Chusca Mountains are fairly well timbered, Yellow and Black Pine being the predominant forest trees. A scattering growth of Cedar, Piñon and Scrub Oak is found on the foot-hills and mesas. Cottonwood, Willow, and Wild Cherry grow along the streams.

SAN MIGUEL COUNTY.

(Area, 11,630 square miles; estimated forest area, 1,300 square miles.)

The northwestern portion of this county, including about one-sixth of its area, is mountainous; the remaining part is an open, rolling country, embracing wide plains and extensive mesas. The surface slopes from the western boundary of the county to the Texas State line on the east, the average or mean altitude being about 5,000 feet above sea-level. The Canadian and Rio Pecos Rivers and their tributaries, which have their sources in the mountains at the north and west, constitute the drainage system.

The most important forests, consisting of Pine and Spruce timber, are situated in the mountains. It is estimated that about one-half of the forest area is well stocked, that most of the remainder is brush of promising growth, and that a small part has been made waste by fire. Scattering groves of Piñon, Cedar, and Scrub Oak are found on the foot-hills and mesas. Cottonwood grows along some of the water-courses.

No changes have been observed in the flow and volume of water in the streams.

SANTA FÉ COUNTY.

(Area, 2,490 square miles; estimated forest area, 1,375 square miles.)

Santa Fé County is situated in the northern-central part of the Territory. It is bordered at the northeast by the elevated crests of the Rocky Mountain range, which here reaches its southern limit. The surface of the county is finely diversified. It is a region of mountains, valleys, mesas, undulating plains, and swift running streams. The altitude varies from 5,500 feet on the mesas in the southern portion of the county, to 7,044 feet at the city of Santa Fé, and to 13,000 feet on Mount Baldy, of the Santa Fé range. The area of the county is quite equally divided between agricultural, fruit, grazing, and timber lands. The temperate climate, fine scenery, and other natural advantages, contribute to render this region most attractive and desirable for residence.

The forest lands are situated mostly in the eastern part of the county. There is a narrow strip of timber at the south called "The Placers," extending from the Placers to the east line of the county, and also a small wooded tract in the southwestern corner. About 30 per cent. of the forest area includes good timber; 20 per cent. is brush of promising growth; a portion has been burned over, and the remainder is an open growth of Piñon, Cedar, and Scrub Oak. Yellow Pine and Spruce are the predominating species in the mountains in the northeastern part of the county; in the more open country at the south and west, Piñon, Cedar, and Oak are the prevailing kinds. Cottonwood and Willow border many of the streams.

SIERRA COUNTY.

(Area, 3,200 square miles; estimated forest area, 250 square miles.)

This county is situated in southwestern New Mexico. Its surface includes mountains, valleys, and mesas. The Rio Grande River, its most important stream, traverses the east-central part from north to south, and its broad valley embraces a large section of arable land. The county is well watered, and the table lands of the western portion afford good pasturage.

The forests are mainly situated in the Black Range at the northwest. Pine and Fir are the predominant trees at the higher elevations; Juniper and Oak are found on the foot-hills and mesas, and a growth of Maple and Walnut borders some of the streams.

When the forests have been destroyed they are rarely, if ever, reproduced. The second growth is usually Scrub Oak.

The large streams are not as continuous in their flow as they were before the timber in the mountains was cut off. There are more floods and longer periods of drought. Many of the small streams have wholly failed.

SOCORRO COUNTY.

(Area, 16,500 square miles; estimated forest area, 2,050 square miles.)

This county has several classes of lands—the agricultural, which are found on the Rio Grande and other streams traversing the county; the uplands or mesas, especially adapted to grazing; and the mountain ranges, upon which the forests are mainly situated. In addition to the above, the San Augustine Plains, centrally situated, cover an estimated area of 2,000 square miles, and are wholly destitute of trees. In the eastern part of the county is a wide extent of desert, embracing barren plains, lava beds, treeless mountain ranges, and "Mal pais."

From one-third to one-half of the county is sparsely covered with forests, if all classes of growth are considered. Along the northern slopes of the Piñon and Datil Mountains, upon the Magdalena Mountains, the San Francisco and Mogollon Ranges, and on the higher portions of the Black Range are forests composed mainly of the Yellow and White Pine and Red, or Douglas, Fir. Extensive tracts of large Pines are rare, although there are a few in the western part of the county. About four-fifths of the entire forest area consists of a small growth of Pine, Cedar, Juniper, and Oak. Burned tracts of limited extent are common, but they are usually confined to the scrub growths. Aspen covers large areas in the mountains. Other species native to the region are Mountain Mahogany, several varieties of Oak, Walnut, Mesquit, Box-elder, Water Maple, Cottonwood, Willow, and Wild Cherry.

After the destruction of the forests, from any cause, there is hardly any chance for their renewal. Tracts burned over ten years ago are still barren.

TAOS COUNTY.

(Area, 2,300 square miles; estimated forest area, 900 square miles.)

This county is centrally situated upon the northern line of New Mexico. Its eastern boundary is the Main Rocky Mountain range. The Rio Grande River runs through the central part of the county, from north to south. Numerous small streams flow from the mountains at the eastward and unite with the Rio Grande. This district is the best watered of any in the Territory. The western portion of the county is more arid than the rest, but is well fitted for grazing purposes.

The forest land is situated mostly in the eastern and southern parts of the county, excepting a narrow strip along the western side. About five-eighths of the forest area is fully stocked—good for timber; the remainder consists of young growth and tracts made waste by burning. In the mountains are quite heavy bodies of Yellow, White, and Black Pine, Spruce, and Fir. Aspen also covers large tracts which have been denuded of the original species. At lower altitudes are Scrub Oak, Piñon, and Cedar, some of the latter being quite large. Cottonwood (*Populus monilifera* and *P. angustifolia*) borders many of the streams.

By a proper system of irrigation, at least one-half of the entire area of the county could be brought under cultivation. At the present time, only a very small proportion of the land is cultivated.

VALENCIA COUNTY.

(Area, 7,700 square miles; estimated forest area, 960 square miles.)

This county, which is situated in central New Mexico, extends from the western border three-fourths of the distance across the Territory. Near the center it is divided by the Rio Grande River, and at a few miles west of that point it is again intersected by the Rio Puerco River. These two streams, and the Zuñi River in the west, are the principal water-courses. Portions of the county are very broken and mountainous. The Zuñi and San Matéo Mountains at the northwest, and the Manzano Mountains east of the Rio Grande, are the most important ranges. Although farming and fruit growing are prosecuted to some extent along the valleys of the streams, the region, as a whole, is better suited for grazing than for other branches of husbandry.

Extensive forests of Yellow Pine exist in the mountains, both in the western part of the county and in the Manzano Range to the eastward. In the last named district the estimated forest area is 280 square miles, three-fourths of which bears good timber. Saw logs obtained here are from 2 to 4 feet in diameter. At lower altitudes Piñon, Cedar, and White and Scrub Oak abound.

UTAH.

As stated in the introduction, a full canvass of this Territory could not be made on account of deficiency of appropriation, and only the following résumé, therefore, is given:

The Territory of Utah comprises 84,476 square miles within the thirty-seventh and forty-second degrees of latitude and the one hundred and ninth and one hundred and fourteenth degrees of longitude, a parallelogram 300 by 325 miles in extent, of which the northeast corner is cut out, however, by the southwestern boundary of Wyoming entering with a right angle; the western line of about 70, the southern of over 100 miles. The country is rugged and broken and is separated into two unequal sections by the Wahsatch Mountains, which cross it from northeast to southwest, while the Uintah Mountains in the northeast have an east and west extension. In the southeast are extensive plateaus, and in the west a series of disconnected ridges, generally extending from north to south.

East of the Wahsatch the drainage is mostly by the streams which form the Colorado, of which the principal are the Grand and Green Rivers, and their tributaries, the White, Uintah, and San Rafael. These rivers are mostly rapid, not navigable, and flow through rocky canyons, whose walls in some places rise 2,000 feet above the streams. The rivers of the western half have no outlet to the ocean, but terminate in the various lakes. Of these the largest is the Great Salt Lake in the northwest, which is 75 miles long and about 130 broad. It is shallow, contains several islands, and receives by means of the river Jordan the waters of Utah Lake, 26 miles to the southeast. Several streams flow into it. It has no outlet and its waters are exceedingly saline, containing about 22 per cent. of salt and having a specific gravity of 1.17. Utah Lake is a beautiful sheet of fresh water, having an area of about 130 square miles, and closely hemmed in by mountains. The Sevier River, rising in the southern part of the Territory, flows north for 150 miles, receiving the San Pete and other smaller streams, then bends southwest and forms Sevier Lake, nearly 100 miles southwest of Great Salt Lake, and about equal in size to Utah Lake. Only that portion of Utah which can be artificially watered is really arable, though lands not irrigable are being more and more brought under cultivation. Of that part of the Territory lying east of the Wahsatch Mountains little use has yet been made. It is mountainous; its valleys are about a mile above the sea-level, and it consists chiefly of grazing and coal lands. The settled parts of the Territory lie along the western base of the Wahsatch Mountains, between them and Salt Lake and Utah Lake, in Cache, San Pete, and other valleys, wherever streams are so situated as to render irrigation practicable. In the northern part of the Territory the Wahsatch is high, there is a great accumulation of snow in winter, and the streams are large and numerous. In the southern part, though the range is nearly as high, the atmosphere is warmer and there is little snow, the streams are smaller and fewer in number, and there is less land capable of cultivation. The isolated ranges in the Great Basin give rise to no streams of importance, and the valleys are mostly of a desert character. The possible amount of farming lands in Utah may safely be put at 3,000,000 acres (probably an underestimate).

The climate of Utah varies with its differing altitudes and exposures. In the lower valleys it is agreeable and salubrious. The air is dry, elastic, transparent, and bracing. The Great Salt Lake exercises a mollifying influence on the extremes of temperatures, while the dry and absorbent character of the atmosphere relieves the oppression felt in humid climates at high temperatures. The average humidity in winter is more than twice as great as in summer. For the year the rain-fall averages 17.3 inches, 40 per cent. of which is in the spring, 9 in the summer, 25 in the fall, and 26 in the winter. The meteorological registers do not show an increased moisture in the climate; but Rush Lake covers what was a meadow twenty years ago, and the water of Great Salt Lake is 10 feet higher than it was in 1863. There has been little gain, however, during the last ten years. It is a peculiarity of climate in Utah, as in some other portions of the arid region, that there is a preponderance of rain-fall in the spring, when it is most needed.

With respect to timber Utah is much like Colorado, combining a treeless plain with timbered mountain ridges on one side of the Territory. The valleys or plains are destitute of forest growth, and in early times willow brush was resorted to for fencing, adobe bricks for building, and sage brush for fuel. The valuable timber is found in the canyons and coves, the mountain sides having mostly only a scrubby growth of comparatively little account. The Uintah Range, the eastern flank of the Wahsatch, with San Pete and San Pitch ranges, are generally more or less wooded with conifers. The western flank of the Wahsatch Mountains has been nearly stripped of what good timber it may have had, and from that range westward to Nevada it may be said that the country is destitute of timber. In the southern and extreme southeastern portions of the Territory there is a thin covering of forests on the mountain ranges, but of an inferior character. Of the timber of Utah it may be said that the best trees furnish lumber of an inferior quality only. The forests are composed chiefly of Red Cedar, Red or Douglas Fir, Spruce, with occasional Bull Pine (*P. ponderosa*), and White Pine (*Pinus flexilis*). More than half of the forest growth of the Wahsatch Range is composed of this last Pine, of inferior quality. On the Oquirrh the trees are chiefly Douglas Fir. A scrubby growth of Red Cedar and here and there Piñon Pine cover the larger part of the mountain sides in the south and west. They are of little value except for posts, ties, and fuel. For lumber of good quality Utah is almost entirely dependent upon supplies from the Pacific slope and Eastern States, yet the total cut of native timber in Summit and Wahsatch Counties has been estimated at not less than 2,000,000 feet of lumber, 300,000 cubic feet of round mine timber, and 12,000 cords of fuel and fencing, and this is claimed to represent only 20 per cent. of the cut in the Territory.

On the whole, Utah ranks very low among our States and Territories in respect to woodlands, having only 7.6 per cent. of her area which can be called forest. One who had occasion to make a special investigation of the resources of this Territory, and supposed to be a competent observer, says: "It may be stated that Utah seemed very generally lacking in serviceable material for fencing or building. The country settled for thirty years has drawn upon the near supply of standing timber, so that now lumber is obtained by great exertion and expense in most of the valley settlements. The labor and expense of fencing caused Brigham Young to enact the no-fence law, which enabled the destitute settlers to break ground, irrigate, and raise grain without the provision of any barrier against stock inroads, the cattleman being held responsible for the damages of his herd. This law in itself is a commentary on the scarcity of timber in Utah."

Iron ores occur all over the Territory in great variety. The most important deposits known are in Iron County, about 300 miles south of Salt Lake. The ore belt is 15 or 20 miles long and 3 or 4 miles wide. The ore is magnetite and hematite. Gold, silver, copper, lead, and other metals also abound in the Territory, and the production of the mines is annually increasing. The reported value of the gold, silver, copper, and lead product for the year 1886 is $7,631,729.

An inexhaustible supply of salt is obtained from the Great Salt Lake, which is constantly fed by salt springs, which abound in the northern part of the Territory and discharge into the lake.

Stock raising is becoming an important industry in Utah. Much land unfitted for agriculture is adapted for grazing purposes, and the mountain slopes are covered with nutritious grasses. Cache Valley, the valley of Green River, and other sheltered situations, offer superior advantages for sheep husbandry.

If Utah is deficient in timber it abounds in building stones of good quality and great variety and very accessible. Among the best known are the granite, from the mouth of Little Cottonwood Canyon, the red sandstone near Salt Lake City, and the secondary sandstone or oolite of San Pete County. At Logan there is an easily quarried limestone. Marbles of various colors and susceptible of good polish, are found at many points, and at Antelope Island is found, in unlimited quantity, a green and purple slate, which for roofing and some other purposes is said to be superior to the eastern slates.

Without subscribing in all respects to the views expressed in the following communication, kindly forwarded by Mr. O. J. Hollister, of Salt Lake City, it is here given in full, as showing in general the manner in which forestry interests are spoken of:

"In the ordinary use of the word, I should say that 'forestry' has no meaning in Utah. There is on the acclivities of some of the mountains a fair growth of coniferous trees, but where these were accessible through canyons the saw timber has mostly been cut out and used. Railroads have stripped other accessible parts of the ranges for ties, and in the mining canyons and districts all the timber has been used in the mines and for fuel—that is, all that is within reach. Now they are obliged to reach out farther, many of them being forced to use the railways to get what they require. No fires ever run in these Utah woods.*

"The natives (Utes) lived more in the valleys than in the mountains. The white settlements along the mountain streams of course protect the wild lands in their vicinity from fires. There is no object in preserving these patches of trees as a protection to the streams, either. The snow-fall on the mountains is very heavy, and does not melt and run off in the streams until June and July. The ground in the mountains is thus kept wet and heavy until the snow begins to fall again. There is little if any waste of timber. Of course all belongs to the Government, save where the miners may have patented the lands as mines. Most of the timber of Utah was originally confined to the Wahsatch and the Oquirrh ranges. The canyons of many streams admitted the lumberers and saw-mills to the former, and to a less extent, the range being far slighter, to the latter.

"In the southern part of the Territory, the varieties—Cedar and Piñon Pine—are more scattered and scrubby. The more valuable varieties of the Wahsatch and Oquirrh are the Red Pine, Black Balsam, and the White Pine. More than half of the finest growth of the Wahsatch is said to be of the white or inferior pine. The Red Pine and Black Balsam make a railroad tie that lasts ten years. On the Oquirrh the trees are chiefly Red Pine. The Scrub Cedar and Piñon Pine are of little value except for posts, ties, and fuel. The larger trees of the better varieties furnish a lumber not technically clear, but the knots are held so fast that they are no great detriment, and the lumber is practically clear. For many years a great part of the lumber used in the Territory has been imported from Nevada or Wyoming. Ordinary rough building and fencing lumber is worth about $25 per thousand; flooring and finishing, perhaps $45. In the early settlement of Utah willow brush and even sage brush were used for fencing. Now the use of barbed wire, strung upon cedar posts, is almost universal. Very little wood is used for fuel, even the mines, as well as the railroads, using coal, of which there is a great abundance in the Territory, and also in Wyoming, near the eastern line of Utah. The native growth of forest exercises the mind of the people not at all. What trees they have they have planted, watered, and tilled. The settlements in the lower valleys are collections of orchards, the streets lined with shade trees. After being once well started, and becoming of some size, they seem to do petty well even without water. Very little attention has been given as yet to starting plantations of trees other than for purposes of shade. It is doubtful, perhaps, if the valleys are very well adapted to the growth of trees; doubtful if they would not come to maturity and begin to decay before reaching any great

*The census of 1880 reports 42,865 acres of woodland in Utah destroyed by fire during the census year.

size or age. One gets that impression from observing the Locusts, the Cottonwoods, the Box Elders, and the Poplars grown in the towns for shade. But possibly they do not have as fair a show for thrifty growth and long life as they would in more secluded places, where the earth would not be tramped upon their roots, and their bodies constantly marred and bruised. Undoubtedly more and more attention will be given in Utah to the raising of forest trees as the Territory becomes more thickly settled. But there is not enough land that can be spared for such a use to ever make it of much importance."

FOREST FLORA OF THE ROCKY MOUNTAIN REGION.

By GEORGE B. SUDWORTH,
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The following chapter is intended to embody an account of all the strictly woody plants occurring in the Rocky Mountain region. These have been divided into arborescent and non-arborescent species. But the dividing line must necessarily be an arbitrary one, and undoubtedly many exceptions could be taken to the species thus termed arborescent, a large number being little more than shrubs as commonly found, yet the controlling feature has been rather the capabilities of each species under specially favorable conditions, such as may occur more or less in the region under consideration.

Besides the range of each species within the Rocky Mountain region, the general distribution of those species not particularly confined to these limits has been placed in parentheses and given mostly in general terms. The descriptions of the species do not pretend to be technical (or even complete), the attempt here made being rather to avoid, as far as possible, the use of such botanical terms as will not be readily understood by the laymen, and to note such characters as are most apt to be seen by the casual observer; hence the lack of attention to floral organs as studied by the professional botanist. An artificial key to the genera and species has been prepared on the same basis, and it is hoped will lend some aid to the laymen in studying the flora. A fuller description has been given only for the arborescent species.

The conifers have been somewhat arbitrarily arranged and placed first, as in this region at least they are without doubt forestally of greatest importance; otherwise the order of arrangement followed is that of Bentham and Hooker's Genera Plantarum. The nomenclature is that given by Dr. Gray in his Synoptical Flora of North America, supplemented by that adopted by Dr. George Englemann, Professors Sereno Watson, M. S. Bebb, and C. S. Sargent. As regards the common names used, such confusion exists that it is difficult to determine which names are most used and most appropriate; for in many sections the same name is applied to different species. But it is highly desirable for practical purposes that a uniformity in nomenclature should be maintained; and it is with this object in view that the selection of the first name given has been made.

Information has been derived from an examination of herbarium and other specimens, as well as from a free use of a large number of forestal and botanical publications; among them Gray's Manual, Watson's Botany of California, Prof. C. S. Sargent's Forests of North America, Coulter's Manual of Rocky Mountain Botany, together with various Government reports and current botanical and forest literature. Information has also been derived from the personal observations and correspondence of Col. E. T. Ensign.

ARTIFICIAL KEY TO GENERA AND SPECIES.

- I. Leaves without a true stem:
  - Needle-shaped or scale-like .... CONIFERS.
  - Sword-shaped, very long, thick, attached to an unbranched trunk .. YUCCAS.
- II. Leaves with a true stem and a more or less broad blade .. BROAD-LEAVED TREES.
- III. Leaves none (anomalous) 49

CONIFERS.

Leaves in clusters:

- 2, 3 (not regularly 4), or 5, with a delicate scaly sheath at the base: PINES:
  - *Leaves 2 in a sheath:*
    - 1 to 2 inches long; cones with blunt scales 5
    - 1 to 3 (mostly 2) inches long; cones with prickle-pointed scales 9
  - *Leaves 3 (sometimes 2) in a sheath:*
    - $2\frac{1}{2}$ to $3\frac{1}{4}$ inches long; cones with delicate prickles 8
    - 3 to 6 inches long; cones with strong prickles 7
  - *Leaves 5 in a sheath:*
    - 1 to $1\frac{1}{4}$ inches long; cones with delicate prickles 6
    - $1\frac{1}{4}$ to $2\frac{1}{2}$ inches long; cones with blunt scales 3
    - $1\frac{1}{2}$ to 2 (exceptionally $2\frac{1}{2}$ to 3) inches long 2
    - $2\frac{3}{4}$ to 4 inches long (often 4 in a sheath); seeds large, wingless 4
    - 3 to 4 inches long; seeds small, winged 1
- More than 5, proceeding from a bud: LARCHES:
  - 14 to 20 leaves in a cluster 20
  - 40 to 50 leaves in a cluster 21

Leaves single:

- Bristling all around the branches; more or less 4-sided and pointed: SPRUCES:
  - *Leaves very stiff, stout, and acutely pointed* 12
  - *Leaves moderately stiff, rather slender, awl-pointed:*
    - Cones with margin of scales entire 10
    - Cones with margin of scales indented 11
- Comb-like, or 2-ranked in arrangement on the branches, flat, blunt, notched, or pointed:
  - *Leaves rather thin, on slender branches;* cones hanging, scales persistent: HEMLOCKS, etc.:
    - With 3-pointed bracts protruding from under the scales 19
    - With no bracts protruding from under the scales:
      - Cones $\frac{1}{2}$ to $\frac{3}{4}$ of an inch long, downy 17
      - Cones 2 to 3 inches long, not downy 18

Leaves single—Continued.

Leaves rather thick and stiff, on stout branches; cones erect, scales deciduous: FIRS:

With a delicately-pointed bract attached to the back and extending beyond the end of each scale.................. 13

With bracts not extending beyond the ends of the scales:

Cones cylindrical, slender (2 to over 5 inches long); leaves 1 to 1½ inches long, glossy, and with white lines on underside 15

Cones broadly ovate stout (2¾ to 5 inches long); leaves 1 to 3 inches long, pale green 16

Cones narrowly ovate (2 to 3 inches long):

Leaves broad, thick, dense, acutely pointed, and attached by a broad base.. 14

Scattered (but somewhat 2-ranked) on the branches, thin, very concave on the underside; with a sharp ridge or keel on the upper side, and tapering suddenly to a short needle-point: YEW 27

Leaves scale-like, 2 opposite, overlapping (sometimes 3 in a whorl) on the branchlets:

Leaves (scales) blunt or only slightly acute; fruit a cone; heart-wood chiefly brownish: CEDARS, etc.:

Forming rather long flat branchlets; cones ovate, made up of a few loose scales.. 22

Forming short 4-angled branchlets; cones ball-like, made up of a few scales, each with a hooked protuberance..... 23

Leaves (scales) needle-pointed, or at least sharp-pointed; fruit a berry, or nut-like; heart-wood chiefly reddish: JUNIPERS:

Forming 4-angled branchlets:

Foliage whitish; fruit large, ½ an inch in diameter...................... 24

Foliage whitish, but with smaller fruit, ¼ of an inch in diameter........ 25

Foliage glossy green (or tawny in winter); fruit less than ¼ of an inch in diameter, with scale-like points............ 26

BROAD-LEAVED TREES.

Leaves simple; *i. e.*, the blade of one piece and not more modified than by lobes or teeth.

A.—Leaves set *alternately*[1] on the branches.

Branches armed:

a. With true thorns; fruit apple-like (not in size): HAWTHORNS:

Leaves smooth, or with few hairs only on the veins; fruit blackish 53

Or with a few hairs generally distributed over the upper surface; fruit black-purple.................................... 54

Leaves downy (sometimes smooth) above; fruit red-orange 55

b. With thorn-like branchlets; fruit berry-like or a plum:

Leaves small, ¼ to ¾ of an inch long; fruit berry-like, with scanty flesh, with a beak: BUCKTHORN.................... 29

Leaves much larger and longer; fruit a plum, fleshy, without a beak: PLUMS:

Leaves 1½ to 2 inches long.. 43

Leaves 2 to 3 inches long 42

Leaves simple, etc.—Continued.

Branches unarmed:

Leaves evergreen—thickish, leathery; densely woolly or minutely downy on the under surface:

a. Margin more or less indented or sometimes entire:

Fruit an acorn:

Leaves 1 to 2 inches long 69

Leaves 2 to $3\frac{1}{2}$ inches long 72

Fruit a tailed seed; leaves $\frac{1}{2}$ to $1\frac{1}{2}$ inches long 51

b. Margin entire and rolled back; fruit a tailed seed 50

Leaves deciduous, thin, not leathery:

Margin entire; leaves very narrow, less than one-quarter of an inch wide:

Fruit a long (6 to 12 inches) pod 61

Margin variously indented, but sometimes entire, or nearly so; leaves more than one-quarter of an inch wide:

a. With fine (not prickle or bristle pointed) *teeth:*

Bark bitter; fruit (seed) borne in deciduous catkins, and when mature, cottony:

Leaves broad, triangle-shaped, or ovate (in 84); branches often angled; buds resinous: POPLARS:

Triangle-shaped:

Smooth on both sides .... 82(86)

White-downy on the under surface 83

Ovate (exceptionally narrow, lance-shaped); smooth both sides. 84

Leaves narrow, lance-shaped; branches round; buds not resinous: WILLOWS:

Less than $\frac{1}{2}$ an inch wide, mostly $\frac{1}{6}$ to $\frac{1}{4}$ of an inch 80

More than $\frac{1}{2}$ an inch wide:

Pale or whitish on the under surface:

Leaf-stems with glands at the base of the blade 79

Leaf-stems without glands 78

Brownish downy on the under surface 81

Bark not bitter:

Separating (on trunk) into thin papery layers or sheets; seeds in a deciduous scaly catkin and with wings: BIRCHES:

Coppery-yellow; leaves 1 to $1\frac{1}{2}$ inches long 74

Chalky-white; leaves 2 to $3\frac{1}{4}$ inches long 73

Not separating into layers or sheets; fruit fleshy, or a winged seed in a persistent catkin:

Leaves unequal-sided (unsymmetrical), mostly entire, but occasionally with small teeth:

Very rough on the upper surface; fruit cherry-like, dry, sweet 63

Smooth above, hairy on under side; fruit a flat winged seed—samara; belongs under "coarse teeth" 62

Leaves equal-sided (symmetrical) and always toothed on the margin:

Rough; freshly-wounded bark exuding a milky juice 64

Leaves simple, etc.—Continued.

Smooth; bark without milky juice:

Fruit fleshy, or at least berry-like:

1-seeded (a stone), globular: CHERRIES:

With mostly rounded teeth on the margin of leaf..... 45

With sharp teeth on the margin of the leaf:

Dull green on upper surface of leaf; commonly downy below; teeth straight................ 47

Shiny green on upper surface; not downy below; teeth more or less incurved:

Green on the under surface..................... 44

Pale on the under surface:

Margin often with teeth of two sizes............. 48

Margin with teeth of only one size............... 46

3-seeded, pear-shaped: BUCKTHORNS:

Margin of leaf wavy, sometimes with *very* small teeth, or nearly entire.............................. 30

Margin of leaf always toothed and somewhat downy on the under surface.......................... 31

Fruit not fleshy nor berry-like—a catkin with persistent woody scales: ALDERS:

Base of the leaf wedge-shaped............................ 75

Base of the leaf rounded or heart-shaped................ 77

b. With coarse (not bristle or prickle pointed) *teeth:*

Leaves equal-sided; teeth of one size or of two sizes and glandular-pointed:

Broadly triangle-shaped, not glandular-toothed; bark bitter: POPLARS:

Teeth hairy, close, and much incurved.................... 85

Teeth not hairy, rather distant, and but slightly incurved.... 86

Ovate or lance-shaped, glandular-toothed; bark not bitter: ALDER 76

Leaves unequal-sided; teeth of two sizes, but not glandular-pointed: ELM.................................. 62

c. With deeply-cut blunt or pointed lobes, distant-undulate, prickle or bristle pointed teeth:

Circular in outline, with 3 to 7 (mostly 5) deep, sharp-pointed lobes; fruit a "ball": SYCAMORE 65

Ovate, etc., in outline; fruit an acorn: OAKS:

Leaves very large, 4 to 10 inches in length, with 3 to 6 pairs of deep blunt lobes.............................. 68

Leaves smaller, mostly less than 3 inches long:

With bristle-pointed, deeply-cut teeth (occasionally with 3 to 5 somewhat equal blunt lobes)................ 67

With prickle-pointed shallow teeth (sometimes with wavy, but not lobed margin):

Halberd-shaped; mature leaves usually glossy green on both sides.. 71

Ovate or elliptic; mature leaves usually downy on the under side.. 70

B.—Leaves set *opposite*[2] on the branches:

Margin deeply cut with 3-pointed lobes; fruit (seed) a 2-winged key[6]: MAPLES:

Lobes mostly entire, or only occasionally with coarse teeth.......... 35

Lobes always with rather fine sharp teeth........................ 34

Margin entire, or only slightly indented with shallow, rounded teeth; fruit a 1-seeded key[5]: ASH........................ 57

Leaves compound: *ie.*, composed of leaflets which are arranged in pairs (opposite) along a leaf-stem (pinnately compound) as in peas and beans; or, a number of leaflets radiating from the end of the leaf-stem (digitate or palmately compound), as in the Horse Chestnut.

A.—Leaves (not leaflets) set *alternately*[4] on the branches.
- Branches armed:
  - *With pairs of straight thorns;* leaflets equal-sided (symmetrical):
    - Branchlets and leaf-stems thickly set with bristle-like hairs with glands at the tips 37
    - Branchlets and leaf-stems not glandular-hairy:
      - Thorns pearly white; fruit-pods closely coiled in a spiral 40
      - Thorns yellowish; fruit-pods flattened (not coiled)................ 39
  - *With short hooked prickles;* leaflets unequal-sided (unsymmetrical)...... 41
- Branches unarmed:
  - *Leaflets evergreen;* fruit a pod (contracted between the beans) with red, white-scarred beans......................... 38
  - *Leaflets deciduous;* fruit not a pod:
    - Leaflets unequal-sided and often not quite opposite on the leaf-stem.. 33
    - Leaflets equal-sided and opposite on the leaf-stem:
      - Leaflets 3; fruit in clusters, a flat, light-colored seed with a wing all around (resembles an Elm-seed)............. 28
      - Leaflets more than 3; fruit berry-like or a nut:
        - Leaflets long-pointed; fruit a nut with a wrinkled shell. 66
        - Leaflets short-pointed:
          - Fruit, berry-like, red, in flat clusters 52
          - Fruit not berry-like—3 dark, shiny nuts in a 3-lobed husk....... 32

B.—Leaves set *opposite*[3] on the branches.
- Wood with a large, white, soft pith; fruit (berries) black, but white with bloom, clustered 56
- Wood with a small, dark, rather hard pith; fruit (seed a thin-winged key:
  - Leaflets 3 to 5; seeds (keys) in pairs, but separable: Box-elder........ 36
  - Leaflets more than 5; seeds (keys) single; ASHES:
    - Leaflets smooth and green on both sides 60
    - Leaflets smooth and green above, but more or less downy on the under-side:
      - Inner bark of the branches red; young shoots and leaf-stems rusty-velvety:
        - Mature seeds (keys) $1\frac{1}{2}$ to 2 inches long........................ 59
      - Inner bark of branches not red; young shoots and leaf-stems downy (not rusty):
        - Mature seeds (keys) $\frac{3}{4}$ to $1\frac{3}{8}$ inches long........................ 58

YUCCAS.

[Trees with unbranched trunks and wood not in annual layers—a mingled mass of fibers.]

- Leaves 1 to nearly 3 feet long:
  - Less than $\frac{1}{2}$ an inch wide.. 87
  - More than $\frac{1}{2}$ an inch wide ($1\frac{1}{2}$ to 2 inches)........................... 88

CONIFERÆ: PINE FAMILY.

1.—White Pine. "Mountain Pine." (*Pinus monticola*, Douglas.)

A large and important timber tree, occurring in northern Montana and Idaho (also in southern British Columbia, and from Washington Territory to southern California) between 3,000 and 10,000 feet elevation, usually occurring on a poor, sandy soil. In northern Montana it attains, perhaps its most valuable size, 60 to 100 feet high and over 3 feet in diameter. The wood is quite similar to that of the White Pine of the Northeast (*Pinus strobus*, Linn.), and is used considerably for lumber throughout its range.

Description.—Leaves in fives (with small distant teeth) often 3 to 4 inches long. Cones 5 to 8 inches long (on long stems), slender, cylindrical, yellowish-brown; pendulous the second year; seeds small, light-colored. Bark pale, rather smooth, breaking up into squarish plates. (Distinguished from *Pinus strobus* by its longer cones and stiffer leaves.)

2.—White Pine. (*Pinus flexilis*, James.)

Next to the Bull Pine (No. 7) in its general distribution, on dry, rocky, ridges; and, although its wood is inferior to that of the former, it is used for many of the same purposes; in parts of Wyoming and Montana furnishing most of the local supply of lumber for domestic purposes. Generally found growing on eastern slopes at altitudes from 4,000 to 10,000 feet, from Montana (probably much farther north) to New Mexico; (also in the Guadalupe and Limpia Mountains, western Texas; the high ranges of Utah, Nevada, northern Arizona, and in the Inyo Mountains and Mount Silliman, California.) It attains a height of 50 to 75 feet, with a diameter of 3 feet and over.

Description.—Leaves in fives, 1½ to 2 (exceptionally 2½ to 3) inches long. Cones on very short stems, oval or rather cylindrical, 3 to 5 inches long and light brown; scales spreading widely at maturity. Crown roundish; branches drooping; bark furrowed and gray.

3.—Hoary-branched Pine. (*Pinus albicaulis*, Engelm.)

A tree of little economical importance, as it rarely attains a useful size. It has a limited range in the Rocky Mountain region, occurring only on high ridges in northern Montana (but on the Pacific coast extends from southern California to British Columbia). It grows in dry, gravelly soil, reaching up to the extreme line of timber growth, where it becomes a shrub; sometimes 40 feet in height and 1 to 1½ feet in diameter, though generally smaller where it occurs in greatest abundance. Wood light and soft.

Description.—Leaves in fives (and fours), 1¼ to 2½ inches long. Cones 1½ to 3 inches long; their few scales thickened at the end and the blunt tip turned up; scales falling away after the cone is ripe; purple when young, reddish-brown at maturity. Bark milky white, especially on smaller branches.

4.—White Pine. (*Pinus reflexa*, Engelm.)

Only sparingly distributed through southwestern New Mexico and southeastern Arizona, usually on rocky slopes between 6,000 and 8,000 feet. It reaches a height of 60 to 90 feet, with a diameter of 2 feet; is generally a taller and more slender tree than the more northern White Pines. The wood is light, hard, very flexible, but little used for lumber.

Description.—Leaves in fives (and fours), slender, 2¾ to 4 inches long. Cones 6 to 8 inches long, on thick stems, ½ to 1½ inches long, and erect the first year, but recurved the second. Seeds large, flattened, wingless; sweet as those of the Nut Pine (*Pinus edulis*, Engelm). Trunk slender, of ten crooked, with few branches at top.

5.—Piñon Pine. Nut Pine. (*Pinus edulis*, Engelm.)

A small tree, but of considerable importance throughout its range, extending through southern Colorado, New Mexico, and western Texas, generally occupying sand and limestone slopes up to 9,000 feet. Said to be found also in southern Wyoming. Varies much in size, from 20 to 50 feet, but oftener about 25 feet, with a diameter of 1 to 2 feet. The wood is light, soft, and quite durable when exposed to moisture. It is especially valuable for fuel, for which it is extensively used, as also for manufacturing charcoal, and for fencing; occasionally used for poor quality of lumber.

Description.—Leaves chiefly in twos, 1 to 2 inches long, rigid, much curved or straight. Cones 1½ to 2 inches long, globose; ends of the few scales prolonged into a truncate-pyramidal tip; light russet color at maturity. The seeds (nuts) are sweet and edible. Generally a low tree with round crown and bushy habit.

6.—Fox-tail Pine. Hickory Pine. (*Pinus Balfouriana* Murray, var. *aristata*, Engelm.)

Rather rare, occurring chiefly in Colorado (but westward through Utah, Nevada, and southeastern California) on dry rocky ridges between 7,500 and 12,000 feet. It attains a height of from 50 to 100 feet, with a diameter of 3 to 8 feet. The wood is hard, tough, of a reddish color, and where found in the mining districts has been much employed for timbering mines, and to some extent for lumber.

Description.—Leaves in fives, 1 to 1¼ inches long, curved toward and closely pressing the branch. Cones terminal, oval; purple when young, russet-brown at maturity; 2½ to 3½ inches long, with delicate prickles, which are recurved as the cone matures. Bark reddish gray.

7.—Bull Pine. Yellow Pine. Heavy-Wooded Pine. (*Pinus ponderosa*, Dougl.)

The predominant and most generally distributed tree of the Rocky Mountain region, and for commercial purposes the most important. It

ITIONS OF THE

plied.	Princip	water in streams.	Effects of forests on the water supply.
....	Fire, u times	snow-fall and me-	They tend to increase the water supply.
r, and fuel; Aspen	Lumbe destr	annual rain-fall ..	But little in this county; amount of rain-fall or precipitation determined by the condensation as caused by the mountain ranges.
ds for fencing and	Fires a	e of water largely	
ood for fence posts	Local c	er for irrigation...	
....	....	....	Forests prevent the snows from melting too rapidly in the spring and protect the springs and rivulets.
e posts; Piñon and	Lumbe	....	
for fuel............	....	venteen years	
....	Fire ...	....	They keep the ground moist and promote rainfall.
nber and fencing; les.	Lumbe	cut off............	The headwaters of all important streams are protected and nourished by forests.
....	Fire, m wind	....	
for fencing; Cedar	....	....	
Pine and Aspen for	Fire, lu tion.	ir flow is more in-	Forests prevent the snows from melting early in the spring and keep the streams alive.
....	....	....	
ed Fir, and Tama-	None as settled	....	
ck for shingles.....	Forest f	son than was the	All streams are, in a measure, dependent on the forests.
ottonwood for fuel.	Fire ...	....	

SUMMARIZED STATEMENT OF THE FOREST CONDITIONS OF THE SEVERAL COUNTIES IN IDAHO, MONTANA, AND WYOMING IN THE YEAR 1887.

IDAHO.

Counties	Approximate area [illegible]: Entire area	Estimated forest area	Character of forest growth.	Predominant species.	Principal uses to which timber is applied.	Principal causes of forest destruction.	Character of second growth.	Measures suggested for the more adequate protection of forest growth.	Noticeable changes in the flow and volume of water in streams.	Effects of forests on the water supply.
Ada	[illegible]	[illegible]	Pine and Fir in the mountains, Cottonwood and Willow along the Boise River	Pine and Fir	Pine and Fir for lumber; Cottonwood for fuel	Fire, usually from carelessness; sometimes from natural causes	Generally the same as the original	Put the forests under the care and control of competent foresters.	Volume of water in the streams dependent on the snow-fall and meteorological conditions in the mountains.	They tend to increase the water supply.
Alturas	16,700	[illegible]	Yellow and Black Pine, Red Fir, Spruce, Aspen, and Cottonwood.	Red Fir and Black Pine	Fir, Pine, and Spruce for lumber, mining timber, and fuel; Aspen for fencing.	Lumbering and mining; fires not very destructive.	Same as the original in most cases; Aspen often follows forest fires.	More abundant precautions against forest fires	None observed, except with direct relation to the annual rain fall	But little in this county; amount of rain-fall or precipitation determined by the condensation as caused by the mountain ranges.
Bear Lake	[illegible]	40	White and Yellow Pine, White Fir, White Cedar, Mountain Mahogany, Cottonwood, and Aspen	Pine and Fir	Pine for building; dead timber of different kinds for fencing and fuel	Fires and lumbering	Usually the same as the original	Prevent fires and depredations; encourage tree planting	Flow of water in streams quite regular; volume of water largely determined by the snow-fall.	
Bingham	[illegible]	[illegible]	Red Fir (ranging in size from saplings to saw timber), Cedar, and Cottonwood	Fir and Cottonwood	Fir for lumber; Cedar for fence posts; Cottonwood for fence posts and fuel	Local consumption only	Fir, Pine, and Cottonwood	Use timber economically; encourage the building of wire fences, and restrain stock from running at large.	None noticed, except as caused by the use of water for irrigation	
[illegible]	[illegible]	1,100	Pine, Fir, and Balsam, growing very large and forming extensive forests	Yellow and Black Pine, Red Fir, and Balsam	Pine and Fir for building; Balsam for fuel			Enforce more strictly the laws against trespassers and for the prevention of fires.		Forests prevent the snows from melting too rapidly in the spring and protect the springs and rivulets.
Cassia	[illegible]	100	Yellow and Black Pine, Balsam, Fir, Piñon, Cedar, and Mountain Mahogany	Pine and Fir	Pine and Fir for coarse lumber; Cedar for fence posts; Piñon and Mountain Mahogany for fuel	Lumbering and fires	Same as the original			
Custer	[illegible]	1,100	Pine, Red and White Fir, and Cottonwood; timber inferior in size	Red and White Fir and Pine	Pine and Fir for common lumber; Cottonwood for fuel		Pine, Red and White Fir		No special changes noticed during a period of seventeen years	
Idaho	9,[illegible]	1,150	White Pine, Tamarack, Cedar, Red and Yellow Fir; some of the timber very large and fine.	Pine and Fir	Pine for lumber; Cedar and Fir for fencing	Fire	Pine and Fir	"Shoot the scoundrels who fire the forests"	No changes observed	They keep the ground moist and promote rain-fall
Kootenai	[illegible]	2,400	Yellow and Black Pine, Fir, Cedar, Cottonwood, Yew, Alder, and Willow; timber the finest in the Territory.	Pine	Pine for building; Tamarack for dimension lumber and fencing; Fir for railroad ties and fuel; Cedar for shingles.	Lumbering, railroads, and fire	Black Pine predominates	Enforce the laws strictly and guard against forest fires	Less water in streams where the trees have been cut off	The headwaters of all important streams are protected and nourished by forests.
Lemhi	[illegible]	2,100	White and Black Pine and Fir, some of the Pine growing very large	Pine and Fir		Fire, mainly; some losses caused by wind falls.				
Nez Perces	[illegible]	150	Yellow and Black Pine, Red and White Fir, Cedar, and Larch; much of the timber of large size	Pine in the mountains; Fir and Cedar at less elevations	Pine and Cedar for lumber; Fir and Tamarack for fencing; Cedar for shingles and fence posts.					
Oneida	[illegible]	150	Pine, Red Fir, Cedar, and Aspen		Pine for building; Cedar for fence posts; dead Pine and Aspen for fuel.	Fire, lumbering, and railway construction.	Same as the first growth	Furnish seeds and cuttings gratis and offer a bonus for planting	The streams have diminished in volume and their flow is more intermittent.	Forests prevent the snows from melting early in the spring and keep the streams alive.
Owyhee	[illegible]	[illegible]	Yellow and White Pine, Cedar, Aspen, and Cottonwood	Yellow Pine				The Government should control all timber lands, and provide for their protection		
Shoshone	[illegible]	1,500	Red and White Fir, Yellow and White Pine, White Spruce, Hemlock, Tamarack, Cedar, Yew, and several minor species		White and Yellow Pine for lumber; Cedar, Red Fir, and Tamarack for mining timber, charcoal, and fuel	None as yet, the county being newly settled.	Scrub Pine and Cedar, Hemlock and Spruce.		None observed during a period of three years	
Washington	[illegible]	500	White and Black Pine, Red and White Fir, Hemlock, and Balsam; but little undergrowth	Pine	Pine and Fir for building and fencing; Tamarack for shingles	Forest fires	Aspen	Guard against the setting of fires by campers in the mountains.	The streams reach a low stage earlier in the season than was the case ten years ago.	All streams are, in a measure, dependent on the forests.
Totals	[illegible]	15,[illegible]								

MONTANA.

Counties	Entire area	Estimated forest area	Character of forest growth.	Predominant species.	Principal uses to which timber is applied.	Principal causes of forest destruction.	Character of second growth.	Measures suggested for the more adequate protection of forest growth.	Noticeable changes in the flow and volume of water in streams.	Effects of forests on the water supply.
Beaver Head	[illegible]	1,100	Red Fir, White and Black Pine, White Spruce, and Cottonwood	Fir, Pine and Spruce	Pine, Fir, and Spruce for building and fencing; Cottonwood for fuel.	Fire	Same as the original species	The laws for the prevention of forest fires should be strictly enforced.		
Choteau	26,100	[illegible]	White Pine, Red Fir, and Cottonwood	Pine	Pine and Fir for lumber; Cottonwood for fuel	Lumbering; but little danger from fire	Pine	Thin out the timber in places where it stands too dense	A slight increase in volume during the last two years, caused by a greater rain-fall.	
Custer	20,[illegible]	200								
Dawson	2[illegible]700	200								
Deer Lodge	[illegible]	2,[illegible]	Red Fir, White and Yellow Pine and Cedar, "Lodge-pole" Pine predominating	Fir and Lodge-pole Pine	Fir and Pine for lumber and mining timber.	Forest fires	Lodge-pole Pine	Prevent fires by wandering Indians, and the wholesale cutting of timber by railway companies.	None observed; the streams are constant and regular in their flow	The extensive forests in the county maintain the streams at a good stage at all seasons.
Fergus	7,500	500	Yellow and White Pine, Fir, Box Elder, and Cottonwood	Pine and Fir	Yellow Pine and Fir for lumber, White Pine for small buildings and fence poles; Cottonwood and Box Elder for fuel.	Fires and lumbering	Usually the same as the original	Have paid agents in each county, with power to summon everybody to put out fires.	Volume of water diminished and flow more intermittent than formerly; caused by violent rain-storms and denudation of the forest and undergrowth.	Forests arrest the extreme desiccation of the atmosphere and rapid surface-drainage into the streams.
Gallatin	7,[illegible]	1,600	Yellow and White Pine (including Lodge-pole Pine), Fir and Cottonwood	Pine	Fir for building, Pine for fencing and fuel	Fire and snow-slides	Pine	Establish a thorough police system for the prevention of fire and depredation.	No marked changes during the last seven years	They tend to hold the snow on the mountains, keeping the ground moist and cool, and promoting the condensation of moisture.
Jefferson	2,[illegible]	[illegible]	Yellow and White Pine, Spruce, and Cottonwood	Pine and Spruce	Pine and Spruce for lumber, mining timber, fuel, and charcoal; Cottonwood for fuel and charcoal	Lumbering and railroads	Pine and Spruce	Severe penalties for the wasteful use of lumber and the setting of forest fires.	Water not so plentiful, and droughts more frequent than in former years.	
Lewis and Clarke	2,400	400	Red Fir, Yellow and White Pine and Cottonwood	Pine	Pine for building, Fir for bridges, fences, etc	Fire	Same as the original growth	Strict laws for the prevention of forest fires, and officers specially constituted to enforce the laws.	None reported.	
Madison	4,[illegible]	900	White and Yellow Pine, Red Fir, and Cottonwood	do	White Pine for lumber, log buildings, and fencing, Red Fir for framing and mine timbering.	Forest fires and mining operations	White Pine	Fires caused by campers and from refuse left by lumbermen should be strictly guarded against	Where the timber has been removed floods are more common and the annual water flow is less and more intermittent.	
Meagher	[illegible]	1,100	Yellow and White Pine, Spruce, Fir, Mountain Mahogany, Aspen, Cottonwood, etc	Spruce and Pine	Pine, Spruce, and Fir for lumber; White Pine for fencing, Cottonwood for fuel.	Fire at present; probably railroads and lumbering in the future.	Spruce and Pine	Local forest officers, with authority to suppress fires, make arrests, etc.	None observed during the last twenty years.	Forests of the county not sufficiently extensive to greatly affect the water supply.
Missoula	[illegible]	[illegible]	Yellow and White Pine, Red and White Fir, White Spruce, Tamarack, Cedar, Larch, Balsam, Balm of Gilead, Birch, etc.	Yellow Pine and White Spruce	Pine, Spruce, and Fir for building and railway and mining timber; Balm of Gilead for fencing, fuel, etc.	Fire, lumbering, and railways	Generally the same as the first growth.	Prevent forest fires, and the manufacture and export of lumber by large companies.	No particular changes noticed	Forests are essential to a good water supply.
Silver Bow	[illegible]	[illegible]	Yellow and White Pine, Red Fir, White Spruce, Cottonwood, and Willow	Fir, Spruce, and Pine	The demand for lumber, mine timbers, and fuel will soon exhaust the supply	Lumbering, mining operations, and fuel	"None; life is too short in this latitude to wait for a second growth."	The case is hopeless, timber being so scarce and the consumption so great.	Flow of water intermittent and greatly diminished; floods and droughts frequent.	
Yellowstone	[illegible]	[illegible]	Pine, Cedar, and Cottonwood; no forests of [illegible]	Pine in the hills, Cottonwood on the Yellowstone River.	Pine for building; Cedar and Cottonwood for fencing and fuel	Fires and lumbering	Same as the original, if any	Enforce the laws against cutting timber and poles for commercial purposes and setting or carelessly leaving fires.	The present season (1888) exceptionally dry, the streams low, and small ones have disappeared; can not say the change is permanent.	
Crow Indian Reservation	[illegible]	500	Pine, Fir, and Spruce							
Totals	[illegible],770	20,[illegible]								

WYOMING.

Counties	Entire area	Estimated forest area	Character of forest growth.	Predominant species.	Principal uses to which timber is applied.	Principal causes of forest destruction.	Character of second growth.	Measures suggested for the more adequate protection of forest growth.	Noticeable changes in the flow and volume of water in streams.	Effects of forests on the water supply.
Albany	6,022	840	Yellow and White Pine, Spruce, Red Cedar, Aspen, Cottonwood, and Box Elder	Pine and Spruce	Pine for lumber; Spruce for railroad ties and posts; Cottonwood and Box Elder for fuel	Lumbering, railways, and fires	Same as the original	Rigidly enforce the laws agains trespassers	No changes noticed as yet; some think there is more snow and rain than formerly.	
Carbon	13,520	1,360	Yellow and White Pine, Tamarack (or "Lodge-pole" Pine), and Aspen	White Pine	Lumber, railway ties, mining timber, fencing, and telegraph poles	Fire	Pine—and same as the former growth.	Protection from fire and corporations	As yet, not sufficient timber has been destroyed to greatly affect the streams.	Bodies of timber tend to increase the rain-fall.
Crook	10,7[illegible]	[illegible]	Yellow Pine, Red Cedar, Oak, and Cottonwood	Yellow Pine	Pine for lumber; the other kinds for fencing and fuel	Lumbering and fires	Same as the first	"Shotgun brigade"	Floods and droughts more frequent than in former years; cause not certainly known.	
Fremont	20,957	3,300	Yellow and White Pine, Lodge-pole Pine, Red Cedar, and Cottonwood	Pine and Cedar	Pine for lumber, fencing, and fuel; Cedar for fence posts, Cottonwood for fuel.	Forest fires	Pine, in the mountains	Protection against fires	Rain-fall and flow of water in smaller streams said to be increasing slightly.	Snow in the mountain forests melts more gradually than on bare surfaces; and thus forests prevent floods.
Johnson	11,[illegible]	1,800	Yellow and White Pine, White Spruce, Aspen, Oak, Cottonwood, Box elder and Willows.	White Pine and White Spruce	Pine and Spruce for lumber; the other kinds for fencing, fuel, etc.	Fires, and the reckless destruction of young trees.	Usually Pine, if anything	Prevent forest fires, and enforce the law against cutting trees less than 8 inches in diameter.	There is less water in streams, and the flow is more intermittent, where the timber has been cut from the headwaters.	Forests increase the water supply.
Laramie	11,200	80	Pine and Cottonwood	Pine	Fencing and fuel; no timber of sufficent size for lumber		Pine and Cottonwood, if any		Volume increased, and flow more continuous; cause assigned to the extensive irrigation systems	Not sufficient timber in county to affect the water supply.
Sweetwater	10,[illegible]	40	Pine, Spruce, Cedar, Aspen, and Cottonwood	do	Fencing and fuel; but little timber suitable for lumber		Same as the original, but very scanty growth.		No special change in streams observed; rains infrequent of late	
Uinta	12,140	2,400	White and Lodge-pole Pine	Lodge-pole Pine	Lumber, railway ties, fencing, and other domestic uses	Fires set by the Indians	Pine	Prevent depredations and setting of fires by the Indians	Volume of waater greater in some of the larger streams, from increased rain-fall; and less in some of the smaller streams, from destruction of timber at their sources.	Forests tend to increase the water supply, heavy rains and snows follow the timber belts.
Yellowstone National Park	3,[illegible]50	1,[illegible]40	Yellow and White Pine, Lodge-pole Pine, Red Cedar, Aspen, and Cottonwood.	White and Lodge-pole Pine				This reservation is under the special supervision of officers of the General Government, and it is presumed the forests will be preserved.		
Totals	100,[illegible]	12,[illegible]								

ater in streams.	Effect of forests on the water supply.
....	Beneficial; distributing the water through the summer season.
g of snow in the mount-	To an extent they control the water supply; as forests are destroyed the supply decreases.
unt of annual snows....	Prevent early melting of snow and rapid evaporation.
melting of the snows....	Water supply governed by the snows; not dependent on the forests.
....	Forests necessary to a late supply of water.

SUMMARIZED STATEMENT OF THE FOREST CONDITIONS OF THE SEVERAL COUNTIES IN COLORADO AND NEW MEXICO IN THE YEAR 1887.

COLORADO.

Counties.	Approximate area, square miles. Entire area.	Forest, estimated area.	Character of forest growth.	Predominant species.	Principal uses to which timber is applied.	Principal causes of forest destruction.	Character of second growth.	Measures suggested for the more adequate protection of forest growth.	Changes in flow and volume of water in streams.	Effect of forests on the water supply.
Archuleta	1,026	450	Excellent, tall and large. Pine, Cedar, Spruce, Cottonwood, Oak, Piñon, Aspen, Willow.	Yellow Pine	Pine for building, fences, bridges, railroad ties, and fuel; Cedar, Piñon, and Oak for fence-posts and agricultural implements.	Fire the greatest danger	Aspen and Scrub Oak	Strictly enforce the laws, both State and national	No changes yet observed.	Beneficial, distributing the water through the summer season.
Boulder	768	275	Pine, Spruce, and Fir; good White Pine, 4 to 8 inches, Yellow Pine, 18 inches.	Pine and Fir	Yellow Pine for lumber; White Pine for poles and shingles; Red Spruce for ties.	Lumbering, mining, and railroads	Same as first growth	Rigid enforcement of the laws	Higher water in spring, from earlier melting of snow in the mountains	To an extent they control the water supply, as forests are destroyed the supply decreases.
Chaffee	900	500	Pine, Spruce, Piñon, Fir, Aspen, and Cottonwood	Spruce, Pine, and Piñon	Red Spruce for railway ties; Pine for lumber, and Piñon for charcoal.	Lumber, charcoal manufacture, and railroad ties.	Pine, Piñon, and Cedar	Government officials to do their duty and prevent trespass.	None, except as caused by variation in amount of annual snows	Prevent early melting of snow and rapid evaporation.
Clear Creek	450	200	Mainly Pine, Spruce, and Balsam	Pine and Spruce	Building and mining timber	Fires and saw-mills		Speedy and sure punishment for the setting of fires	Greater flow in early summer, from earlier melting of the snows	Water supply governed by the snows, not dependent on the forests.
Conejos	1,320	300	Spruce, Pine, Cottonwood, Quaking Aspen, and Willow	Pine	Pine for lumber; Spruce for railroad ties, piling, etc.; Quaking Aspen for fence-poles; Willow for making dams	Fires and railroads	Quaking Aspen	Keep fires out and provide severe penalties for the setting of fires—willfully or carelessly	No material change noted	Forests necessary to a late supply of water.
Costilla	1,450	450	Spruce, Aspen, Pine, Piñon, and Cedar	Pine and Spruce in the mountains.	Pine for building; Spruce for railroad ties and fencing; Piñon for fuel; Cedar for fence-posts; Aspen and Cottonwood for fence-poles.	Fires, railroads, and saw-mills	After fires, Quaking Aspen; in favorable places, Pine and Spruce.	Heavy penalties for setting fires, carelessly or otherwise, and high reward for evidence to convict of setting fires.	No change yet noticeable, when the timber does disappear floods and droughts will be in order.	The more trees the more water.
Custer	750	200	Piñon, Pine, Spruce, Cedar, Balsam, and Quaking Aspen		Pine and Spruce for lumber; Cedar for fence-posts; Quaking Aspen and Spruce for fencing.	Fires and lumbering	Pine, Spruce, Balsam, and Quaking Aspen on the range.	Enforce the law in regard to putting out camp fires	In the lowlands floods more frequent than formerly from cloud bursts or sudden rains.	
Delta	1,150	500	Yellow Pine, Spruce, Cedar, and Cottonwood	Cedar	Yellow Pine and Spruce for lumber; Cedar for fence posts; Cottonwood for fence-poles.	No danger at present; timber inaccessible.	Pine and Cedar on the mesas; Cottonwood on the streams.	None at present	None perceptible in the few years since settlement	They prevent rapid melting of snows and extremes of high and low water.
Dolores	860	150	Spruce, Aspen, Yellow Pine, and Piñon		Spruce for lumber and mining timber; Aspen for fuel and charcoal. Piñon for fuel.	Mining (chiefly) and fires	Aspen and Spruce		Volume of water greater, owing to more snows and no fires in timber	Forests increase the water supply.
Douglas	850	100	Pine in the valley; Pine and Spruce in the mountains		Building, railroad ties, and bridge timber	Lumbering and railroads	Pine on southern slopes; Spruce at the north.	"Stop the railroads and lumbermen from stealing the timber."	Diminished, from effect of forest fires, and clearing of headwaters of streams.	Forests in the mountains act as reservoirs holding the water.
Eagle	1,750	500	White Pine and White Spruce		Both kinds used for lumber, charcoal, and fuel; Pine used mainly for railroad ties and mining timber.	Fires	Same as original when land not burned; otherwise Aspen.	Abolish tariff on lumber; pass stringent laws, with severe penalties, for setting fire or allowing it to escape; form societies to see that the laws are enforced	Some decrease in the water supply	Said to have no effect on the water supply.
Elbert	5,800	160	Trees small; unfit for timber	Pine and Spruce	Pine and Spruce for building, railroad ties, bridges, etc	Saw-mills and railroads	Pine	"Hang all the mill men, and all who should attempt to put a mill in the county."	Floods have become more frequent than formerly, causing loss of bridges, etc	
El Paso	2,670	500	Scattered Pine and Spruce, with some Piñon; Cottonwood on streams.	do	Lumber, bridge timber, railroad ties; dead Spruce for telegraph poles.	Lumbering, railroads, and fires	To a limited extent, same as the original growth; Aspen follows fire	More stringent laws, and their better enforcement	Diminished volume and more intermittent flow than formerly	There is more rain and snow and more gradual distribution of water where forests abound.
Fremont	1,450	450	Pine, Piñon, and Cedar	Piñon and Pine	Pine for lumber and railroad ties; Piñon for charcoal	Charcoal burning	Aspen		No special changes noted unless it is that floods are more frequent of late	The effect of forests is to render the water supply more constant and regular.
Garfield	7,250	800	Spruce, Pine, Piñon, and Cedar	Piñon and Cedar	Pine for building; Piñon, Cedar, and Quaking Aspen for fencing and fuel	Fire by the Ute Indians	Quaking Aspen	Remove Utes to their reservation	Increase of flow in small streams and less intermittent	Forests greatly increase the water supply, especially in holding the snow
Gilpin	110	50	White and Yellow Pine, Spruce, and Balsam	White Pine	Pitch Pine for mining purposes; other Pines for general building.	Fire, saw-mills, and railroads	Various kinds of Pine	Post notices warning people to extinguish camp fires, etc	Diminished and more irregular	They prevent heavy floods and excessive dryness.
Grand	1,860	700	Pine, Spruce (three varieties), Fir (two varieties), Aspen	Pine and Spruce	For houses, stables, corrals, bridges, fences, etc., used in shape of logs and poles; little sawed lumber as yet.	Fire	Mainly same as original	Guard against forest fires	Not as yet enough denudation of forest to affect the water supply	
Gunnison	4,000	1,200	Pine, Spruce, and Quaking Aspen on mountains; Cottonwood and Alder on streams.	Spruce and Pine	Pine and Spruce for building, fencing, and railroad ties; Cottonwood, Aspen, Cedar, and Alder used a little for fuel. Coal abundant.	do	Same as the first growth	Protection from fire	The cutting of timber has been so slight that no difference is noticed in flow and volume of water in streams.	
Hinsdale	1,440	450	White and Red Spruce, Yellow Pine, and Quaking Aspen	Spruce and Quaking Aspen	White Spruce for lumber and mine timbers; Red Spruce, Aspen, and Yellow Pine for fuel.	Mining and fuel	Spruce and Quaking Aspen	More thorough protection from fire		
Huerfano	1,160	250	Pine, Spruce, Cedar, Piñon, and Quaking Aspen	Pine, Piñon, and Cedar	Pine for lumber and railroad ties. Cedar for fence posts; Piñon and Cottonwood for fuel	Lumbering and fires	Pine and Quaking Aspen	Stop the wasteful use of timber and prevent forest fires	Small decrease in volume of water	[illegible] tends to diminish the supply of water
Jefferson	770	175	Pine, Red and White Spruce, Quaking Aspen, and Cottonwood		Pine the most valuable for lumber; next, Red Spruce, used for many purposes; other Spruces, Box Elder, and Cottonwood used for fuel.	Fire and wasteful modes of lumbering	Pine, Spruce, Quaking Aspen, Willow, etc.	Establishment of forest police, prevention of [illegible] and rigid supervision of mills cutting timber from Government lands.	[illegible] in August, September, and October [illegible] increase	[illegible]
Lake	420	200	Coniferæ of medium size	Pine and Spruce	In order of importance—lumber, mining, timber, charcoal, railroad ties, fencing, and fuel.	1. Fires. 2. Charcoal burning and lumbering.	Pine, generally		No changes noticed	
La Plata	4,200	1,500	Pine, White and Red Spruce, Cedar, Piñon, and Cottonwood	Pine	Pine and Spruce for lumber and railroad ties, other kinds for fuel and fencing.	Lumbering, railroads, and fires	Same as original; after fire, Aspen	Guard against fire and wasteful cutting, provide for [illegible] of full-grown timber, and preserve the young timber	High water higher and low water lower; loss of timber [illegible] less absorption and more rapid shedding of water	[illegible]
Larimer	1,060	700	White, Yellow, and Black Pine, Spruce and Hemlock; Cottonwood on the streams.	do	White Pine for railroad ties; Black and Yellow Pine for building; Spruce and Hemlock for bridges.	Fires and railroads	White Pine and Aspen	Properly execute the forest laws.	The cutting of "tie timber" on the range has caused the water supply to be limited after the middle of June.	Forests retain a more copious fall of moisture, and shield the snows from sudden melting in the spring.
Las Animas	6,530	500	Red and White Spruce, Pine, Piñon, Cedar, and Cottonwood	Spruce and Pine	Pine and White Spruce for lumber; Red Spruce for joists, piles, and telegraph poles; Cedar for fence posts.	Lumbering and fire	Same as first growth; Aspen and Scrub Oak follow fires.	Allow small growth to mature, prevent fires, sell timber lands to individuals, and exempt same from taxation.	None other than temporary changes have been observed.	Forests retard surface drainage, promote percolation, check evaporation, equalize and make more permanent the water supply, and in[illegible]
Mesa	3,850	275	Spruce, Cedar, Scrub Oak, Piñon, and Quaking Aspen	Cedar and Piñon	Spruce for building; Cedar, Piñon, and Aspen for fencing and fuel.				County newly settled, no changes observed	Removal of forests causes more rapid melting of snows, and more intermittent flow of water.
Montrose	2,040	640	Pine, Spruce, Cedar, Aspen, Cottonwood, and Oak	Pine, Spruce, Cedar, and Aspen.	Pine and Spruce for lumber; Cedar for fence posts; Aspen and Cottonwood for fence poles.	Lumbering	Same as the original; Cottonwood after fire.	Regulate and restrict lumbering operations	No changes noticed as yet	
Ouray	190	110	Yellow Pine, Balsam Fir, Cedar, Piñon, Cottonwood, Box Elder, Quaking Aspen, and Oak	Yellow Pine	Yellow Pine for building; Spruce for building and mining; Cedar for fence posts; Aspen for fence rails; Piñon for fuel	Lumbering and fires	Cedar and Piñon	Compliance with the law; prevent waste by saw mills; enforce law in regard to fires.	None reported [illegible] droughts infrequent	[illegible]
Park	2,100	600	Pine and Spruce, small size	Spruce	Both kinds used for lumber and mining timber; Pine the best	Saw-mills, tie-cutting, and fire	White Pine or Spruce; the former after fires generally.	Prevent fire and wasteful use.	[illegible]	
Pitkin	1,000	540	Pine, Spruce, Piñon, and Cedar	Pine	Pine for building and mine timbering; Cedar for fencing	Fire, lumbering, and snow-slides	Scrub Oak, Quaking Aspen, Cottonwood, etc.	Severe penalties for the setting out of fire or other wanton destruction of timber.	[illegible] are more frequent of late.	
Pueblo	2,350	125	Cottonwood in valleys; Pine, Piñon, and Cedar on high lands		Pine for lumber; Cedar and Piñon; for fence posts, fuel, etc	None	Same as first growth	None. Would encourage and promote by liberal legislation the planting and culture of forest trees.	The smaller streams are more intermittent in flow	
Rio Grande	1,360	275	Spruce, Pine, Piñon, Cedar, and Quaking Aspen	Spruce and Pine		Mining and saw-mills			Increased flow in early spring, owing to cutting of timber	They hold the snow late until water is needed for irrigation.
Routt	6,200	1,050	Pine, Spruce, Balsam, Quaking Aspen, generally of medium size	Pine and Spruce	Pine and Spruce for lumber; Quaking Aspen for fencing and fuel; Oak and Cottonwood for fuel.	Fire	Pine, mainly	Keep out the Indians; enjoin greater care upon settlers, tourists, and hunters regarding camp-fires.	No changes noticed; county newly settled	Green timber increases rain fall.
Saguache	3,150	1,175	Pine, White Spruce, Piñon, Cedar, and Cottonwood	Pine and Piñon	Pine and Spruce for lumber, railroad ties, and fencing; Cedar for fuel and fence posts; Piñon for fuel	Railroads and fire	Same as original	Prevent fires and undue consumption by railroads	Scarcity of water and droughts in 1879-'80-'81; since then an increased water supply.	
San Juan	450	160	White Pine, Spruce, Balsam, and Aspen; very little small growth	White Pine and Balsam	Mining timbers, fuel, and fires	Mining	Aspen	None. In the future expect to draw upon La Plata County for fuel, coal, lumber etc.	No known changes, [illegible]	
San Miguel	1,375	260	Spruce and Aspen in east part, scattering Piñon, Cedar, and Oak in the west.		Building, mining timber, and fuel	Lumbering and fire			No changes observed	[illegible]
Summit	750	275	Red and White Spruce, Balsam, Pine, Hemlock, Cedar, Piñon, Quaking Aspen, Juniper, Cottonwood etc		Spruce and Pine for lumber, fencing, and fuel; Quaking Aspen (dry) the best for domestic purposes.	Railroads, lumbering, and fires	Quaking Aspen; Pine on southern slopes.	Educate the masses to the importance of preventing fires and post notices relative thereto	No change noticed	[illegible]
Weld	9,360		No forest land in county; Cottonwood along the streams, and some timber claims planted.	Cottonwood	Fuel and fencing			Restrain stock from running at large.	The irrigation systems in the county regulate and equalize to a great extent, the flow and volume of water in the streams.	[illegible] supply.
Totals	100,200	16,625								

NOTE.—The counties of Arapahoe, Bent, Logan, and Washington, in the State of Colorado, contain no forests, and are not included in the above list.

NEW MEXICO.

Counties.	Entire area.	Forest, estimated area.	Character of forest growth.	Predominant species.	Principal uses to which timber is applied.	Principal causes of forest destruction.	Character of second growth.	Measures suggested for the more adequate protection of forest growth.	Changes in flow and volume of water in streams.	Effect of forests on the water supply.
Bernalillo	8,350	1,450	Yellow and White Pine, Piñon, Red Cedar and Scrub Oak	Scrub Oak	Pine for lumbering and mine timbering; Cedar for posts; the other kinds for fuel.	Forest fires	Piñon and Scrub Oak	Restrain live stock from running at large.	As much water as formerly, but floods more frequent	
Colfax	7,000	1,275	Pine, Spruce, Piñon, Dwarf Cedar, Scrub Oak, and Cottonwood	Pine and Piñon	Pine and Spruce for lumber, railway ties, telegraph poles, log houses, and corrals; Cedar and Piñon for fencing.	"The man with an ax," and forest fires.		Prevent wasteful and illegal use by corporations and burning by the Indians	Less water in midsummer than in former years, and floods and droughts more common	They tend to increase the volume of water in the streams
Doña Aña	10,260	75	Pine, Fir, Cedar, Juniper, Piñon, Oak, Ash, Mesquit, Cottonwood, and Willow.	Pine, Cedar, and Piñon	Pine for lumber, Fir for coarse lumber and railway ties; Cedar, Juniper, and Piñon for fencing and fuel, Oak and Ash for carriage work.	Fires set by Indians and others	Pine and Scrub Oak, when any at all	Remove Indians, attach severe penalties to the firing of timber, with liberal reward for evidence to convict	Where the mountain slopes have been left bare, the springs and streams have diminished greatly in volume.	The mountain forests collect the clouds which yield rain to feed the streams; water is always high when the snows in the mountains are melting
Grant	10,090	800	Pine, Juniper, Scrub Oak, and Cottonwood—very scattering	Pine and Juniper	Pine for lumber; Juniper for fence-posts and fuel; Oak and Cottonwood for fuel	Lumbering; timber too scattering to suffer from fires.	Hardly any chance for a second growth.		No changes observed.	
Lincoln	24,450	920	Pine, Spruce, Piñon, Cedar, Oak, Yucca, and Madroña	Piñon, "Scrub Pine," and Cedar.	Pine and Spruce for building, Piñon and Cedar for fencing and fuel	Use of timber in mining	Not known, original growth been recently cut.	Extensive planting to keep the growth equal to the consumption	Reported increase in flow of certain small streams ascribed to the tramping of cattle in their beds, thus bringing the water to the surface	They preserve the water supply; planting of trees along the margins of streams and ditches prevents rapid evaporation
Mora	3,830	720	Yellow and White Pine, Spruce, Aspen, Piñon, Cedar, Scrub Oak, Mesquit, Cottonwood, Box Elder, Hackberry, etc.	Pine	Pine for building and railway purposes, Cedar for fence posts; Spruce for fence poles, Piñon for fuel.	Railroads and lumbering	No second growth, excepting Cottonwood.		Supposed to be a slight increase in volume of water in the streams	Forests attract the rain clouds, rain storms commence in the timber belts, and follow them and the water-courses.
Rio Arriba	7,500	175	Yellow and Black Pine, Spruce, Cedar, Piñon, Scrub Oak, Cottonwood, Willow, and Wild Cherry.	Pine and Spruce	Building, railway timber, fencing and fuel	Lumbering and railroads	Pine and Spruce, if any	Restrain lumbermen and railway contractors.	No changes noticed in the annual discharge, more floods than formerly	
Santa Fé	2,400	1,375	Yellow Pine, Spruce, Cedar, Piñon, Scrub Oak, Cottonwood, and Willow.	Yellow Pine, Cedar, and Piñon	Pine for lumber and railway ties; Spruce for piling, Cedar for fence posts and fuel, Piñon for charcoal and fuel.	Fire, lumbering, and railroads	Same as the original, if any	Government agents should act more promptly in protective measures, and the consumption of timber be limited to local needs	No material changes observed	
San Juan	7,200	250								
San Miguel	11,030	1,300	Pine, Spruce, Piñon, Cedar, Scrub Oak, and Cottonwood	Yellow Pine, Spruce, and Cedar.	Pine and Spruce for lumber, railway ties, and mine timbers; Cedar for fence posts, and Piñon for fuel.	Consumption by railroads, lumbering, and fires.	A stunted growth of the original species	The Government should offer more inducements for the cultivation of trees.	None have been observed	
Sierra	3,200	250	Pine, Fir, Juniper, Piñon, Oak, Maple, Ash, Walnut, Box Elder, Cottonwood, etc.	Pine, Juniper, and Fir	Pine for building and mine timbers; Juniper, Oak, and Maple for fuel.	Mining, domestic uses, and fire	Principally brush	Closer supervision on the part of the General Government.	The small streams have disappeared, and the flow of large ones is not so continuous as in former years, more floods and longer spells of drought.	
Socorro	16,500	2,050	Yellow and White Pine, Red Fir, Aspen, Piñon, Cedar, Juniper, Oak, Walnut, Mountain Mahogany, Mesquit, Box Elder, Water Maple, Cottonwood, and Willow.	Pine, Spruce, and Cedar	Pine for lumber, Cedar and Juniper for fencing, Oak for carriage work, Piñon for charcoal and fuel.	Fire, railways, and lumbering	Denuded tracts remain bare, or produce a growth of small brush and weeds.	More stringent laws for the protection of timber, and their better enforcement.		
Taos	2,300	900	Yellow, White and Black Pine, Spruce, Fir, Aspen, Piñon, Cedar, Scrub Oak, and Cottonwood	Yellow Pine and Piñon	Pine and Spruce for lumber; Cedar for fence posts, Piñon, Oak, and Cedar for fuel.	Fire and railways	Aspen and Scrub Oak	Provide forest officers, prevent the cutting of young timber, plant trees and print a forestry bulletin in the Spanish language, to circulate among the Mexican people.	Volume of water diminished and flow more intermittent, some streams, once of considerable size, have become dry.	They protect the sources of streams, and make the water supply more constant and regular.
Valencia	7,700	960	Yellow Pine, Piñon, Cedar, White and Scrub Oak	Pine and Cedar	Pine for lumber and house logs, Cedar for fencing, Piñon and Oak for fuel.	Fire, and, to a limited extent, lumbering.	Usually the same as the original growth.	Encourage settlement of the public lands, and the taking up of timber claims.	"More rain-fall and more water in the streams than in former years."	
Totals	122,500	12,500								

MAP
OF THE
ROCKY MOUNTAIN REGION

SHOWING THE APPROXIMATE LOCATION AND EXTENT OF FOREST AREAS AND IRRIGATION DITCHES IN 1885.

COMPILED FROM COUNTY RETURNS

BY

COL. E. T. ENSIGN, Forestry Agent of the Department of Agriculture.

REFERENCES:

Forest Lands shown in green.
Main Irrigating Canals shown in red lines.

is among the hardiest of the Conifers, and grows in the most arid and exposed sites, usually occupying southern exposures. It occurs at elevations between 4,500 and 6,500 feet. It does not attain as large a size in the Rocky Mountains as in the California Sierras, although in Montana sometimes reaching 100 feet in height, and 6 to 7 feet in diameter. The wood is quite resinous, of a reddish color, with a handsome grain, and is largely employed for lumber, railroad ties, mining timber, and somewhat for interior finish.

Description.—Leaves in threes (often in twos), 3 to 6 inches long, brush-like at the ends of the branchlets; persistent three years. Cones 2 to 3 inches long (or more), gray-brown, with strong prickles. Bark very thick, in old trees, 3 to 4 inches.

8.—Chihuahua Pine. (*Pinus Chihuahuana*, Engelm.)

Somewhat rare and of limited range; found on rocky slopes of southwestern New Mexico (extending into southern Arizona and northern New Mexico), at elevations between 5,000 and 7,000 feet; 30 to 70 feet high, $1\frac{1}{2}$ feet in diameter. Wood light and strong.

Description.—Leaves mostly in threes (twos and fours also), $2\frac{1}{2}$ to $3\frac{1}{4}$ inches long: cones on stems $\frac{1}{4}$ to $\frac{3}{4}$ an inch long, $1\frac{1}{2}$ to $2\frac{1}{4}$ inches long; dark brown, with short delicate prickles.

9.—Black Pine. Lodge-Pole Pine. Tamarack. (*Pinus Murrayana*, Balfour.)

Rather abundant throughout the Rocky Mountain region, extending westward and northward, but more common in the northern portion, forming large forests of pure growth. It is said, however, to attain its greatest size in southern California—60 to 100 feet, with a diameter of over 3 feet.*

Usually found growing in slightly moist or dry gravelly soil between 6,000 and 9,000 feet elevation. The wood is soft and light, not unlike that of the White Pines; employed to some extent for lumber, railroad ties, and much for "lagging" in mines.

Description.—Leaves in twos, 1 to 3 inches long, but chiefly 2 inches, with fine teeth. Cones 2 to 3 inches long, reflexed, and with delicate recurved prickles. Bark very thin and scaly, grayish-brown. Crown conical. Resembles the Scrub Pine (*Pinus contorta*, Dougl.), but distinguished from it by having longer and wider leaves, as well as by a much thinner bark.

10.—White Spruce. Single Spruce. (*Picea alba*, Link.)

A large and important timber tree, growing in rather wet soil on the borders of ponds and streams, reaching over 100 feet in height and 2 to 3 feet in diameter. In the Rocky Mountain region it occurs only in northern Montana, and attains its greatest size in the Flathead region

* When growing in thickets it is often imperfectly developed, and is called "Lodgepole Pine;" such trees sometimes being over fifty years old, with a diameter of not more than 6 to 8 inches.

at altitudes of 2,500 to 3,500 feet. (From British Columbia and northward the range of this species extends along the northern boundary of the United States to Maine and northward.) Extensively used for lumber, and as such not distinguished from that of the Black Spruce (*Picea nigra*, Link.), with which it is much associated in its northern distribution.

Description.—Leaves $\frac{1}{4}$ to $\frac{3}{4}$ of an inch long, stiff, erect, or curved. Cones nearly sessile or on stems $\frac{1}{10}$ to $\frac{1}{4}$ of an inch long; 1 to 2 inches long, cylindrical or oblong; scales with entire margin.

11.—Engelmann's Spruce. White Spruce. Red Spruce. (*Picea Engelmanni*, Engelm.)

The most valuable timber tree in the Rocky Mountain region, forming large forests. It ranges from New Mexico to Montana (westward and north of the United States boundary), usually seeking dry gravelly ridges between 5,000 and 11,500 feet; in Colorado, where it attains its greatest size, occurring at elevations from 9,000 feet up to the timber line; 100 to 130 feet in height, and over 3 feet in diameter; but at the highest limit of growth only a prostrate shrub. The wood is tough, strong, and elastic. Nearly all the rough and dressed lumber used in the Rocky Mountain region is of this spruce. It is best adapted to inside work, but when well seasoned and protected with paint can be used outside; is said to warp and crack too much for good shingles. The wood is also largely used for fuel and charcoal. Bark valuable for tanning.

The spruce forests in the Rocky Mountain region are very important in holding the snow and preserving a flow of water in the streams. Thus the snow is often retained as late as the 1st of August; and the growing season for these trees does not average more than two months.

Description.—Leaves $\frac{1}{2}$ to $\frac{9}{10}$ of an inch long, strongly keeled, and awl-pointed. Cones ovate-cylindrical; $1\frac{1}{2}$ to $2\frac{3}{4}$ inches long, and $\frac{3}{4}$ to 1 inch in diameter; on stems $\frac{1}{4}$ to $\frac{3}{4}$ of an inch long; reddish brown when mature; scales thin, horny, rhomboidal, with truncate tip, which is entire, with two to three small teeth, or rounded. Branches mostly short and small. Bark scaly, grayish, or reddish-purple.

12.—Blue Spruce. White Spruce. "Balsam." (*Picea pungens*, Engelm.)

A local and somewhat rare tree occurring in central Rocky Mountain region—Wyoming, Colorado, and Utah—between 6,000 and 9,000 feet. It prefers a damp soil, and grows rapidly in such situations, attaining a height of over 100 feet, with a diameter of 3 feet or more. The wood is light, soft, weak, and probably of little value. The trunks taper too rapidly to be cut into lumber to advantage.

Description.—Leaves $\frac{1}{2}$ to $\frac{9}{10}$ of an inch long, rigid, 4 angled, needle-pointed. Cones light reddish-brown, $3\frac{1}{2}$ to 4 (often 5) inches long, by $1\frac{1}{2}$ inches in diameter; scales very thin, rhomboidal, truncated, with wavy, irregular, or entire margin. Bark grayish on large trees, very thick and furrowed; that of the branches rather smooth and glossy. A beautiful tree, of fine ornamental appearance, with more or less silvery-white foliage and sharply-tapering crown.

13.—BALSAM FIR. BALM-OF-GILEAD FIR. (*Abies balsamea*, Miller.)

A rather small tree growing in damp or swampy sites of the Rocky Mountains of Idaho and Montana (found also in northeastern United States and north of boundary). It is a short-lived tree, and owing to the small size, lack of strength, hardness, and durability of its wood of little importance as a timber tree; 50 feet in height, and 1 foot or more in diameter; at high elevations much reduced in size.

Description.—Leaves sessile, ¼ to 1 inch long, narrow, flat, with small notch at the tip and white lines above, a silvery tinge below; thickly spreading, somewhat regularly in spirals on all sides of the branches, but on horizontal twigs, crowded chiefly on the upper side. Leaf-scars oval, prominent, lasting. Cones 2 to 4 inches long, 1 to 1½ inches in diameter, upright on short footstalks (upper branches), cylindrical, tapering slightly; scales blue-purple, broad, roundish, entire, each with an accompanying outside bract. Branches chiefly in whorls of about five.

14.—BALSAM. (*Abies Subalpina*, Engelm.)

A tall, slender tree much isolated and rarely forming forests. Generally growing in gravelly soil of slopes and canyons between 4,000 and 12,000 feet elevation. It occurs in the mountain ranges of Utah, and from Colorado to Montana (westward to Oregon and Washington Territory, and north of United States boundary). It seldom attains more than 100 feet in height, and from 2 to 3 feet in diameter. The wood is very soft and light, possessing little strength.

Description.—Leaves of the lower branches usually long, narrow, and blunt, in two ranks; those of the upper young branches *shorter*, much broader, thicker, acutely pointed, attached by a *broad base*, dense, somewhat in two ranks; whitish beneath; $\frac{7}{10}$ to 1½ inches long. Young branches with longitudinal ridges.

15.—GREAT SILVER FIR. WHITE FIR. (*Abies grandis*, Lindley.)

A very large and important timber tree occurring in Bitter Root Mountains, Idaho, and in ranges of northwestern Montana (also on Pacific coast from latitude 40° to boundary of United States and northward); 250 to 300 feet high, with a diameter of 4 to 5 feet. It prefers bottom-lands and northern and western slopes below 4,000 feet, but producing the largest timber in the former situations. It is perhaps of greatest importance in the northern Pacific region, where it is said to attain its largest dimensions, and is employed considerably for lumber. The wood, however, is light, soft, and quite inferior to that of the Douglas and Sitcha Spruce.

Description.—Leaves ½ to 1½ inches long, narrow, flat, channeled, blunt, with a small notch at the tip, comb-like in arrangement, an upper and lower horizontal rank on each side of the branchlets; leaves of lower rank much longer; glossy and with two white lines beneath. Cones solitary, 2 to 5¼ inches long, cylindrical, on very short footstalks; scales *very broad*, entire. Bark scaly and brownish.

16.—White Fir. Balsam Fir. Black Balsam. (*Abies concolor*, Lindl. and Gordon.)

Found in New Mexico and southern Colorado (westward in central Utah, northern Arizona, southern California to Oregon). It is most abundant along the Pacific coast, occupying moist slopes and canyons, between 3,000 and 9,000 feet elevation. It commonly grows to a height of 100 feet, with a diameter of 4 feet and over. The wood is soft, very light, and little used for lumber, except in temporary constructions, and for domestic purposes.

Description.—Leaves ½ to 2, sometimes 3 inches long, thick to thin, flat, blunt to awl-pointed, or slightly notched at the tip; in two ranks, chiefly on the upper side of the branchlets; pale green, whitish beneath. Cones nearly sessile, 2¾ to 5 inches long, and 1¼ to 2¼ inches in diameter; ovate, cylindrical, pale green, dull purple, or light reddish brown; scales ¾ to 1½ inches broad. Bark light gray. Branches quite regularly in whorls.

17.—Western Hemlock. (*Tsuga Mertensiana*, Carrière.)

A Western representative of the Eastern Hemlock (*Tsuga Canadensis* Carr.), but much larger and with finer-grained wood. It ranges from western Montana westward to the Pacific coast, and north of the United States boundary; southward on coast through northern California, forming large forests at elevations between 1,000 and 4,000 feet. It is quite adaptive in point of soil conditions, thriving on poor dry ridges, but prefers a moist soil. Probably reaches its greatest development in Oregon and Washington Territory; 180 feet high, and 6 to 8 feet in diameter. The wood is rather heavy, hard, and quite free from resin, but somewhat lacking in strength; employed to some extent for coarse lumber, while the bark supplies an important demand for tanning.

Description.—Leaves flat, very narrow, ⅓ to ¾ of an inch long, blunt at the top, tapering suddenly to a slender stem (petiole). Cones ovate-cylindrical, ½ to ¾ of an inch long, light brown, with delicate pubescence; sscale few (and much longer than those of *Tsuga Canadensis*). Crown roundish to somewhat conical; branchlets numerous, slender, drooping.

18.—*Tsuga Pattoniana*, Engelm.

An alpine species having about the same range as the Western Hemlock (*Tsuga Mertensiana*, Carr.). It occupies dry slopes and ridges between 2,700 and 10,000 feet, but is reduced to a shrub as it approaches the timber-line. The wood is light and soft.

Description.—Leaves ½ to ¾ of an inch long, about four-angled, rather sharp-pointed, or blunt tapering to a stem at base. Cones 2 to 3 inches long, cylindrical-ovate. Bark thick, much cracked, reddish-gray; branchlets pubescent.

19.—Douglas Spruce. "Red Spruce." Yellow Fir. Red Fir. Oregon Pine. (*Pseudotsuga Douglasii*, Carrière.)

A remarkably large and one of the most important timber trees, quite generally distributed throughout the Rocky Mountain region (along the Pacific coast and north of the United States boundary). It is largely associated with pine, forming pure growths only in a few localities, and then of small extent. It grows from the sea-level to 10,000 feet, attaining from 200 to 300 feet in height and 10 feet in diameter. The wood is hard, strong, and durable, being especially valuable for large timber and coarse lumber, where durability and strength are needed.

Description.—Leaves, comb-like in arrangement, ½ to 1½ inches long, slender, flat, with stems, rather blunt-pointed; whitish on the under surface. Cones 2 to 4 inches long, 1 inch in diameter; somewhat cylindrical or ovate, with a fringe of three-pointed bracts from among the scales. Seeds reddish brown on one side, white on the other. Bark grayish brown: when young, smooth; in old trees rough, deeply furrowed, and sometimes over 1 foot thick.

20.—WESTERN LARCH. TAMARACK. (*Larix occidentalis*, Nutt.)

A western representative of the northeastern Tamarack, but a much larger, and in some respects a more valuable, tree. It is found in western Montana (also ranging westward in Oregon and Washington Territory and north of the United States boundary), usually occupying moist slopes between 2,500 and 5,000 feet. It is almost always associated with other species, and rarely, if ever, forming pure growths. In Montana it attains its most valuable size, reaching a height of 100 to 150 feet, with a diameter of 4 feet or over. The wood is heavy, very hard, strong, and durable, and is employed somewhat for lumber, but chiefly for posts, ties, fuel, etc.

Description.—Leaves 14 to 20 in a bundle, ½ to ¾ of an inch long, narrow, somewhat four-angled, slender at the base, pointed at the tip; pale green. Cones ovate-globose, ¾ to 1½ inches long, by ¾ of an inch in diameter; solitary, erect or bent down; scales few, ½ of an inch long, roundish, loosely overlapping, squarish or notched at the tip, shining on the back; an elliptical, finely-toothed, acutely-pointed bract extending from the base and beyond the point of each scale, chiefly the long points only being visible beyond the ends of the scales. *Larix Europaea* and *Lyallii* also have an extended bract, but of different form. Branches, short; lower ones horizontal, upper ones ascending. Young shoots smooth, with many round black buds.

21.—*Larix Lyallii*, Parlatore.

A strictly alpine species, of small size, growing in dry rocky situations of northwestern Montana (and westward) at elevations between 5,500 and 7,000 feet; generally much scattered and associated with other conifers. The timber is little used, on account of its inferior size and the usually inaccessible positions occupied by it.

Description.—Leaves ¾ of an inch long, 40 to 50 in a bundle, very narrow, on young shoots single and longer. Cones 2 inches long, ovate-oblong (only immature specimens examined) and 1 inch in diameter; deciduous, greenish purple; margin of scales woolly-fringed; awl-pointed bracts from among and longer than the scales, the broad bases of the bracts being visible. Much branched; young shoots and buds clothed with a whitish wool.

22.—CANOE CEDAR. RED CEDAR. YELLOW CEDAR. (*Thuya gigantea*, Nutt.)

A large-sized tree and one of great economical importance. It occurs in northwestern Montana (and from California to Washington Territory and north of the boundary), growing chiefly in moist, but sometimes in dry, situations up to an elevation of 5,000 feet. In the northern Pacific coast region it reaches its most valuable dimensions—100 to 130 feet, and 6 to 9 feet in diameter. The wood is soft, light, and lacking in strength, but furnishes excellent material for inside work, as well as for coarse lumber, shingles, staves, etc.

Description.—Leaves short, scale-like, pointed, somewhat closely overlapping, and forming *short* internodes; no glands or tubercles (or very obscure); bright to glaucous green. Cones ½ of an inch long, ovate, of few scales, clustered at the ends of the branches, drooping; seeds winged all around. Crown narrow, pyramidal; branches spreading and somewhat drooping. Liable to be confounded with the California White Cedar (*Libocedrus decurrens*, Torrey).

23.—*Cupressus Guadalupensis*, Watson.

Little is known of the economic importance of this tree, as it is a comparatively new species, discovered in eastern Arizona in 1880. It occurs in southeastern New Mexico, eastern and southeastern Arizona, and southward, forming dense forests on rocky sites of from 5,000 to 8,000 feet elevation. It commonly grows to a height of 40 to 70 feet, and 2 to 4 feet in diameter. The timber is light and straight-grained, and splits very readily; the heart-wood resembles that of the Red Cedar very closely. In mining districts it has been employed considerably for wood and charcoal.

Description.—Leaves small, scale-like, opposite, appressed, overlapping, and forming short 4-angled branchlets, whitish (glaucous), free from pits or glands. Cones globe-like 1 to 1¼ inches in diameter, composed of from 6 to 8 thick, plate-like scales with large curved bosses, crowded on short, strong, footstalks. Bark dark red and fibrous, showing bright vermilion surface when newly scaled off. Closely grown, it is a tall and straight tree, but shorter and with greater ambitus when isolated.

24.—JUNIPER.* (*Juniperus pachyphloea*, Torrey.)

A tree 30 to 50 feet high and 3 feet or more in diameter, occurring in southern Arizona, New Mexico (in the mountains of western Texas, and southward into Mexico). It is confined chiefly to dry slopes and ridges between 2,000 and 3,000 feet, and in its mountain range is the principal juniper, especially in Texas. The wood is light, soft, and easily wrought. Fruit an important article of food among the Indians of the Southwest.

Description.—General aspect white. Leaves in threes, overlapping closely, rather sharp-pointed, ridged on the back, with a gland in the center; very glaucous. Fruit solitary, globe-like, ½ of an inch in diameter, brownish, white with bloom, sweetish, borne at the ends of short erect branchlets, the latter somewhat four-angled.

* See non-arborescent Junipers, page 197.

25.—"Rocky Mountain Juniper." (*Juniperus occidentalis*, Hooker, var. *monosperma*, Engelm.)

A scraggy, stunted tree, occupying low, dry hills between 3,500 and 7,000 feet elevation. It ranges through southern Colorado, New Mexico (and westward through southern Arizona to southern California). In some localities it forms pure growths, but is chiefly associated with the Nut Pine (*Pinus edulis*) and *Juniperus pachyphlœa*, together forming the principal timber growth of the hilly sections; 25 to 30 feet in height, and $1\frac{1}{2}$ feet or more in diameter. Wood rather light and soft, but very durable in contact with the soil, and employed largely for fuel and fencing.

Description.—Leaves in twos (alternate opposite pairs) and threes, fringed. Berries blue-black or copper-colored, resinous-fleshy; one to two, or more, grooved seeds in each berry. Branches short, horizontal, and often from the ground.

26.—Red Cedar. Savin. (*Juniperus Virginiana*, Linn.)

A valuable tree, and one of the most widely distributed of the North American Conifers. It is a very adaptive species, but the character of the soil has much to do with its success as a timber tree; in bottom-lands it reaches a height of nearly 100 feet, with a diameter of 3 feet or more, while in dry, barren soil it is a small, slow-growing tree, or little more than a shrub. In the Rocky Mountain region it occurs chiefly in the mountains of Colorado, Wyoming, Montana, and Idaho (also through eastern United States and north of the boundary). The timber is light, soft, and possesses remarkable durability in contact with the soil. It is employed principally for posts, ties, and cabinet work.

Description.—Leaves scale-like, in twos, sometimes in threes, mostly in alternate opposite pairs, of two forms: on young plants and shoots, needle-pointed and somewhat spreading; on mature branchlets, awl-pointed and closely overlapping; bright glossy green to tawny brown in winter; midrib indistinct. Branchlets slender, four-angled. Berries small, ovate, smooth, but with few small, scaly protuberances; whitish with bloom.

27.—Yew. (*Taxus brevifolia*, Nutt.)

A somewhat rare and small tree as it occurs at its eastern limit in the Rocky Mountains of western Montana and Idaho. In its more westerly range, however (through Washington Territory and Oregon to central California), it attains a much larger size, 40 to 70 feet in height and $1\frac{1}{2}$ to $2\frac{1}{2}$ feet in diameter. It generally prefers a moist, rich soil, and on the Pacific Coast is much associated with Lambert's Pine and the Douglas Spruce. The wood is hard, durable, and very elastic, and is used considerably for fence posts, tool-handles, bows, etc.

Description.—Leaves scattered, $\frac{3}{4}$ to 1 inch long, narrow, flat, curved, sharp-pointed, ribbed above, on yellowish footstalks; yellowish glossy green above, whitish (*glaucous*) below. Fruit solitary, borne on the under side of the branches, amber-red or yellowish brow Branches long, slender, and pendulous; bark yellowish.

RUTACEÆ: RUE FAMILY.

28.—Shrubby Trefoil. Hop-Tree. (*Ptelea angustifolia, Benth.*)

Chiefly a shrub, or sometimes a small tree 15 to 25 feet in height, with very slender trunk, usually growing on hillsides in dry, gravelly soil, through southern Colorado (extending southward into Mexico and Texas). Rarely attaining sufficient size to be of economic value. The wood is heavy and hard.

Description.—Leaves compound, composed of three leaflets, which are given off at the end of a slender (leaf) stem, 1 to 2 inches long and ¼ to 1 inch wide, lance to oblong-lance-shaped, usually tapering to a point at either end; margin entire or with shallow rounded teeth; smooth, old leaves shiny. Fruit (much like that of the elm) surrounded by an early orbicular, thin, veiny wing, ¼ to ⅝ of an inch in diameter. Bark dark brown and often thickly dotted.

RHAMNACEÆ: BUCKTHORN FAMILY.

29.—Blue Wood. Log Wood. Purple Haw. (*Condalia obovata,* Hooker.)

A small tree or shrub, at best seldom more than 10 to 30 feet in height and with very slender trunk—3 to 6 inches in diameter. It is found in southern New Mexico (southern Arizona and southwestern Texas, where it is said to reach its greatest development), especially along streams. Abundant and in many localities forming dense, impenetrable thickets. The wood is hard and very heavy.

Description.—Leaves ¼ to ¾ of an inch long, by $\frac{1}{10}$ to ½ of an inch wide, chiefly broad at the top end (obovate), tapering to a long point at the base; rounded at the upper end, or with a lance-shaped point. Branches with smooth thin bark of a dull white or grayish color; branchlets spine-like or terminating in a small sharp spine. Fruit a globular berry (drupe) with scanty flesh and large hard stone; a short point or beak (the persistent stigma) adheres to the end.

30.—"Indian Cherry."* (*Rhamnus Caroliniana,* Walter.)

A small tree, 15 to 30 feet in height, with a trunk 6 to 10 inches in diameter; or sometimes reduced to a slender shrub. It is found in the mountains from Colorado to Montana (eastward it ranges from western Texas to northern Florida, and northeastward through the valley of the Ohio River to long Island, New York). It prefers the rich soil of bottom-lands and along streams: probably reaching its largest size in Texas and Arkansas. The wood is rather light and hard, but not strong.

Description.—Leaves 3 to 6 inches long, 1 to 2 ¼ inches wide; oblong lance-shaped or ovate-oblong; with rounded base and rather short point; margin wavy, nearly entire or with very small teeth; leaf-stems hairy. Flowers and fruit borne in the axils of the leaves, the latter black, somewhat pear-shaped, and with three large seeds; sweet and edible.

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* See *Rhamnus* in list of shrubs, page 190.

31.—Bearberry. Bear Wood. Shittim Wood. (*Rhamnus Purshiana*, De Candolle.)

A shrub or small tree, 6 to 25 feet in height, and from 4 to 12 inches in diameter. It occurs in northern Montana and Idaho (also along the Pacific coast from northern California to Washington Territory). Generally associated with conifers in canyons and low places. The wood is light and hard, but brittle, being of little importance. The bark, however, has of late become an important article of of commerce, being extensively employed for officinal purposes under the name of *Cascara sagrada*.

Description.—Leaves chiefly alternate, elliptical, $1\frac{1}{2}$ to $3\frac{1}{2}$ inches long, $1\frac{1}{2}$ to $1\frac{3}{4}$ inches broad, finely toothed on the margin, and somewhat downy below. The fruit is berry-like, black, 3-lobed, larger at the top, 3-seeded, and borne in clusters on rather long stems from the axils of leaves; about $\frac{1}{4}$ of an inch in length. Young branches and stems of the leaves woolly.

SAPINDACEÆ: SOAPBERRY FAMILY.

32.—Spanish Buckeye. (*Ungnadia speciosa*, Endlicher.)

A shrub or small tree, 20 to 30 feet in height and 6 to 12 inches in diameter, found growing abundantly on moist bottoms and rich slopes of southern New Mexico (western Texas, and northern Mexico). The wood is soft, rather heavy, but lacking in strength. The fruit and leaves are said to be poisonous.

Description.—Leaves compound, composed of from $3\frac{1}{2}$ to $5\frac{1}{2}$ pairs of leaflets, which are on very short stems, ovate, lance-shaped, and with a rather long point; the margins have fine, or large and distant teeth; in length the leaflets vary from 2 to 4 inches and from $\frac{3}{4}$ to $1\frac{3}{4}$ inches in width. Shell of fruit thin, smooth, brown, strongly 3-lobed, containing as many dark, shiny nuts about $\frac{1}{2}$ an inch in diameter. The flowers appear in advance of the leaves in small lateral clusters. Young shoots and leaf-stalks downy.

33.—Wild China. Soapberry. (*Sapindus marginatus*, Willdenow.)

A rather large and somewhat important tree, occurring in southern New Mexico (and Arizona; eastward through the Gulf States to the Atlantic coast). It grows chiefly in mountain valleys and river-bottoms, attaining its largest size in eastern Texas, 10 to 60 feet in height, with a diameter of $\frac{1}{2}$ to $1\frac{1}{2}$ feet. The wood is heavy, hard, and strong; it splits easily, and is extensively used in the manufacture of cotton baskets.

Description.—Leaves compound; leaflets nine to eighteen, arranged in opposite pairs or alternate, lance-ovate, hooked, unequal sided, unsymmetrical; veins prominent above. Fruit globular, berry-like, borne in the axils of leaves.

MAPLES.

34.—Dwarf Maple. (*Acer glabrum*, Torrey.)

As indicated by its name, this species is seldom more than a shrub 3 to 6 feet high; occasionally it reaches a height of 10 to 20 feet, with a diameter of 4 to 6 inches. It is widely distributed throughout the Rocky Mountain region (on Pacific coast to British Columbia), growing along water-courses, in sheltered canyons, and on moist slopes; said to reach its best development in western New Mexico and eastern Arizona. The wood is heavy and hard. It is a very hardy tree and considerably used for ornamental planting.

Description.—Leaves somewhat kidney-shaped, 3-lobed to 3-parted; divisions themselves somewhat 3-lobed, middle one wedge-shaped, short, broad, margin sharply cut and toothed; smooth both sides. Generally branching from the ground.

35.—*Acer grandidentatum*, Nuttall.

A small and rather rare tree, found growing along water-courses in western Montana and southern New Mexico (also in eastern Arizona and central Utah). It is seldom more than 20 feet in height and 4 to 10 inches in diameter. The wood is heavy and hard.

Description.—Leaves heart-shaped or cut straight across (truncate) at the base, somewhat deeply 3-lobed; divisions sharp-pointed and mostly entire, but occasionally with few coarse teeth; velvety on the under surface, or sometimes smooth.

36.—Box-elder. Ash-leaved Maple. (*Negundo aceroides*, Mœnch.)

One of our most widely-distributed forest trees, occurring throughout the Rocky Mountain region at elevations between 5,000 and 6,000 feet (east of the Rockies to the Atlantic coast, and north of the U. S. boundary), preferring the more southerly ranges. It is adapted to a variety of soil conditions, but generally attains its best dimensions on moist bottom-lands and along streams. Commonly 30 to 60 feet in height and 1 to 3 feet in diameter. As an ornamental tree it is quite popular, being easily handled and reaching a desirable size in a comparatively short time.* The wood is of rather an inferior quality, being light, soft, and lacking in strength. It is little used for manufacturing purposes, except occasionally for interior lumber, and to some extent in turnery, cooperage, and for paper-pulp.

Description.—Leaves compound, composed mostly of 3 (sometimes 5) leaflets, which are ovate, pointed, often with entire margin, but usually coarsely toothed, and strongly veined; smooth or occasionally downy on the under surface. The flowers appear in advance of the leaves, and hang down in green, tassel-like clusters. The seeds are usually very abundant, and have long, curved, veiny wings, and hang in thick clusters on long slender stems. Young branches greenish.

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* It is also desirable as an admixture in forest planting, the heavy foliage furnishing a good soil cover.

LEGUMINOSÆ: PULSE FAMILY.

37.--LOCUST. (*Robinia Neo-Mexicana*, Gray.)

Usually a small tree, 20 to 25 feet, with a diameter of 3 to 6 inches; or a shrub under 6 feet in height. It occurs in southern Colorado, southwestern and western New Mexico (and in Arizona and southern Utah between 4,500 and 7,000 feet elevation). It is said to reach its best development in the valley of the Purgatoire River, southeastern Colorado. At high elevations often reduced to a shrub. The wood is heavy, very hard, and strong.

Description.—Leaves composed of from 4½ to 9½ pairs of elliptical leaflets, which are more or less clothed with a whitish silky down, especially prominent on very young leaves. Leaf-stems and branchlets thickly set with stiff, straight, glandular hairs, as also are the pods. The latter are flat, often jointed, and vary in length from ½ to 3¾ inches, with a width of not more than ½ an inch; the end of the pod terminates in a curved awn. Two rather strong thorns ¼ to ½ an inch long) at the base of each leaf-stalk. Flowers showy, purplish.

38.—FRIGOLITO. (*Sophora secundiflora*, Lagasca.)

Chiefly a shrub, forming dense growths along streams or growing sparingly on rocky hill sides; as a tree it is seldom more than 30 feet high, with a slender trunk. It extends from the mountains of New Mexico to the Gulf coast of Texas, and where large enough to be available its hard heavy wood is highly esteemed for fuel. Very ornamental in appearance.

Description.—Leaves compound, evergreen, with from 3½ to 5½—scarcely opposite—pairs of leaflets; the latter 1 to 2½ inches long and ½ to 1 inch wide, elliptic-oblong or ovate, with a wedge-shaped base and a usually rounded apex; margin entire, smooth, often shiny above; leaf-stems with a groove on top, and when young velvety, as are the flower-stems. Pods thick, woody, silky, with 1 to 2 speherical or elliptical (rarely 3 or 4 fertile) joints, which are ¾ of an inch in diameter and contain one or two red, very hard-shelled beans, bearing a deep white scar. They are said to have produced poisonous effects in persons who have eaten them, although the Angora goats feed upon the leaves of the plant and often swallow the beans without injury; but the shells of the latter are rarely, if ever, crushed by the animal's teeth.

39.—MESQUIT. ALGAROBA. HONEY-POD. HONEY LOCUST. (*Prosopis juliflora*, De Candolle.)

A tree of great economic importance. It is found in southern Colorado, and through New Mexico (to southern California; occuring also in western Texas, southern Utah, and Nevada, Mexico, and southward). Along streams and in valleys it sometimes forms forests of considerable extent, though never attaining a height of more than 50 feet, with a diameter of 1 to 2½ feet; commonly much smaller, and in dry rocky situations, especially those subject to annual burning, reduced to a shrub; but the root system is then enormously developed—locally termed " under-ground forests"—and furnishes a cheap and valuable fuel. The timber is heavy, very hard, and possesses remarkable durability. It is employed chiefly for fuel, tie-timber, and fencing, but somewhat for heavy wheel stock and in the manufacture of charcoal.

Description.—Leaves compound, twice pinnate, single or in clusters, with a pair of stiff, straight, yellowish thorns $\frac{1}{4}$ to $\frac{1}{2}$ inch long at the base of each leaf-stalk or cluster; leaflets $\frac{1}{4}$ to $1\frac{3}{4}$ inches long, by $\frac{1}{10}$ to $\frac{1}{4}$ of an inch wide, elliptic-oblong to lance-linear. A cup-shaped gland at the end of the main leaf-stem, (where the usually single pair of smaller stems (pinnæ) with leaflets is given off). Pods somewhat flattened, straightish or curved, 3 to $7\frac{1}{2}$ inches long, $\frac{1}{4}$ to $\frac{1}{2}$ an inch wide; composed of 12 to 25 lobe-like joints (containing as many seeds), and terminating in an awl-point; young pods covered with a dense velvety down, yellowish-white when mature. They have a sweet taste, and are often used for fodder.

40.—SCREW BEAN. SCREW-POD. MESQUIT. TORNILLA. (*Prosopis pubescens*, Benth.)

A small tree or shrub growing on gravelly or sandy bottom-land, through New Mexico (in western Texas, through Arizona to California; southward into Mexico); said to attain its largest size within the United States in the valleys of the lower Colorado and Gila Rivers—20 to 25 feet in height, and 6 to 12 inches in diameter. The wood is heavy, very hard, and brittle, but exceedingly durable, and is used for fencing and fuel. Pods sweet, sometimes used for fodder, and for flour by Indians.

Description.—Leaves essentially as in *Prosopis juliflora* (No. 39), with a pair of straight pearly-white thorns at base of each leaf or cluster; leaflets elliptic-oblong, often with a short fine point (probably less variable in size than those of the preceding species), $\frac{1}{4}$ to $\frac{1}{2}$ an inch long, and $\frac{1}{12}$ to $\frac{1}{6}$ of an inch wide. Pods cylindrical, 1 to $2\frac{1}{2}$ inches long, $\frac{1}{6}$ to $\frac{1}{4}$ of an inch in diameter, straightish or crooked, closely coiled in a spiral; clothed with a fine velvety down; light brown at maturity. Branchlets with white longitudinal (decurrent) lines proceeding from the bases of the thorns.

41.—CAT'S CLAW. (*Acacia Greggii*, Gray.)

Often a shrub, or a low much-branched tree, 20 to 25 feet in height and sometimes 10 inches in diameter, growing abundantly on the dry table-lands and in the low canyons of southern Utah (Dr. Palmer), New Mexico and Arizona (extending to California; also in northern Mexico and western Texas). The wood is heavy, very hard and strong, furnishing good fuel. Large trees often hollow.

Description.—Leaf-stems short, giving off 2 to 3 pairs of smaller stems (pinnæ) which bear 3 to 6 pairs of very small ($\frac{1}{8}$ to $\frac{1}{3}$ of an inch long) oblong-ovate (broader above) unequal-sided leaflets, with a rounded or abrupt apex, downy. Pods smooth, flat, curved, 3 to 6 inches long, and $\frac{1}{2}$ to $\frac{3}{4}$ of an inch broad; usually with constrictions between the seeds; the latter flat, obicular, and dark brown. Branches sparingly armed with short hooked prickles, or occasionally unarmed, sometimes with whitish lines.

ROSACEÆ: ROSE FAMILY. CHERRIES AND PLUMS.

42.—WILD YELLOW OR RED PLUM. CANADA PLUM. HORSE PLUM. (*Prunus Americana*, Marshall.)

A small thorny tree, abundant, and forming thickets in dry or moist situations. It is seldom more than 15 to 30 feet high, with a diameter of 3 to 10 inches. In the Rocky Mountain region it is found chiefly in central Colorado, but has a wide range through the eastern United States and north of the boundary. It reaches its largest size in eastern Texas. The wood is heavy, very hard and tough, and is used occasionally for fuel, light tool-stock, etc. The fruit is often large, edible, and with a pleasant taste when fully matured. Sometimes cultivated or used for grafting stock.

Description.—Leaves 2 to 3 inches long, ovate, pointed, coarsely or finely toothed on the margin; smooth and with prominent veins when mature. Fruit somewhat spherical to ovoid in shape, ½ to 1 inch in diameter; dark, with reddish tinge and yellowish areas.

43.—CHICKASAW PLUM. HOG PLUM. (*Prunus angustifolia*, Marshall.)

Supposed to be a native of the eastern slopes of the southern Rocky Mountains, here found at elevations up to 7,000 feet. (But by cultivation it has become widely distributed eastward to the Atlantic coast, south of Pennsylvania.) It is a small tree, 20 to 30 feet in height, with a trunk 4 to 10 inches in diameter, or in some situations reduced to a shrub. It prefers a rich, moist soil, and is found growing chiefly along water-courses and the borders of rich woods. The wood is rather heavy, but soft and brittle. Cultivated considerably for its fruit.

Description.—Leaves 1½ to 2 inches long, thin, smooth, lance-shaped, with fine, sharp, incurved teeth on the margin. Fruit ½ to ¾ of an inch in diameter (borne on short stems), spherical, yellowish red, and with little bloom; thin-skinned, sweetish. Chiefly shrubby and inclined to be thorny.

44.—WILD RED CHERRY. PIN CHERRY. PIGEON CHERRY. (*Prunus Pennsylvanica*, Linn.)

Commonly a very small tree or shrub as it occurs in the Rocky Mountains of Colorado. In its eastern range through northern and central United States it becomes somewhat larger, but seldom more than 15 to 30 feet in height, and 6 to 12 inches in diameter. The wood is soft and light, and where large enough is occasionally cut for fuel. Fruit used sometimes for medicinal purposes.

Description.—Leaves 2 to 3½ inches long, ovate, lance-shaped, long-pointed, finely and sharply toothed on the margin; thin, shiny, green above and below. Fruit small, globular, very dark red; flesh scanty and sour. Bark reddish brown.

45.—OREGON CHERRY. (*Prunus emarginata*, Walpers.)

A tree sometimes 20 to 30 feet in height, and 4 to 10 inches in diameter, occurring abundantly along streams and in moist valleys of the mountainous portions of northern Idaho and western Montana (on Pacific coast and north of United States boundary), reaching elevations from 3,000 to 4,000 feet; but at high altitudes reduced to a shrub. Remarkable for the density of its growth, covering quite large areas. Variety *mollis* (Brewer) is the form commonly met with in the northern Rocky Mountain region. The timber is light, soft, and brittle.

Description.—Leaves oblong-ovate, or lance-shaped, chiefly with a blunt apex, tapering to a short stem; with small, rounded teeth on the margin, and woolly pubescence on the under surface. Fruit small, globular, red or blackish, with bitter astringent taste; not edible; stone with a grooved ridge on one side. Bark much like that of the common cherry tree of cultivation. Notable for its slender, straight trunks.

46.—WILD CHERRY. (*Prunus Capuli*, Cavanilles.)

A rather small tree, growing in light, rich soil of canyon bottoms, and ranging through Arizona, New Mexico (western Texas, and southward), usually between 5,000 and 7,000 feet. It is a very prolific species, but does not attain its largest size in the United States; commonly not more than 30 feet in height, with a trunk 3 to 10 inches in diameter. The wood is heavy and rather hard.

Description.—Leaves 1 to 3¼ inches long, ovate to lance-shaped, sometimes with rather long tapering point; finely and sharply toothed on the margin; smooth, paler on under surface. Very young shoots and leaf stalks downy. Fruit globular, ⅝ of an inch in diameter, dark red, with large stone and scanty flesh; edible.

47.—WILD CHERRY. (*Prunus Demissa*, Walpers.)

Chiefly a small shrub as met with on the western slopes of the Rocky Mountains of Montana. In its more westerly range on the Pacific coast it becomes larger, sometimes 30 feet in height, and 6 to 12 inches in diameter, usually preferring rich valleys. The wood is heavy, hard, but brittle.

Description.—Leaves ovate to oblong-ovate, tapering suddenly to a point, rounded or heart-shaped at the base; sharply toothed (teeth straight) on the margin; commonly downy on the under side and dull green above. Fruit purplish or dark red, with sweetish-astringent taste; edible.

48.—CHOKE-CHERRY. (*Prunus Virginiana*, Linn.)

Chiefly a slender shrub, but sometimes a small tree 10 to 15 feet in height. A widely-distributed species, occurring generally throughout the northern Rocky Mountain region (also eastward and north of the United States boundary), usually preferring moist positions. The wood is light and rather hard.

Description.—Leaves thin, usually smooth and shiny above, paler beneath, 1 to nearly 5 inches long, mostly broad-ovate (wider near the top) to oblong, tapering suddenly to a short point at either end, sometimes heart-or wedge-shaped at the base; margin finely cut with sharp teeth (often of two sizes). Flowers (white) and fruit borne in a rather long cylindrical cluster (*raceme*); the latter when ripe ¼ to ⅓ of an inch in diameter), dark red, very astringent, though with more or less pleasant taste.

49.—*Canotia holocantha*, Torrey.

An anomalous shrub, or small tree, 10 to 20 feet high, and entirely without leaves. It occurs on the dry plateaus of Arizona, and probably in New Mexico. The wood is heavy and hard, but of little use except for fuel.

Description.—The branches are straight, spine-like, and peculiar for their smooth green bark with black scars. The seeds are borne in a solitary, erect, woody pod (1 inch long) with thin, sharp point, at maturity splitting open at the top, thus forming 10 bristle-pointed teeth; seed small, flat, dark, with a thin wing attached to one end.

50.—MOUNTAIN MAHOGANY. (*Cercocarpus ledifolius*, Nuttall.)

A low tree or shrub, rarely more than 35 feet in height and 2 feet in diameter; usually much smaller—10 to 20 feet. It generally grows on dry rocky slopes between 6,000 and 8,000 feet elevation, and is found in the mountain ranges of northern Idaho, western Montana and Wyoming, Arizona, and New Mexico (it occurs also on the Pacific coast from Washington Territory to southern California). The wood is dark, exceedingly heavy and hard, but not strong. It furnishes the most valuable fuel of the Rocky Mountain region, and is extensively employed in making charcoal.

Description.--Leaves ½ to 1½ inches long, narrow lance-shaped, sharp-pointed; margins entire, and commonly rolled back; thick, leathery, slightly resinous; smooth above, downy on the under surface; evergreen. Seed with a hairy tail 2 to 3 inches long. Usually a low and much-branched tree; crown dense.

51.—MOUNTAIN MAHOGANY. (*Cercocarpus parvifolius*, Nuttall.)

Chiefly a shrub, but sometimes attaining a height of 20 to 30 feet, with a diameter of 6 to 12 inches. It generally occurs on dry gravelly soil at elevations between 6,000 and 8,000 feet, ranging through the Rocky Mountains of Wyoming, Colorado, and New Mexico, where it is said to reach its largest size (southern Arizona and southward; also on coast of California and southward). Like the preceding species, it affords excellent fuel, and where large enough is used considerably for this purpose.

Description.—Leaves ½ to 1½ (commonly ½ to ¾ inch) long, on short stems; mostly wedge-shaped at the base, rather coarsely toothed at the upper end, which is rounded or sharp-pointed; young leaves with silky hairs above, with age less prominent or wanting; whitish on the under surface, with fine, dense wool; evergreen. Seed with a hairy tail 2 to 2½ inches long, sometimes 3½ to 4 inches.

52.—WESTERN MOUNTAIN ASH. (*Pyrus sambucifolia*, Cham. and Schlecht.)

Chiefly a shrub 6 to 10 feet high, or occasionally a small tree 20 to 25 feet, with a trunk sometimes 8 or 10 inches in diameter; usually confined to deep swamps and the banks of streams. In the Rocky Mountain region it extends from New Mexico to Colorado (westward to California, north to British Columbia and northward; eastward along the northern tier of States to the Atlantic), attaining its largest size in latter range. The wood is light, soft, and of no special value except for fuel.

Description.—Leaves compound, composed of from $3\frac{1}{2}$ to $7\frac{1}{2}$ pairs of leaflets, the latter varying in length from $1\frac{1}{4}$ to 3 inches, and in width from $\frac{1}{2}$ to nearly 1 inch (exceptionally $1\frac{1}{2}$ inches wide); mostly ovate-oblong or lance-shaped, and tapering suddenly to a short point at either end, or rounded at the top; margin sharply toothed (sometimes with teeth of two sizes), smooth. Fruit abundant, in flat clusters, berry-like, red, globular, $\frac{1}{5}$ of an inch in diameter; together with the bark sometimes used officinally.

BLACK-FRUITED HAWTHORNS.

53.—*Cratægus rivularis*, Nuttall.

A shrub or small tree sometimes attaining a height of 10 to 20 feet, with a diameter of 3 to 10 inches. It occurs in the mountain ranges of Idaho, Montana, Utah, Colorado, to southern New Mexico (Pinos Altos Mountains), forming impenetrable growths along water courses and on the borders of swamps (it is found also in eastern Oregon, Washington Territory, and north of the United States boundary). The wood is hard, heavy, and tough.

Description.—Leaves ovate to lance-ovate, 1 to 3 inches long, $\frac{3}{4}$ to 2 inches wide, more or less wedge-shaped at the base, blunt or sharp-pointed; entire margin often with fine and coarse teeth, but chiefly confined to the upper part; smooth above, or with few delicate hairs, especially on the veins; pale below. Fruit blackish, $\frac{3}{8}$ inch in diameter. Thorns few, rather short and thick, $\frac{1}{2}$ to $1\frac{1}{4}$ inches long; seeds (nutlets) prominently ridged on the back. Generally much branched.

54.—*Cratægus Douglasii*, Lindley.

The most westerly of the thorns, occurring in Idaho, western Montana (and from northern California to Washington Territory and north of United States boundary). Sometimes 30 feet high and 10 inches in diameter. It prefers a somewhat moist sandy soil, forming dense thickets along streams and in valleys, reaching its largest size on the Pacific coast (Oregon) but chiefly a shrub in the Rocky Mountain region. The wood is heavy, hard, and tough, being locally used for wedges, mauls, etc.

Description.—Leaves $1\frac{1}{4}$ to 4 inches long, $\frac{3}{4}$ to $2\frac{1}{2}$ inches wide, oblong-ovate to broadly ovate, with rounded, somewhat wedge-shaped, or sharply-tapering base; rounded or sharp pointed; entire margin sometimes with fine sharp teeth, or more often with large teeth above, which are themselves entire or finely toothed; smooth on the upper surface, or with few delicate silky hairs; pale beneath. Young branchlets and leaf-stalks woolly. Fruit $\frac{3}{8}$ of an inch in diameter, black-purple, sweet, edible; often collected and eaten by the Indians; seeds (nutlets) strongly ridged on the back. Thorns short and strong, $\frac{3}{4}$ to $1\frac{3}{4}$ inches long.

55.—Black Thorn. Pear Thorn or Haw. (*Cratægus tomentosa*, Linn.)

One of the most widely distributed of the North American Thorns, varying much, and in size from a low shrub to a tree sometimes 30 feet in height and 1 foot or more in diameter, often forming dense growths along streams and in valleys. It is found in southwestern New Mexico, southwestern Colorado (eastern Washington Territory and Oregon; also ranging through the eastern half of the United States and north of the boundary). The wood is heavy and hard, but rather brittle.

Description.—Leaves varying in length from 1¼ to 4½ inches, and from 1 to 3 inches in width; oval to broadly ovate or slightly oblong-ovate, sharp-pointed or rounded; at the base tapering sharply, somewhat wedge-shaped, or rounded; margin usually cut with large teeth (sometimes lobe-like), which are themselves finely toothed (doubly serrate); upper surface smooth, or more or less downy, as are the leaf-and flower-stems. Fruit globular to slightly pear-shaped, ⅜ to nearly ¾ of an inch in diameter, light red or orange-colored; edible. Thorns 1 to 2½ inches long, thick and sharp.

CAPRIFOLIACEÆ: HONEYSUCKLE FAMILY.

56.—ELDER. (*Sambucus glauca*, Nuttall.)

A large shrub or tree, sometimes attaining a height of 20 to 25 feet, with a diameter of 6 to 12 inches. It is found abundantly in the Wahsatch Mountains of central Utah, usually along valleys in a dry soil, but is met with chiefly on the Pacific coast, extending from Mexico to British Columbia and northward. The wood is light, soft, and little esteemed. As an ornamental tree it is quite popular, being used considerably for this purpose.

Description.—Leaves compound, with 2½ to 4½ pairs of ovate or oblong lance-shaped leaflets, which vary in length from 1½ to 4½ inches, and in width from ¾ to 1½ inches; base of the leaflet acute and often with unequal sides (*uniquilateral*); apex usually with long thin point; margin sharply toothed; generally smooth (but sometimes slightly pubescent). Fruit in a flat-topped cluster, black, but covered with a *dense white bloom*—a striking characteristic. Pith of young branches white.

OLEACEÆ: OLIVE FAMILY.

57.—"SINGLE-LEAF ASH." (*Fraxinus anomala*, Torrey.)

Abundant on shady hillsides and plateaus. A small tree, rarely more than 20 feet in height and 3 to 6 inches in diameter, occurring in southern Utah and southwestern Colorado. The wood is hard, heavy, and coarse-grained.

Description.—An anomalous species, lacking the usual compound leaf peculiar to other ashes. Leaves simple, opposite, 1 to 2 inches long, ovate, orbicular or heart-shaped (chiefly the latter), often with a broad notch at the end, mostly rounded above or with short point; margin entire or with shallow, rounded teeth; sometimes smooth, but usually more or less downy on the under surfaces, as are the leaf-stems and young shoots, but more densely so. Seeds ¾ to ⅞ of an inch long, ovate, pointed at the base, rounded and with notch above, strongly veined in the center. Young shoots often strongly quadrangular, with thin raised ridge (wing) at the angles.

58.—(*Fraxinus pistaciæfolia*, Torrey.)

A small but rather abundant ash occurring along streams and on rocky plains, often growing in the crevices of rocks where there is but little soil. It ranges through southern New Mexico (southern and eastern Arizona; also in southern Nevada, in the mountains of western Texas, and south into Mexico). Thirty to 40 feet, with a diameter rarely more than 1 foot. The timber is heavy, coarse-grained, and decays rapidly, but is apparently useful for many of the same purposes as the eastern White Ash; sometimes employed for wagon-stock, handles, etc.

Description.—Leaves compound, with from $2\frac{1}{2}$ to $3\frac{1}{2}$ pairs of leaflets, the latter varying much in size and form; 1 to $4\frac{1}{2}$ inches long, $\frac{1}{4}$ to 2 inches wide, ovate to narrowly lance-shaped; margin sometimes entire, but chiefly with short, shallow, distant teeth; smooth above and below, but latter surface often downy, the veins always more or less so, as also are the young shoots and leaf-stems. Seeds $\frac{3}{4}$ to $1\frac{3}{8}$ inches long, narrow, with a spatulate wing at the end, which is rather broadly notched, rounded, or with sharp point; abundant. Branches round.

59.—Red Ash. (*Fraxinus pubescens*, Lam.)

A rather small tree, 30 to 40 feet in height, with a diameter seldom more than $1\frac{1}{2}$ feet; very rare in the Rocky Mountain region (being found chiefly in the northern and Atlantic States); generally growing along water-courses and in swampy situations. The wood is rather heavy, hard, and strong, but large timber is often brittle and much inferior to that of the White Ash, though occasionally used for the same purposes as the latter.

Description.—Leaves compound with $3\frac{1}{2}$ to $4\frac{1}{2}$ (commonly the former) pairs of leaflets, varying in length from 3 to 5 inches, and in width from 1 to nearly 2 inches; ovate to oblong—lance-shaped, with rounded base and rather long, thin point; margin chiefly entire, but sometimes with shallow or indistinct teeth; smooth above and woolly beneath; leaf-stems and young shoots rusty-velvety. Seed $1\frac{1}{2}$ to 2 inches long, narrow and pointed at the base, broadening into a narrow wing above $\frac{1}{4}$ of an inch or less in width. Freshly parted bark of the branches reddish.

60.—Green Ash. (*Fraxinus viridis*, Michx. f.)

A middle-sized tree of considerable importance on account of its adaptability to various situations, though in its natural state found mostly in rather moist soil of bottoms and along streams. It occurs in the eastern Rocky Mountain ranges of Montana, Wahsatch Mountains (in central Utah), and in the ranges of eastern and northern Arizona (eastward it is found along the Atlantic coast and north of the United States boundary). Forty to 60 feet in height and 1 to $1\frac{1}{2}$ feet in diameter. The wood is heavy, hard, and strong, often coarse-grained, and although generally inferior in quality to that of the White Ash, it is used as a substitute for the latter.

Description.—Leaves compound, with $2\frac{1}{2}$ to $4\frac{1}{2}$ pairs of leaflets, which are 2 to $5\frac{1}{2}$ inches long and from $\frac{1}{2}$ to $1\frac{3}{4}$ inches wide; ovate, oblong-ovate to lance-shaped, often with long tapering point, sometimes rather wedge-shaped or rounded at the base;

margin entire, with acute or blunt teeth, or sometimes with teeth only near the point; smooth and green both sides, but with fine, close down on midrib below. Seeds 1 to $1\frac{5}{8}$ inches long, $\frac{1}{4}$ to $\frac{1}{2}$ (commonly $\frac{1}{4}$) of an inch wide, slender and sharp-pointed at the base, broadening into a lance-shaped or spatulate wing above; ridged Branches round. Young seedlings *smooth* and *straight.*

BIGNONIACEÆ: BIGNONIA FAMILY.

61.—"Desert Willow." (*Chilopsis saligna*, D. Don.)

A small shrub or tree, 10 to 25 feet in height and 4 to 10 inches in diameter, growing only near water, and preferring a light sandy soil. It occurs through southern Arizona and New Mexico (west into southern California, east into Texas, south into northern Mexico). The wood is light, soft, and much like that of the Black Walnut, but lighter, and very suitable for cabinet-work, though large trees are apt to be hollow and useless for lumber.

Description.—Leaves alternate, $1\frac{1}{2}$ to $5\frac{1}{2}$ inches long, commonly less than $\frac{1}{4}$ inch wide; linear to linear-lance-shaped, usually tapering to a very slender point at either end. Flowers large, (2 inches long) white or purplish. The seeds are borne in a long slender pod (like the Catalpa bean), 6 to 12 inches long; seeds small, flat, and with a thin brush of whitish wool at each end.

URTICACEÆ: NETTLE FAMILY.

62.—White Elm. American Elm. Water Elm. (*Ulmus Americana*, Linn.)

A large tree, attaining a height sometimes of over 100 feet, with a diameter of 4 to 6 feet. It occurs sparingly in the northwestern Rocky Mountain region (but has an extended range east of the Rockies to the Atlantic and somewhat north of the United States boundary); very adaptive to different soils, but preferring moist bottom-lands, where it reaches its largest size. The wood is heavy, rather hard, and tough, often very difficult to split; in its eastern range used considerably for coarse lumber, flooring, staves, wheel-stock, and fuel. When employed for lumber, it requires care in seasoning to prevent it from warping badly. Often used as an ornamental tree.

Description.—Leaves 2 to 4 inches long, oval or oblong (broader above), tapering suddenly to a short, narrow point; base rounded (unequal-sided—peculiar to elms); margin sharply cut with teeth of two sizes; smooth above, hairy below, though often becoming smooth. Fruit (*samara*, $\frac{1}{2}$ inch long) with thin wing all around, borne on drooping stems in small clusters; ovate, with a notch at the apex closed by two incurved teeth; margin of the wing with hair-like fringe. Branchlets and buds smooth. Large tree, with thick, grayish, and deeply furrowed bark; with room, producing low trunk, and a broad, much-branched crown; closely grown, the latter is contracted and the trunk tall and straight.

63.—Western Sugar-berry. Hack-berry. Palo Blanco. (*Celtis occidentalis*, Linn., var. *reticulata*.)

A rather small tree, usually growing along streams in high mountain canyons, or in less favorable situations reduced to a shrub. It occurs from the mountains of southern Arizona through the Rocky Mountains to eastern Oregon; sometimes 30 feet high, with a trunk 18 inches in diameter, but mostly with a short, thick trunk, and branching near the ground, thus furnishing but little good timber, although the latter is sound, heavy, hard, and desirable for turnery. The wood is not generally distinguishable from that of the type which is found farther east.

Description.—Leaves thickish, 1 to 2½ inches long and ¾ to 1½ inches wide, mostly heart-shaped, with an acute apex, sometimes ovate lance-shaped; base often with unequal sides (oblique); margin entire or sharply toothed; upper surface *rough*, with *fine, sharp* teeth pointing toward the apex; usually with soft pubescence below or roughish on the veins, which are peculiarly joined into a net-work (*reticulate*). Fruit globular, cherry-like, reddish-yellow (purple with age), ¼ of an inch in diameter, with large stone and scanty flesh (sweetish); on slender stems, ¼ to ½ of an inch long from axils of leaves. Young shoots hairy. Resembles an Elm in its general appearance.

64. Mexican Mulberry. (*Morus microphylla*, Buckley.)

A small tree, sometimes 20 to 25 feet high and 6 to 10 inches in diameter, or reduced to a shrub. It occurs most commonly in the mountain canyons of southern New Mexico, where it probably attains its largest size (also in western Texas and Mexico). The wood is hard and heavy, but of little use, except for fuel as the trunks are generally much distorted, flattened, and twisted.

Description.—Leaves small, 1 to 1¾ inches long, ½ to 1 inch wide, ovate-heart-shaped, sharp-pointed, margin sharply toothed; rough, with short bristly hairs above and below; leaf-stems and young shoots velvety. Fruit small, often sweet and pleasant. Bark much broken, except in young trees. Milky juice exudes from a freshwound.

PLATANACEÆ: PLANE-TREE FAMILY.

65.—Sycamore. (*Platanus Wrightii*, Watson.)

A middle-sized tree, 40 to 60 feet in height and 1 to 2 feet in diameter, abundant in the mountain canyons of southwestern New Mexico, and in some localities being the predominant species (it occurs also in southeastern Arizona and in Mexico). The wood is light, soft, and brittle.

Description.—Leaves alternate, rounded in outline, 5 to 7 inches broad, deeply cut into 3 to 7 (chiefly 5) sharp-pointed lobes; usually a deep sinus at the base; young shoots and leaves densely clothed above and below with a velvety down, which is more or less persistent with age. The seeds are packed in a spherical head—"ball"—which is ¾ of an inch in diameter, 3 to 5 of these balls borne on a long pendent stem. The trunks are often crooked and more winding than other species of *Platanus*.

JUGLANDACEÆ: WALNUT FAMILY.

66.—WALNUT. (*Juglans rupestris*, Engelm.)

A tree of considerable economical importance, occurring quite abundantly in the rich soil of mountain canyons at elevations between 5,000 and 8,000 feet, ranging through southern New Mexico (Arizona and along the coast from southern to central California; eastward through western Texas); 30 to 60 feet in height and 1 to 2 feet in diameter. The wood is hard and heavy, but brittle, with a dark rich brown color, and nearly or quite as valuable for cabinet-work as that of the Black Walnut of the East.

Description.—Leaves compound, with from 5 to 10 pairs of leaflets, which vary in length from 2 to 3¾ inches by ¼ to 1 (chiefly ½ to ¾) inch wide; lance-shaped to somewhat broadly so, pointed or rounded at the base, and narrowing to a usually long thin point; margin finely toothed; young leaflets velvety, as are the buds, shoots, and leaf-stems; with age the former almost without the down, except on the veins. Fruit small, velvety when young, becoming more or less smooth at maturity; globular or slightly ovate; ½ to 1 inch in diameter, with a very thin husk; shell smooth, wrinkled; sweet and edible.

CUPULIFERÆ: OAK FAMILY.

67.—SCRUB OAK. (*Quercus undulata*, var. *Gambelii*, Engelm.)

Often a low shrub, or rather small tree, rarely more than 50 feet in height (exceptionally 75 feet) and 1½ feet in diameter, occurring abundantly on the eastern slopes of the Rocky Mountains of Colorado, in the high mountains of southern New Mexico and Arizona, where it probably attains its largest size. (It is also found in the Wahsatch Mountains of central Utah and in the mountains of western Texas.) The timber is heavy, hard, and strong, and rather tough when young, but it is important chiefly for fuel and tan-bark, as the large trees are too often hollow and defective for lumber.*

Description.—Leaves 1 to 5 (mostly 1 to 3) inches long, and ¾ to 3 inches wide, ovate (larger at upper end) or oblong in outline; margin with bristle-pointed coarse teeth, or rather deeply cut into from 3 to 5 somewhat equal lobes, with rounded ends; young shoots, leaf-stems, and under surface of leaves clothed with velvety yellowish down. Acorns, mostly solitary, sometimes in pairs, ovoid or oblong with sword-shaped point, ½ to ¾ of an inch in length, and ⅜ to ½ an inch in diameter, sometimes quite enveloped by the closely scaly and downy cup.† A variable variety, and for the present purpose no attempt is made to describe in any but general terms the many forms that probably belong here.

68.—BURR OAK. MOSSY-CUP OAK. OVER-CUP OAK. (*Quercus macrocarpa*, Michx.)

One of the largest and most important timber trees, extending farthest west and northwest of any of the eastern Oaks. It is somewhat rare

* It is a useful tree, furnishing desirable soil cover and shade for denuded hillsides.

† Trunk and branches often much twisted.

and much smaller as it occurs on the eastern foot-hills of the Rocky Mountains of Montana than in its more eastern range—central, north central, and northeastern States; here, being especially well developed on rich bottom-lands and prairies, sometimes reaching a height of 100 feet with a diameter of 4 to 6 feet. The wood is heavy, hard, and tough, and the most durable of any of our oaks. In its Rocky Mountain range it is scarcely of any economic importance, but eastward is extensively employed for carriage- and wagon-stock, agricultural implements, lumber, tie-timber, posts, etc.

Description.—Leaves ovate, broader above or oblong in outline, tapering rather sharply at the base, 4 to 10 inches long, and 2 to 6 inches wide, more or less deeply lobed (3 to 6 pairs), the latter entire or with shallow blunt teeth or sub-divisions; young shoots minutely downy, as are the young leaves above and below, though usually becoming smooth on the upper surface at maturity. Acorns large, broadly ovate, solitary or in pairs (on strong footstalks an inch long), nearly or quite enveloped by a thick, scaly, mossy-fringed cup, together ¾ to 1¼ inches long and ¾ to 1 inch in diameter.

69.—"Evergreen Oak." "Live Oak." (*Quercus oblongifolia* Torrey.)

A small tree of little economic value, found along the foot-hills of the mountain ranges of southern Arizona and New Mexico (southward into Mexico; also on the foot-hills of the San Gabriel Mountains, southern California). Twenty to 40 feet high, and ½ to 2½ feet in diameter. The wood is very heavy and hard, but brittle; the largest trees are apt to be hollow, and hence seldom used except as fuel.

Description.—Leaves evergreen, leathery, 1 to 2 (exceptionally 3) inches long, and ½ to 1 inch wide, chiefly oblong, sometimes ovate-oblong, rounded or slightly heart-shaped at the base, rounded or pointed at the tip; margin entire or with a few shallow, distant, and usually sharp teeth; smooth above, minutely downy below, but less so in old leaves; young shoots and short leaf-stems velvety. Acorns sessile, or on very short stems, solitary or two to three together, ovate or oblong, ½ to ¾, sometimes 1 inch long; cups hemispherical, with tuberculate scales.

70.—White Oak. (*Quercus grisea*, Liebmann.)

A tree 40 to 60 feet in height and 1 to 1½ feet in diameter, or a low shrub, ranging through the mountains of southern Colorado, southern New Mexico, at elevations between 5,000 and 10,000 feet (westward through southern Arizona to Colorado River, southern California, and southward through northern Mexico). Rather rare in parts of its range. The wood is exceedingly heavy, hard, and strong, but the large-sized trees are too often hollow and almost useless for timber.

Description.—A variable species presenting many forms, the position of which is difficult to determine; approximations to closely allied species are especially frequent in the shape and character of the leaves. Leaves ¾ to 2½ inches long, and ¼ to 1 inch wide, ovate, oblong, or narrowly elliptical in outline, rounded or somewhat heart-shaped at the base, pointed or rounded at the apex; margin entire, undulate-toothed to that with sharp or prickle-pointed teeth (var. *pungens*, Engelm.); young shoots and short leaf-stems downy, as is also the under surface of the leaves; mostly smooth above. Acorns sessile, or on short stems, oblong, ¾ to 1 inch long, and nearly ½ an inch in diameter; cups hemispherical, ½ inch broad; scales tuberculate.

71.—Black Oak. "Mountain Oak." (*Quercus Emoryi*, Torrey.)

A tree 40 to 50 feet in height and 1 to 3 feet in diameter, or a shrub at the eastern limit of its range; it occurs abundantly through the mountain ranges of southern New Mexico (eastern and southern Arizona, and western Texas) at elevations between 5,000 and 7,000 feet; rarely if ever found on hills or far from streams, preferring the fine gravelly or sandy soil of open canyons. The wood is very heavy and brittle, of a poor quality, and little esteemed, except for fuel, the large trees often becoming hollow or otherwise defective.

Description.—Leaves thick, ¾ to 2½ inches long, ½ to 1¼ inches wide, ovate, oblong-ovate, often approaching halberd-shape, with an acute point, and chiefly (sometimes rounded or with strongly) heart-shaped base; margin entire, but mostly wavy, with distant, shallow or rather large prickle-pointed teeth; mature leaves usually dark glossy green both sides; when young minutely downy, as are the young shoots and short leaf-stems, but the latter more densely so. Acorns mostly sessile—sometimes with short stem—ovate, with a rather sharp and prolonged point, ½ to ¾ of an inch long, and ⅜ of an inch in diameter; cup hemispherical, ½ inch broad, with close, smooth scales. Acorns abundant, sweet, edible. A tree with a scraggy appearance.

72.—(*Quercus hypoleuca*, Engelmann.)

A small but very handsome tree with evergreen foliage, found in the high mountain ranges of southwestern New Mexico, Santa Rita Mountains, southeastern Arizona (southward into Sonora, and in the Limpia Mountains of Texas), at elevations above 6,000 feet, usually preferring rocky or gravelly sites in deep canyons and valleys. Commonly 15 to 20, occasionally 50, feet in height, with a diameter of 2 feet; the trunks usually large for the height. The wood is heavy, very hard, and strong, but large-sized trees are often defective. In localities where it can be grown it would be a popular ornamental tree.

Description.—Leaves thick, commonly 2 to 3½ inches long and ⅝ to 1 inch wide, lance-shaped, with rounded, slightly heart-shaped or acute base, the upper end usually tapering to a long thin point; margin *rolled down*, entire, or wavy, with few indistinct or shallow teeth—sometimes sharply toothed; young leaves downy above, always densely woolly below, but with age becoming smooth and dark green above; stems downy. Acorns usually sessile or sometimes with short stems, ovate, ½ to ¾ of an inch long; cups hemispherical, with thin, downy scales. Trunk and branches generally gnarled and twisted.

73.—Canoe Birch. White Birch. Paper Birch. (*Betula papyrifera.** Marshall.)

A rather large tree, growing chiefly in rich woodlands and along watercourses, and extending farther north than any other American deciduous tree. It has a limited range in the Rocky Mountains region, being

* See Dwarf Birch in list of shrubs, page 196.

found only in the Mullen Trail of the Bitter Root Mountains and in the region of Flathead Lake, Montana (eastward it ranges through the northern tier of States to the Atlantic coast, and far north of the United States boundary from the Atlantic to the Pacific). Sixty feet or more in height, with a trunk 2 to 3 feet in diameter. The wood is very close-grained, hard, and strong, being employed quite extensively in turnery, in the manufacture of paper-pulp, and for fuel. The tough durable bark separates readily into layers, and is often used for making canoes, etc.

Description.—Leaves, ovate to broadly ovate, 2 to 3¼ inches long, 1½ to 2¼ inches inches wide, with a rather long, narrow point, mostly abrupt or heart-shaped at the base (sometimes slightly wedge-shaped), smooth and dark green above, paler and with few hairs on the veins below. Seed small, with two thin wings, borne in a cylindrical scaly catkin 1 to 1½ inches long. Young branchlets often with numerous dots. Bark of the trunk chalky-white.

74.—BLACK BIRCH. "WESTERN POGUE-BIRCH." (*Betula occidentalis*, Hooker.)

Usually a small tree, 20 to 30 (exceptionally 60) feet in height and ½ to 1 foot in diameter, growing abundantly in moist soil of mountain canyons and along streams in the Rocky Mountains from northern New Mexico to Montana (also on the Pacific coast from the Sierra Nevadas of central California to Washington Territory and north of the boundary). It often forms dense thickets, a number of stems growing close together, and producing a useful local supply of straight timber for fencing, as well as for fuel. The wood is rather soft, but strong. The bark separates readily into layers, and is sometimes used for canoes.

Description.—Leaves generally quite small and thin, 1 to 1½ inches long and 1 to 1¼ inches wide, ovate-lance-shaped to broadly ovate—sometimes orbicular—with an acute, rounded, abrupt, or wedge-shaped base, and with a short or sometimes rather long point; margin cut (occasionally lobed) with glandular-pointed teeth; mostly smooth, or with few close hairs below; young leaves hairy: leaf stems slender, ½ inch long. Fertile catkins oblong or cylindrical, ¾ to 1 inch long, with hairy three-pointed scales (bracts); seeds with thin broad wing on two sides. Branches thickly dotted with resinous spots, especially on the recent wood. Bark close, dark to light brown; when newly parted, pale copper-yellow.

ALDERS.

75.—"WHITE ALDER." "CALIFORNIA ALDER." (*Alnus rhombifolia*, Nuttall.)

A small tree, seldom more than 30 feet in height and 1 foot in diameter, or reduced to a shrub. It is found in northern Idaho and along the valley of the Flathead River, northwestern Montana, growing mostly on the banks of streams (westward it ranges along the Pacific coast from southern California to British Columbia). The wood is light, soft, and brittle.

Description.—Leaves $1\frac{1}{4}$ to 3 inches long, ovate (sometimes broader above), or oblong-ovate, blunt or with sharp point, wedge-shaped at the base; margin with small teeth of two sizes; smooth (or nearly so) above, more or less downy on the under surface. Catkins bearing the seed (nutlets) oblong, $\frac{1}{2}$ to $\frac{5}{8}$ inch long; seeds small ($\frac{1}{12}$ of an inch long), ovate, very broad at upper end, and with a wing-like, thickened margin.

76.—*Alnus oblongifolia*, Torrey.

One of the largest deciduous trees of the southern Rocky Mountain region, growing abundantly on nearly all the mountain streams and very close to the water. It occurs in the ranges of southern Arizona, extending to New Mexico as far as the Rio Grande (southward into Mexico, and also in ranges of southern California). Forty to 60 feet, with a trunk from 2 to 3 feet in diameter. The wood is light, soft, and brittle, decaying rapidly, and of little value except for fuel.

Description.—Leaves commonly $1\frac{1}{2}$ to $3\frac{1}{2}$ inches long, and 1 to 2 inches wide (exceptionally 4 to 6 inches long), lance- to oblong-lance-shaped (sometimes ovate), apex acute or with a long narrow point; base wedge-shaped; margin (often rather coarsely) cut with glandular teeth of two sizes; slightly hairy below, especially on the veins, smooth above; leaf-stems $\frac{1}{4}$ to $\frac{1}{2}$ inch long. Fertile catkins ovate-oblong, $\frac{1}{2}$ to $\frac{3}{4}$ inch long; seeds (nutlets) ovate—very broad above, about $\frac{1}{10}$ of an inch long, with a narrow wing-like margin. A handsome tree.

77.—SPECKLED ALDER. HOARY ALDER. BLACK ALDER. (*Alnus incana*, Willdenow.)

A shrub or small tree, 15 to 20 feet in height, with a slender trunk, seldom more than 3 to 6 inches in diameter. It occurs along water-courses and on the borders of swamps in the Rocky Mountain region, ranging from Colorado to Montana and northward (extending eastward to the Atlantic; also in Europe. A well-marked variety of this species (*virescens*, Watson) is found in the mountain ranges of the Pacific coast from southern California to British Columbia and northward). The wood is light and soft, and is used quite extensively for fuel in brick-making.

Description.—Leaves 2 to 4 (exceptionally 5) inches long, and $1\frac{1}{2}$ to $3\frac{1}{4}$ inches wide, oval to broadly ovate, with rounded or heart-shaped base and more or less pointed apex; margin finely toothed, or with coarse teeth, which are themselves cut with smaller teeth; young leaves velvety on both sides, but with age becoming pale, and retaining the pubescence only (or chiefly) on the under surface (variety *virescens* has leaves smooth on both sides); leaf-stems and recent shoot rusty downy. Fertile catkins ovate, $\frac{1}{2}$ to $\frac{5}{8}$ inch long; fruit flat, orbicular, with thin margin mostly on two sides. Bark of brances reddish or grayish brown, with numerous light-colored dots.

SALICINEÆ: WILLOW FAMILY.*

78.—*Salix amygdaloides*, Anderson.

A small tree, found throughout the Rocky Mountain region on the banks of streams (also eastward through the northern United States);

* See Willows, in list of shrubs, page 196.

10 to 30 feet high and 6 to 10 inches in diameter. The timber is soft, light, and weak.

Description.—Leaves lance-ovate, 2 to 4 inches long, ½ to 1 inch broad, margin finely and sharply toothed; pale or whitish beneath; footstalks (petioles) without glands.

79.—*Salix lasiandra*, Bentham.

An important willow for commercial purposes, several well-marked varieties of which having proved quite satisfactory osiers. Abundant on banks of streams in Rocky Mountains of Colorado and northern New Mexico (on the Pacific coast from central California to and north United States boundary). Generally more common and much larger tree than the preceding, although the wood is not materially different; in favorable localities it reaches a height of from 25 to 60 feet, with a diameter of 1½ feet or more.

Description.—Leaves 1 to sometimes 6½ inches long, lanceolate, with long thin point, finely and sharply toothed on the margin; smooth above, pale or whitish on the under surface; footstalks glandular at the upper end. The old bark is rather strongly furrowed, and is of a grayish or brownish color; the young branches are glossy yellow, and in habit not unlike the Weeping Willow.

80.—SAND-BAR WILLOW. (*Salix longifolia*, Muhlenberg.)

A small but widely-distributed species, occurring throughout the Rocky Mountain region (also in eastern United States and in the Pacific States). It is commonly found growing on the moist banks of streams and on sand-bars, in some cases forming thick growths. In the central Pacific coast region it is said to attain its greatest development, but it is a small tree, rarely more than 25 to 30 feet high and ½ to 1 foot in diameter. The wood is light and soft.

Description.—Leaves 3 to 4 inches long, $\frac{1}{12}$ to ½ (commonly $\frac{1}{6}$ to ¼) of an inch wide, linear to lance-shaped, long-pointed, tapering at the base, sessile or with short stems; margin entire, or with very small somewhat distant teeth.—Two or three varieties of this species occur, which differ from the type chiefly in the form of the leaves and pubescence.

81.—(*Salix flavescens*, Nuttall.)

A tree of 20 to 25 feet in height and 6 inches to 1 foot in diameter, found on the banks of streams in the mountains from New Mexico to Montana and Idaho (also occurring in central Pacific coast region.) It reaches its largest size in the southern Rocky Mountain region. The wood is light and lacking in strength; a variety of this species, called the Black Willow, and confined to the Pacific coast, has tough, strong wood.

Description.—Leaves 2 to 3 inches long, 1 to 1½ inches wide, ovate or lance-shaped, tapering at the base; with age becoming smooth and a dull green above, below whitish or with yellowish-brown pubescence.

POPLARS.

82.—Quaking Aspen or Asp. American Aspen. (*Populus tremuloides*, Michaux.)

One of the most widely distributed of our forest trees, but of little value as a timber tree, yet of considerable importance for quickly covering mountain and hillsides denuded by fires, thus furnishing the necessary conditions for the growth of other longer-lived and better timber. Twenty-five to 50 feet in height, and 1½ feet or more in diameter. It is found abundantly throughout the Rocky Mountain region (northern United States, north of boundary, in south central and Pacific coast region,) at elevations between 6,000 and 10,000 feet. The wood is soft, light, weak, and little used except for light fuel and in the manufacture of paper-pulp; the poles occasionally for fencing.

Description.—Leaves 1 to 3 inches long, rounded-ovate, short-pointed, somewhat wedge or heart-shaped at the base; smooth on both sides, margin with fine teeth; footstalks slender and flattened at right angles to the plane of the leaf. The bark is chiefly smooth and of a grayish-white color.

83.—Balsam Poplar. Balm-of-Gilead. Tacamahac. (*Populus balsamifera*, Linn.)

A large tree occurring in the Rocky Mountains of Montana and Idaho (it also extends eastward through the Northern States and north of the United States boundary). It generally prefers and thrives best in moist situations along water-courses, often attaining a height of 60 to 80 feet, with a diameter of 3 to 6 feet. The wood is quite similar to that of the Big Cottonwood (*Populus monilifera*, Ait.), and a good substitute for it in more northern localities.

Description.—Leaves ovate, gradually tapering to a point, finely toothed on the margin, smooth above, whitish below. Branches round; large buds, coated with resinous gum, which is sometimes used in officinal preparations.

Variety *candicans*, Gray, of this species is found in Colorado, northward, and eastward, but is quite unknown in the wild state, being chiefly, if not entirely, introduced in the above range; very common. The wood is considerably heavier than that of the type.

Description.—Leaves usually larger, heart-shaped, *densely white beneath*, and with hairy footstalks.

84.—Black Cottonwood. "Bitter Cottonwood." (*Populus angustifolia*, James.)

Rather abundant throughout the Rocky Mountain region (also in southwestern Dakota and eastern Arizona); less common in southern part of its range, but one of the least valuable deciduous trees of the region. It grows in damp situations, along the borders of mountain streams, at elevations between 6,000 and 10,000 feet. A considerably smaller tree than the better known Big Cottonwood, seldom reaching a height of more than 30 or 50 feet, and 1½ feet in diameter. The timber is very light and soft.

Description.—Leaves smooth both sides, chiefly ovate-lance-shaped (sometimes narrowly lance-shaped), with a long tapering point, mostly rounded at the base, or sometimes tapering slightly at the base; margin with small rounded teeth. Branches round, with smooth bark.

85.—COTTONWOOD. CAROLINA POPLAR. BIG COTTONWOOD. NECKLACE POPLAR. (*Populus monilifera*, Aiton.)

The common cottonwood along the eastern base of the Rocky Mountains (and eastward to the Atlantic Coast). It is abundant on all the water-courses, and valuable chiefly for the rapidity of its growth. The timber is of little commercial importance, yet it is considerably used for cheap lumber, light fuel, and in the manufacture of paper-pulp; unless well protected, it decays rapidly when exposed to the weather. In western towns this tree is largely employed as a shade tree, as it reaches a desirable size in a comparatively short time, and is therefore often preferred to other trees. It grows to a height of over 100 feet, and 4 to 6 feet in diameter.

Description.—Leaves broadly triangle-shaped, somewhat heart-shaped or truncated at the base, long-pointed; margin with blunt incurved, hairy teeth. Young branches angled, but becoming round with age.

86.—COTTONWOOD. WHITE COTTONWOOD. (*Populus Fremontii*, Watson, var. *Wislizeni*, Watson.)

This species is found in southern Colorado, through New Mexico (western Texas, Arizona, southern California), and is the prevailing Cottonwood of the arid localities; rather abundant along streams in open country, but quite rare on precipitous sites. It is a large tree, commonly attaining a height of 50 to 80 feet, with a diameter of 3 to 4 feet. The wood is soft and light, but supplies the ordinary fuel of the region.

Description.—Leaves broadly triangle-shaped, sharp-pointed, somewhat wedge-shaped or truncate, and with more or less broad shallow sinuses at the base; margin with a few distant, blunt (occasionally incurved) teeth. Young bark yellowish, but becoming gray with age.

LILIACEÆ: LILY FAMILY.

[The plants belonging to this family are termed endogenous or inside growers, the woody stems being made up of a mingled mass of fibers, and not marked by annual rings as in the pines, maples, elms, etc.—exogenous or outside growers.]

87.—SPANISH BAYONET. (*Yucca elata*, Engelmann.)

A small tree, with a trunk usually not more than 10 to 15 feet in height and 4 to 7 inches in diameter. It is commonly met with in the dry gravelly soil of table-lands, ranging through western Texas, Arizona to Utah (probably in New Mexico), and southward into Mexico; wood light, soft, and brittle.

Description.—Leaves 1 to 2 feet long, very narrow, $\frac{3}{8}$ of an inch or less wide, thick, stiff, terminating in a needle-point; margin with a narrow white border and more or less with thread-like filaments; base of the leaves much expanded, usually smooth. Flowers white, 1 to 2 inches long; fruit, a woody, oblong-ovate or cylindrical capsule $1\frac{1}{2}$ to $2\frac{3}{4}$ inches long and $1\frac{1}{4}$ inches in diameter, obtuse at the base and beaked at the top; seeds rather large, *thin*, and *flat*, $\frac{3}{8}$ to $\frac{1}{2}$ inch wide.

88.—Spanish Bayonet. Mexican Banana. (*Yucca bacatta*, Torrey.)

Sometimes a tree 20 to 30 feet in height, with a trunk 1 foot or more in diameter, or at the northern limit of its range a stemless plant, bearing only a tuft of leaves. It occurs through New Mexico to southern Colorado (westward into southern California, southward into northern Mexico, and also in western Texas), in the latter range often forming quite extensive forests on the plains. The wood is of little economic value. The fiber of the leaves is strong, and when properly prepared by maceration is soft and pliable, furnishing an excellent material for making ropes, for which it is considerably employed, as well as by the Indians in making horse-blankets and mats. Fruit sweetish, edible, and locally an important article of food.

Description.—The trunk is more or less set with dead leaves, which are broken down at the base. The mature leaves are thick, stiff, lanced-shaped, and from 1 to nearly 3 feet long, with a width of $1\frac{1}{2}$ to 2 inches, broad at the base, narrowing, broadening again midway, and terminating in a long keen spine-point; margined with rather coarse threads, curved backward, usually rough or sometimes smooth, and concave above. The flowers are large and showy, 2 to 3 inches long; fruit hanging down, 2 to 4 (sometimes 5) inches long, ovate, oblong or cylindrical, usually with a beak; purple; seeds blackish, $\frac{1}{3}$ to $\frac{2}{3}$ inch broad, triangular, flattened on two sides.

SHRUBS NOT BECOMING ARBORESCENT.

As far as known, the following list of shrubs comprises those that rarely, if ever, become arborescent; and the chief object in introducing them here is to complete, as far as possible, a full enumeration of the woody plants of the region. Plants woody only at the base have been mostly excluded. The annotations added may in some cases assist the reader in recognizing the species.

BERBERIDACEÆ: *Barberries.*

BERBERIS REPENS, Lindl. One foot or less in height: found throughout the Rocky Mountains, also on the Pacific coast; wood yellow.

BERBERIS FENDLERI, Gray. Three to 6 feet: southern Colorado and southward (westward to southern California).

ZYGOPHYLLACEÆ.

CREOSOTE-BUSH, *Larrea Mexicana,* Moric. Four to 10 feet: southern Colorado (to California; also in Texas): *strong-scented;* foliage *evergreen,* dense; flowers yellow; fruit beaked.

CELASTRACEÆ: *Staff-tree Family.*

PACHYSTIMA MYRSINITES, Raf. Low; Rocky Mountain region (northward and westward); foliage *evergreen,* forming dense clumps on timbered slopes.

RHAMNACEÆ: *Buckthorn Family.**

BUCKTHORNS:

Rhamnus alnifolia, L'Her. Two to 4 feet: Wyoming (westward and eastward). Fruit black, berry-like; 2 to 4 seeds (*nutlets*).

Rhamnus Californica, Esch. Southwestern Colorado and New Mexico (to California and northward to the valley of the upper Sacramento River). As it occurs in the Rocky Mountain region it is a low, spreading shrub (with young branches and under surface of the leaves white-woolly), but in California becoming a small tree 20 to 30 feet high: foliage evergreen; fruit black-purple, with scanty flesh and 2 to 3 seeds. (Introduced among the shrubs, because the Rocky Mountain form is never arborescent.)

NEW JERSEY TEA:

Ceanothus velutinus, Dougl. Two to 3 feet: Colorado, Utah (and northwestward): leaves thick, entire, resinous above; often velvety below. Var. *lævigatus,* (Torr. & Gray) with leaves mostly smooth below, is commoner than the species.

Ceanothus ovatus, Desf. Two to 3 feet: Colorado and Wyoming: leaves with small glandular teeth.

* See arborescent species, page 168.

NEW JERSEY TEA—Continued.

Ceanothus sanguineus, Pursh. Four to 12 feet: on tributaries of Missouri River in Rocky Mountain region: *branches reddish.*

Ceanothus Fendleri, Gray. One to 2 feet: New Mexico to Colorado: branches grayish, spiny; leaves *small,* white-silky below.

VITACEÆ: *Vine Family.*

WILD GRAPE. *Vitis riparia,* Michx. Colorado (abundant in Atlantic region): leaves with 3 long-pointed lobes; fruit more or less with bloom.

VIRGINIA CREEPER. *Ampelopsis quinquefolia,* Michx. Colorado (and throughout eastern United States): fruit blackish; 5 leaflets, crimson in fall. "American Ivy. "Woodbine."

ANACARDIACEÆ: *Cashew Family.*

SMOOTH SUMACH. *Rhus glabra,* L. Three to 12 feet: Colorado, Utah, Idaho (eastward to the Atlantic): fruit in *dense mass* (*thyrse*), *crimson, hairy.*

POISON IVY. POISON OAK. *Rhus Toxicodendron,* L. Climbing: Colorado, Wyoming, Utah (eastward to Atlantic): 3 leaflets; fruit whitish; *poisonous to the touch.*

RHUS AROMATICA, Ait., var. *trilobata,* Gray. Two to 5 feet: abundant in Rock Mountain region (and westward): 3 leaflets; strong-scented.

ROSACEÆ: *Rose Family.*

MEADOW SWEET. *Spiræa betulifolia,* Pallas. One to 2 feet: head-waters of Misssouri River in Rocky Mountain region (westward to northern California and northward beyond the United States boundary; eastward to Alleghanies): flowers purplish; bark reddish. Var. *rosea* (Gray), has rose-colored flowers: Wyoming, Idaho (to Oregon and California).

NINE BARK. *Physocarpus opulifolia,* Maxim. Three to 10 feet: throughout the United States: flowers white, in flat clusters; bark grayish, loose, parting in layers.

PHYSOCARPUS TORREYI, Maxim. Lower and with leaves smaller than in the preceding: Colorado to Nevada, in the mountains.

CHAMÆBATIARIA MILLEFOLIUM, Maxim. Western Wyoming to California: flowers large, white; stout, much branched, *glandular-hairy.*

HOLODISCUS DISCOLOR, Maxim. Four feet or more: New Mexico, Colorado (and westward to Pacific), flowers white; hairy, spreading, and with gray-brown bark. Var. *dumosa* (Maxim.), 1 to 3 feet, with smaller leaves and less spreading.

SALMON BERRY. *Rubus Nutkanus,* Moçino. Three to 8 feet: Colorado to Montana (westward to the Pacific; eastward to northern Michigan): glandular-hairy; flowers large, white; fruit large, *red,* pleasant.

RUBUS DELICIOSUS, James. Three to 4 feet: Colorado: flowers very *large,* white; fruit large, purple, not agreeable.

WILD RED RASPBERRY. *Rubus strigosus,* Michx. Two to 3 feet: New Mexico to Montana (in Nevada; eastward through northern half of the United States) fruit *red,* pleasant; stiff-bristly; wood dying down every two years.

BLACK RASPBERRY. THIMBLE BERRY. *Rubus occidentalis,* L. Three to 8 feet: New Mexico to Wyoming (westward to the coast; eastward to Missouri, thence throughout Eastern States): stems with *keen, hooked prickles;* fruit blackish, pleasant.

PURSHIA TRIDENTATA, DC. Two to 5 (exceptionally 10) feet: Rocky Mountain region (and from Arizona to Southern California): spreading, much-branched, with gray or brown bark; young branches hairy; leaves *small*, crowded, wedge-shaped, 3- to 5-lobed, white-woolly below; upper surface of leaves with *sticky glands*; with pungent, balsamic odor; fruit velvety.

COLEOGYNE RAMOSISSIMA, Torr. Southern Colorado (to Nevada and Arizona); spiny, spreading, much-branched, bark grayish; leaves leathery and with delicate hairs; flowers yellow, conspicuous.

CLIFF ROSE. *Cowania Mexicana*, Don. One to 6 feet: New Mexico to Southern Colorado (also in northern Mexico and northern Utah): much-branched; bark whitish, stringy; flowers yellow; seed (akene) with tail 2 inches long.

EARLY WILD ROSE. *Rosa blanda*, Ait. One to 3 feet: Eastern Montana (and eastward through northern half of United States): with few delicate (or no) prickles; flowers pale rose-color.

ROSA SAYI, Schwein. One to 2 feet: common from Colorado to Montana (eastward to northern Wisconsin): thickly set with prickles; flowers solitary.

ROSA ARKANSANA, Porter. One to 6 feet: New Mexico to Montana (eastward to the Upper Mississippi): usually with closely-set prickles; flowers clustered.

ROSA NUTKANA, Presl. One to 4 feet: northern Utah to Montana (westward to Oregon and northward): thick stems with strong, straight to curve prickles; flowers single, 2 to 3 inches broad.

ROSA FENDLERI, Crepin. Four to 8 feet: New Mexico (western Texas, Sierras, California, and northward beyond United States boundary): with delicate straight or curved prickles; flowers *small*, single or clustered.

ROSA WOODSII, Lindl. One-fourth to 3 feet: Colorado (to Missouri) and northward through western Montana (and north of the United States boundary to the Saskatchewan), plains and valley: with delicate or curved prickles; flowers single or clustered, 1½ to 2 inches broad.

ROSA GYMNOCARPA, Nutt. Three to 10 feet: northwestern Montana and Idaho (also on the Pacific coast): prickles straight, delicate; flowers single or *few*.

JUNE BERRY. SERVICE BERRY. (*Amelanchier alnifolia*, Nutt.) Three to 8 feet: New Mexico to Montana westward to California; eastward to the Mississippi): smooth or woolly; flowers white, in cylindrical clusters; fruit ten-seeded, purple, edible.

PERAPHYLLUM RAMOSISSIMUM, Nutt. Four to 6 feet: southwestern Colorado (Utah, California, and Oregon): exceedingly branched; bark gray; flowers single or two to three together; light rose; fruit globe-like, edible.

SAXIFRAGACEÆ: *Saxifrage Family.*

MOCK ORANGE, SYRINGA. *Philadelphus microphyllus*, Gray. Southern Colorado and southward: flowers single, or two to three together; white, conspicuous.

JAMESIA AMERICANA, Torr. & Gray. Two to 3 feet: New Mexico, Colorado (and Utah): spreading, slim-branched shrub; branchlets hairy, as are the leaves below, but *whitish;* flowers in loose clusters.

FENDLERA RUPICOLA, Eng. & Gray. Southern Colorado and southward: erect, smooth, or hairy; flowers single, or two to three together; white.

WILD GOOSEBERRIES:

Ribes Leptanthum, Gray. One to 4 feet: Colorado, New Mexico (and in Sierras, California): branches stiff; thorns single or in threes, large; flowers yellow, one or two together; fruit smooth.

Ribes divericatum, Dougl., var. *irriguum*, Gray. Five to 12 feet: Colorado to Oregon: spreading; thorns single or in threes; flowers white, on 2- to 4-flowered stems; fruit smooth, dark purple, pleasant.

WILD GOOSEBERRIES—Continued.

Ribes oxicanthoides, L. One and one-half to 3 feet: Colorado to Montana (and north of the United States boundary; eastward through Northern States to the Atlantic): thorns single or in threes; flowers greenish; fruit purplish, small, smooth, pleasant; two to three berries on a stem.

Ribes rotundifolium, Michx. Northeastern Rocky Mountain region (and eastward to the Atlantic): fruit smooth, 1 to 3 berries on a stem.

Ribes Cynosbati, L. Two to 3 feet: sources of the Platte River, Colorado, Wyoming (and eastward through the Northern States): spiny; fruit large, *burr-like*, with *long* prickles; purple, edible.

Ribes lacustre, Poir. Rocky Mountain region (and westward to California; eastward through Northern States to Labrador): young stems *densely prickly;* fruit small, glandular-bristly, not pleasant. Variety *parvulum*, Gray, is smaller, nearly smooth, and commoner westward than the type. Swamps.

WILD CURRANTS:

Ribes prostratum, L'Her. Nearly recumbent: Colorado to Montana (and northward; also in Atlantic region): fruit *light-red*, glandular-bristly; gives off disagreeable odor when bruised, hence, "Fetid Currant."

Ribes Hudsonianum, Richards. Wyoming, Montana (and northward to Hudson's Bay): much like the preceding, but with white flowers and *dark-red smooth fruit.*

Ribes cereum, Dougl. New Mexico to (Washington Territory) Montana (and Dakota): minutely hairy and often gluey; flowers (calyx tube) *waxy-white;* fruit smooth, reddish, sweet. Variety *pedicellare*, Gray, has longer fruit-stems than the type: in Montana.

Ribes viscosissimum, Pursh. Idaho, Montana (and California): hairy, *glandular*, and *sticky;* fruit smooth, black.

Ribes floridum, L. Two to 3 feet: southeastern Colorado (and in the Great Lake and Atlantic regions): leaves with yellow resin-dots; fruit black, sweetish. "Wild Black Currant."

Ribes sanguineum, Pursh. Two to 12 feet (Colorado and California): sometimes white-woolly and glandular; flowers numerous, drooping, *rose-red;* fruit dark, tough, dry. Variety *variegatum*, Watson, small; flower clusters not drooping, *white.*

Ribes aureum, Pursh. Five to 12 feet: Colorado and northward (westward to the Pacific coast; common in cultivation eastward): flowers yellow, fragrant; fruit blackish. "Missouri Currant." "Buffalo Currant."

CORNACEÆ *Dogwood Family.*

DWARF CORNEL. *Cornus Canadensis*, L. Colorado and northward (eastward through northern United States): stems about half a foot, from a creeping trunk; flowers surrounded by four whitish leaves (involucre); fruit *bright red.*

RED-OSIER DOGWOOD. *Cornus stolonifera*, Michx. Two to 6 feet: same distribution as preceding; young shoots bright red; white flowers in flat clusters; fruit *white* to *lead-colored.*

CAPRIFOLIACEÆ: *Honeysuckle Family.*

RED-BERRIED ELDER. *Sambucus racemosa*, L. Three to 10 feet: "across the continent," in swamps: *pith* of *young shoots brown;* fruit *red.*

SAMBUCUS MELANOCARPA,* Gray. New Mexico to Montana (westward to Oregon and California): *pith* of *shoots brown;* flowers white; fruit black.

* See arborescent species, No. 56, page 177.

COMMON ELDER. *Sambucus Canadensis*, L. Four to 10 feet: southern Rocky Mountain region (and eastward to the Atlantic from Canada to Florida): *pith* of *shoots pearl-white;* fruit blackish with some bloom.

"HIGH-BUSH CRANBERRY." *Viburnum pauciflorum*, Pylaie. Two to 5 feet: Colorado and northward (eastward in northern regions): smooth or hairy; fruit clustered, globular, *red, acid,* edible, flat-seeded. In cold situations.

"WOLF-BERRY." *Symphoricarpos occidentalis*, Hook. Colorado and Montana (northward and eastward): low, stout; flowers small, white to pinkish, *hairy* inside; *fruit white.*

SNOWBERRY. *Symphoricarpos racemosus*, Michx. "Across the continent" (common generally in cultivation): slender; flowers smaller and less hairy than in preceding species; fruit *large, white.* Variety *pauciflorus*, Robbins, low, more spreading, with few flowers: in mountains of Colorado (to Oregon, Vermont, and northward).

SYMPHORICARPOS OREOPHILUS, Gray. Mountains of Colorado (Utah and Arizona, to California and Oregon): flowers ¼ to ½ inch long, much larger than in preceding species.

HONEYSUCKLES (*Two to three flowers in the axils of the leaves*):

Lonicera Utahensis, Watson. Mountains of Montana (Utah, Oregon, and northward): erect; flowers ¾ of an inch long, straw-colored; berries red.

Lonicera involucrata, Banks. Mountains of Colorado (and California to Alaska; eastward into Canada): erect, 2 to 10 feet; flowers yellow with sticky hairs; two blackish or purple berries—often joined.

Lonicera ciliosa, Poir. Mountains of Montana; northward and southward to Arizona and California: twining; one or two pairs of the topmost leaves joined into one piece; flowers yellow to crimson; berries orange to red.

COMPOSITÆ: *Composite family* (Sunflowers, Thistles, Etc).

THOROUGHWORT. *Eupatorium ageratifolium*, D C. Three to 7 feet: southern Colorado to Texas: branches chiefly herbaceous.

GROUNDSEL-TREE. *Baccharis salicina*, Torr. and Gray. Three to 12 feet; Colorado to Texas: sticky, with resinous exudation.

TETRADYMIA CANESCENS, D C. Northern Wyoming to New Mexico (also in Arizona, California, and British Columbia): clothed with a close *persistent white wool;* leaves *narrow*, 1 inch long; flowers yellow; branches *close* and upright. Variety *inermis*, Gray, has shorter leaves and closer branches; more common than the type.—Under 2 feet, as are the following.

TETRADYMIA GLABRATA, Gray. Colorado (and from Utah to California and Oregon): clothed with a white loose wool, which is not persistent; branches spreading; leaves ½ inch long; flowers yellow.

TETRADYMIA NUTTALLII, Torr. and Gray. Wyoming and Utah: *white* with a *persistent wool* and armed with *stiff spines*; branches short and close; flowers yellow.

TETRADYMIA SPINOSA, Hook. and Arn. Two to 4 feet: southern Wyoming to Arizona (also in southeastern California and eastern Oregon): branches spreading widely, densely white-woolly, and with curved or straight spines.

ERICACEÆ: *Heath Family.*

BLUE BERRIES:

Vaccinium occidentale, Gray. One foot or more: Uintah Mountains, northeastern Utah (and in Sierra Nevadas, California): leaves bluish; berries small, blue-black, with bloom.

BLUE BERRIES—Continued.

Vaccinium caespitosum, Michx. Less than ½ foot: Rocky Mountains from Colorado northward (to Alaska, and eastward in Labrador, and the White Mountains, New Hampshire; growing in tufts: berries rather large, blue (bloom), sweet. Variety, *cuneifolium,* Nutt, is ½ to 1 foot: mountains of Colorado (to California, British Columbia, and Lake Superior).

Vaccinium Myrtillus, L. One foot or less: Colorado, Utah, and northward (to Alaska): branches *angled, green;* berries black.—"Whortleberry," "Bilberry." Variety *microphyllum,* Hook., 3 to 6 inches, with leaves ⅙ to ⅓ of an inch long, and berries reddish at first.

"BEARBERRY." "KINNIKINNICK." *Arctostaphylos Uva-ursi,* Spreng. New Mexico (to California, to New Jersey), and northward: creeping; foliage *thick, evergreen; berries red.*

WINTERGREEN. *Gaultheria Myrsinites,* Hook. Colorado and Utah to Montana (northward and westward): procumbent, tufted; foliage *evergreen,* with aromatic flavor; berries scarlet.

BRYANTHUS EMPETRIFORMIS, Gray. One-half a foot or more: western Wyoming, Montana, (and northward): leaves *crowded, evergreen;* flowers, rose-colored.

PALE LAUREL. *Kalmia glauca,* Ait. One to 2 feet: Colorado and northward in the Rocky Mountains (eastward through the northern United States): cold bogs; branchlets two-edged; leaves *evergreen,* white beneath, margin rolled; flowers large, lilac-purple.

LABRADOR TEA. *Ledum glandulosum,* Nutt. Two to 6 feet: northern Idaho and western Montana (also in the Pacific region and British America): leaves 1 to 2 inches long, persistent, with resinous dots below, fragrant when bruised; flowers white.

OLEACEÆ: *Olive Family.**

FORESTIERA NEO-MEXICANA, Gray. Six to 10 feet: southern Colorado to New Mexico (also in Texas): branches warty; leaves 1 inch long; flowers inconspicuous; fruit dark, cherry-like.

CHENOPODIACEÆ: *Goosefoot Family.*

GREASEWOOD. *Sarcobatus vermiculatus,* Torr. Two to 8 feet: southern Wyoming and southward (also in the Great Basin to the Upper Missouri): spreading, scraggy; branches stiff, with white bark; leaves *narrow.* Most abundant of the shrubs called "Greasewood."

ELAEAGACEÆ: *Oleaster Family.*

ELAEAGNUS ARGENTEA, Pursh. Six to 12 feet: Utah to Dakota (and eastward to Canada): young branches with *rusty scales;* flowers yellowish inside, fragrant; fruit cherry-like, mealy, edible, with an eight-grooved stone.

BUFFALO BERRY. *Shepherdia argentea,* Nutt. Five to 18 feet: in the mountains from Mexico to Montana (and northward to the Saskatchewan River, British America; westward to the Pacific coast ranges): spiny; leaves *silvery;* berries scarlet, almost stemless, acid, edible, with flat shiny seed.

CANADIAN SHEPHERDIA. *Shepherdia Canadensis,* Nutt. Three to 6 feet: in the mountains from New Mexico to southern Montana (also ranging eastward from the Columbia River to the Atlantic): young branches, leaves, and yellowish flowers *rusty-scaly;* berries yellowish, red, tasteless.

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* See arborescent species, page 177.

CUPULIFERÆ: *Oak Family.*

DWARF BIRCH. *Betula glandulosa,** Michx. One to 6 feet: Rocky Mountain region (and northern—latitude 40°—California to Washington Territory; eastward through the Northern States to the Atlantic, and north of the United States boundary): peculiar for its *small, rounded leaves,* and *resinous, glandular spots* on the young branches.

BEAKED HAZEL-NUT. *Corylus rostrata,* Ait. Two to 5 feet: Colorado to Montana (westward to Washington Territory, northward and eastward to the Alleghenies): hard-shelled nut inclosed by a leafy cup, which terminates in a beak.

SALICINEÆ: *Willow Family.*†

WILLOWS:

Salix cordata, Muhl.; var. *Mackenziana,* Hook.; var. *vestita,* Anders. "Diamond Willow." Ranging through the northern part of the United States from the Atlantic to the Pacific and northward to the Arctic coast.

Salix Novæ-Angliæ, Anders.; var. *pseudomyrsinites,* one to 3 feet; var. *pseudocordata,* Anders., not tall: mountains of Colorado and Montana (northward to the Saskatchewan and Mackenzie Rivers).

Salix irrorata, Anders. Six to 8 feet: central Colorado (mountains near Golden, Manitou, and Empire City): leaves 3 to 4 inches long, ½ inch or less wide; year-old twigs white with bloom.

Salix monticola, Bebb. Eight to 12 feet: central Colorado (Golden, Georgetown, Empire City), marshy situations in the mountains: very dense shrub; leaves 3 to 6 inches long, 1 to nearly 2 inches wide.

Salix rostrata, Richards. Northern Idaho and Montana (to Vancouver Island, northward to the Saskatchewan, eastward to New England): with somewhat the habit of low bushy tree.

Salix chlorophylla, Anders. One and one-half to 6 feet: Rocky Mountains (and northward to the Saskatchewan; also in the Wahsatch Mountains, central Utah, and in the Cascade Mountains, Oregon, and Washington Territory), at an altitude of 11,000 feet: straggling, year-old twigs shiny chestnut. "Green Willow."

Salix candida, Willd. Rare; 2 to 5 feet: bogs and foot-hills of the Rocky Mountains; noted near Cutbank Creek, Montana, and in Colorado: young shoots with white wool; older twigs shiny red; leaves 2 to 4 inches long, ½ to ¾ inch wide.

Salix glauca, L., var. *villosa,* Anders. Three to 7 feet: low meadow and foot-hills of the Rocky Mountains: a spreading shrub, with leaves 2 to 4 inches long and entire margin.

Salix desertorum, Richards. One to 2 feet; leaves 1 inch long and less than ¼ inch wide, white-woolly beneath, with a prominent yellow midrib (in variety *Wolfii* the leaves finally become smooth, and are nearly the same color on both sides): a scraggy shrub, forming clumps on mountain slopes of the Rockies considerably above the timber line.

Salix arctica, R. Br.: var. *petræa,* Anders. Colorado, (California, and far northward): creeping, the half-buried branches sending up twigs 2 to 3 inches long.

Salix vestita, Pursh. Old Marias Pass, northern Montana, at altitudes of 6,000 to 8,000 feet (also in Canada and Labrador): procumbent, sending up branches 2 to 3 feet high, and forming massy growths in rocky places sometimes 10 feet in diameter.

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* See arborescent species, Nos. 73, 74, pages 183, 184.

† See arborescent species, Nos. 78 to 81, page 185.

WILLOWS—Continued.

Salix reticulata, L. In the Rocky Mountains (and northward to the Arctic coast): a dwarfed species with twisted and buried stems, the leaves rising only a few inches above the ground.

CONIFERÆ: *Pine Family.*

COMMON JUNIPER. *Juniperus communis*,* L. Four to 10 feet (or with care and cultivation occasionally becoming arborescent): in the Rocky Mountains from New Mexico to Montana (eastward through the Northern States and northward throughout British America; native also in Europe). With somewhat erect and spreading branches; leaves in threes, ½ to ¾ of an inch long, narrow, needle-pointed, whitish and concave above: berries ¼ of an inch in diameter, *densely white with bloom.* Bark of branches with ridged scales. Variety *Alpina*, Linn., differs from the type in being quite or nearly prostrate, forming mat-like growths with its widely extended branches; leaves ¼ to ⅜ of an inch long, broader, curved, and less spreading: chiefly northern in the Rocky Mountains and eastern United States. Considerably used as an ornamental shrub.

CREEPING JUNIPER. *Juniperus Sabina*, L., var. *procumbens*, Pursh. Abundant in the mountains from Colorado to Montana (westward to the Pacific coast eastward through the Northern States to the Atlantic, and north of the United States boundary): a prostrate shrub of considerable importance in the forest economy of the region, as by its abundance it retains the snow, and thus preserves a much-needed supply of water in mountain streams. Foliage dense; prostrate branches taking root; often scaly with persistent dead leaves; berries ¼ to ⅓ of an inch in diameter.

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* See arborescent Junipers, Nos. 24, 25, 26, page 166.

THE FORESTS OF LOS ANGELES, SAN DIEGO, AND SAN BERNARDINO COUNTIES, CALIFORNIA.[1]

By ABBOT KINNEY, California.

The term "forest," as it is understood in the older States, is applicable in only a limited extent to the natural tree and brush growths of southern California.

Upon the mountain heights alone would the Eastern man feel himself to be in a forest. No account of the forests of southern California would, however, be complete without a description of all the natural tree and brush growths found here.

As has been said, there are no forests, properly speaking, in the valleys or on the plains. The growths in these portions of the country consist of the following: On the plains, near the sea, and near rivers or damp swampy places, Willows grow in rank dense groves, and furnish a large amount of fire-wood. The Sycamore strays down the canyons and water-courses to within sound of the ocean breakers. It is only used for fire-wood.

In the valleys large groves of Oak occur; these trees are from 20 to 40 feet apart, and are often magnificent old monarchs, most picturesque and attractive. *Quercus lobata*, or the White Live-Oak, forms the larger part of the groves, but the Red Oaks, *Quercus chrysolepis*, and *Quercus agrifolia*, with their dark-green, glistening, holly-like leaves, are the most attractive. These are scattered through the groves and canyons. The oak groves resemble the plantations of the most beautiful

[1] This short report by Mr. Abbot Kinney, now chairman of the California State Board of Forestry, was prepared for this Division in the spring of 1886, in the hope that by aiding such work the then incipient forestry interests of California might be fostered. It has been printed in the report of the California Board of Forestry, and is here produced because it serves to show how even the preservation and protection of natural brush lands may become a subject of solicitude on the part of States and communities. The report was accompanied by an incomplete paper on the trees and shrubs of San Diego County, for which has been substituted a complete list, prepared by Mr. Sudworth, of the Forestry Division.—B. E. F.

English parks. The magnificent trees spread a generous shade over the fields of wild flowers and grasses. Grain is often planted under the oaks and matures well, only a little later than that in the open plains.

It is a great regret to every lover of nature to see such characteristic beauty, so difficult to recreate, rapidly disappearing. The broader canyons, when there is enough good soil, are enchanting.

As we leave the sea, the water-courses, or more properly flood-courses, of the country are covered by Cottonwood trees (*Populus Fremontii* and *Populus trichocarpa*). These, like the Oaks, frequently form beautiful parks on the damp lands where they grow. One of the handsomest of these groves is at San Jacinto, in San Diego County.

In the great Colorado Desert and on its edges are found several useful stunted trees that form in favorable locations considerable plantations. These are the Iron-Wood, Mesquite, the Screw-Bean, and the Piñon Pines. The last three bear edible fruit, which is collected by and forms the main support of the desert Indians.

In the Mojave Desert a tree cactus grows which is being made into paper, on a large scale, by an English company. This is the *Yucca brevifolia*. It grows about 20 to 30 feet high, and forms the same grove-like plantations so frequent in this dry country. In the mountain canyons opening on the desert side grow the striking California Palms, *Washingtonia filifera*.

The edible Oak acorns, the nut of the California Walnut, and the fruit of the desert trees spoken of form important possible sources of food.

Speaking generally, it must be borne in mind that the plains and deserts of southern California are devoid of trees, and when trees do occur they never form forests.

In the lower mountain canyons, wherever there is water, the growths are dense. The principal trees are the Willow, Alder, Maple, and Mountain Live Oak (*Quercus oblongifolia*). These are mixed with trees coming up from the valleys on the one side, principally Oaks, and down from the mountain heights on the other, principally Spruce (*Abies Douglasii*). The whole is inextricably tangled up with dense chaparral and charmingly ornamented with large fern-brake.

The deciduous trees of the country are almost exclusively confined to the canyons or the damp land below them, or to the courses of the waters. The *Quercus oblongifolia* is the only one of our Oaks valuable for timber.

On the mountains the real forest is found. Considerable quantities of valuable timber exist on the Sierra Madre, San Bernardino, San Jacinto, and Cuyamaca Mountains. The Sierra Madre range has been too steep and inaccessible as yet to be exploited; but on San Bernardino and San Jacinto large saw-mills are continually at work, supplying the colonies below in the valleys with lumber, but furnishing none for export.

The principal timber cut is Pine. Spruce and Cedar are also cut and sold; the latter largely split for posts. The most important trees in the mountains are:

Pinus Lambertiana, Sugar Pine.
Pinus ponderosa, Pitch Pine.
Pinus Coulteri, Nut Pine.
Pinus Sabiniana, Digger Pine.
Pinus Jeffreyi, Yellow or Bull Pine.
Pseudotsuga Douglasii, Spruce.
Juniperus Californica, Juniper.
Libocedrus decurrens, White Cedar.
Abies concolor, Silver Fir.
Quercus chrysolepis, Red Live Oak.
Quercus Kelloggii, White Oak.

The timber is said by the lumbermen to be softer and less valuable than that farther north. The low foot-hills near the coast are generally devoid of trees or shrubs. Those on the desert are absolutely bare. With these exceptions, all the foot-hills and mountains not covered with trees are more or less thickened with evergreen bushes, called, collectively, chaparral. These grow from 3 to 15 feet in height and are frequently almost impenetrable. This chaparral is composed principally of Scrub Oaks, Manzanita, Wild Lilac, Grease-wood, and Sumac. On the lower foot-hills this brush is cut and grubbed up for fire-wood. In the mountains and canyons it furnishes food for the bees, and, most important of all, it acts as a reservoir, in allowing the rains of the wet season time to seep into the soil and rock veins, to appear again in the dry season as springs in the low country. This brush, together with the trees, also protects the country from the formation of destructive torrents and floods, and modifies the desert winds, which are already somewhat detrimental, at times, to vegetation.

These brush lands almost all belong to the Government, and, being of little direct value, will probably long remain its property. Every year disastrous fires sweep off great areas of this mountain covering. The Government sets no watch and takes no heed of its property, and the fires run into and destroy the timber as well as the brush. Every year, as a consequence, water-rights are decreased in value, through the springs diminishing in summer, and torrents run more violently and bring down more sand and stones to scatter on the farms. The floods each wet year are more destructive than before. Lately, floods have swept away twenty-two houses in Los Angeles, and interrupted travel for weeks on the Southern Pacific Railroad, in the Soledad Canyon, and for months on the California Southern road, in the Temecula Canyon. On each of these water-sheds extensive destruction of trees and brush had taken place in the Soledad by deliberately set and deliberately repeated fires.

It is very important that steps should be taken to preserve these mountain coverings, so as to maintain the tax-paying power of the community, which can not exist here if the springs become dry.

For the forest maps of these counties, comprising an empire of land, I am indebted, for Los Angeles, to Mr. George E. Jackson, and, for San Diego, to Mr. T. E. Vandyke and Mr. M. G. Wheeler.

Cupressus macrocarpa and *Guadalupensis* are not found in Los Angeles County, to my knowledge, in a state of nature. Some of the Sumacs, as the one with edible berries, do not extend to us.

The *Pinus Torreyana* is confined to one little nook of San Diego County. On the other hand, the *Yucca brevifolia*, or tree cactus, seems not to be known in San Diego County, and the beautiful, fragrant, Bay-tree does not extend south of the Los Angeles canyons.

In the second Sierra Madre range of Los Angeles County there are about two hundred Redwood trees, *Sequoia sempervirens*—a fact not generally known, owing, doubtless, to the inaccessible character of the mountains where they are.

In this connection it is proper to call attention to the considerable number of trees and shrubs perpetuated in California that have long become extinct elsewhere. One may well think it probable that the mild and equable climate where this has happened may be as favorable to man as it has been to vegetable growth.

The necessity of the hour is the intelligent supervision of the forests and brush lands of California, with a view to their preservation. The cutting and use of the forests should be so reasonably regulated as to insure their reproductive power, and, above all, maintain the forest influence on the climate and secure to the farmer the perennial character of the springs and streams necessary in the dry season for irrigation; also to protect the low lands against floods and torrents that occur here whenever the mountains are denuded.

TREES AND SHRUBS OF SAN DIEGO COUNTY, CALIFORNIA.

(*Shrubs not woody throughout have been excluded.*)

ANACARDIACEÆ: Cashew Family.

Rhus diversiloba, Torr. & Gray. "Poison Oak": climbing.

Rhus aromatica, Ait., var. *trilobata*, Gray. Two to 5 feet.

Rhus integrifolia, Benth. & Hook. Five to 10 feet; evergreen.

Rhus laurina, Nutt. Large shrub, with evergreen foliage.

BATIDEÆ:

Batis maritima, Linn. Seaside shrub 3 to 4 feet, generally prostrate.

BERBERIDACEÆ: Barberries.

Berberis repens, Lindl. Less than 1 foot high.

Berberis pinnata, Lag. Two to 6 feet high.

BIGNONIACEÆ: Bignonia family.

Chilopsis saligna[1] Don. Shrub or small tree 10 to 20 feet high.

BUXACEÆ:

Simmondsia Californica, Nutt. Low Shrub.

CAPPARIDACEÆ: Caper family.

Isomeria arborea, Nutt. Three to 5 feet high.

CAPRIFOLIACEÆ: Honeysuckle family.

Sambucus glauca[2] Nutt. Elder. Shrub, or small tree.

Symphoricarpos racemosus, Michx., Snowberry. Two to 4 feet.

Lonicera hispidula, Dougl., Honeysuckle. More or less twining.

Lonicera involucrata, Banks. Two to 10 feet high.

CHENOPODIACEÆ: Goosefoot family.

Sarcobatus vermiculatus, Torr. Two to 8 feet high; commonest of the "Greasewoods," and very probably occurs in this range.

COMPOSITÆ: Composite Family.

Baccharis pilularis, D C. Two to 4 feet high.

Tetradymia spinosa, Hook. & Arn. Two to 4 feet high.

Tetradymia canescens, D C. One to 2 feet high.

CONIFERÆ: Pine Family.[3]

Juniperus Californica, Carr. A shrub or small tree, sometimes 20 to 30 feet.

Thuya gigantea, Nutt. Canoe Cedar. A very large tree (100 to 250 feet high) said to occur in this range.

Libocedrus decurrens, Torr. One hundred to 150 feet high.

Pseudotsuga Douglassii, Carr., var. *macrocarpa*. A rather large tree 40 to 50 feet or more in height, probably occurring in this range.

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[1] See No. 61, page 179.

[2] See No. 56, page 177.

[3] See Coniferæ in Rocky Mountain Flora, page 159.

CONIFERÆ: Pine family—Continued.

Pinus Lambertiana, Dougl. "Sugar Pine." A very large tree, sometimes 150 to 300 feet.

Pinus monophylla, Torr. & Frem. Twenty to 25 feet high, probably to be found in this range.

Pinus Parryana, Engelm. Twenty to 30 feet high; probably occurs in this range.

Pinus Torreyana, Parry. Twenty to 30 feet high.

Pinus ponderosa, Dougl. "Yellow Pine." One of the largest pines, sometimes 150 to 300 feet high.

Pinus Jeffreyi, Murray. "Bull Pine." One hundred feet high.

Pinus Sabiniana, Dougl. "Nut Pine," "Digger Pine." Sixty to 100 feet high.

Pinus Coulteri, Don. Sixty to 100 feet or more in height.

CORNACEÆ: Dogwood Family.

Cornus Californica, C. A. Meyer. Six to 15 feet.

Cornus pubescens, Nutt. Four to 10 feet.

Garrya flavescens, Watson, var. *Palmeri,* Watson. Four to 8 feet; foliage evergreen.

CUPULIFERÆ: Oak Family.

Quercus lobata, Née. Large tree, often 100 feet high.

Quercus undulata, Torr., var. *pungens,* Engelm. A shrub under 8 feet.

Quercus dumosa, Nutt. A slender shrub or small tree 20 feet high.

Quercus oblongifolia, Torr.[1] Twenty to 30 feet high.

Quercus chrysolepis, Liebm. "California Live Oak." At high elevations a shrub, but elsewhere generally a large tree.

Quercus Palmeri, Engelm. A shrub 8 to 10 feet high.

Quercus agrifolia, Née. "Encino." A large tree. Variety *frutescens* is a shrub under 5 feet.

Quercus Wislizeni, A. D C. "Desert Oak." Sometimes a shrub, but chiefly a large tree. Variety *frutescens* is a shrub 3 to 10 feet high.

Quercus Kelloggii, Newberry. Shrub or middle-sized tree.

Castanopsis chrysophylla, A. D C. Western Chinquapin. A small shrub or large tree; found only sparingly.

Alnus rhombifolia, Nutt. A rather large tree known as "White Alder," "California Alder."

Alnus oblongifolia, Torr. A small tree 20 to 30 feet high.

ERICACEÆ: Heath Family.

Arctostaphylos pungens, H B K. Manzanita. Procumbent or rising 8 to 10 feet high.

Arctostaphylos glauca, Lindl. Great-berried Manzanita. Eight to 20 feet, and often 1 foot in diameter at the base.

Arctostaphylos bicolor, Gray. Manzanita. Three to 4 feet high.

Arctostaphylos polifolia, H B K. Five to 8 feet high.

Rhododendron occidentale, Gray. Azalea. Two to 6 feet high.

EUPHORBIACEÆ: Spurge family.

Acalypha Californica, Benth. Shrub.

Euphorbia misera, Benth. Two to 3 feet high.

HYDROPHYLLACEÆ: Water-leaf family.

Eriodictyon tomentosum, Benth. Six to 10 feet.

Eriodictyon glutinosum, Benth. Three to 5 feet.

JUGLANDACEÆ: Walnut family.

Juglans Californica, Watson. California Walnut. A shrub or tree sometimes 60 feet high; occurs only sparingly in this range; cultivated.

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[1] See No. 69, Rocky Mountain Flora, page 182.

LAURACEÆ: Laurel family.

Umbellularia Californica, Nutt. "Mountain Laurel," "Spice Tree." Shrub or tree 10 to 70 feet.

LEGUMINOSÆ: Pulse family.

Pickeringia montana, Nutt. Four to 7 feet high.

Amorpha Californica, Nutt. Three to 8 feet.

Olneya Tesota, Gray. "Iron-Wood." Small tree, 15 to 20 feet high.

Cercis occidentalis, Torr. Red-Bud, Judas tree. Small tree, 10 to 15 feet high.

Parkinsonia aculeata, Linn. A small tree.

Parkinsonia microphylla, Torr. Shrub 5 to 10 feet high.

Parkinsonia Torreyana, Watson. "Palo Verde." A tree 20 to 30 feet high.

Prosopis juliflora,[1] D C. "Honey Mesquit." A tree 30 to 40 feet high.

Prosopis pubescens,[1] Benth. "Screw-Pod Mesquit." A tree 15 to 30 feet high.

Acacia Greggi,[1] Gray. Cat's Claw. Small tree, 10 to 20 feet high.

LILIACEÆ: Lily family.

Yucca baccata,[2] Torr. "Spanish Bayonet." Mexican Banana. Sometimes 20 feet high.

OLEACEÆ: Olive family.

Fraxinus dipetala, Hook and Arn. Small tree.

PAPAVERACEÆ: Poppy family.

Dendromicon rigidum, Benth. Two to 8 feet high.

PLATANACEÆ: Plane-tree family.

Platanus racemosa, Nutt. "Buttonwood." Sycamore. Large tree, often 100 feet high.

POLYGALACEÆ: Milkwort family.

Krameria parvifolia, Benth. One to 2 feet high.

Krameria canescens, Gray. One to 2 feet high.

RHAMANCEÆ: Buckthorn family.

Zizyphus Parryi, Torr. Four to 15 feet high.

Karwinskia Humboldtiana, Zucc. Two to 6 feet.

Rhamnus crocea, Nutt. Three to 15 feet high.

Rhamnus Californica, Esch. Four to 18 feet high; var. *tomentella* more southern than the type.

Adolphia Californica, Watson. Two feet high.

Ceanothus sorediatus, Hook and Arn.

Ceanothus divaricatus, Nutt.

Ceanothus integerrimus, Hook. and Arn. Two to 3 feet high.

Ceanothus crassifolius, Torr. Four to 12 feet high.

Ceanothus cuneatus, Nutt. Three to 12 feet high.

ROSACEÆ: Rose family.

Prunus demissa,[3] Walpers. Wild Cherry. Shrub or small tree.

Prunus ilicifolia, Walpers. "Islay." A shrub 8 to 12 feet high with evergreen foliage.

Prunus fasciculata, Gray. Two to 3 feet high.

Chamæbatia foliolosa, Benth. One to 2 feet high.

Purshia tridenta,[4] D C. Two to 8 feet high.

Cercocarpus parvifolius,[5] Nutt. Mountain Mahogany. Two to 10 feet high.

Andenostoma fasciculatum, Hook. and Arn. "Greasewood." Two to 10 feet high, shrub-like; evergreen foliage.

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[1] See Nos. 39, 40, 41 Rocky Mountain flora, pages 171, 172.

[2] See No. 88 Rocky Mountain flora, page 189.

[3] See No. 47 Rocky Mountain flora, page 174.

[4] See *Purshia*, list of shrubs in Rocky Mountain region, page 192.

[5] See Nos. 51 Rocky Mountain flora page 175.

ROSACEÆ: Rose family—Continued.

Andenostoma sparsifolium, Torr. "Deer-brush." A shrub 6 to 10 feet, or small tree; evergreen.

Rosa Californica, Cham. and Schlecht. Two to 8 feet high.

Rosa gymnocarpa, Nutt. One to 4 feet high.

Heteromeles arbutifolia, Roemer. "Tyon," "Tollon." Four to 15 feet high.

Amelanchier alnifolia,[1] Nutt. Three to 8 feet.

RUBIACEÆ: Madder family.

Cephalanthus occidentalis, Linn. Three to 10 feet or more; sometimes a small tree.

RUTACEÆ: Rue family.

Ptelea angustifolia,[2] Benth. Hop-tree. Five to 25 feet high.

Thamnosma montanum, Torr. One to 2 feet high.

Cneoridium dumosum, Hook. f. Two to 4 feet high.

SALICINEÆ: Willow family.[3]

Salix lævigata, Bebb. A tree 15 to 20 feet high. Two varieties are distinguished from the type; var. *angustifolia* and var. *congesta*.

Salix longifolia, Muhl. Three to 15 feet high. Two varieties are known; *argyrophylla*, Anders., and *exigua*, Bebb.

Salix taxifolia, H B K. Five to 6 feet high; very probably occurs in this range.

Salix lasiolepis, Benth. Under favorable conditions a tree 40 to 60 feet high. Two varieties; *Bigelovii*, Bebb; *falax*, Bebb.

Populus trichocarpa, Torr. and Gray. Thirty to 50 feet high. One variety, *cupulata*, Watson.

Populus Fremontii, Watson, var. *Wislizeni*, Watson. A large tree.

SAPINDACEÆ: Soapberry family.

Æsculus Parryi, Gray. Buckeye. A shrub occurring farther south, but possibly to be met with in this range.

Acer macrophyllum, Pursh. Broad-leaved Maple. Tree 50 to 90 feet high.

SAXIFRAGACACEÆ: Saxifrage family.

Ribes speciosum, Pursh. Gooseberry. Six to 10 feet; stout.

Ribes Menziesii, Pursh. Gooseberry. Two to 6 feet.

Ribes sanguineum, Pursh. Currant. Two to 12 feet.

Ribes aureum, Pursh. "Missouri Currant." Five to 12 feet high; cultivated largely as an ornamental shrub.

SOLANACEÆ: Nightshade family.

Lycium Californicum, Nutt. Two to 4 feet; spiny.

Lycium Torreyi, Gray. Three to 8 feet.

STERCULIACEÆ.

Fremontia Californica, Torr. Ten to 20 feet high.

TAMARISCINEÆ: Tamarisk family.

Fouquiera splendens, Engelm. Candlewood. Often 10 to 20 feet high.

VITACEÆ: Grape Vines.

Vitis Californica, Benth.

ZYGOPHYLLACEÆ:

Larrea Mexicana,[4] Moric. "Creosote-bush." Four to 10 feet high.

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[1] See *Amelanchier*, list of shrubs in Rocky Mountain region, page 192.

[2] See No. 28 Rocky Mountain flora, page 168.

[3] See this family in Rocky Mountain flora, page 185.

[4] See *Larrea*, list of shrubs in Rocky Mountain region, page 190.

THE NEEDS OF THE YELLOWSTONE NATIONAL PARK.

U. S. GEOLOGICAL SURVEY,
Washington, December 27, 1887.

SIR: During your visit to the Yellowstone Park last summer you expressed so warmly your keen appreciation of the region as a forest reservation that I desire to call your attention to some of the more salient features of the country, and to point out what I consider the important reasons for not only maintaining the national park, but for enlarging its boundaries. In the arid and sparsely timbered regions of the eastern ranges of the Rocky Mountains few areas equal and none surpass the Yellowstone Park in its advantages to the nation as a forest reservation. While much may rightly be said in favor of the maintenance of the park, based upon sentimental grounds, the necessity of protecting the scientific curiosities, the advantages of the place as a game-preserve, and the benefits to be derived from it as a health resort, the object of first importance is the preservation of its timber. The park is a natural reservoir, adapted by geographical position to receive a copious snow and rain-fall, and by its topographical structure to store up the waters which it receives.

In its broader physical features the Yellowstone Park is an elevated volcanic plateau shut in on the south, east, north, and northwest by mountains rising from 2,000 to 4,000 feet above the general level of the inclosed table-land. It presents a broken, roughly undulating surface, varying from 7,000 to 8,500 feet above sea-level, with an average elevation of about 8,000 feet.

The Gallatin Range, with Electric Peak a culminating point, shuts in the park on the west and north. To the northeast the Snowy Range, deriving its name from the white-capped summits, towers high above the plateau. Along the eastern side of the park for more than 80 miles stretches the Absaroka Range, which rises as a bold, unbroken barrier above the table-land, many of the mountain tops reaching elevations varying from 10,000 to 11,500 feet above sea-level. To the southward the plateau is rimmed in by the Grand Tetons and Wind River Range. All these surrounding mountains, covered with snow the greater part of the year, are constantly pouring immense volumes of water into the plateau region. The continental water-shed enters the park near its southeast corner, crosses the summit of Two Ocean Plateau, and with an irregular, winding course follows along the top of the volcanic lava-flow in a general northwesterly direction, leaving the park nearly west of the Upper Geyser Basin.

Five main channels carry off the waters from the park to the valleys below. On the eastern side of the great water-shed the Yellowstone, Madison, and Gallatin contribute their waters to the Missouri, while the Snake and Falls Rivers on the opposite side add their share to the Columbia. The Yellowstone River, already a magnificent stream before it leaves the mountains, drains more than one-half the area of the park, including the entire eastern border, together with the eastern side of the Gallatin Range, which, through the Gardiner River, pours its waters into the Yellowstone. The streams upon the western slope of the Gallatin Range empty into the Missouri by the Gallatin River. Both the Gibbon and the Firehole find their sources among springs on the plateau, and after draining the principal geyser basins unite to form the Madison. Falls River, a picturesque stream, collects the large drainage from the Pitchstone Plateau and the southern end of the Madison Plateau, and leaves the park at the extreme southwest corner. Snake River, however, drains the greater part of the country on the west side of the water-shed, collecting immense bodies of water coming from the northern ends of the Teton and Wind River Ranges and the southern slopes of the volcanic plateau. Taken together, these accumulated waters make the Snake a broad river before it leaves the mountains.

On the plateau, upon both sides of the water-shed, occur several large bodies of water, Yellowstone, Shoshone, Lewis, and Heart Lakes being especially noteworthy for their size and beauty. Scattered over the country, both on the plateau and in the surrounding mountains, are numerous smaller lakes and ponds, occupying for the most part shallow basins of glacial origin. The view from the summits of either Mount Sheridan or Mount Hancock presents a grand and picturesque scenery of diversified forms, and a country so dotted over with lakes as to receive the appellation of the lake region of the Park. Thousands of hot springs add their waters to the cold water of the surface. Meadows, marshes, and swampy areas characterize the entire area in strong contrast with most Rocky Mountain scenery. These lakes are the reservoirs of the larger streams. The Yellowstone is the largest lake in North America at so high an elevation (7,741 feet). It has a surface area of 121 square miles, and an indented shore-line of nearly 100 miles. Only preliminary soundings have as yet been made, but over a very considerable area the depth is known to be more than 250 feet. Less than 6 miles from the Yellowstone, in a deep depression on the plateau, lies Shoshone Lake, with an area of nearly 12 square miles. A short distance to the southward, at the west base of Mount Sheridan, occurs Lewis Lake, measuring 4½ square miles, and on the opposite side of the mountain lies Heart Lake, with a surface area of 3 square miles. All three of these lakes are important feeders of Snake River.

The greater part of the Park plateau and the adjacent mountains, more especially the western slope of the Absaroka Range, are densely covered with timber. After a careful study of the forests, I think it may be safely said that 84 per cent. of the area of the country is forest-clad. The broad bottoms of the main river valleys, the steeper mountain slopes, the meadows, marshes, and geyser basins, and the tops of ridges above timber-line, comprise the timberless areas. Frequently the broad summits of the higher elevated ridges present more or less barren areas due to the almost incessant exposure to high winds, but over the greater part of the country timber line ranges from 9,600 to 9,800 feet above sea level. Over the Park plateau the timber offers a somewhat monotonous aspect, with little variety of species. Fully two-thirds of the forest trees belong to one species, the Black Pine (*Pinus Murrayana*), a straight, slender tree which rarely attains a height exceeding 75 feet. Frequently it occurs only a few inches in diameter,[1] when it is generally known as "Lodge pole" Pine. Next to the Black Pine comes the Balsam (*Abies subalpina*), which also covers considerable areas, most frequently on steep slopes and generally on moist ground. Associated with this last species is found the Spruce (*Picea Engelmanni*), more abundant, however, on the slopes of the Absaroka Range than over the plateau. The grandest tree of the region is the Douglas, or Red Fir (*Pseudotsuga Douglasii*), which occurs scattered over the Park, more especially in the neighborhood of Mount Washburn and Specimen Ridge. The only other species common enough in any way to characterize the forest, or to call for special mention, are the *Pinus flexilis*, and its associated variety, *Pinus albicaulis*, the latter widely distributed in the southern end of the Park at high altitudes, where it occurs as a common tree on the slopes of Mount Sheridan and Mount Hancock. According to Mr. Frank Tweedy, only five genera and eight species of coniferæ are known to occur within the present Park limits, the additional species being the *Juniperus communis* and *J. Virginiana*, both found over very limited areas. The arborescent growth in no way equals the grand forests of California, Oregon, and Washington Territory, either in size and development of the trees or in the quality of the wood. It is in general stunted in growth, and furnishes but a poor quality of timber in comparison with the magnificent forests found to the westward. Its importance to the nation does not consist in its marketable value, but rather in its power to store up the water and to regulate the flow of streams. For this purpose it is of incalculable value, and quite as serviceable in its way as the timber of the western Cordilleras.

The life of the forest is of short duration. The scanty, gravelly soil affords at best but slight protection to the roots against the force of the winds blowing almost incessantly from the west, as is only too well

[1] Owing to its dense growth.—B. E. F.

shown in the extensive acreage of fallen timber. On the other hand, I know of no region throughout the Rocky Mountains where the conditions seem so favorable for a young growth. During the five years that I have carefully observed the forests nothing has so impressed me as the rapid, healthy development of the young trees which in a few years replace the down timber. In most instances the young growth belongs to *Pinus Murrayana*, and in every case it is the first tree to spring up over a burnt district.

I need not enter here into a lengthy discussion of the influence of the forest upon the supply of water. I simply desire to call your attention to the special advantages of the Yellowstone Park forest for maintaining a water supply of a country singularly well situated to gather and distribute a large annual precipitation of moisture. This uplifted mountain mass measures 90 miles in length by 60 in breadth. From the southwest the moisture-laden winds blowing across the Madison plateau precipitate immense quantities of snow and rain over the cold, wet table-land. Storms gather over the mountains at all times of the year. The annual precipitation is excessive as compared with the adjacent regions of the Rocky Mountains. Rains are of common occurrence between May and September, while during eight months of the year nearly all precipitation falls as snow, which lies upon the ground well into midsummer, and on the northern slopes, at higher altitudes, remains throughout the year. Frosts occur nearly every week during the summer, and observations in July and August for several seasons, at various stations over the plateau, show that the minimum thermometer registers below 40° every night.

The forests exert a powerful influence in sheltering the snow fields, marshes, and meadows from the direct rays of the sun and the dry moisture-absorbing winds blowing from the west. Strip the plateau and mountains of timber, and early freshets would soon lay waste the lower country in spring and leave it arid and parched throughout the summer and autumn. Not only would streams diminish, but the loose gravelly soil which now everywhere covers the Park would rapidly be washed away, laying bare the underlying rocks. The soil, with the accompanying roots and grasses, playing the part of a sponge, exert a powerful influence in maintaining the water supply. They serve to keep the ground cool and moist and allow the water to percolate slowly from the surface to innumerable springs below and thence to the reservoirs of the great rivers.

With a view of determining with some degree of accuracy the volume of water flowing from the Park, the largest lakes and streams were carefully gauged. The measurements were made in early September, 1886, not only the dryest period of the summer but the dryest season known at any time within the previous five years. Evidence was ample to show that Yellowstone Lake had fallen 20 inches below high-water mark of early July. Measurements were made of the discharge from the lake at a point on the river about one-quarter of a mile below the outlet.

The results obtained gave a minimum outflow of 1,525 cubic feet per second, or, expressed in other words, of 34,000,000 imperial gallons per hour. Shoshone, Lewis, and Heart Lakes poured into Snake River 104 cubic feet per second. With few exceptions all the principal rivers leaving the Park were gauged and the discharge from the others carefully estimated, taking as a basis the number of square miles contained in the drainage basin and the flow of the streams. The results give what may be considered as approximately the minimum discharge from the Park—a volume of water equal to 1 cubic foot per second per square mile over an area somewhat more than 4,000 square miles; or as Dr. Hallock, of the U. S. Geological Survey, who supervised the gauging of the streams, has stated it, "an amount of water which would make a river 5 feet deep and 190 feet wide, with a current of 3 miles per hour." For a region bordering on the arid plains to the eastward this is certainly an excessive amount.

According to Humphreys and Abbott, the mean annual discharge from the Mississippi River at its mouth amounts to 675,000 cubic feet per second from a drainage basin of 1,147,000 square miles. This gives .53 cubic feet per second per square mile, or a trifle more than one half the minimum estimate for the Yellowstone Park country. Surely is it not one of the treasures of the nation, to be carefully guarded in every possible way?

If the broad valley of the Lower Yellowstone from Glendive to Livingston is ever to be occupied by an agricultural population, they will at no distant day need all the water flowing from the sources of the river for purposes of irrigation. In the Gallatin Valley, the finest wheat region in Montana, the hard-working farmers are already quarrelling over the distribution of the water running into their inadequately supplied irrigating ditches, while the equally industrious wood-chopper is busily cutting away the timber from the headwaters of the streams in the mountains.

In another way this broad forest-protected reservoir is singularly well situated to be of incalculable service to the nation. Throughout the summer the prevailing dry winds from the west in their passage across this moist mountainous region absorb immense quantities of water ready under favorable conditions to be again precipitated over the agricultural and grazing lands to the eastward. In camping near timber line for weeks at a time, I have never failed to be impressed with the absorbing powers of these winds, the effect of which may be seen upon the snow fields any hot summer day. The melting of the snow and the running down of the water frequently appears inconsiderable as compared with the absorbing power of the hot, thirsty winds. Where all the available lands on the Great Plains is being taken up for settlement by a rapidly advancing civilization, the economic distribution of the Park waters is a question of the utmost importance to the nation.

It is proposed to extend the boundaries of the Yellowstone Park to the south and east so as to include a dense forest region abounding in mountain torrents, the headwaters of the Yellowstone and Snake Rivers. At the time the Park was set aside by act of Congress in 1872 but little was known of the region and its relations to the adjacent country, and still less was its real value appreciated as one of the nation's most available reservoirs. This proposed enlargement embraces all the water draining into the Yellowstone river and lake from the Absaroka range and all affluents of the Snake from the northern spurs of the Grand Tetons and Wind River range. To accomplish this enlargement necessitates placing the boundaries 25 miles farther to the eastward and 9 miles to the southward of the present lines. By this addition to the domain of the Park the headwaters and timber areas around Soda Butte, Cache Calfee, Miller, and the Lamar Rivers on the west side of the range, and Crandall, Sunlight, and Dead Indian Creeks, tributaries to Clark Fork and the Stinking Water, an affluent of the Big Horn, which ultimately drains into the Yellowstone, on the east side, will fall within the reservation.

Unless protected, encroachment will soon be made upon this valuable inheritance of the nation. No serious difficulties arise against placing this additional territory within the Park forever. If timber lands near the sources of our large rivers are to be carefully guarded by national legislation there is no better place to begin the work than right here at the headwaters of the Yellowstone and Snake, which send their waters from the heart of the continent to both the Atlantic and Pacific.

Very truly, yours,

ARNOLD HAGUE.

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SUMMARY OF LEGISLATION FOR THE PRESERVATION OF TIMBER OR FORESTS ON THE PUBLIC DOMAIN.

By N. H. Egleston,

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The earliest action of the General Government having regard to the preservation of timber was in 1799, when Congress appropriated $200,000 for "the purchase of growing or other timber, or of lands on which timber is growing, suitable for the Navy, and for its preservation for future use." The special object of this legislation was to secure a supply of Live-Oak timber, which was considered peculiarly valuable for ship-building and was in great demand for that purpose, both at home and abroad, while its growth was confined to a limited portion of our territory in the vicinity of the Gulf. Two small islands on the coast of Georgia, containing together about 2,000 acres, were purchased under the act of 1799. Another act (Revised Statutes, section 2458), having the same object in view, was passed in 1817, by which the Secretary of the Navy was directed to cause lands producing Live Oak or Red Cedar to be explored, and to have selections made of tracts necessary to furnish for the Navy a sufficient supply of such timbers. Under this act 19,000 acres in Louisiana, which had recently become ours by purchase from France, were reserved.

Additional enactments were made in 1820 and 1827, by which the selection of lands to be reserved was intrusted to the surveyor of Public Lands in place of agents appointed by the Secretary of the Navy, and the President was authorized to withhold such lands from sale.

In 1822, an act was passed (Revised Statutes, section 2460), authorizing the President to employ the land and naval forces so far as necessary effectually to prevent the felling or other destruction of timber in Florida, and to take such other measures as might be deemed advisable for the preservation of timber there. (Florida had recently been ceded to the United States by Spain, and was known to abound in Live-Oak timber.)

In 1831, an act was passed (Revised Statutes, sections 2461, 2462, and 2463) of wider scope than that of 1822. This made it a felony, with penalty of fine and imprisonment, to cut or remove timber from any of the public lands, whether reserved or not, except for the use of the

Navy, and subjected any vessel transporting such timber without proper authority and for any other purpose than for the use of the Navy, to confiscation and the master ot the vessel to a fine.

This act is the one under which, up to the present time, all the protection they have had has been secured to the public forests, the Supreme Court having construed the act (9 How., 351) as authorizing the protection of all timber on the public lands, and punishment for trespass upon the same. Under the act of 1831, the Treasury Department undertook a partial oversight and protection of timber on the public lands through its ordinary agents. In 1855 this oversight was transferred to agents of the Land Department, registers and receivers being instructed to act also as timber agents, but without any additional compensation. Where trespass was willfully committed, payment of stumpage was demanded or the timber was seized and sold and the proceeds paid into the Treasury. Where the trespass was committed ignorantly, actual entry of the land only was required, with payment of the usual entry charges.

The first appropriation for the payment of agents specially employed for the protection of timber on the public lands was made in 1872, when $5,000 were appropriated. A like sum was appropriated annually thereafter for five years. In 1878, to meet expenses for suppressing depredations upon timber on the public lands, $25,000 were appropriated. Subsequent appropriations for this purpose are noticed in another place.

The following synopsis shows the course of legislation by the General Government in behalf of the forests and timber lands since the passage of the act of 1831.

It will be noticed that, with the exception of the acts of 1876, 1878, 1880, and 1883, none of the many bills which have been proposed have been given the form of law. But the failures to secure legislation may be as instructive and as important in a correct history of forestry in our country as the record of successes. This will justify the somewhat extended, though not exhaustive, list of bills here given:

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1871	41st, 3d sess.	H. R. 2930, Sargent.	For the sale of timber lands in California and Oregon.	Referred to Committee on Public Lands.
1871	41st, 3d sess.	H. R. 3005, Sargent.	To authorize the sale of timber lands in California, Oregon, and Washington Territory, not exceeding 640 acres to one person or association, without residence, at $2.50 per acre.	Passed in House. In Senate referred to Committee on Public Lands.
1871	42d, 1st sess.	H. R. 274, Garfielde.	Same as the preceding	Referred to Committee on Public Lands.
1872	42d, 2d sess.	H. R. 2197, Haldeman.	To encourage the planting of trees and the preservation of woods on the public domain. (The first real and comprehensive forestry bill.)	Referred to Committee on Agriculture. Reported favorably. Failed of passage—81 yeas, 87 nays.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1872	42d, 2d sess.	....	Resolution that the Committee on Agriculture inquire whether a certain percentage of each quarter section of public lands sold must be planted with trees or a certain percentage of existing forests preserved for the purpose of preventing or remedying drouth.	No action.
1873	3d 1st sess.	H. R. 410, Page.	Same as Garfielde bill (274) above.	Referred to Committee on Public Lands. June 3, reported back with amendments and recommitted. December, 1874, H. R. bill 4194 reported by committee as substitute. Passed February 22, 1875. In Senate February 22, referred to Committee on Public Lands.
1874	43d, 1st sess.	Senate 471, Boutwell.	For the survey and disposal of the timber lands of the United States. Miners may buy stumpage, not more than 160 acres, till that is cut, at $2.50 per acre. Homesteaders may buy 40 acres of timber land near agricultural land at same price.	Referred to Committee on Public Lands. Reported with amendments.
1874	43d, 1st sess.	H. R. 2497. Herndon.	For the appointment of a commission for inquiry into the destruction of forests and into the measures necessary for the preservation of timber.	Referred to Committee on Public Lands. Reported back with H. R. 2540 as a substitute.
1874	43d, 1st sess.	H. R. 2540, Dunnell.	For the appointment of a commissioner to inquire into the destruction of forests and into the measures necessary for the preservation of timber.	Reported by Committee on Public Lands as a substitute for preceding bill, H. R. 2497.
1875	43d, 2d sess.	H. R. 4430, Averill.	To regulate the survey and sale of the timber lands of the United States. Commissioner of the Land Office to survey and appraise lands more valuable for their timber than for agricultural use. Such lands not to be entered under homestead or preemption laws, but appraised and offered at public sale, and if not sold then to be open to private entry at a price not less than the appraisal.	Referred to Committee on Public Lands.
1875	44th, 1st sess.	H. R. 323, Dunnell	To regulate the survey and sale of the timber lands of the United States. Same bill as the preceding.	Referred to Committee on Public Lands.
1875	44th, 1st sess.	Senate 2. Clayton.	To repeal section 2303 of the Revised Statutes, thereby opening timber lands in Southern States to private entry in unlimited quantities and at the reduced price of $1.25 per acre.	Referred to Committee on Public Lands. Reported back and passed. In H. R. referred to Committee on Public Lands. Passed H. R. and became a law July 4, 1876, through inaction of the President.
1875	44th, 1st sess.	Senate 6, Kelley.	For sale of timber lands in California, Oregon, and the Territories. Same as previous bills with similar title.	Referred to Committee on Public Lands. Passed Senate February, 1876. In H. R., February, 1876, referred to Committee on Public Lands. March, 1877, House refused to suspend rules and pass the bill.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1876	44th, 1st sess.	H. R. 660, Maginnis.	For the sale of the timber lands in the Territories. Lands valuable for timber but not for cultivation to be sold at $2.50 per acre, not more than 40 acres to one person.	Referred to Committee on Public Lands.
1876	44th, 1st sess.	H. R. 1191, Sayler.	To regulate the survey and sale of the timber lands of the United States. Lands valuable chiefly for timber not to be subject to entry under pre-emption or homestead laws, but to be appraised and sold at not less than the appraised value.	Referred to Committee on Public Lands. Reported with amendments and recommitted.
1876	44th, 1st sess.	H. R. 1310, Dunnell.	For the appointment of a commission, etc. Same as preceding bill (H. R. 2540).	Referred to Committee on Public Lands. No opportunity was afforded for regular action on the bill, but, on motion of Mr. Dunnell, the substance of it was added as an amendment to the general appropriation bill, and became a law August, 1877.*
1876	44th, 1st sess.	H. R. 2075, Fort.	For the preservation of the forests adjacent to the sources of navigable rivers and other streams. Such timber lands to be withdrawn from sale and a commission to determine what should be reserved so as to prevent scanty supply of water.	Referred to Committee on Public Lands.
1877	45th, 1st sess.	H. R. 797, Maginnis.	For the sale of timber lands in the Territories. Same as bill (660) of Mr. Maginnis in Forty-fourth Congress.	Referred to Committee on Public Lands.
1877	45th, 1st sess.	H. R. 1154, Pacheco.	To regulate the survey and sale of timber lands of the United States. Same as bills in the Forty-third and Forty-fourth Congresses.	Referred to Committee on Public Lands.
1877	45th, 1st sess.	H. R. 1525, Herbert.	To put into market certain timber lands of the United States. Declaring subject to entry, in any quantity, all public timber lands in Alabama, Louisiana, and Minnesota which have been subject to entry in limited quantities for twenty years, and after entry of such lands to be no prosecution for trespass or timber cutting.	Referred to Committee on Public Lands.
1878	45th, 2d sess.	H. R. 2658, Maginnis.	To provide for the entry of unsurveyed timber lands. Allowing the owner of a mine to take 160 acres of timber land for every 20 acres of mineral land owned by him, and the owner of agricultural land 40 acres for every quarter section, and for every $20,000 expended on a mill or furnace 640 acres may be taken at $2.50 per acre.	Referred to Committee on Public Lands.

* By this enactment the Commissioner of Agriculture was directed to appoint a competent person to make the contemplated inquiries and investigations. The Commissioner appointed for this work Mr. F. B. Hough, and the prosecution of the work led to the establishment of the Forestry Division in the Department of Agriculture. The result of Mr. Hough's inquiries has been published in three volumes. The work begun by him has been continued by his successors in charge of the Forestry Division, so far as the small appropriation made by Congress for the purpose would allow, and additional reports have been published.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1878	45th, 2d sess.	H. R. 3981. Patterson.	Withdrawing lands chiefly valuable for timber from entry under pre-emption or homestead laws. Such lands to be surveyed and divided into "timber lands" and "mineral timber lands." On the latter the timber only to be sold. Timber lands to be appraised and sold by commissioners. Such lands as are needed for irrigation purposes to be withheld from sale.	Reported by Committee on Public Lands as a substitute for several bills. Recommitted.
1878	45th, 2d sess.	....	$25,000 appropriated to suppress depredations on public timber.	
1878	45th, 2d sess.	Senate 926, Sargent.	Allowing sale of timber lands unfit for cultivation in California, Oregon, Nevada, and Washington Territory at $2.50 per acre. No one person or association to enter more than 160 acres.	Referred to Committee on Public Lands. Passed Senate. Reported to and passed H. R. Approved by President June 3.
1878	45th, 2d sess.	H. R. 3800, Wren.	Bill similar to next below.........	Referred to Committee on Public Lands.
1878	45th, 2d sess.	Senate 20, Chaffee.	Allowing residents of Colorado, Nevada, and other Territories, and all mineral districts, to fell and remove, for building and other domestic purposes, trees on mineral lands.	Referred to Committee on Public Lands. Amended and passed by Senate. Passed H. R. and signed by President June 3.
1879	45th, 3d sess.	H. R. 6087, Dunnell.	To regulate the survey and sale of timber lands. Same as bill presented December, 1875 (H. R. 323), providing that timber lands more valuable for lumber than for agricultural purposes be reserved from entry under homestead or pre-emption laws, appraised, and sold to highest bidder, but not for less than appraisement.	Referred to Committee on Public Lands.
1879	46th, 1st sess.	H. R. 1164, Dunnell.	To regulate the survey and sale of timber-lands of the United States. Same as last bill above.	Referred to Committee on the Public Lands.
1880	46th, 2d sess.	H. R. 6321, Carlisle.	To prevent depredations upon timber in the Indian Territory.	Referred to Committee on Indian Affairs.
1880	46th, 2d sess.	H. R. 6340, Downey.	Authorizing citizens of Colorado, Nevada, and the Territories, to fell and remove timber on the public domain, for mining and domestic purposes. Extending the act of June, 1878.	Referred to Committee on the Public Lands.
1880	46th, 2d sess.	Senate 1812, Coke.	To prevent depredations upon timber on Indian reservations.	Reported from the Committee on Indian Affairs.
1880	46th, 2d sess.	H. R. 6371, Hooker.	To prevent depredations upon timber on Indian reservations. Same as last bill above.	Referred to Committee on Indian Affairs.
1880	46th, 2d sess.	H. R. 1846, Herbert.	Act condoning trespass on public lands prior to March, 1879. Persons against whom suits were pending prior to that date to enter lands trespassed upon and pay accrued costs, thereupon suits to be discontinued. At same time price to be paid for lands to be reduced from $2.50 to $1.25.	Approved by the President June 15, 1880.
1882	47th, 1st sess.	Senate 760, Teller.	For the classification of the public lands in Colorado and the sale of timber thereon. The Secretary of the Interior to regulate the sale, and may reserve timber on head-waters of streams and on mountains.	Referred to Committee on Public Lands.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1882	47th, 1st sess.	Senate 1641, Teller.	To amend act of 1878, so as to allow any one in Western States and Territories to remove timber from mineral lands for any purpose, under rules and regulations of the Secretary of the Interior and payment of \$2.50 per acre for the timber. No timber to be cut by mill-owners or lumber manufacturers.	Referred to Committee on Public Lands.
1882	47th, 1st sess.	Senate 1826, Sherman.	For the preservation of woods and forests adjacent to sources of navigable rivers. Same as bill introduced in H. R. 1st session, Forty-fourth Congress.	Referred to Committee on Agriculture.
1882	47th, 1st sess.	H. R. 6315, Butterworth.	For the preservation of woods, etc. Same as Senate bill next above.	Referred to Committee on Agriculture.
1882	47th, 2d sess.	H. R. 6997, Strait.	To provide for the classification and disposition of pine timber-lands. Such lands, chiefly valuable for their timber, not to be subject to pre-emption or homestead entry, but to be appraised by the Secretary of the Interior, and sold from time to time at public sale, for not less than two-thirds the appraisement. Mineral lands exempt from the act.	Referred to Committee on the Public Lands.
1883	47th, 2d sess.	H. R. 7509, Dwight.	To regulate the sale of the timber-lands of the United States. Similar to last bill above, but lands remaining unsold to be subject to private entry at the appraised value.	Referred to Committee on the Public Lands.
1883	47th, 2d sess.	Senate 2496, Tabor.	For the protection and preservation of the forests of the United States. One hundred thousand dollars to be appropriated to Colorado for the establishment of an experiment station under the direction of the Department of Agriculture.	Referred to Committee on Appropriations.
1883	47th, 2d sess.	H. R. 4757.	Act to exclude the public lands in Alabama from the operation of laws relating to mineral lands. (In reality an act to sell all mineral lands in Alabama as agricultural lands, at private sale, in unlimited quantities, and at the reduced rate of \$1.25 per acre, to citizens or aliens.)	Approved by the President March 3, 1883.
1883	48th, 1st sess.	H. R. 832, Strait.	For the classification and disposition of pine timber-lands. Same as above bill presented in Forty-seventh Congress.	Referred to Committee on the Public Lands.
1883	48th, 1st sess.	Senate 1258, Sherman.	For the preservation of woods and forests adjacent to sources of navigable rivers, etc. Same as bill in Forty-seventh Congress.	Referred to Committee on Agriculture.
1883	48th, 1st sess.	H. R. 4811, Hatch.	For the preservation of woods, etc. Same as last bill above.	Referred to Committee on Agriculture.
1883	48th, 1st sess.	H. R. 5206, Deuster.	For the preservation of woods, etc. Same as last bill above.	Referred to Committee on Agriculture.
1884	48th, 1st sess.	Senate 1544, Dawes.	To prevent cutting of timber on military or Indian reservations.	Referred to Committee on Indian Affairs. Passed in Senate April 23. In H. R. referred to Committee on Indian Affairs.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1884	48th, 1st sess.	Senate 1188 Cameron.	For the protection, preservation, and extension of the forests of the United States. To establish an experiment station in connection with the Department of Agriculture, west of the Mississippi River. To propagate and distribute forest trees, investigate qualities, time of growing, profit, etc. One hundred thousand dollars appropriated.	Referred to Committee on Agriculture and Forestry.
1884	48th, 1st sess.	Senate 1824, Edmunds.	Act to establish a forest reservation on the head-waters of the Missouri and Columbia Rivers.	Passed Senate June 1884. In House printed.
1884	48th, 2d sess.	Senate 2451, Miller.	For the protection of forests on the public domain. Withdraws all timber land from sale under existing laws. Forest Commission to be appointed to examine and classify forest lands and determine what should be permanently reserved. Timber on reserved lands to be sold under direction of the Commissioner of the Land Office.	Referred to Committee on Agriculture. Reported favorably.
1885	49th, 1st sess.	Senate 581, Edmunds.	To establish a forest reservation in Montana. Same as bill S. 1824, in Forty-eighth Congress.	Referred to Committee on Agriculture. Reported favorably. Passed Senate. In H. R. on calendar.
1885	49th, 1st sess.	H. R. 379, Payson.	To repeal act of 1878, for the sale of timber-lands in California, Oregon, Nevada, and Washington Territory.	Referred to Committee on the Public Lands.
1885	49th, 1st sess.	H. R. 2946, Hatch.	For the preservation of woods and forests adjacent to sources of navigable rivers, etc. Same as bill offered in Forty-eighth Congress.	Referred to Committee on Agriculture.
1885	49th, 1st sess.	Senate 551, Sherman.	For the preservation of woods and forests adjacent to sources of navigable rivers, etc. Same as bill next above.	Referred to Committee on Agriculture.
1886	49th, 1st sess.	H. R. 5556, Oates.	To define and punish the offense of setting fire to woods or forests belonging to the United States.	Referred to Committee on Judiciary. Reported at second session, with amendments, and placed on the Calendar.
1887	49th, 2d sess.	H. R. 10430, Markham.	For the protection of forests in California. To withdraw from sale Government forest lands in California not suited to agriculture. Such lands not to be alienated from the Government, but to be placed temporarily under the management of the forest commissioners of California. Fifty thousand dollars appropriated to carry out the act.	Referred to Committee on Public Lands. Reported favorably.
1888	50th, 1st sess.	H. R. 6045, S. V. White.	For the protection and administration of the forests on the public domain. Provides for the classification of forest lands, the reservation of a proper amount of forest land from sale, the timber on the same alone being sold under direction of forest commissioners to be appointed, who are to have entire management of the public forests. Timber lands not necessary for reservation to be sold.	Referred to Committee on Public Lands.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1888	50th, 1st sess.	Senate 1779, Hale.	For the protection and administration of the forests on the public domain. Same as H. R. bill 6045 above.	Referred to Committee on Agriculture and Forestry.
1888	50th, 1st sess.	H. R. 1353, Weaver.	To further amend the public-land laws, and for the preservation of natural forests on the public domain, the protection of water supply, and for other purposes.	Referred to Committee on Public Lands.
1888	50th, 1st sess.	H. R. 7901, Holman.	To secure to actual settlers the public lands adapted to agriculture, to protect the forests on the public domain, and for other purposes.	Reported by Committee on Public Lands as a substitute for H. R. bill No. 6045 and other bills relating to the public lands. Passed. In Senate referred to Committee on Public Lands.
1888	50th, 1st sess.	Senate 2510. Teller.	To amend act authorizing citizens of Colorado, Nevada, and the Territories to fell and remove timber on the public domain for mining and domestic purposes.	Referred to Committee on Public Lands.
1888	50th, 1st sess.	Senate 2877 Teller.	Authorizing citizens of Colorado, Nevada, and the Territories to fell and remove timber on the public domain for mining and domestic purposes.	Referred to Committee on Public Lands.

To give a more complete view of the action of the Government in its bearings upon forestry, it seems proper to append to the foregoing synopsis the following record of legislation, actual as well as only proposed:

TIMBER CULTURE ACTS.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1873	42d, 2d sess.	Senate 680, Hitchcock.	To encourage the growth of timber on Western prairies. A person planting 40 acres of timber trees on Government land to be entitled to 160 acres at the expiration of ten years. The so-called timber-culture act.	Referred to Committee on Public Lands. Reported favorably and passed. Approved March 3, 1873.
1874	43d, 1st sess.	H. R. 743, Dunnell.	To amend the above act. Confines privilege of entry to heads of families or persons over twenty-one years of age and to citizens of the United States. Reduces the time for perfecting title to eight years. Restricts the amount to be entered by one person to 160 acres. Allows homesteaders to obtain patent by planting one-sixteenth of homestead with trees.	Passed and approved March 13, 1874.
1876	43d, 1st sess.	H. R. 2427.	To amend act of 1873. Allows extension of time for perfecting title in case of the destruction of trees by grasshoppers; also permits seeds and nuts to be planted instead of trees.	Referred to Committee on Public Lands. Reported favorably, passed, and approved May 20, 1887.

TIMBER CULTURE ACTS—Continued.

Year.	Congress.	House in which originated.	Object of bill.	Action taken.
1878	45th, 2d sess.	H. R. 3235, Strait.	To amend the act of 1873. Reducing the number of acres to be planted to 10 for every quarter section and in the same proportion for smaller quantities, but requiring closer planting—twenty-seven thousand trees per acre. Five acres to be broken first year and 5 the second, and planted with trees in the third and fourth years. Repeals the homestead provision of the act of 1874.	Reported with amendments by committee, passed, and approved June 14, 1878.
1881	47th, 1st sess.	H. R. 430, Ryan.	To amend the act of 1878. Specifying the kinds of trees to be planted.	Referred to Committee on Public Lands.
1882	47th, 1st sess.	H. R. 4497, Deering.	To repeal the act of 1878	Referred to Committee on Public Lands.
1885	49th, 1st sess.	Senate 65, Dolph.	To repeal all laws for the pre-emption of public lands and those allowing entries for timber culture, the sale of desert lands, etc.	Referred to Committee on Public Lands.
1885	49th, 1st sess.	H. R. 452, Cobb.	To repeal all laws for the pre-emption of public lands and those allowing entries for timber culture.	Referred to Committee on Public Lands.
1885	49th, 1st sess.	H. R. 380. Payson.	To repeal pre-emption and timber-culture laws. Nearly identical with bill 452.	Referred to Committee on Public Lands.
1886	49th, 1st sess.	H. R. 5210, Henley.	To repeal all laws for the pre-emption of public lands and for timber-culture entries.	Referred to Committee on Public Lands.
1886	49th, 1st sess.	H. R. 1238, Strait.	To amend the act of 1878	Referred to Committee on Public Lands.
1888	50th, 1st sess.	Senate 2893, Paddock.	To amend act to encourage the growth of timber on the western prairies.	Referred to Committee on Public Lands.

FOR THE ESTABLISHMENT AND ENDOWMENT OF FORESTRY SCHOOLS.

1882	47th, 1st sess.	Senate 1880, McMillan.	To aid in the endowment of a school of forestry at Saint Paul. Granting 300 sections of public land for the purpose.	Referred to Committee on Agriculture.
1883	47th, 2d sess.	H. R. 7440, Pettigrew.	To grant lands to Dakota for the purpose of establishing a school of forestry. Granting 400 sections of land for the purpose.	Referred to Committee on Public Lands.
1884	48th, 1st sess.	H. R. 4361, Raymond.	To grant lands to Dakota for the purpose of establishing a school of forestry. Same bill as the preceding.	Referred to Committee on Public Lands.
1886	49th, 1st sess.	H. R. 2826, Gifford.	To grant lands to Dakota for the purpose of establishing a school of forestry. Same as two preceding bills.	Referred to Committee on Public Lands.

THE CLIMATE OF COLORADO AND ITS EFFECT ON TREES.

By GEORGE H. PARSONS, Colorado Springs, Colo.

A discussion of climatic effects upon trees in Colorado must necessarily, from the lack of exact records, be rather general in its nature. It is to be regretted that no experimental plantations of trees have been made in various parts of the State, where the behavior of different species, under the peculiar conditions of this climate, could be regularly observed and noted. Such a systematic record, showing in a concise form the history of each tree, would be of much more benefit than the general and irregular observations of any number of planters, provided, always, that the observer is thoroughly trained in the work he has to do, otherwise his records will be worse than useless, like many of the tables of meteorological phenomena, laboriously constructed after the most approved scientific methods, which are now thrown aside as fallacious.

In the absence of these experimental stations and skilled observers, the province of science may be to examine and record such irregular observations as may be found. This is what I propose to do, confining myself to the results of my own general observations, and that of others, regarding trees.

A detailed description of the whole climate of so large a State as Colorado, and one of so great variation of surface, will be impossible in the limits of this paper. The discussion will therefore be more particularly confined to the best-known and more densely peopled portion lying where plain and mountain meet around the cities of Denver, Colorado Springs, and Pueblo. Indeed, only in this region have climatic observations been taken and recorded for a period long enough to give any reliable data of the average conditions; and only here have trees been planted to an extent sufficient to enable the observer to learn some of the effects of the climate upon them.

Still, a study of the climate of this region will be, to a certain extent that of the whole State, for the difference between this and any other portion is only one of degree. The temperature will change with altitude and latitude, and the moisture among the mountains will be greater than on the plains.

That we may enter more intelligently upon the consideration of the climate of Colorado, we will briefly glance at the various influences that control a climate.

Great altitude has perhaps the most important influence on climate, because of the rarity of air that accompanies it, producing rapid evaporation, dryness, variability, and extremes of temperature, clearness of skies, and all the effects opposite to those of the sea-level, where the thick stratum of humid atmosphere intercepts the sun's rays, retains heat, obstructs radiation, and produces equability of temperature. Low humidity is the main characteristic of high elevations, and is caused principally by the lower temperature reigning at such elevations, but also by the diminution of atmospheric pressure, allowing less moisture to be held in a given space of air at a given temperature than at lower levels. Authorities state that there is an average lowering of temperature of three degrees Fahrenheit for each thousand feet of ascent, and this cooling lessens the capacity of air to contain moisture.

Latitude has a strong influence on climate, acting in much the same way as altitude; the effects of a high degree of latitude being, in a general way, similar to those of a great altitude. Professor Loomis states that beyond the parallel of sixty degrees north latitude, at a short distance from the ocean, the mean annual rain-fall seldom exceeds 10 inches.

Distance from the ocean naturally promotes dryness, and to this fact is due, in no small degree, the uniform lack of humidity in the atmosphere upon the extensive plateaus of Wyoming, Colorado, and New Mexico, which is not found in the high altitudes of Switzerland. The evaporation constantly going on over the ocean and all bodies of water, supplying the atmosphere with moisture, which returns to the thirsty land in rain, is wanting in the elevated interior of our continent. And there can be no satisfactory compensation on our open plains for this absence of water distribution, as long as there are no forests, undergrowth, or thick grasses to prevent evaporation and drying of the land, and to provide by their natural reservoirs and springs and differences of temperature a substitute for the ocean. A far inland position also has a powerful influence upon temperature. The specific heat of land being only one quarter that of water, it both absorbs and gives out heat more rapidly, consequently the more land the greater the heat and the wider the fluctuation, especially when there is nothing to obstruct the sun's rays or the earth's radiation.

High mountain ranges exert a powerful influence upon the moisture conditions of a climate, by intercepting the air currents which come from a distant, warm, damp region. Such currents are quickly brought to the point of saturation as they mingle with the cooler elevated atmosphere of the mountains, and precipitating their moisture in rain or snow upon the mountain sides, they pass on in a dry and highly electrical condition. Mountains also influence a climate by the shelter they afford from severe winds. They also increase the local showers by gathering and precipitating the moisture accumulated in the atmosphere by evaporation from the earth's surface. This effect of mountains is also shown by the opposite influence of level, barren plains, where not even a tree is found to intercept the moisture-laden currents.

The absorptive power of the earth has a climatic influence of greater or less degree according to the nature of the soil. A very dry atmos. phere will be rarely found where the soil is composed of closely-packed clay, with a tendency to form swamps, morasses, and sloughs. On the contrary, a porous, dry sand and light, friable, loose earth absorb, to a great extent, the moisture from the air. Sand also loses its moisture more easily than clay; it heats more quickly, and also cools more rapidly.

Such are, in general, the influences that control a climate, and with a knowledge of these and of the physical nature of this selected section of Colorado we may form a good idea of what to expect here.

The altitude of this region, outside of the mountains, is from 5,000 to 7,000 feet above the sea. The latitude is between the thirty-eighth and forty-first parallels, about the same as the cities of Washington, Philadelphia, and New York. The distance from the Pacific Ocean is about 1,440 miles, and from the Atlantic about 2,100 miles.

The principal portion is a rolling prairie, bare and brown, except along the few water-courses, where sparse belts of cottonwood trees relieve the monotonous and desert-like appearance. The earthy billows of this ocean-like plain rise and break against the rocky slopes of a vast mountain range, running nearly north and south, and stretching westward to the Pacific. Its lofty peaks rear their summits 14,000 feet above the level of the sea, and promontories or spurs jut forth here and there into the plain. From these rocky slopes the decomposed sandstone has been washed down upon the plain below, and formed sandy, gravelly deposits of wonderful porosity and depth, capable of absorbing any quantity of rain and moisture.

And now, with this bird's-eye view of the climate, let us examine it more closely and in detail and see how it affects tree-growth. In this we shall be aided by the constancy and regularity of most of the phenomena.

The following table, compiled from the meteorological records taken in Denver for thirteen years, from 1872 to 1884, will give an idea of the climate there, as far as such observations can do so:

Table showing average climate at Denver for each month for thirteen years.

Months.	Mean temperature.	Mean daily range of temperature.	Highest observed temperature.	Lowest observed temperature.	Average maximum temperature.	Average minimum temperature.	Mean relative humidity.	Total precipitation.	No. of days rain or snow fell.	No. of clear days.	No. of fair days.	No. of cloudy days.	No. of sunny days.	Average cloudiness.	Average velocity of wind per hour.
							P. ct.	*Inch.*							*Miles.*
December	30.5	23.9	71	−25	64.4	−7.6	55.8	.72	5	15	13	3	29	2.2	6.2
January	27.5	23.5	67	−29	60.2	−11.5	53.5	.66	5	16	11	4	28	2.0	6.5
February	31.4	21.4	72	−22	62.0	−2.7	53.5	.46	5	13	12	3	27	2.2	6.0
Winter	29.8	.....	72	−29	62.2	−7.3	54.3	1.84	15	44	36	10	84	2.1	6.2
March	39.7	20.6	81	−10	71.3	8.6	48.8	.86	6	14	11	6	28	2.6	7.4
April	46.0	21.1	83	4	76.9	17.3	49.2	1.83	8	10	13	7	25	3.2	7.3
May	53.9	22.5	92	27	85.4	31.6	49.2	3.17	11	9	15	7	28	3.3	7.1
Spring	47.2	.....	92	−10	77.9	19.2	49.1	5.86	25	33	39	20	81	3.0	7.3
June	66.8	24.3	99	37	94.4	41.7	40.8	1.59	7	13	13	4	29	2.5	6.3
July	72.2	28.3	102.3	42	97.4	50.2	46.4	1.78	9	12	15	4	30	2.8	6.4
August	70.5	23.8	105	44	96.0	49.4	47.4	1.54	10	12	14	5	30	2.8	5.7
Summer	69.8	.....	105	37	95.9	47.1	44.9	4.91	26	37	42	13	89	2.4	6.1
September	60.9	26.8	93	28	89.7	35.2	43.8	.90	5	17	9	4	29	2.0	5.5
October	50.3	26.7	86	1	82.1	20.7	45.0	.74	5	16	10	5	29	2.3	6.2
November	37.6	26.4	76	−18	70.0	3.6	47.7	.70	5	16	10	4	28	2.2	6.2
Autumn	49.6	....	93	−18	80.6	19.8	45.5	2.34	15	49	29	13	86	2.2	5.6
Year	49.1	.....	105	−29	79.2	19.7	48.4	14.95	81	163	146	56	349	2.6	6.3

NOTE.—The data for this table are derived from the meteorological summary furnished by J. J. Gilligan, U. S. signal officer, Denver, Colo.

TEMPERATURE.

From the physical nature of Colorado we must expect a low average temperature. The mean annual temperature at Denver is 49 degrees, about the same as at Chicago and Boston; but it is actually more extreme than this would indicate, for we also find that the lowest point the thermometer reached was 29 degrees below zero, and the highest point was 105 degrees. But these extremes are few and of short duration, and the records of the maximum and minimum temperature will be a better indication for this region than for many others. More often than this severe cold will come soft, balmy days in midwinter, when wraps are cast aside and the houses are thrown open in the genial sunshine.

In comparing the records of each season here with those of other parts of the country, we find that the average temperature is more equal here throughout the year. We have the winter temperature of

Saint Louis, the spring temperature only a little cooler than Washington, and the summer and autumn temperature of Boston.

Every one has perceived that the sensation of cold depends on many other things besides the temperature. The dry and rarefied air of this altitude, allowing the rays of the sun to pass through with but trifling loss of heat, renders the lowest temperature much more endurable than it would be in moister climates. If the sun be shining and the air still, it matters little how low the thermometer may fall, and zero weather will be pleasant and agreeable. This warmth of the sun is not shown in the meteorological tables, for the thermometers are set in the shade. By sun thermometers temperatures of 110 degrees and upwards are quite usual in winter, while 120 degrees has been observed in January. In the summer months the temperature in the sun usually ranges between 130 and 150 degrees. This heat would be difficult to endure if it were not for the same rarefied condition of the air which we have just found softening the effects of extreme cold. It gives a bracing, stimulating quality to the air in summer, and a fresh coolness to the slightest breeze, such as we never find in the low altitudes. Then, too, no matter how hot it may be in the sun, there is always a cool spot in the shade, and summer nights are rarely too warm for a blanket. This marked difference between sun and shade is the result of the lack of aqueous vapor in the air to become heated by the sun, for air of itself is diathermanous to the rays of the sun, letting them through without practically absorbing any of their heat. The great difference between day and night temperatures is shown in the large ranges of temperature, being for the mean daily range 30 degrees, the mean monthly range 53.7 degrees, and the mean annual range 131 degrees. For comparison, the same ranges of temperature at New Haven are, respectively, 16, 42, and 91 degrees.

Sudden changes of temperature are a peculiar feature of this climate. Without the sheltering influence of forests or mountain ranges on the north, something of the fierce cold is felt here of the blizzards or northers which, coming from the fields of ice and snow in the north, sweep with such deadly power over the plains farther east. They come suddenly, with little warning, chilling with their icy breath the soft, balmy air that precedes them, and causing the mercury to drop 40 degrees in half an hour, and from 80 degrees at noon to zero at night. But their violence soon carries them past, and the following day may be as pleasant as before the blizzard came. The changes from cold to heat are just as sudden and great, under the influence of the warm west wind, which comes down from the mountain sides extremely dry and electrical, driving the frost before it and absorbing the moisture of the ground and air. Under its influence the thermometer has risen, by actual observation, 40 degrees in thirty-five minutes, and after it had passed the thermometer has fallen 30 degrees in five minutes, so suddenly did its influence cease. This peculiar west wind will be discussed later.

From the foregoing we find that the peculiar features of temperature in Colorado are great extremes, great range, and sudden changes. Upon trees the effect of great extremes is not necessarily injurious, except in connection with a dry, porous soil, which, holding no moisture to form an icy protection, allows the frost to penetrate so deep as to reach the tender rootlets of a young tree. Frost has been found in the ground in Colorado 5 feet below the surface. The evil effects of this may be lessened by heaping snow around the foot of the tree, where it will melt and freeze and protect the ground. When snow can not be had water may be used. Late fall irrigation, just before freezing weather sets in, is therefore beneficial, from the coating of ice formed near the surface. Winter irrigation should also be practiced for the same reason.

The great range of temperature in Colorado is more injurious to trees than extreme cold, for all vegetation thrives best in equable climates. In winter the powerful heat of the midday sun in this thin air excites the flow of sap in a tree to such an extent that it does not recover its normal condition before it is frozen by the severe cold of the night. Trees are found injured on the south, but never on the north, side. To remedy this, the trunk is shaded by a board, or wrapped with matting, burlap, or straw. More trees perish during the warm, summer-like days of February than in the coldest weather. This great difference of temperature in sun and shade has also an unfavorable effect on trees in summer, retarding their growth and preventing the warm nights so beneficial to all vegetation.

It is a well-known fact that sudden thawing is more injurious to plants than freezing, and therefore the effects of cold are increased tenfold when followed by great warmth. For this reason sudden changes of temperature are the hardest for trees to endure. The hot blasts which come down from the mountains during severe cold often scorch the life from the tree, and the fierce blizzard from the north, which may suddenly appear on the warmest day in winter, chills it to the marrow.

We find little spring weather in Colorado, and the approach of summer is not gradual, as at lower elevations. Trees will be often tempted to open their buds in the warm sunshine of many days in March and April, only to be nipped by late frosts. For this reason fruits are difficult to raise, especially the early blossoming varieties.

On account of this peculiar winter weather, trees planted in autumn suffer more than those planted in spring, which have the benefit of a whole season to become accustomed to the new and peculiar conditions. Those trees succeed best here which form their terminal buds early in autumn, and make a definite annual growth, so that their tops may not be killed in the first frosts.

HUMIDITY.

Humidity, or the amount of moisture in the air, is a more powerful agency in climate than is generally recognized. It regulates light and heat, and checks evaporation from the earth by absorbing the heat and partly arresting the direct rays of the sun. It is the medium for the formation of dew, rain, and snow, and when examined in connection with temperature, gives the only true indication of the dryness of a climate.

Relative humidity, as given in the table, indicates the ratio between a given amount of vapor in the air and that which saturated air at the same temperature could contain. It enables us to form an idea of how near to saturation and therefore to possible precipitation the air has come. But it does not represent the actual amount of moisture contained in the air. This is dependent upon the temperature, for air when warm takes up more moisture than when cold, and the point of saturation may therefore represent more or less actual moisture in the air.

It has been found that "the expansion of air under the influence of heat increases its capacity for retaining invisible vapor from about half a grain in a cubic foot—the limit at zero, with the barometrical pressure at 30 inches—to 19.84 grains, the limit at 100° F." Therefore, in a cool climate like that of Colorado, the air will absorb and hold much less moisture than in a warmer one. Altitude has also a direct effect upon the amount of atmospheric moisture, for as the air becomes lighter and more rarefied, its capacity for moisture decreases, and in Colorado it will contain much less at the point of saturation for the same temperature than at sea-level. There often occur here what are popularly called "dry showers," in which the rain dries so quickly that its effect disappears almost immediately. The actual amount of moisture in the air or the number of grains in weight of vapor contained in a cubic foot of air is termed its absolute humidity, and is the only exact measure for comparison of atmospheric moisture in various climates. Knowing the relative humidity and the temperature and altitude of any place, the absolute humidity may be calculated. From the weather maps published by the Signal Service at Washington, we find it (the absolute humidity) to be 1.9 grains at Denver, 4 at Los Angeles, 3.5 at New York, and 3 at Boston.

From these figures it is readily seen that humidity has not necessarily direct connection with rain-fall, for at Denver the humidity is only half of what it is at Los Angeles, although the annual rain-fall in both places is about the same; at Los Angeles it is one-third greater than at Boston, though the rain-fall at the latter place is three times as much as at the former. We also find the humidity at Los Angeles to be greatest in summer, although the rain-fall is practically nothing. Air may be quite humid, but, if there are no cold currents, the vapor will not be precipitated in rain.

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The small amount of moisture in the atmosphere of Colorado is indicated by the almost total absence of dew, fog, mist, and hoar-frost, by the scarcity of clouds, and by the rapid evaporation of rain and snow. It is also shown by the power in this climate of the solar rays to heat solid bodies exposed to them, while the neighboring air remains comparatively cool. Humidity is least on the open, unsettled plains, where there is nothing to prevent rapid evaporation, and it is greatest in the canyons and parks among the mountains, where the mosses, grasses, and trees retain the moisture in the soil, giving it out slowly and continuously to the air.

Trees depend upon the air for a portion of the moisture they receive, which, absorbed through the leaves, keeps up the free circulation necessary for their growth. Without moisture leaves can not take up from the air the carbonic acid and other gaseous products upon which they exist. Where this moisture is limited, more is demanded of the roots, and the relative proportion between them and the leaves must be increased. This therefore is one reason for the slow growth of trees here as compared with other places, and only those succeed well that have large and rapid root-growth, and especially those with a tap-root, or roots which naturally reach far down in the ground, where they find a greater supply of moisture. A tree in Colorado may have all the irrigation it can possibly need, but will never have the rich, luxuriant foliage seen along the Atlantic and Pacific coasts. During the spring and autumn rain-storms, already noticed, there is much humidity, as shown by mists and fogs, and under its influence the foliage of the trees always swells and expands, and starts into new growth. Moisture in the air will also benefit a tree through its roots, if enabled to reach them through a spongy, porous soil, or by cultivation with a spade or plow, which loosens the soil around the tree and allows the air to penetrate to a sufficient depth. This accounts for the fact that trees in cultivated ground will endure drought better than those not so favored. The porous nature of the soil in this region is therefore not so great a disadvantage as it might be, for it helps to carry to the roots whatever moisture the air may provide. Irrigation would be unnecessary if we had the moist atmosphere which enables farmers on the southern plains of Texas, for instance, to raise the richest crops without irrigation.

RAIN-FALL.

The rain-fall, or moisture precipitation, is the most important factor of any climate in relation to trees. It is also the most irregular of meteorological elements. But the records of thirteen years will show what may be accepted as the rule, though subject to many exceptions. The average annual rain-fall at Denver is 14.99 inches, and at Colorado Springs 15.87 inches. In comparison with this, at Los Angeles it is

18.25, at Chicago 37.34, and at New York 43.58 inches. The general distribution of rain-fall in this region is shown by the table, which gives the amounts for each month and season. In Colorado winter is the dry season and summer is the wet season; the driest months are January and February, and the rainiest are May and July. This is due to the altitude and inland position, for we find just the reverse at Los Angeles, where 10.43 inches, more than half the annual rain-fall there, falls in winter, and only 0.22 inches in summer. At New York the rain-fall is very evenly distributed throughout the year. A fact, not evident from the table, is that no rain falls, as a rule, in Colorado, between October and April. The storms that gather then are accompanied by such cold as to precipitate only snow, which is quickly melted and absorbed or evaporated. The heaviest fall of snow during the last ten years, about 2 feet deep, totally disappeared within a week. The large snow storms invariably come from the southeast, though a whirl of snow is generally driven before the fierce northers. This snow-fall being small and quickly disappearing in the warm sun and dry air, it has no opportunity to exert upon the air its cooling influence by increasing radiation and by hindering the warming of the ground.

The winter weather, as we have already found, extends into April and even May, and ends with a heavy snow or rain storm, lasting two or three days. Settled warm weather may then be depended on, but not before. The wet season begins generally about the first of July and remains six or eight weeks. During this season almost every day will bring its shower, which, coming in the afternoon, passes over before night, leaving the evening cool, fresh, and beautiful, or it will clear during the night, bringing most delicious mornings, with a wonderful clearness of atmosphere. The summer ends as it began, with a heavy rain-storm, late in August or early in September. This latter month is generally more or less rainy, but October and November bring the perfection of autumn weather, extending often to Christmas.

With so little of their chief means of support, it is not to be wondered at that the only trees growing spontaneously in Colorado are the narrow belts of Cottonwood that mark the course of the streams on the plains, and the groups of hardy Pines, Spruces, and Firs on the northern slopes of the mountains, or in the sheltered canyons. When these are destroyed nature finds it hard to renew the growth in any way, and only succeeds in the more favored localities. It may be accepted as a general truth that on these plains, and in many parts of the mountains, in most situations no tree can be expected to grow by the natural rain-fall. Irrigation is therefore a necessity, and as a system it has been brought to a high state of perfection during the past twenty years.

Water must be supplied to trees, not only in their growing season, but also during the dry winter months to aid in the small circulation of sap required to keep life in the tree during its long sleep, and to compensate for the evaporation from its bark. The tree needs much water during the dry, hot days of May and June, before the summer rains begin. During the wet season it will almost take care of itself, but when the rains cease in August the principal danger of the whole year comes, and as day follows day of hot, dry, scorching weather, the tree must be liberally supplied with moisture to take the place of that absorbed by the thirsty air.

This region does not receive the benefit it might from the rain-fall, on account of the deep, gravelly, porous soil, through which the rain sinks quickly, leaving but a small portion behind, a large part of which is soon taken up by the air, and but little remains for the tree.

EVAPORATION.

The evaporative power, or thirstiness, of the air is increased by high temperature, low humidity, low pressure, and high rate of motion. It is most powerful in summer in the sun and wind, and only slight in winter in shade and when the air is calm. In any place like Colorado, where are found many upturned faces of broken rocks and large uncovered areas of sand and gravel, evaporation and radiation will be much greater than in places where the surface is protected from sun and wind by vegetation. This is shown by the entire absence of dew on the plains and the rocky slopes of the mountains, and its formation when trees and lawns are planted.

Trees are injured by rapid evaporation, because it produces an unnatural activity in the roots and stem to supply the drain from the cells of the leaves and bark, and unless the tree has a large root-system and great vigor in all its functions, it will be unable to keep up the proper circulation. This is a reason for the fact already cited, that the trees which succeed best here are those of rapid, vigorous root growth, with a solid leaf structure. Evaporation is more rapid in winter, and therefore fall planting is objectionable. Imported trees always thrive best if they are cared for in a nursery for a year or two, until their roots, leaves, and bark become accustomed to the new conditions of climate.

WINDS.

The winds of this region, which, from the level character of most of its surface, are very constant and often of great velocity, have a strong influence upon the production of increased evaporation. In the daytime throughout the year the prevailing winds are from the south and southeast, while at night they are from the north. This is an advantage to trees, for the south and east winds, always more or less laden with moisture, come at a time when evaporation is most active, and tend to relieve its evil effects. The north wind, direct from the region of perpetual ice and snow, is the wind of blizzards and storms, and is the most injurious of all, from the sudden changes of temperature, already described, which it produces. The warm west or northwest winds, whose effect on temperature and evaporation, as already noticed, is so marked, are of such peculiar nature as to demand our especial examination. They are the same as the Chinook winds of Montana and the Foehn wind of Switzerland, and similar currents are found on the leeward sides of all extensive mountain ranges. Starting, it may be, from the surface of the Pacific, or in the warm valleys of the western slope, this aerial current is cooled and more or less completely deprived of its moisture while climbing the mountains; and in sliding rapidly down on the other side, it becomes gradually warmed by compression, amounting to six or seven degrees for each thousand feet, and arrives at the foot even warmer than it started. The direct effect of this higher temperature is to increase its capacity for holding moisture, and having no means in its descent of regaining what was lost in the cool, rarefied region above, it is intensely dry and parched, increasing evaporation to such an extent as to dry up small ponds and streams, and cause the snow to literally fade away. These winds are only noticed in cold weather, for when the air is already warm, the change in temperature on their account is not appreciable. Their effect on climate is to make the region they frequent of higher average winter temperature than in the center of the continent, as may be seen by the isothermal lines of any climatic map of the United States.

Their deleterious effect upon trees, besides the sudden changes of temperature, is more especially from their extreme dessicating power, which increases to an intense degree all the evils already described of rapid evaporation, acting on vegetation like fire. The barreness and somber appearance of the eastern slopes of the Rocky Mountains, as compared with the western, is caused partly by the blasting, scorching effect of these winds on many of the native trees, not vigorous enough to stand the sudden drain on their vital forces. They also, no doubt, play an important part in the treelessness of the western plains.

In general it is found that they harden and dry the fruit on the side exposed to them, blacken, char, and curl up the young and tender leaves, cut off the fragrance of odorous plants, and kill young sprouts in a few hours.

The winds of the greatest velocity in this region are from the north and northwest. The strongest wind that has ever occurred at Colorado Springs was from the northwest, in January, 1887. It began at about 8 o'clock in the morning, and gradually increasing in power, until at noon its velocity was 72 miles per hour, it died away entirely by 4 o'clock in the afternoon. But these extreme winds only come two or three times a year, and a velocity exceeding 40 miles per hour is very rare. The destructive tornadoes of lower elevations are unknown, and this region is not subject to the continuous gales found elsewhere. This is demonstrated by the average yearly wind-velocity shown by the table, which is only 6.3 miles per hour. And this figure does not properly show its effect, from the fact that the force of the wind, with any given velocity, is less in the light air of this altitude than at lower elevations. Another advantage here is that the strongest winds come in winter or early spring, when they have less effect on the leafless trees than they would have in summer, the windy season in many regions. It is very rare to find trees blown down, and seldom are branches torn off. The specially injurious effect of extreme winds upon trees in Colorado is from the gravel, or small sharp stones, caught up by them from the dry, loose, gravelly soil, and hurled with such force against the trunk and branches as to cut the bark, and give it the appearance of having been rubbed down by some rough substance. The bark of young trees has been often found scraped entirely off on the north and west sides after such a wind storm.

CLEARNESS OF THE SKIES.

Clearness of the skies is a direct result of the low humidity of this climate, and is one of the peculiar features of high altitude. Rapid radiation from the earth, the absence of moist currents in the air, the rarity of the atmosphere, all these prevent the formation of haze, mist, or clouds. The table gives the average number of days clear, fair, and cloudy, in each month, at Denver. In these records the observer counts the thinnest cloud, and many days are classed as cloudy or fair which would be generally termed fair or clear. The record of sunny days gives a better idea of the fine weather. At Denver the records also show that the average number of days in a year on which rain or snow fell is eighty-one, and the yearly average cloudiness in tenths of the sky is 2.6. During thirteen years the average number of days during the year on which the sun was not visible was three, and from October 30, 1879, to February 5, 1881, fifteen months, the sun was not obscured an entire day.

This clearness of the sky is one cause for the daily fluctuations of temperature already noted, and its effect on solar and terrestial radiation is very marked. Solar radiation at this high altitude is rapid soon after sunrise, because of the slight resistance which the dry, rarified air offers to the rays of the sun. While after sunset terrestial radiation is also rapid because there is no moist envelope shrouding the face of the earth to prevent the natural cooling of the dry ground. This is one cause for the late frosts which are so hurtful to trees and which farmers and cultivators never expect without a clear sky and dry air. Sunlight in Colorado is a nearer approach to white light than at the sea-level, and many persons find it necessary to wear blue or smoked glasses to protect their eyes against its effects.

Sunlight plays a very important part in the development of plants, and the various questions of the sun's rays, their quantity and action, their variations in the different hours and for different states of the sky, and the relative effects of their different elements, should be the subject of more research than they are. It may be thought that the clearness of the atmosphere in Colorado, bringing a superabundance of sunshine, is a great gain to all life. It is so to many conditions of human existence, but not to all, and under certain circumstances is directly injurious to vegetation. True it is that "Light is the source of life," but its very greatness and power require tempering, softening, and restraining, like fire and water. Sunlight and warmth start the machinery of a tree and produce the chemical combinations which are necessary to its life. Under its influences the mineral substances, drawn from the soil by its roots, are combined with the carbon and other matters received from the air through the leaves, and the resultants, carbon and oxygen, are produced, the former for the building up of the various parts of the tree and the latter by exhalation into the atmosphere, for the use of animal life. This machinery of the tree, under proper conditions, works as steadily and smoothly as the best regulated engine. But if the speed of an engine is increased too greatly there follows vibration, increased friction, a falling out of adjustment, and soon it becomes worn, broken, and useless. So with a tree, the rapid action produced by the bright sun and clear air may draw too greatly upon its means of subsistence, more or less limited in this dry region, and the tree, unable to keep up the supply, dies.

Thus we have found that trees in Colorado, especially in the section around Denver and Colorado Springs, suffer principally from extreme temperatures with sudden changes, and from lack of rain to supply the needed moisture for the roots. When water is supplied artificially by irrigation, they still suffer from insufficient humidity in the atmosphere to provide moisture for the leaves and stems, from rapid evaporation caused by the dryness and rarity of the atmosphere and the frequency of winds, and from the clearness of the sky, or lack of cloud and mist to intercept the dry, scorching rays of the sun, and to prevent the sudden changes of heat and cold. Truly, indeed, this is not a favorable climate for the growth of trees. But we have dwelt more particularly upon the injurious qualities of the climate. The conditions are not all unfavorable, and notwithstanding the many drawbacks trees will and do grow in Colorado and fulfill the objects for which they were created.

ADVICE TO TREE-PLANTERS.

We have already, from time to time, indicated some of the peculiar modes of treatment necessary for the successful growth of trees in this region, and a brief summary of these will be useful.

Those localities should be selected for planting, if there be a choice, which, by the configuration of the ground will be most protected. Among the mountains, this will be on the northern slopes, where the rays of the sun are least powerful and evaporation is least rapid. If possible the useful operation of plowing and cultivating the ground before planting should be performed. In this way the soil, besides being broken and softened, will be in much better condition to hold moisture and will require less irrigation than otherwise.

Choose those trees that are hardy, rapid, and vigorous in their growth. The following have been found to thrive well here when planted under the proper conditions: Soft or Silver Maple, Box-Elder or Ash-Leaved Maple, White Elm, Red Elm, White Ash, Black Walnut, Butternut, American Chestnut, Black or Yellow Locust, Honey Locust, American Linden or Bass-wood, Black Cherry, Black Birch, Red Oak, Pin Oak, Black Alder, Russian Mulberry, Mountain Ash, and the many varieties of Poplars and Willows.

Foreign conifers have not succeeded well as yet. From the nature of their foliage they seem to be less able to endure the hot sun and dry atmosphere than deciduous trees. Even the native conifers from the mountains are difficult to transplant to the plains on account of the increased dryness and exposure, and only succeed with the greatest care.

Plant in the spring, as early as possible, but so as to escape the hard frosts. If possible select trees which have grown in a nursery in this climate at least one year, in preference to trees brought from lower elevations and different conditions. In general it is better to buy small trees than attempt to raise from seed, which requires peculiar and careful treatment.

Dig large holes, much larger than are needed for the roots of the tree, cover the bottom of the hole with 6 inches of good top soil, mixed if possible with a little manure. Just before planting fill the hole with water. Plant the tree a little deeper than it was before and spread out the rootlets, sifting the dirt well around them and stamping it down solid. A mulching around the tree, if nothing more than of small stones, will be of much benefit to prevent the rapid drying of the ground. The irrigation ditch should run 2 or 3 feet from the tree, and a small branch ditch carried around a foot from the trunk, in which the water may stand and soak into the ground. In dry weather irrigate once a week, and during the rainy season only when the tree seems to need it. Irrigate in the autumn at such time as to freeze the soil around the tree, and two or three times in the latter part of winter when continued warm dry weather occurs. Remember that a tree may have too much water even in this dry climate. Snow heaped around the tree is beneficial. During the winter matting should be wrapped around the trunk to protect it from sun and wind.

With such treatment trees may be made to succeed well in this hard climate, and, though never so rapid and luxuriant in their growth as in lower elevations, they will amply repay the planter.

Nowhere are trees more needed than in this State, and nowhere should more efforts be made to obtain them. They should be planted on the plains, for shelter, and to hold the little moisture that falls. They should be planted on the mountains, to store up the rain-fall and keep the streams full. They should be planted everywhere, to bring to this barren region their beneficial influences.

With trees, as in all things, it is the first step that costs. Each growing tree tends to make its surroundings more adapted to its needs, and as trees are multiplied the climate must necessarily change. The currents of air will be checked and modified, preventing the high winds, sudden changes, and great extremes of temperature. The rain-fall will be retained longer in the ground, providing more moisture for the tree to carry through its leaves to the atmosphere and increasing the humidity. The air being moister, there will be more fogs and mists, and consequently more modified and less sunshine and less radiation. Evaporation will be also retarded by the mechanical obstruction of the branches. All these changes will increase the favorable conditions for the growth of trees, and while we have begun with the native Cottonwood, we will end with the less vigorous but far more useful sorts.

NOTE.—The planting of trees in the Rocky Mountain region has been confined mainly to ornamental and fruit trees, grown in towns and on farms and ranches. Some forest-tree planting has been done under the "timber-culture act," but the results so far are very meager.—B. E. F.

SNOW-SLIDES AND AVALANCHES—THEIR FORMATION AND PREVENTION.

By B. E. Fernow.

The question of protection against the disastrous effects of snow-slides and avalanches has been an important one for centuries in Switzerland, where it seems that not only special conditions favorable to their formation exist, but where, on account of the dense settlement of the mountainous region exposed to their course, their destructive effects are more intensely felt. So regularly, from period to period or year to year, do these avalanches occur in given localities, pursuing the same track down the mountain sides, that they have their names like the mountains themselves, or like the geysers, which may go off at any time, pouring forth their waters at irregular periods.

Note.—The dictionaries and encyclopedias do not seem to know the word "snow-slide," which is the term used in the Rocky Mountain region. The word "snow-slip" is used to denote "a large mass of snow, which slips down the side of a mountain and sometimes buries houses" (*Webster*), while "avalanche" is defined as a "large mass of snow, earth, and ice sliding or rolling down a mountain" (*Webster*), "or falling down a precipice" (*Ogilvie*). (To avale—to fall, descend, be lowered, old French *aval*—towards the valley.) There exists, therefore, no definite distinct idea that might belong to the one word or the other exclusively, and the words, have therefore been used as synonyms.

The question of the formation, dangers, and preventives of avalanches forms the subject-matter of a very interesting volume published at the instance of the Swiss agricultural department, in 1881, by I. Coaz, the general forest inspector of the Republic, whose personal observations and experiences for many years in the work of abating these dangers deserve special attention. While the conditions, atmospheric and geologic, of our Rocky Mountain region may not coincide or compare exactly with those prevailing in the Alps, yet a study of the causes and effects there observed through a long series of years and of the methods there employed to remove the causes and alleviate the effects of these dangers of mountain life may suggest a closer observation of our own conditions and the invention of expedients of protection better suited to our own needs. The accounts given on another page of this bulletin show that the phenomenon of avalanches is not unfrequent in the Rocky Mountains, and that their frequency and the extent of damage occasioned by them must be expected to increase as population and development there progress.

NOTE.—Mr. William N. Byers, C. E., a close observer and long resident of Colorado, says: "The main difference existing between our mountains and those of the Old World lies in the fact that there glaciers abound while we are free from them. The great extent of plateau country causes the high temperature of the mountain ranges, and is the cause of the snow melting off yearly, in direct contrast to the mountains of Switzerland, thus causing a higher snow-line with us.

"Snow-slides are very common in Colorado, and most common in the San Juan near the main range. They occur every year, and, when snow falls to any extent, frequently, and many lives are lost." (Last year two hundred lives are reported to have been lost.)

March is said to be the most dangerous month in the San Juan, and, as an old miner expresses himself, "It is hard to say as to where it is safe to live in San Juan."

Commissioner of the Land Office, Williamson, in his report for 1885, states: "It may be noted also as another incident to this total destruction of timber along the canyons, that 'snow-slides' are of frequent occurrence in the denuded localities of the mining settlements, and that during the past winter some were attended with serious loss of life and property.

To show the not infrequent occurrence and disastrous effects of snow-slides and land-slides, the following newspaper clippings, taken within the last few years, have been here in part reprinted:

The well-known disaster at the Emma mine, a few years ago, will probably be remembered by all in Utah.

Helena, Mont., May 7, 1885.—The land-slide 1 mile east of Thompson's Falls, May 4, is not yet cleared. Water oozes from the ground 1,000 feet above the track. It is feared that the entire mountain side will be precipitated.

Silverton, Colo., December 22, 1885.—The first snow-slide of the winter occurred today, coming down the mountain into Minnesota Gulch. The slide struck the mouth of the Prodigal Son mine, filling the 85-foot shaft and burying two men who were working at the bottom. The snow was packed so tightly that it was found to be impossible to move the bucket. The news of the accident was a great surprise, as it was not supposed sufficient snow had fallen on the mountain to make a slide that would cause damage.

Ouray, Colo., January 17, 1886.—Ruby Trust's cabin, on Mount Sneffels, was carried away this morning by a snow-slide, burying six men.

Robinson, Colo., January 25, 1886.—A snow-slide occurred near Summit City this afternoon, which buried a team and two men.

Aspen, Colo., January 25, 1886.—A snow-slide of considerable dimensions passed over the Jessie mine, on Aspen Mountain, at noon to-day, demolishing the machinery and ruining the buildings. Fortunately no lives were lost.

Durango, Colo., January 26, 1887.—Leonard Sutton, who has been working in the Silver Lake basin in the La Plata mine, reached Durango last night with an account of a slide which wrecked the cabin at the Daylight mine, Tuesday last.

Gunnison, Colo., January 26, 1886.—A snow slide occurred on Sunday and carried away the cabin of the Excelsior mine, located in Poverty Gulch near Crested Butte.

Ouray, Colo., January 15, 1887.—Marshall basin was visited by another snow-slide yesterday.

Gunnison, Colo., January 18, 1886.—W. J. Fine, S. F. Winters, and Will Turner, returning from a surveying party to Spring Creek this evening, had a narrow escape. When directly opposite the mouth of Dead Man's Gulch, they noticed a snow-slide coming down the mountain. The edge of the slide caught three men and horses.

Aspen, Colo., January 20, 1886.—Numerous snow-slides are reported here. A snow-slide of gigantic proportions passed over the Aspen mines. The engine-house was crushed in, and the engine and boiler buried, and several men killed. Half an hour later another slide occurred in an adjoining gulch, which passed over the Last Chance mine, but without damaging effect. At 5.30 the fire-bell announced the occurrence of another slide, and investigation revealed that two ore-wagons, mules, and drivers had been buried in another slide near the Late Acquisition.

Another slide occurred on Castle Creek last night which caused the closing down of the electric-light works. The seven men who started for Maroon Pass yesterday morning have not yet been heard from. A slide between here and Ashcroft last evening took away a shanty, in which a man and woman were known to have lived.

Just before dark last night three teams and four men were caught on Aspen Mountain near the Last Chance mine. They were found to-day uninjured, having been imprisoned nineteen hours.

Aspen, Colo., January 21, 1886.—The results of the terrible snow-slides of Tuesday continue to arrive. (Accounts of accidents are given.) During the past three days twenty-seven snow-slides have occurred in the neighborhood of Maroon Pass. This evening a miner from Conundrum stated that a fearful slide occurred this afternoon in exactly the same spot where occurred the fatal slide two years ago in which several men were killed.

Ouray, Colo., January 21, 1886.—George Boss, mail-carrier, reported a large slide on the Dutton mine, in which four miners were swept away and the new plant of machinery and houses a total wreck. The Gilpin County Mining Company's building and George Porter's store at Sneffels are all gone. The loss of life and property will be large.

Leadville, Colo., January 21, 1886.—About 10 this morning a slide occurred on the Blue River Branch of the Rio Grande near Chalk ranch. The track covered at least 10 feet.

Gunnison, Colo., January 26, 1886.—News has just been received here of two snow-slides which occurred yesterday morning, in the northern end of this county, in which five men lost their lives. The Excelsior mine in Poverty Gulch, 8 miles north of Crested Butte, was the scene of the horrors. The second slide occurred on White House Mountain, in Crystal Basin. Many small slides and narrow escapes are also reported in different sections.

In the following, therefore, that which appeared worth noting in the volume referred to has been presented. As far as could be ascertained no literature on the subject is extant in this country.

NATURE OF SNOW.

Snow is of different qualities according to the temperature of the atmosphere, and on its quality depends the form, the manner of formation, and the progress of snow-slides and avalanches.

The temperature at which snow may fall (in the Alps) ranges between 40° and 12° Fahrenheit. At low temperatures snow falls rarely, and then only in fine needle-like crystals. With a north wind it snows mostly at a temperature below, with a south wind above, the freezing point. The snow-fall at temperatures above zero is to be explained by the existence of a lower temperature in the higher strata of the atmosphere where the snow forms. During a continuous snow-fall, and especially if the wind changes, the temperature, and with it the form of the snow, may change considerably.

Snow falling at low temperatures is dry and composed of small flakes, because the dry crystals do not hang to each other; such snow does not hang on or ball easily nor does it make good sleighing. It lies so loose that it is easily moved by the wind, like sand, and causes snow-drifts, while the wet snow falling at higher temperatures, which has begun to thaw and contains much air inclosed, packs tight and shrinks quickly.

The first snows of the season soon melt away, except in the highest altitudes, because the temperature of the soil and atmosphere are still too high for it to remain. As soon as the soil is cooled down to freezing point the snow remains. If the temperature rises above freezing point the snow begins to thaw superficially, part of the water evaporates, part seeps through the snow and saturates it with water, or else the water penetrates to the soil and softens this gradually. The snow thus shrinks and settles until the temperature sinks again to freezing point, when snow and water freeze together.

Thawing, evaporation, settling of the snow, depend on temperature, the relative humidity of atmosphere, clear or cloudy sky, and on the direction of the winds.

It would be supposed that winters of much snow-fall would bring the greatest number of snow-slides. This is not the case in the Alps, on account of the dry southern wind (Foehn) prevailing in such winters, which evaporates with great rapidity much of the snow. If, in addition, the soil was not frozen before the snow-fall and is capable of taking up the snow water, snow-slides are made still less frequent.

NOTE.—The existence of a "Fœhn" in our own mountain region is perhaps interesting enough to justify the following extract from a paper by Prof. W. M. Davis, of Harvard, especially as it may suggest explanations of other climatic characteristics of the Rocky Mountain region:

"First in Switzerland and afterwards in other mountainous countries, the attention of meteorologists was called to the occurrence, especially in winter time, of a warm, or even hot, dry wind, blowing briskly down the valleys from the high, cold passes. The Swiss name for such a wind is "Fœhn," said to be derived from the old Latin name Favonius. Various local names are used in other countries, but with the present understanding of the origin of the wind, all examples of it may be included under the Swiss term, which has now become of generic value. When the Fœhn blows, it is common to see a bank of dark clouds over the pass at the head of the valley from which the wind descends. Under its effects the snow-fields melt away, and the streams rise in freshets.

"The origin of the wind should be looked for, not on the farther side of the mountains, whence it blows, but in the direction towards which it flows. Its warmth and dryness were first properly, but, as will be seen, not fully, explained as follows: When a current of air, moving on its oblique path towards a center of low pressure, encounters a transverse mountain range, and is forced to ascend over it, the air expands and is thereby cooled; in consequence of the cooling, its vapor is condensed into cloud, and soon begins to fall as rain, so that on reaching the summit of the range the air contains less vapor, although it is very moist and cloudy; its fall in temperature has decreased its absolute humidity, while increasing its relative humidity. It must be further noted that on account of the release of the energy before employed in maintaining the rain in the state of vapor, the cooling of the ascending current is considerably retarded; the rate of cooling in an ascending mass of saturated air being only from one-third to one-half as fast as in non-saturated air. As soon as the current begins its descent on the leeward slope of the range, it is warmed by compression, but until all its cloud is evaporated it warms as slowly as it cooled before; however, by reason of having lost some vapor that fell on the windward slope as rain, the cloud mass to be evaporated in descent is less than the total cloud mass formed in ascent; the descending current soon becomes clear, and then warms at the relatively rapid rate proper to non-saturated air, and as a consequence of warming faster than it cooled it must reach the valley bottom as a warmer wind than it was on starting to ascend the other side of the mountains. Having lost some of its humidity and gained in temperature, it must be relatively dry; it is a Fœhn.

"Only one element remains to be added to the explanation, but it is a significant one. Thus far the production of the Fœhn depends on the evolution of 'latent heat,' while the wind is rising and raining on the farther side of the range; now it appears from more precise observations that the winter Fœhn is often felt in the northern valleys of the Alps a day, or even more, before any rain falls on the southern slope; and therefore, although the rain is an aid when it begins, it must in these cases be preceded by some other cause not dependent on the ascent of air towards the passes and the condensation of vapor on its way. The solution of the difficulty is as follows: The average rate of variation of temperature in the atmosphere is closely one degree Fahrenheit to 300 feet of descent. Inasmuch as the air is less active than the ground in changing its temperature, this rate will be increased in the summer season and decreased in the winter; in winter the rise of temperature encountered in descending through the air is generally less than the gain of temperature given to a descending mass of air by reason of its compression. If at such a time the air in a valley be withdrawn by flowing away in answer to the call of an area of low pressure, and its place be taken by air descending from the passes to windward, this fact of descent will require that the new supply of air shall be warmer than that which has moved away; it is necessarily very dry, because it gains capacity for vapor as its temperature rises, without gaining the vapor to satisfy its capacity. This is the first cause of the Fœhn, and explains in good part why it is more pronounced in winter than in summer. When the wind over the pass is well established, it may be joined by currents of air rising from the further slope; these soon become cloudy and yield rain, and then the second cause of the Fœhn is in operation, as already explained.

"The Chinook wind of the northwest, along the eastern foot of the Cordilleran ranges, is described by G. M. Dawson as 'a strong westerly wind becoming at times almost a gale. It is extremely dry, and, as compared with the general winter temperature, warm. Such winds occur at regular intervals during the winter, and are also not infrequent in the summer; but being cool as compared with the average summer temperature, are in consequence then not commonly recognized by the same name. When the ground is covered with snow the effect of the winds in its removal is marvelous, as, owing to the extremely dessicated condition of the air, the snow may be said to vanish rather than to melt, the moisture being licked up as fast as it is produced.' (Science, 1886, vii, 33).

"Professor Loomis notes the following case of rapid temperature changes at Denver, Colo., on the plains just east of the front range of the Rocky Mountains: 'An area of low pressure passed over San Francisco January 14, about 4 p. m. During the following night the center passed near Salt Lake City, and at 4 p. m., January 15, the center was near Leavenworth, having traveled about 1,400 miles in twenty-four hours. It was this storm which brought the air from the west side of the Rocky Mountains over to Denver. The vapor contained in this air would be mostly precipitated on the west side of the Rocky Mountains so that it would descend on the east side deprived of its moisture and with a temperature above that which prevailed in the Salt Lake basin, on account of the latent heat liberated in the condensation of the vapor. After the center of low pressure passed Denver, the northeast wind returned and brought back the cold air which had constantly prevailed at stations not very distant. Thus we see that in winter, during periods of extreme cold on the east side of the Rocky Mountains, when the temperature at Denver sometimes sinks more than 20° below zero, there prevails in the Salt Lake basin an average temperature of about 30°; and when by changes of atmospheric pressure this air is carried over the mountains it may reach Denver with a temperature of 50°, resulting from a precipitation of vapor on the mountains. We thus find a mass of air having a temperature of + 50° in close proximity to a mass having a temperature of −20°, and by the movements of the atmosphere attending the progress of a great storm these different masses of air may be brought successively over the same station, causing a change of temperature of 50° in a single hour.'

"The following tables present numerical accounts of these changes from the same authority:

Temperature and relative humidity, January, 1875.

Date.	Hour (Washington time).	Salt Lake.		Cheyenne.		Denver.		Pike's Peak.		North Platte.	
		Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.
		°	*Pr. ct.*	°	*Pr. ct.*	°	*Pr. ct.*	°	*Pr. ct.*	°	*Pr. ct.*
January 14.....	7.35	34	61	−11	76	−14	100	1	100	−13	74
	4.35	43	50	− 1	68	− 4	64	8	100	− 6	61
	11.00	43	50	24	60	1	71	5	100	−11	76
January 15.....	7.35	32	84	28	67	43	21	6	100	− 8	79
	4.35	26	52	5	75	10	17	12	100	− 1	68
	11.00	23	73	− 6	61	13	44	10	100	− 4	64

"Salt Lake, at the western foot of the Wahsatch range, in the Great Basin, is constantly rather warm, and of ordinary humidity. Pike's Peak is cold and constantly at its dew point. North Platte, on the plains east of the mountains, is much colder and distinctly drier. Denver and Cheyenne are much alike in changes of temperature, as these stations are about equally distant from the eastern foot of the mountains; but Denver shows much the greater decrease in relative humidity, perhaps because the range west of this station is higher than farther north. The second table shows in greater detail how violent the changes of temperature were at Denver and how completely they accorded with changes in the wind:

Temperature and wind, Denver, January 14, 15, 1875.

Date.	Hour.	Temperature.	Wind.
		°	
January 14	2.43 p. m.	− 4	NE.
	9.00 p. m.	+ 1	NE.
	9.15 p. m.	20	SW.
	9.20 p. m.	27	SW.
	9.30 p. m.	36	SW.
	9.35 p. m.	40	SW.
January 15	5.43 a. m.	43	SW.
	10.30 a. m.	52	SW.
	12.30 p. m.	4	NE.
	2.43 p. m.	+10	....

"An observer who was considered perfectly reliable says that between 11 a. m. and noon the thermometer fell from 58 to 22 (that is, 36°) in five minutes." (Amer. Journ. Science, 1875, x, 12; 1880, xxii, 13, 14.)

Any one who wishes to understand the climate of the Rocky Mountains will also do well to read an excellent paper on the Chinook winds by Prof. M. W. Harrington in the American Meteorological Journal for 1887; from which we cite only a few points:

"The dry character of these winds is usually seen only to the eastward of the mountains. In western Oregon and Washington they are moist, and the same is true of the western slopes of Idaho and Montana. But as the name is more generally used east of the mountains, where the idea of dryness is a fundamental one, the Chinooks are defined as warm, dry westerly or northerly winds occurring on the eastern slopes of the mountains of the Northwest, beginning at any hour of the day and continuing from a few hours to several days. Their effects are felt at least as far as 500 miles east of the divide. On the arrival of the Chinook the winter appears to yield, the air becomes mild and spring-like. This effect appears in the winter isotherms, making the average winter temperature on the plains east of the Rocky Mountains in the great interior basin and the narrower interior valleys to the north, notwithstanding their continental position and high elevation, actually higher than on the same latitudes east of the Mississippi River; yet at the same time the range of temperature for the northwestern plain and the changes more sudden and severe. These changes are injurious to tree life, and in them can be found one reason for the difference between the eastern and western slopes of the mountains. The eastern slopes are bare, rugged, and somber; the western heavily clothed with timber. These trees, largely conifers, which can endure without injury very low temperatures, are very sensitive to extreme dryness. The dry air injures the foliage, and when accompanied by wind may kill the cambium on the windward side of the trunk, thus permanently injuring and in time destroying the tree. The Chinooks have probably played an important part in the treelessness of the Western plains and interior basins."

MOVEMENT OF THE SNOW, FORMATION OF AVALANCHES.

On the plain the snow moves only by settling and by drifting. On an incline, even if only slight, there is a side movement, following the law of gravity and depending in its amount on the angle of inclination, configuration, and especially cover of the ground, and also on the nature and amount of the snow. If the snow is frozen to the soil, it can not of course move. Otherwise, even if the conditions are not favorable to motion, and a movement may be hardly noticeable, yet it exists within the mass, and becomes apparent by the formation of horizontal rills on the surface of the snow. This movement and the pressure due to it is capable of displacing buildings without much injuring them. The more favorable the conditions are for motion the greater becomes this movement, until at last a slide occurs, moving in larger or smaller masses, more or less rapidly over the incline.

According to the temperature or the nature of the snow dependent thereon, the form and effect of the avalanche vary.

If in cold temperature a large amount of dry snow falls on a steep, deforested mountain side, it behaves like a sand-heap, the particles getting into motion for lack of stability in the mass, and moving forward, the mass carries with it any other masses of snow that are in its way. The heavy particles arrange themselves towards the soil, the finer particles forming a cloud of snow bursting into the air and like dust settling down only gradually.

This falling cloud, which obscures the mountain view for some time, compresses the air to such an extent that like a cyclone it precedes the avalanche, followed and pressed on by the latter in hasty flight and exerting an enormous pressure, often over great distances, sometimes 2 or 3 miles beyond the actual course of the avalanche.

The destruction, which is due to the snow-masses of such a slide, are insignificant in comparison to those of the compressed air-current, since the snow is light, and by the fall dispersed and scattered and may pass through a thinly stocked forest without doing much damage. One of such air currents preceding an avalanche is reported to have carried a full-grown larch tree bodily over the tower of a prison, lodging it 300 yards beyond, and to have laid low timber drift 200 to 300 feet beyond the avalanche. Such slides are called *dust*, or *powder avalanches.* They usually occur during a heavy snow-fall, and are but rarely occasioned by winds afterwards, if perchance the snow has been able to preserve its loose and dry condition and could keep in position long enough. It seems that most of the snow-slides of the Rocky Mountains are of this nature.

If the snow falls when the temperature is not low, it is wet, heavy and compact, and hangs to the soil closely. If not much snow fell, it remains lying undisturbed, provided the soil is not wet or slippery and the ground not very steep. The larger the mass of snow and the warmer the temperature, the greater is the danger of a movement of the mass in itself and a consequent slide. In such a slide the snow remains compact and does not disperse unless falling over precipices. It does not therefore exert much pressure upon the air, flows more like a snow-stream, now sliding and now rolling over and balling together. Its velocity in spite of its great weight, on account of its friction against all obstacles on its road, is much less than that of a dust-slide and its effects reach over a smaller space. These may be called *ground slides*, or true slides.

Lastly, a third kind of avalanche is mentioned, with which we have nothing to do in this country, except perhaps in Alaska and Nevada. These are the glacier avalanches, which are formed when large masses of the glacier disconnect themselves from the main flow, and falling over a precipice break up into something like a dust avalanche.

MECHANICAL AND ATMOSPHERIC CONDITIONS.

Apart from the nature of the snow the following conditions are of moment in the formation of avalanches:

First, the geological formation of the mountains: Compact rock-formations are less favorable to formation of avalanches, especially ground-slides, than stratified rocks. The latter offer more opportunity on the side of the dip than on the side of the outcropping (head). Granite and granitic gneiss mountains are therefore less liable to avalanches than slates, limestone, Flysch*—only often the angle of inclination

* A formation composed of alternating layers of black slate and sandstone.

on the dip is less than on the head, when a reverse of favorable conditions occurs, but the slides on the head side usually do not fall into places where much damage can be anticipated.

Rocks easily disintegrated, like the slates, Flysch, etc., are more favorable to the formation of slides than solid rock.

Very dangerous are steep, stratified rock faces, from which spring and seepage water oozes out, which keeps the surface moist and slippery, or else when frozen gives no chance for the snow to lie.

On a rocky and very steep mountain side the snow when reaching a certain depth must slide for lack of internal coherence, especially when dry. During a continual snow-fall several slides may fall from the same place, but they are mostly of small dimensions and little effect.

If the rock has a soil over it without vegetation, the formation of slides is dependent in the first place on the degree of steepness. Yet other factors, as the height of the snow, the height of the mountain wall, etc., are of such influence that the angle of elevation may not be made a mathematical expression of the danger.

If the foot of the snow-wall is washed by a brook, or if a spring or other circumstance disturbs the continuity of the snow-masses, the formation of avalanches is favored; it is therefore dangerous in places liable to avalanches to open a track or even to wade through the snow.

A declivity which offers varying angles, or is broken by occasional steps or terraces, offers so many points of support to the snow-masses, that avalanches are less liable to occur; roads, ditches, or other artificial barriers to an even descent, offer also such points of support.

Most important is the soil-cover. The more and the larger the loose rocks, the more in the line of the horizontal they are placed, the more hold and support has the snow.

Vegetation has a varying effect upon the formation of slides, according to the kind of plants that occupy the ground and their size. A grass cover or turf is favorable to the sliding of the snow. It has been observed in the mountain meadows, where the hay is made every second year, that slides are less frequent the winter after the grass is cut.

Low shrubs and tree-forms offer a better support to the snow, unless their stems are, as in the case of the Mountain Alder, so elastic that after being pressed down they exert a pressure against the snow which tends to interrupt the coherence of the mass, when, with the aid of wind or additional snow-fall, the snow may be set in motion.

High timber affords the best protection against snow-slides, and if the mountaineer had not in his ignorance removed and destroyed this protector, many dangers of a mountain home would be avoided. The importance of the forest in this respect was recognized in the Alps centuries ago, and wherever "ban" forests were maintained, immunity from avalanches to the extent of the forest has been secured. An interesting account is given of the ban forest of Urseren, which was reserved by the community as early as the year 1397, and of the constant fight which was necessary against reckless advisers to keep it intact, until now the beneficial effect is fully recognized, and reforestations have been begun everywhere under the protecting walls or other safety-works wherever the danger of avalanches exists.

Yet even timber-forest is not always absolute protection against avalanches; since the place of incipient formation of the slide may lie above timber-line. Such avalanches, formed above the forest line, if small, first break a wedge into the forest below them, but by repeated action the wedge is enlarged and gradually a road broken through the forest. Large avalanches break, even in their first attempt, through the best rooted full-grown forest of entire mountain sides, hurling earth, rock, and timber into the valley below.

Water, the great mover of the earth, is an active agent in the formation of avalanches. Not only the spring and seepage water, but also rain and melting snow-water exert their influence. Ground-slides (in the Alps) occur mostly in warm weather in the spring, when the snow melts. Then the snow settles and becomes more compact, has a greater specific weight, and therefore more tendency to slide; the snow water penetrates through to the soil, and if the soil is not frozen, saturates it and then seeks to flow off between soil and snow, by which the hold of the snow on the soil is loosened, the latter made slippery, and the sliding facilitated. How soon this influence of water becomes active depends on how soon the soil is filled up with water, and this again on the kind of soil and subsoil.

Clay soils soon fill up in their upper strata and the snow-water sooner begins a superficial flow; a penetrable soil on the contrary with penetrable subsoil does not attain saturation at all and the danger is avoided. If the soil is frozen, the water can not penetrate at all and the sliding takes place the sooner. Rain of course adds to the water which loosens the snow.

Configuration, as has been said, may prevent formation of avalanches by presenting a number of points of support. Yet where there are sink-holes or troughs in which the snow accumulates, the melting snow-water collects below the snow and loosens the masses, which may thunder into the valley, following the course of the ravine.

Lastly, even an exterior pressure or disturbance may loosen the masses. A stone or an icicle falling, or snow dropping from the branches of a tree, when accompanied by strong wind, is liable to start the snow. So can one avalanche, by the concussion of the air which it produces, start others in its neighborhood. It has also been frequently observed that a sound, as of a gun, of church bells, of an explosion from mines, etc., may start the snow. This has given rise to the proposal to start the slides by shotguns before they are likely to become dangerous.

On the other hand, sometimes in the stillest weather the danger may be greatest, as the snow falling during such weather accumulates to large amount before it breaks loose; while in stormy weather smaller masses are constantly set in motion and come to strand on the terraces, etc., thus reducing the danger.

Some special conditions for the formation of slides exist, when days with a temperature above freezing which thaws the surface of the snow, alternate with cold nights when the surface freezes together. If fresh snow falls on such a surface, it is most liable to form into an avalanche, and sometimes if a heavy snow-fall occurs, it may break through the crust and carry the lower masses with it. This kind of slide occurs mostly on southern exposures.

As regards season and periodicity of slides the greatest diversity exists. New tracks are opened every year, while in other places the old tracks become scenes of disaster in varying intervals, some yearly, some every half or every full century. It depends of course on the amount of snow fallen, in connection with weather conditions, especially the direction and force of winds. The most regular falls occur in spring during time of thaws.

In wind-still weather and warm sunshine, the time of fall occurs in the first hours of the afternoon, yet if a warm wind blows any time of day or night, the avalanches may start.

PROGRESS OF AVALANCHES.

The ground-slides follow more or less the contour of the ground, like running water. Usually the masses start sliding, later on they roll over when passing over steeper and rocky ground, and in *rills* and *funnels* they are compressed and compacted.

As in a stream of water, the greatest velocity lies in the center of the slide, where in a straight track the largest mass and the least friction exists. If turned from the straight track the force is greatest on the outer curve, where trees, turf, soil, and rocks are torn up and swept away together.

Dust-slides occur most frequently during snow-falls at low temperatures, especially in windy weather. They occur oftener in clear weather than when the sky is clouded.

RESCUE OF PERSONS BURIED BY AVALANCHES.

After pointing out the different localities which are exposed to avalanches in the Alps, and giving an account of some special cases of disasters, which forms most interesting and instructive reading, a chapter is devoted to the measures to be taken in saving men lost in snow-slides. The procedure is somewhat like the following:

First look over the surface of the snow, where the slide has come to rest, after signs of the unfortunate victims. If no parts of the body are visible outside, determine, according to the location and the track which the slide took, the place where most probably the entombed lie. Then let the rescuers take position in line, and with the handles of shovels, or with poles, push into the snow every foot or so, progressing forward as they do so. If a human body is touched, the elasticity will be noted; also, the poles pushed down around the body will sink deeper, for the entombed usually do not lie on the ground, but are imbedded in the snow. Accounts are given of men who have been imbedded for fourteen, nineteen, and twenty-four hours, and one case, in which a woman was found living after one hundred hours, is almost incredible.

The work of rescue should, therefore, never be speedily abandoned.

Death usually occurs either through bodily injuries or through suffocation, mostly the latter. The more or less rapid effect of suffocation depends on the density of the snow and the position into which the body comes to lie. Naturally, if the head lies downward, and is packed into compact snow, death must occur sooner than when the body gets into an erect position with less snow pressing upon head and breast.

If the face comes near a hollow space in the snow, and breathing is facilitated, the entombed can live in spite of the cold for a long time, and can be saved or even save himself; for the heat of the body thaws the snow gradually, around breast and abdomen first, around legs and arms more slowly, because these parts are more distant from the source of warmth.

From this some rules for the conduct of those who can not escape the slide may be inferred, namely, that they should try to preserve an erect position in the fall, and to keep the arms near the body, so that the arms may sooner be released by thawing and become useful in the rescue.

When the slide comes to rest the entombed at first feels a pressure; this is soon relieved, after a few seconds, by the partial freezing of the snow-masses and a consequent contraction.

The entombed hear and understand any noise or voice above them, but their own voice can not be heard above; this probably because the sound waves can not sufficiently develop in strength in the surrounding snow.

The treatment of the rescued depends of course on the circumstances of the case. Resuscitation is often possible, even if the rescued is apparently dead. In all cases the first duty of the rescuers, when they discover the body in the snow, is to provide means for breathing by opening up a channel to the mouth. If the rescued is apparently dead respiration must first be restored. This is done by placing the body on the belly, supporting the front of the head lightly, pressing evenly and slowly with flat hands upon the sides of the breast, rolling the body over on the side and a little further and back on its belly, repeating the pressure on the sides; this movement should be repeated sixteen to twenty times per minute.

Another mode is to place the body in sitting posture, supporting the head, grasping from behind the two forearms in the middle and moving them forward and upward, until they touch both sides of the head, then move them down and press with them against the sides of the breast, repeating the process sixteen to twenty times a minute.

This treatment should be continued for twenty to thirty minutes if necessary, while rubbing the patient vigorously with flannel or woolen cloth, in the direction from feet and hands toward the body.

Besides absence of respiration, cold and hunger may add to the causes of asphyxia. In such cases, too, artificial respiration is first to be supplied. The warming should be only gradual, never in a warm room, or with heated bottles, but always by rubbing.

When the body becomes warm the danger in nose, ears, hands and feet of a surplus of blood or of impeded blood-circulation is avoided by cold compresses, by rubbing with snow, and elevating the affected parts.

As soon as respiration is restored small doses of coffee, tea, or brandy should be given.

MEASURES OF PROTECTION.

The damage done by avalanches, besides the immediate one of destroying life and property and devastating meadows and agricultural lands, lies in the tearing up of tracks in the ground in the shape of rills and furrows, which may become the beginnings of dangerous torrents and land-slides.

Those slides which fall into wild mountain gulches do damage by tearing down the decomposed rock and stones, which high water may carry to the valley and over fertile fields.

Measures of protection against avalanches and snow-slides have been applied, of course, by the dwellers of the mountains since their occupancy began. These consisted, where the ground permitted, in placing the buildings into the mountain side, when the avalanche would shoot over the building, or by building safety places, where to retreat in case of danger. Probably, when by deforestation the danger from avalanches had increased, a protecting wall or a stone or dirt heap was erected, close above the houses which were to be protected, with an acute angle towards the mountain top and with walls entering to right and left; such protective walls sometimes included a number of houses.

On the mountain roads galleries were built, either cut into the living rock, or with stone or timber, over which the snow masses would slide.

These measures were intended to prevent the damage from avalanches and slides, but to prevent their origin and their start measures were also adopted early in this century. Such measures were the making of ditches in horizontal lines, to prevent the snow from sliding, or of terraces, and the proper preservation of the forest growth.

But only since 1867 has a systematic treatment of the avalanches been begun under technical direction. Since then, up to the year 1881, thirty-four tracks of avalanches or snow-slides have been systematically secured with perfect success.

In undertaking such work, it is first necessary to establish from testimony the uppermost point from which the avalance has been observed to start, which testimony, however, must be verified by a careful study of the natural conditions of the locality. Usually the place of beginning lies higher up than observed. If the start lies on extensive, steep, rocky faces, there is no use in trying to secure it; if there are only interrupted walls and rock portions, or if a ravine form the starting place, securing is possible, and the question then simply is, whether the cost of doing so is in proportion to the benefit to be derived.

The works consist of walls or woodwork, or a combination of both. Ditches are not without influence, but are by no means as effective as wall and woodwork, and present, besides, several objections; they are collectors of water, which is liable to carry away the earth work; they are soon filled up or trodden down; similar objections exist to terraces.

The choice of stone or wood for safety works depends mainly on the costliness of either. Above the timber line stone would of course be preferable, below the line it is employed only where reforestation, and, therefore, temporary constructions are not possible.

Wood structures consist of rows of pile work, for which of course the most durable wood obtainable in the region is used. Split wood is better than round, which latter does not hold the snow as well. The piles are usually made 4½ to 5 feet long, and have a diameter of 5 to 6 inches. Preserving processes, charring, etc., are unnecessary in the altitudes where this work is to stand. The posts are pointed at one end, and driven with a wooden wedge, so as not to split them, if possible, 2½ feet into the ground, perpendicularly to the horizontal plane, and secured with stones. They should not be above ground more than 3 feet, and on thin soil not as much.

The intervals between the piles should be 2 feet. It is not necessary to connect them by wicker work, as the snow does not slide through the piles; but where the ground is thin, or very dry, or very steep, or otherwise lacking in hold, such wicker work may be made of branches to connect, and thus to strengthen the piles. The two end piles must be especially secured. The length of the rows of piles and their distance from each other depend upon the configuration and the angles of inclination of the ground.

The choice of the place where the row of piles is to be put is of importance. The work is begun at the top or starting place of the avalanche and progresses downwards. The piles must be driven in the horizontal line, so that the pressure of the snow will be evenly distributed over the whole line. They are also to be placed where a change of fall (angle of inclination) from a less steep into a steeper incline occurs. If no natural terraces are found, such may be made by cutting into the ground above the piles, making a terrace of 2 feet in the side of the mountain. The ground thus removed is placed on the lower side of the piles and covered with turf.

Where piles can not be driven "snow-bridges" are constructed Where narrow rills or runs are to be protected a tree is thrown across and secured at its ends against other trees, or by posts, or placed upon trestles, if necessary, supported in the middle by posts. Over this tree are placed sticks, with a slight inclination to the mountain side, somewhat in the shape of a corduroy bridge, and fastened with wooden nails to the tree and secured by stones on the ground, if possible.

The retaining-works of stone are the strongest, most lasting, and are possible everywhere, but also the most expensive. For a foundation a space of about 3 feet is leveled, with a slight inclination into the mountain side, as if cutting out a road; the base must be natural, not made, soil. The proper making of this foundation-base is of the highest importance. The height of the wall must be 3 feet above the ground on the upper side; the steeper the ground, therefore, the higher necessarily becomes the wall work. Simple dry walls are all that is needed, which, in addition to being cheaper, permit rain and snow water to seep through.

Especially the ends of the wall must be well secured, and the use of cement in this part of the wall is recommended. The roof is made of large slabs or, in their absence, of sods.

The length of walls, as of pile rows, depends on the configuration of the soil. The distance of the walls from each other may be greater than with wood-work.

There have also been used iron rods let into the rock and covered with wood-work.

The choice of work and the adaptation to the configuration is of greatest importance.

If the slope presents an even surface, like a roof, the pile rows and walls are placed at intervals, so that the next series covers the even spaces of the one before.

In ravines, the work is to be placed where the slope changes to the steeper wall. Large bowlders or rocks rising above the surface are often the incipient cause of slides. The safety-work is to be placed at their foot, so, however, that the snow sliding from such elevations should not fall upon the wall, but in front of it, to be there retained.

Springs and collections of seepage water must be taken care of and properly conducted.

A yearly inspection and repairs are, of course, necessary.

After the starting-point of avalanches has been thus secured reforestation is at once begun, with such species as belong to the locality. The planting is done with seedlings, at a distance of 40 inches, as a rule. This reforestation of the tracks of avalanches, especially in steep situations, including after-planting, is very expensive, and amounts to $25 to $40 per acre in Switzerland.

In conclusion, it may be stated that the Swiss Government bears 40 per cent.—in extraordinary cases 50 per cent.—of the cost of building retaining-works. In reforestation in existing protective forests, 20 to 50 per cent., and in planting new forests, 30 to 70 per cent. of the cost is borne by the Government, the communities being liable for the balance.

INDEX.

ERRATA.

Page 75, last line, for 686,827 read 686,781.
Page 128, line 25, for Poplar read Aspen.
Page 128, bottom, for Vine read Dwarf.
Page 129, third line, for Poplar read Aspen.
Page 131, third line from bottom, transpose "long" and "wide."
Page 132, ninth line from bottom, for 21,000 read 2,100.
Page 133, fifth line, for 84 read 74.
Page 136, tenth line from bottom, for 7,600 read 8,490.
Page 136, add at last line, There are 15 miles of mining and milling ditches.
Page 137, tenth line, strike out "union colony."
Page 146, fifteenth line, strike out "and Mal pais."

DEPARTMENT OF AGRICULTURE.

FORESTRY DIVISION.

BULLETIN No. 3.

PRELIMINARY REPORT

ON

THE USE OF METAL TRACK ON RAILWAYS AS A SUBSTITUTE FOR WOODEN TIES.

BY

E. E. RUSSELL TRATMAN, C. E.

TO WHICH IS ADDED

A REPORT OF EXPERIMENTS IN WOOD SEASONING BY THE CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY, AND OTHER NOTES.

COMPILED BY

B. E. FERNOW,

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CONTENTS.

LETTER OF SUBMITTAL.

FORESTRY DIVISION, DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 28, 1889.

SIR: I have the honor herewith to submit for publication as a special Bulletin a preliminary report by Mr. E. E. Russell Tratman, C. E., on the use of metal track for railways, which gives, in concise form, information in regard to the use of this substitute for timber ties in foreign countries.

This report forms a fit sequel to Bulletin No. 1, from this Division, on the "Relation of Railroads to Forestry," which has found so much favor with railroad managers and engineers.

Recognizing that the enormous drafts of the railroads on our timber resources and especially on the young growth—the hope of our future forestry—are among the most dangerous factors in the exhaustion of our timber supply, it is in the interest of forest preservation to keep railroad managers informed of the possibilities in the use of substitutes and the advantages to be derived therefrom.

Through the courtesy of Mr. George C. Smith, manager of the Chicago, Burlington and Quincy Railroad Company, I am enabled to add, as of interest to the same class of readers, an account of the highly valuable experiments on seasoning of timber, undertaken by the chemist of that company.

Notes of interest bearing on the same line of inquiries, such as have accumulated in the Division since the issue of Bulletin No. 1, have also been incorporated in the present issue.

Respectfully submitted.

B. E. FERNOW,
Chief of Forestry Division.

Hon. NORMAN J. COLMAN,
Secretary.

METAL TRACK FOR RAILWAYS.

(*Preliminary Report on the Use of Metal Track on Railways in Foreign Countries.*)

LETTER OF TRANSMITTAL.

BROOKLYN, N. Y., *February* 1, 1889.

SIR: In accordance with the arrangements made some time ago, I have been engaged for several months in collecting material to be used in the preparation of a report to the Department of Agriculture upon the use of metal track upon railways in foreign countries; and I beg to submit, herewith, a brief preliminary report, showing the scope of my investigations, and giving a general idea of the extent to which such track is in use. Attention has for some years past been directed by the Department to the destruction of the forests of this country; and as the consumption of timber for railway ties is very great (as shown in Bulletin 1, of the Forestry Division, on the "Relation of Railways to Forestry," and subsequently in a paper by me presented at the annual meeting of the American Forestry Congress, at Atlanta, Ga., in December, 1888), suggestions have from time to time been made that some form of metal track should be introduced, both to effect an economy in the consumption of our timber resources and to give a more efficient, durable, and economical track. The matter has, however, been given very little practical attention, and it has been generally taken for granted that the use of such metal track in several foreign countries (of which the home and foreign technical journals give occasional information) has been entirely experimental. This is an erroneous impression, the facts being that experiments begun many years ago have led to the adoption of various systems of metal track in different countries. A number of the systems tried have proved fairly efficient in service, if not economical; the systems which have combined efficiency and economy are few, but such a combination has been effected, and there is no reason why it cannot be adapted to and applied in American practice. The experiments are still in progress, and careful records are being kept of the results obtained, both with regard to economy and efficiency; but the questions of the advantages and the feasibility of metal track have passed beyond the experimental stage, and metal track for railways has been brought to a very practical issue.

My first proceeding, after the preparation of the report had been decided upon, was to draw up a list of leading questions respecting the subject of my investigations and to have the list printed. A copy of this list is appended hereto. Personal letters have been written to engineers, managers, manufacturers, etc., in all parts of the world, asking for information, and in each case a copy of these questions has been inclosed in order to show the character of the information desired. At the commencement of this comprehensive system of correspondence I was not very sanguine as to the results, but after about a year's experience I find that they have been eminently satisfactory and have far exceeded my expectations. There have been written about two hundred and fifty separate letters of application, and replies have been received to about one hundred and twenty; some in brief, but a large number in detail, accompanied by plans, etc. These answers required acknowledgment and sometimes a request for further information, and this has entailed a very large amount of personal correspondence; aggregating, in all, between three hundred and fifty and four hundred foreign letters. This work has been rather laborious, but the matter collected has been well worth the trouble, while the work has resulted in the getting together of a mass of information which has probably never before been gathered for purposes of compilation and comparison. The home and foreign technical journals have also been closely studied. The varied information thus obtained, with details of the various systems experimented with or adopted, it is intended to present in full in the main report; meanwhile, I am continuing the investigations.

As the particulars respecting the length of line laid with metal track have been obtained from many separate companies and officers in many countries, it is difficult to even approximate the total mileage; but the figures given in the succeeding pages will prove the great extent of such track in the aggregate.

In Europe it is the usual practice, in addition to the use of metal track for railways, to use steel or iron longitudinals or cross ties, or cast-iron "chairs," for street railway tracks, using no wood at all, but only metal and concrete. Steel ties are also extensively used for contractors' tracks, portable railways, narrow-gauge and light railways, etc., in various parts of the world.

With regard to this country, very little has been done, although from time to time a few ties of different patterns have been put down experimentally. The Pennsylvania Railroad has tried the steel tie used on the London and Northwestern Railway of England, but the trial included the entire system of English track,* with its objectionable double-headed rail supported in chairs; a form of track which it is to be hoped will never be introduced in this country. This trial does not count for much, especially as the tie complete is very expensive, owing to the amount of shop-work. (See "England.")† The Boston and Maine Railroad has tried a few wrought-iron plate ties, and the New York Central

* For description of this, see my paper on "English Railroad Track," in the Transactions of the American Society of Civil Engineers, June, 1888.

† Four or five different types of ties have been tried by the Pennsylvania Railroad Company, all of which have been taken out, with the exception of those obtained from the London and Northwestern Railway (England), which, as stated, have been

and Hudson River Railroad has tried cast-iron "pots" experimentally on a small scale. This latter road will make a careful trial of the "Hartford" steel tie, which promises well; eight hundred of these ties have been ordered and will be laid in April. Another tie about to be given a practical trial is the "Standard" steel tie, in which the rails rest on wood blocks, on end grain, the arrangement being somewhat similar to a form of track tried on the Eastern Railway of France. Of these types of ties, however, I prefer to say nothing further at present, for the reason that however advantageous they may seem, practical service alone can decide as to their practical advantages; and, if successful, they will doubtless be modified to some extent to meet requirements met with in experience, as has been the case with the "Post" and all other successful forms of ties.

It should be borne in mind that metal ties should be adopted not only as a substitute for timber when the latter becomes scarce or expensive, but also (and more particularly on main lines) as giving a better and more efficient form of track for fast and heavy traffic. For a further explanation of this view I would refer to a paper on "Maintenance Expenses of Track on Metal and Wooden Ties," by J. W. Post (with a discussion written by myself), in the Transactions of the American Society of Civil Engineers, June, 1888.* Descriptions of some of the earlier forms of metal track are given in Engineering News, New York, January and February, 1887.

In concluding this introduction, I give the following abstract of the opinions presented at the International Railway Congress, held at Milan, Italy, in 1887: The opinion presented at the Congress at Brussels, in 1885, that metal ties are able in point of efficiency to compete with wooden ties, is not weakened by the results of experience of the two years, and the use of metal ties is extending. In point of economy, considering the first cost and the durability, the result depends upon the material, the state of the metal market, and upon local circumstances. As to the cost of maintenance, the question was not considered to be fully decided on lines with a fast and heavy traffic, but for lines with moderate traffic and speed it was the opinion of the majority that the metal tie presented advantages, especially after the lapse of a sufficient time for the earth works to have thoroughly settled and for the taking up of all slack in the fastenings.

I am, sir, respectfully yours,

E. E. RUSSELL TRATMAN,
Jun. Am. Soc. C. E.

B. E. FERNOW,
Chief of Forestry Division, Department of Agriculture.

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found objectionable. It is also stated that as long as white-oak ties can be got at 65 to 70 cents each it would be foolish to use metal ties, "costing \$3 to \$4" each. That the cost for metal ties is not necessarily as high as that given as objectionable will appear further on in this report; a good tie (Durand patent) being claimed to be produced from old rails at the cost of \$1.—B. E. F.

* See reprint in this Bulletin, p. 25.

CIRCULAR.

The following circular was addressed to various railroad companies and managers in Europe and other countries.

Metal Track for Railroads.

The information outlined below is desired for the purpose of a report to the U. S. Department of Agriculture on the use of metal ties (sleepers) for railroad tracks, and it is requested as a favor that all information furnished should be as complete as possible and sent at the earliest possible convenience.

Respectfully,

E. E. RUSSELL TRATMAN, C. E.,
144 *Remsen street, Brooklyn, New York, U. S. America.*

INFORMATION.

Railroad:

1. Name.
2. Route.
3. Length of lines laid with metal sleepers.
4. Character of same. (Particulars of grades, curves, etc.)
5. Dates when laid.
6. Engineer in charge.
7. Character of traffic.
8. Weight of locomotives and weight on driving wheels.

Sleeper:

9. Longitudinal, transverse, or bowl.
10. General form.
11. Dimensions, including thickness. (Figured drawings.)
12. Weight.
13. Material.
14. Spacing center to center.
15. How treated. (Paint, anti-rust process, etc.)
16. Manufacturer.
17. First cost, at factory or delivered.
18. Expense of maintenance.
19. Attachment of rails. (Details and drawings.)
20. Arrangements for curves.

Sleeper—Continued.

21. Tie-rods; if used, how attached and adjusted for gauge.
22. Durability.

Track:

23. Material of ballast.
24. Behavior of ballast under sleeper.
25. Construction of road-bed. (Drawing.)
26. Section and weight of rail.
27. Rail joints: how made.
28. Rail joints; on sleeper or suspended.
29. Reasons for adopting metal sleepers.
30. General results: satisfactory or otherwise.
31. Is there trouble with maintenance of track?
32. Is there trouble with rail attachments?
33. Is there trouble from breakages; how and where do they usually occur?
34. Efficiency, etc., as compared with wooden sleepers.
35. Cost, material, and durability of wooden sleepers.
36. Climate; and effect of same on metal or wooden sleepers.
37. General remarks.
38. Opinions.

REPORT.

EUROPE.

England.—In England, steel ties have during the past few years been tried to a greater or less extent on quite a number of the principal lines. Foremost among them is the London and Northwestern Railway, which has between 20 and 30 miles of track laid with the steel cross-tie invented by Mr. F. W. Webb, the locomotive superintendent of the road. In 1888 there were 83,204 of them in use, and the experience with them had covered then six and one-half years. These ties have been experimented with on the Pennsylvania Railroad.

The general type used is the steel "inverted trough" in different forms, either rolled or stamped. As the system of track, however, includes the double-headed rail, these ties are fitted with the usual heavy cast-iron chairs to hold the rail (the Webb tie has the chairs made of steel plates), and the track is unnecessarily heavy and costly. The chief difficulty is said to be in adapting the steel tie to the double-headed rail, it being difficult to make a good piece of work. The Northeastern Railway, however, is trying steel ties under flange rails weighing 90 pounds per yard, which is a step toward the ideal track for main lines.

France.—Experiments with metal cross-ties have been made on nearly all the principal railways, and a large number of types have been tried, but several of them have been of complicated design, and therefore uneconomical. Longitudinal systems have been tried to a small extent.

On the State Railways a number of trials have been made, and with some forms of tie very good results have been obtained, enabling a reduction to be made in the maintenance staff. In 1886 there were ordered 17,000 ties of the "Post" type and 80,000 ties of the old "Berg-et-Marche" type. In 1888 there were (*a*) 2.10 miles laid with the "Paulet-Lavallette" ties, with double-headed rails in chairs; (*b*) 7.35 miles laid with a tie similar to the "Post" type, with double-headed rails, and 30,000 more of these ties had been ordered; (*c*) 8.86 miles laid with similar ties, but with flange rails. Of these (*a*) had been laid in 1885, (*b*) and (*c*) in 1887. On the Paris and Bordeaux line, 4.4 miles of "Vautherin" ties of uniform thickness were laid between November, 1886, and February, 1887; 4.5 miles of "Vautherin" ties of varying thickness (similar to the "Post" type) were laid in February and March, 1887, and .56 mile was laid with the "Boyenval and Ponsard" ties in April, 1888.

The Paris, Lyons and Mediterranean Railway used an old type of iron tie several years ago, but abandoned it on account of the ties costing more than the wooden ties and giving a less firm and durable track;

this latter defect was probably due to the old-fashioned "gib and cotter" fastening employed. These ties were laid in 1862 and following years, and had all been taken out in 1872. Good results have been obtained with metal ties on the Algerian system controlled by this company. (See "Africa.")

The Northern Railway laid trial sections of its Belgian lines with the "Severac" and "Bernard" ties in 1885, and laid 10,000 of the former on its French lines in 1888.

The Western Railway, which used the old double-headed rail, has experimented with iron ties upon which the rail chairs were cast; about 1.3 miles were laid in 1887.

The Eastern Railway has tried steel ties with wooden cushions or bearing blocks under the rails, and has also laid about one hundred of the "Post" ties.

Holland.—In this country probably the most extensive and most valuable, because continuous and systematic, trials have been made, and the trials have resulted in improvements which have served to develop the now well-known and extensively-used "Post" steel cross-tie of varying thickness, the thickness being increased under the rail seat. The "Post" tie, the invention of Mr. Post, the engineer of permanent way of the Netherlands State Railway Company, is economical both in construction (owing to its requiring a minimum of shop-work, all of which adds to the cost of a tie) and in maintenance, and has proved very efficient in service.

On the Netherlands State Railways the experiments have been in progress since 1865, and the steel tie designed by Mr. Post and improved by him from time to time in the light of practical experience has been adopted on this system. In the early part of 1888 the system, which comprises 910 miles of road, had 91 miles of track laid with these ties. Of 10,000 ties laid in 1865, 9,550 were still in the track and were expected to last twenty years more, although they were of the earlier type of the tie, which has since been improved upon. As to breakages, out of 162,634 ties laid, not one had broken.

In the early part of 1888 there were in use 457,300 ties (about 23,800 tons) of the "Post" type in Holland, Belgium, France, Germany, Switzerland, and Asia (colonies); about 272,700 ties (about 12,700 tons) more, including ties for narrow-gauge railways and for the rack railway in Sumatra, were being manufactured; making a total of about 730,000 ties, or 36,500 tons, of this one type. (See page 25)

Belgium.—On the Belgian State Railway system the "Post" tie has been laid, but it is heavier than that used on the Netherlands State Railway and heavier than the inventor considers necessary or desirable. It should be noted that it is not economical to use more metal than experience has shown to be necessary. Experiments have been made on rather a large scale, and in 1887 three types were experimented with on various lines, and one of these types appeared to meet the requirements for fast and heavy traffic. In 1885 it was decided to put down

35,000 ties of the "Post" (old) type, 35,000 ties of a type invented by the chief engineer of the road, and 5,000 ties of the "Bernard" type. Some "Bernard" ties were also laid in 1886–'87.

The Grand Central Railway has also had satisfactory results with metal ties. In 1873 the superintendent of permanent way reported that he was fully satisfied with the experience then acquired with metal ties, but he was unable to adopt them further at that time owing to a great advance in the price of iron. In his reports for 1886 and 1887 he stated that the favorable results had been still more marked, and during 1887 there were 6,000 metal ties laid.

Metal ties of the "Coblyn" type, for light railways, have been definitely adopted by the Société Anonyme des Chemins de Fer Économiques, and have also been tried on the lines of the Société Nationale des Chemins de Fer Vicinaux, the Netherlands lines, the Liegeois and Luxembourg division (on Belgian territory) of the Netherlands State Railway, and on the Liege and Seraing line. Metal ties have been tried on the Belgian division of the Northern Railway of France, including 5,500 ties of the "Bernard" type.

Germany.—On the State Railways a number of different systems of metal track of longitudinal and transverse types have been tried for several years, and some types have been regularly adopted on certain divisions. The investigations and trials are still in progress. In 1887 the State Railway system had a length of about 13,193 miles, with about 23,662 miles of track; of this amount about 5,530 miles had metal track—3,131 miles being laid with cross-ties and 2,399 miles with longitudinals. Very careful records of the trials have been kept. In the year 1886–'87 there were laid 868,262 new cross-ties and 64,094 longitudinals. In February, 1888, 500,000 "Post" ties were being made for German lines.

For the Rhenish Railway system 308,000 ties (10,775 tons) were purchased in 1877–'79. On the Left-Bank-of-the-Rhine Railway, which comprises 1,681 miles, there are 943 miles with metal cross-ties and 211 miles with longitudinals, the balance being on wooden cross ties. The first cross-ties were laid in 1876 and the first longitudinals in 1872. Since 1879 metal sleepers only have been used. On the Elberfeld division of the Prussian State Railways (1,646 miles) there are 790.5 miles laid with wooden ties, 762.5 with iron ties, and 93 miles with iron longitudinals. They were laid in different years between 1869 and 1880.

The experience with iron longitudinals and cross-ties was very favorable, but still better results have been obtained since steel was introduced. Wooden ties are still used in great numbers, partly on account of their lower first cost and partly on account of the policy of the Prussian Government to keep up the supply of timber by domestic cultivation and forest management.

Austria.—In this country, longitudinal systems of metal track have been extensively used. The Northwestern Railway has a total of 59½ miles of track laid with the "Hohenegger" system of longitudinals, and the economy over wood is reported to be noticeable. These longitudinals have been laid in small sections year by year since 1876; the earlier ones were of iron, but the latter ones are of steel. The "Heindl" system of longitudinals is in use on a number of roads; the first were laid in 1883, and at the end of 1887 there was an aggregate of about 141 miles laid with this system of track, a considerable portion being on mountain divisions and including 6.634 miles on the Arlberg tunnel line.

Switzerland.—The Central Railway had 100,000 metal ties in use at the end of 1884, and proposed to lay 30,000 per annum till its whole system had been thus laid. The Western and Simplon Railways began using metal ties in 1883, and have been very well satisfied with them. The Gotthard Railway uses them very extensively, and they have also been adopted on the Mount Pilatus Rack-Railway. In February, 1888, the Hoerde Works reported that they were delivering 160,000 "Post" ties to the Gotthard Railway and 160,000 to the Western Railway.

Italy.—Metal track has been used very little, if at all, and oak ties are obtainable in ample quantities and at a moderate price; and as there are extensive timber resources such track will not be necessary for many years. It has been proposed, however, to lay steel ties on some sections of the Mediterranean Railway system. The Government has used steel ties for short military railways in its African campaigns.

Spain.—The line from Bilbao to Las Arenas has 7.1 miles laid with steel cross-ties, and it is believed that they will prove more economical than wood. The line is 1-metre gauge. The Almanza, Valencia and Tarragona line has 251 miles laid with the De Bergue system of cast-iron plates connected by tie-rods. This system is found to give greater economy, and the gauge is maintained better than with wooden sleepers. The division between Valencia and Tarragona was laid with this track in 1860, and the division between Almanza and Valencia in 1873.

Sweden.—On the State Railways about two-thirds of a mile were laid with metal ties, for experimental purposes, in June, 1886. This is the only case where they have been used in Sweden or Norway.

Denmark.—On the State Railways steel cross-ties were laid for about 18 miles in 1883-'84; but the results, as reported to me in 1888, have not been entirely satisfactory, owing to the insufficient weight and strength of the ties.

*Russia.**—Metal ties have only been used to a very limited extent, on two branch lines, and even there they have not been sufficiently used to enable any reliable conclusions to be drawn from the experiments.

AFRICA.

Cape Colony.—The Cape Government Railways have some sections of the lines laid with cast-iron bowls; they are arranged in pairs and con-

* The metal ties laid on the Moscow Kursk Railway were removed because their maintenance was found more expensive than that of wooden ties. It is claimed that at present prices for wood and for metal in Russia, the metal ties, weighing 105.8 pounds, with an estimated duration of thirty-five years, were two and a half times as expensive as the pine ties impregnated with chloride of zinc, lasting ten years, and one and one-half as expensive as oak impregnated and lasting six years. Conditions in Russia, however, are exceptional as regards labor and material.—B. E. F.

nected by transverse tie-rods. The Delagoa Bay Railway, one of the new lines opening up the interior, is laid principally with steel ties.

Senegal.—About 5,000 ties of the "Severac" type have been ordered for the railways in this French colony. Cast-iron bowls are used on the French island of Réunion.

Egypt.—On the Egyptian Agricultural Railways, wrought-iron plates connected by tie-rods have been used, and also cast-iron "pots" or bowls. In the English campaign of 1885 a short length of light railway of 18-inch gauge, with corrugated steel cross-ties, was laid at Suakim, but the line was soon taken up.

Algeria.—Metal ties are used on the Algerian lines controlled by the Paris, Lyons and Mediterranean Railway Company (France); 10,000 ties were laid in 1870, and have given good results. In 1867–'69 the Algiers and Oran line put down 90,000 iron ties of the "Vautherin" type; the Bône and Guelma line put down 3,500 ties of the "Severac" type and 2,500 of the "Boyenval-Ponsard" type. It is estimated that the use of metal ties has saved one-fourth of the labor formerly required for maintenance, or about $60 per mile per annum.

ASIA.

India.—In this country, steel cross-ties and cast-iron bowls and plates (the latter types arranged in pairs) are very extensively used, and the use of metal track is extending very rapidly, large contracts being frequently awarded for the companies' and the Government lines. Even in Burmah, where wood has been generally used till recently, steel ties are beginning to be introduced.

About 525,000 tons of steel ties have been sent out from England during the last few years, and there are nearly 300 miles of the State lines now laid with this form of track; a large number of miles of private companies' lines are also laid with steel ties. The general results are reported to be good, and the ties give, on the whole, much satisfaction. They are used for lines of 1 metre and 5 feet 6 inches gauge.

There are over 1,600 miles laid with cast-iron track of different types, and these also give satisfactory results in general. Such tracks have been in use for twelve or fourteen years. Of the "Denham-Olpherts" type alone more than 2,000,000 pairs have been made for double-headed rails and about 600,000 pairs for flange rails. On the East Indian Railway there were 1,311,000 of these "Denham-Olpherts" plate sleepers at the end of 1887, and the breakages since 1885 had averaged only 0.84 per cent. per annum. They give good results in reducing the work of maintenance, there being a saving of about 6½ per cent. of renewals per annum. In some of these sleepers wooden cushions are used for the rails to rest on. On one division of the Indian Midland Railway the percentage of renewals of the "Denham-Olpherts" plate sleepers was 0.31.

Japan.—A few cast-iron "pot" sleepers were laid when the first lines were built, about 1871, but they have nearly all been taken up again and hardly any now remain in the track, while for new lines timber ties are used exclusively.

China.—Steel cross-ties are to be tried as an experiment on the new railway which was opened last year.

AUSTRALIA.

Queensland.—The first metal sleepers ever made in Australia have been tried in this colony, an experimental section of a few miles long having been laid with the "Phillips" type. This is a steel cross-tie intended for prairie work, where the track is laid on the surface of the ground; it is designed to be used without ballast, being simply packed with surface soil. Some years ago about 1,000 wrought-iron ties were laid, but they only lasted about five years, as they generally fractured under the rail-seats, owing, it is said, to defective fastenings; they were laid in broken-stone ballast.

In regard to the "Phillips" type, Mr. Phillips kindly reports to me as follows, under date of January 2, 1889, and it is especially interesting as showing that metal track is adapted for other lines than those with heavy traffic:

I have just returned from North Queensland, where I have been constructing a section of railway 36 miles in length on my system. The country I am dealing with is between the port of Normanton, in 17° 45′ S. lat. and 141° 10′ E. long., and a new goldfield by the name of Croydon, situated about 85 miles E. S. E. from Normanton. The country is almost uniformly even, and the Norman River is the only important river crossed. The first 4 miles are over gravel ridges, when a descent of 1 in 70 for half a mile brings the line down to the level of the river flats; the soil is dark clay with a slight admixture of alluvial sand. This description of country extends to 14 miles, where the river is crossed with a low level timber bridge (principally 20-feet spans) on a sandstone rock bottom. Thence to Croydon the country is very uniform in character—fine sandy soil, covered with a more or less thick forest of inferior and stunted timber, sometimes dense enough to be called brush or scrub. There is no forest timber of sufficient dimensions in the district available for ties or bridge work, neither is there any stone for ballast, except by quarrying below the surface, and that is sandstone of an inferior and very soft description. The country is almost uniformly even, except at the 4-mile peg, where there is a cutting of about 5 feet and an embankment of equal height. I commenced track-laying July 7, and completed 32 miles on December 29; fully seven weeks were lost through non-delivery of ties, so that the average rate of progress was 1¾ miles per week of six working days. The number of men employed in (*a*) clearing track 66 feet wide, (*b*) grubbing, (*c*) ploughing, harrowing, and rolling central width of 10 feet, (*d*) track-laying, (*e*) lifting and packing ties, and (*f*) straightening track, never exceeded 65, with one team of bullocks (12) and one horse. Cost per mile for labor only, $630; wages for laborers, $2.50 per day; gangers, $3.15. The ploughing, harrowing, and rolling cost $75 per mile, and is included in the $630. The total cost was under $15 per lineal foot. The best day's work was .525 mile, and the best week's work a little over 2 miles. No ballast has been provided and no side or cross drains cut; the only waterways are at well-defined and water-worn channels. The total timber bridging on the 36 miles is 1,108 lineal feet, and only one box-drain has been put in. From 20¼ miles to 36 miles there is not a single water-way of any description. The cost is under $15 per lineal foot.

The material train has never failed to run to the head of the road daily, from the commencement of track-laying, although there have been some very heavy thunderstorms with 1 to 2 inches of rain-fall in an hour. The track is laid with steel flange rails, 41¼ pounds per yard, 26 feet long, fastened to mild steel cross-ties, weighing 84 pounds each, 11 ties to a rail length. The average gross load of the material train, 100 tons. The locomotive employed is a six-wheeled engine of English build. The country passed through is believed to be the softest in wet weather to be found in Australia, but so far no trouble has been experienced with the line. The country is infested with white ants (termites), and ties of the best hard woods of the colony will not last more than 3 years in the form of ties. The government now in power are not very favorable to my system, but I hope to be able to induce them to complete the Croydon Railway on my system. I believe my system might be applied with advantage to your prairie country subject to heavy rain-falls.

New South Wales.—About 1,000 steel cross-ties were laid in 1882. In 1887 it was reported that they were in bad condition, but this may have been due (if correct) to the fact that the manufacture of steel ties was in its infancy in 1882.

South Australia.—In March, 1888, the agent-general in England reported to me that metal sleepers were being laid on a new line 145 miles long, not then open to traffic.

SOUTH AMERICA.

Argentine Republic.—In this State, cast-iron "pot" sleepers are used almost exclusively, except in the far west and north. The Buenos Ayres Great Southern Railway, which began operations in 1865, has 13¾ miles of double track and 819½ miles of single track laid with cast-iron sleepers of an improved design. They are adopted on account of the difficulty of procuring good hard-wood ties in sufficient quantity and the greater expense of these wooden ties; also because they give a more rigid and satisfactory track. The Central Argentine Railway has 246 miles laid with cast-iron track. The Santa Fé and Cordoba Railway ordered 20,000 steel ties in England in 1888.

Chili.—Steel ties have been tried to a small extent, but the type was considered too heavy and expensive. Previous to the award in November last, to an American syndicate, of the contract for building about 780 miles of railways for the State, proposals had been invited by the Chilian legation in France for the supply of 739,400 metal ties 9 feet long and 725,100 ties 4¼ feet long.

United States of Colombia.—There has been some talk of adopting metal ties on the Bolivar Railway.

MEXICO.

The Mexican Railway (Vera Cruz line) is using a large number of steel ties of the type in general use in India, and has obtained very good results with them, especially at times when the road has been flooded. These ties were first used in 1884, and at the end of June, 1888, there were 46¼ miles of track laid with steel ties. The Mexican Central Railway has been contemplating the adoption of the same type of tie on the mountain division of the road, the advantages being that they last longer than wooden ties and keep the track in perfect gauge.

The above report is respectfully submitted for consideration.

E. E. Russell Tratman,
Jun. Am. Soc. C. E.

February 1, 1889.

Appendix A.

THE "POST" TIE.

This tie, of which so much has been heard, is probably the most successful of all the various types of metal ties that have been put in service, and the success is largely due to the care which has been taken in noting the results obtained and in making such improvements as experience has shown to be desirable. Consequently, the present form of the tie is the result of many improvements, and represents several years of experience and careful study. It is a cross-tie rolled from mild steel (Bessemer, Thomas, or Siemens-Martin); its section is that of an inverted trough, with flaring sides forming a section of a polygon; it is narrow and deep in the middle, the ends are closed, and the bottom edges are thickened to form a rib. One of its special features is its varying thickness, giving an ample thickness of metal at the rail seat, where the greatest strength is required, and a less thickness at the middle and ends. Thus the weight of the ties as now used is from 110 pounds to 121 pounds each, corresponding to 126.5 and 139.15 pounds if they were of uniform section. This feature represents, therefore, an economy of 15 per cent. of metal as compared with a tie with a uniform thickness equal to the maximum thickness of the "Post" tie. In the operation of rolling, the varying thickness is given and also the shape of the tie, while the bending of the ends to give the rails an inward inclination of 1 in 20 (in accordance with European practice) is done during the same operation.

The shape of the middle portion of the tie is designed with a purpose, as it is claimed that by narrowing this portion the ballast is kept from working away from under the rail seat, and in this way a stable road-bed and track are secured, thus diminishing the work of maintenance. It prevents the tendency of the ballast to work towards the middle and form a ridge on which the tie would rest, giving a rocking motion to the track, but gives it a tendency to pack well under the rail seat. The increased depth of this portion gives additional strength to resist bending and also offers increased resistance to creeping.

The following are the principal dimensions, given in the original metric measure and also reduced to feet and inches: Length over all, 2.55 to 2.65 metres (8.364 to 8.692 feet); width over all at rail seat, 235 millimetres (9.40 inches); width over all at middle, about 5.30 inches; width of rail seat, 110 millimetres (4.40 inches); width of end, 280 millimetres (11.20 inches); depth under rail, 74.5 to 75.5 millimetres (2.98 to 3.02 inches); depth at middle, 125 millimetres (5 inches). Thickness of cross-section at rail seat varies as follows: Thickness at bottom of flange, 6 millimetres (.24 inch); thickness at upper part of flange, 7 millimetres (.28 inch); thickness at rail seat, 9 to 10 millimetres (.36 to .40 inch); thickness at bolt-holes, 12 to 13 millimetres (.48 to .52 inch); thickness at middle and ends, 6 to 7 millimetres (.24 to .28 inch). The rib on the lower edge of the flanges has a depth of about 18 millimetres (.72 inch) and projects about 13 millimetres (.52 inch) beyond the outer face of the flange.

For narrow-gauge and light railways the dimensions would be reduced in accordance with the weight, and for such lines a weight of 72.6 to 77 pounds is considered sufficient.

For rail fastenings reliance has been placed upon bolts, and the results have been entirely satisfactory; the fastenings keep tight, prevent vibration and rattling, and require little attention after the track has become well settled. The bolt-holes are oblong, and have rounded corners. The bolt used is 91 millimetres (3.64 inches) long and 22 millimeters (.88 inch) in diameter; it has a T-head 38 by 46 millimetres (1.52 by 1.84 inches), and a cam-shaped or eccentric neck 22 by 30 millimetres (.88 by 1.20 inches), for the purpose of allowing an adjustment of gauge at curves, switches, etc. The bolt passes up through the tie and through a "crab" washer which bears on the flange of the rail and the face of the tie; a Verona nut-lock is then put on and the nut screwed down upon it. The upper face of the washer and the lower face of the nut are indented, so as to give a good hold on the nut lock. The ties are sent out to the track with the fastenings separate in kegs, or with the bolts in place and the nuts loosely screwed on, according to the wishes of the division engineers; some of whom prefer one plan and some the other.

This tie presents the following advantages:

First. Economy in material; owing to the maximum thickness being given at the rail seat and a less thickness at the middle and ends, this effects a decided saving in weight and first cost.

Second. Economy in manufacture; owing to the shaping, bending, and varying of the section being all done in the operation of rolling, thus reducing the shop-work to a minimum; which is an important consideration.

Third. Economy in maintenance; owing to the little care and attention required, as shown by years of actual service.

Fourth. Efficiency in making a good track; as also proved by years of actual service.

Fifth. Adjustment; owing to the arrangement of the fastenings permitting the gauge to be widened at curves and narrowed at switches; which is an important feature when a tie is adopted on a considerable length of track.

E. E. R. T.

Appendix B.

SOME AMERICAN METAL TIES.

The International tie.—This is a rolled steel tie, the section of which resembles a printer's "brace" (⏞); originally it was made in two pieces, riveted together at the middle flange, but it is now to be rolled in one piece. The dimensions are as follows: Length, 8 feet; width, 10 inches; side flanges, $2\frac{3}{4}$ inches deep; middle flange, 2 inches high; thickness, from $\frac{3}{16}$-inch at the lower part of the side flanges to $\frac{5}{16}$ inch at the middle. The middle flange is cut away in two places for the rails. The fastenings consist of flat wrought-iron clips, one on each side of the rail, which are bolted to the flange of the tie and have projections which bear upon the rail flange. Some of these ties have been in use for more than two years on the Boston and Maine Railroad and the Maine Central Railroad; the Long Island Railroad is now giving them a trial.

The Hartford tie.—This is a rolled steel tie, of inverted trough section, with a channel or groove along the whole length of the top table, and having the ends curved down to hold the ballast. The dimensions are as follows: Length, 7 feet 6 inches; width at top, 8 inches; width at bottom, $10\frac{1}{4}$ inches; depth, $2\frac{1}{2}$ inches; thickness, $\frac{3}{8}$ inch at sides and $\frac{5}{16}$ inch at top; the channel or groove is $2\frac{1}{2}$ inches wide and $\frac{5}{8}$ inch deep. The weight is about 120 pounds. The fastening for each rail consists of two clamps $\frac{5}{8}$-inch thick, with a hooked projection at the broad end, which holds the flange of the rail; these clamps are wedge-shaped in plan, and lie in the channel above mentioned. A bent bolt, with its head at an angle of 53 degrees with the body, is used on each side of the rail; the head is on the under side of the tie and the body passes up through the tie and clamp, the nut bearing on the inclined face of the clamp. This is the fastening as improved by Mr. Katté, the chief engineer of the New York Central and Hudson River Railroad. By this arrangement, the bolt being at an angle, a strong grip is secured, and there is little tendency to jar the bolts loose; to prevent such loosening, however, the bolt has the Harvey grip thread, which forms a nut-lock in itself. The fastening permits of a very wide range of adjustment of gauge. These ties have not yet been tried, but the New York Central and Hudson River Railroad will lay 800 of them in April, and careful observations will be made as to the results.

The Standard tie.—This is a steel tie of channel section (⊔) stamped to shape from a plate. The bottom is cut away at the middle, and is bent up at an angle to offer resistance to lateral motion, the ends being open. The rail does not rest upon the vertical sides of the tie, which are cut away for a depth of three-fourths of an inch under the rail, but rests upon a block of preserved wood (placed with the grain vertical). The tie is intended to be filled with ballast. The fastenings consist of Z-shaped clips, the upper part holding the rail flange and the lower part taking a bearing on the under side of the bottom of the tie; the upright web is nearly vertical, but curved so as to grip the wood block. A bolt passes horizontally through the two clips and the block, near the top of the latter, holding all the parts firmly together. At the rail-joints it is intended to use a tie of extra width, with wide clips and two bolts, and it is claimed that this fastening will be sufficient in itself, and will obviate the necessity of using splice plates. These ties have not yet been in service, but arrangements have been made for their manufacture, and it is said that they will soon be tried on a Western road. The claim is made that they are specially adapted for roads with a narrow width of ballast, owing to the resistance to lateral movement being at the middle instead of the ends of the tie.

The Taylor tie.—This is an iron or steel tie on the "bowl" system, each tie consisting of a separate piece under each rail, connected by a third piece forming a tie-bar. The rail-bearers are short pieces of inverted trough section, placed longitudinally with the rail, and have a vertical transverse slot through which the deep flat tie-bar passes. The inside flange of the rail is held by clips, forming a part of the top table of the trough, and the outside flange is held by a hooked projection at the end of the tie-bar. No bolts or other loose parts are used.

The Toucey tie.—This is a cast-iron "pot" tie designed by Mr. Toucey, general superintendent of the New York Central and Hudson River Railroad. Each tie consists of two "pots," of H-section, with outward flaring sides; the "pots" are connected by a tie-rod, the ends of which are bent at right angles to fit into a hole in the horizontal web, the rod passing through a hole in the side. The "pots" are 18 inches long, $9\frac{3}{4}$ inches wide on top, $16\frac{1}{2}$ inches wide at bottom, and $8\frac{5}{16}$ inches deep; the thickness varies from one-half inch to 1 inch. The space above the web is filled with an oak block, to which the rail is secured by the Bush interlocking bolts. These ties are in use at the Grand Central Depot in New York City.

A channel tie.—A channel tie was used by the Pennsylvania Railroad for some years subsequent to 1880. In that year some were laid on the Filbert Street extension, and in 1885 about 400 or 500 were laid on the main track in the West Philadelphia yard. The tie consisted of an ordinary 7-inch channel iron (⊓) 8 feet 6 inches long; the ends were closed by a piece of angle-iron riveted on, and a cross piece of angle-iron was also riveted inside the channel, just under the outer flange of the rail. The fastenings for each rail consisted of a piece of angle-bar riveted to the face of the tie (the rivets passing through the angle-bar, tie, and inside angle-iron) on the outside of the rail, and a loose flat clip on the inside of the rail, fastened by bolts. Writing in 1886, Mr. Brown, the chief engineer of the Pennsylvania Railroad, said:

> These ties cost from $3 to $4 each. As long as we can get good oak ties for not exceeding $1 each, I would not recommend making the change, although they give perfect satisfaction and are no more trouble to keep in line and surface than wooden ties. E. E. R. T.

THE DURAND TIE.

This tie, among the latest patented in this country, has been in use on a private trial line in the French Alps.

It resembles most nearly the "Post" tie.

It is produced by converting old rails into metal sheets, from which the tie is stamped out by special machinery, requiring no further shop work than the fastening of the bolts, which are welded to the tie while hot.

The cross section is of the "Vautherin" or "Zores" type, like the "Post" tie, narrowed, and depressed in the center and slightly curving towards the ends, as well as to the middle of the tie. Lengthwise corrugations on the face of the tie under the rail-seat, and if deemed necessary, vertical corrugations on the side-faces, are intended to give additional strength, allowing a saving of metal as against the "Post" tie. The width on top under the rail-foot is 10 inches and across the lower edges 12 inches.

The ends are open but can be closed if desired by a special cap, which is put on after the tie is placed and can be easily removed if necessary, permitting access to the lower side, bolts, etc., without removing the tie entirely. Experience, however, with the open-end type seems to have proved that the curvature of the ends is sufficient to prevent the blowing out of ballast.

The fastening of the rails is effected by means of four bolts with specially-fitted T-heads, which are inserted and partially welded to the tie from below during its manufacture, and are prevented from turning by a shoulder in the tie. A washer of soft metal is so adapted as to prevent any loosening of nuts above, an indentation on the lower side fitting into a similar indentation in the tie, and one flange being bent upwards after screwing down.

For curves, switches, etc., the adaptation of shape, inclination, and gauge is effected in the manufacture by interchangeable pieces in the stamping apparatus.

The placing of the tie is effected by laying it on the ballast and burying it in the same by means of a rocking motion with the help of levers inserted into holes made at the ends of the tie in manufacturing. No digging of a tie-bed, no tamping is needed. The drainage, a very important requirement, is well provided for.

The weight of the tie is made variable by either rolling the metal-sheets to three-sixteenths of an inch, which gives a 65 pound tie, or five-sixteenths of an inch, which will make it about 100 pounds.

The cost is claimed to be $1 or $1.35 respectively, if manufactured in the United States. The cost of manufacture is calculated at 30 cents, allowing a railroad company to use up the old rails. The plant for rolling the rails to shape and stamping the tie is simple; its cost is estimated at $5,000.

The Durand tie, with less metal, promises to give the same strength and is more easily placed than the "Post" tie.—B. E. F.

METAL TIE NOTES.

The following matter has been appended as of interest in the discussion of the desirable change from wooden to metal ties.

These notes originate in part with Mr. Tratman, or else are copied from other publications.

The ephemeral literature on the subject is growing rapidly, and by the time Mr. Tratman's final report will go to press, it will have become desirable, with it, to present in abstract the useful information which has thus accumulated. By that time it is hoped that more experiences from trial tests on railroad lines of our own country may also be recorded.

As this Bulletin goes to press, two interesting items of news on the railroad tie question have reached this office. The one relates to the remarkable durability of lignum-vitæ cross-ties on the Panama Railroad—thirty-five years. That there is any likelihood, as some papers seem to anticipate, that this discovery will in any way influence the use of metal ties by possible competition of this wooden tie, I am inclined, for various reasons, to doubt.

Perhaps of more influence on this subject may become the introduction of stone sleepers in combination with the "Elastic Tie-Plate," which was originally intended to improve the track on wooden ties, but has proved itself of service on rock sleepers in an experiment made by the Ystad-Eslof Railway in Sweden. Yet we are inclined to think that even this kind of substructure, if found as efficient as is claimed, would not threaten as much competition with the metal track as it might at first appear to do, except under special conditions.

The theoretical requisites for a perfect metal tie are now quite well understood and have been discussed at length in Bulletin I, from this Division. The task of inventors henceforth must be, while complying with these theoretical requisites, to do it in such a manner as to reduce the cost of the manufacture to its lowest possible figure without loss of required strength. With the extendeg experience before us there can not longer be a doubt that it is possible to construct a metal tie which will be superior in all respects to wooden ties; yet to bring its first cost down to such a figure that the future saving in its maintenance need not enter into consideration, but may be taken as an agreeable surprise in the cost of management—this is what railroad companies are most bent on obtaining. Especially in our country, where the present accounting outweighs in importance all future possible profits, this consideration alone, of reduced first cost, may be sufficient to work a revolution in the use of railroad ties. On the other hand, the bugbear of cheapness, which is often mistaken for an equivalent of economy, is apt to mislead the inventor into risking the factors of safety and strength in order to attain cheapness.

"If a man wants a 'cheap' track he had better continue to pay 50 and 75 cents for wooden ties. And if he wants an economical track he must use steel ties with enough metal in them to insure permanency."

There is also no doubt that the metal tie which is suitable for one set of conditions is not suitable for others. The amount of traffic, and especially the condition of track and ballast, will dictate changes in shape, weight, etc.

It had been the intention to review all the patents which had concerned themselves with introducing metal for railway tracks, but the large number—not less than 256 patents so far, very many of which are obviously impracticable—made the task too laborious for the practical result to be expected from it. Therefore, only a brief reference list to these patents has been prepared by Mr. Tratman.

The first suggestion for the use of metal track seems to date back to the year 1839; a patent by J. Stimpson, proposing a construction of metal and wood combined, similar to a construction now much used in street railways. The next attempts did not follow until 1857, 1858, and 1861.

The flood of patents begins with the year 1883, the last five years having produced not less than one hundred and sixty devices.

Some of the more prominent devices, which have been actually manufactured in the United States, are briefly described in Appendix B.

B. E. Fernow.

MAINTENANCE—EXPENSES OF TRACK ON WOODEN AND METAL TIES.

By J. W. Post, permanent way engineer, Netherlands State Railroad Company.

Read at the annual convention of the American Society of Civil Engineers, July 2, 1888.

Though the track of European railroads shows in material, construction, and maintenance a great difference from the track on American lines, the following data concerning the use of steel cross-ties, gathered methodically since 1865 on the lines worked in Holland, Belgium, and Germany by the Netherlands State Railroad Company, may be of some interest to American railroad engineers.

The first trial of metal ties on the Netherlands State Railroad dates from 1865, in which year 10,000 Cosijns ties* were laid. In 1880 these ties, of a system now considered poor, had given satisfactory results as to the metal part during their fifteen years of service, but the oak blocks had to be frequently renewed. Moreover, the following considerations induced the company to search for a good metal tie:

First. It was feared that prices of timber would gradually rise, owing to the increasing devastation of forests.

Second. Even with the wood deemed best for ties, viz. oak, it was difficult to secure satisfactory results; some lots of oak ties, severely inspected, appeared first-rate when new, but had to be renewed after only one year of service. The time of felling seems to be of great importance, and cannot be determined at the moment of purchase even by the severest inspection.

Third. Even the best methods of impregnating proved unreliable; of ties coming from the same boiler some were quite saturated, others only on the surface; some lasted one year only, others twenty years. Uniformity in this respect is desirable for the track.

Fourth. No timber merchant guarantees his ties; whereas steel ties are generally guaranteed for two years.

Fifth. There is a great loss of interest during the time timber ties are piled in order to dry; whereas metal ties are often in the track before being paid for.

Sixth. There is a great loss of timber ties by bursting, caused by sunshine, water, frost, driving the spikes, etc.

Seventh. Timber ties being heavier than metal ties, the transport to the place where they are put in the track is more expensive.

Eighth. The difficulty and cost of the respiking and readzing of timber ties, and of the replacing by new ones, increases with the daily number of trains. Ties of more durable material are desirable also from that point of view.

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* This tie consisted of an I beam laid horizontally, thus ⊢⊣, with a wooden block under each rail.

Ninth. The selling price of old metal ties is considerably higher than the price of old timber ties.

Tenth. A calculation* of the total annual sum required for purchase, laying, maintaining, and renewing tracks on timber and on metal ties gave a favorable result for the metal.†

All these considerations induced the company to charge the writer in 1880 to study, both at home and abroad, the different systems of metal ties then in use, both from the point of view of manufacture and of maintenance, and to propose a method of trial enabling the company to get the most complete information possible on the subject.

This charge resulted in the following different systems of ties and fastenings being laid in the track from 1880 to 1888:

	Pounds.
Type I, Vautherin section; iron	88
Type II, Vautherin section; iron	103.84
Type III, Haarmann section; mild steel	110
Type IV, Haarmann section; mild steel	114.4
Type V, Haarmann-Lichthammer section; mild steel	95.48

	Ties.
In 1881, type I	4,133
In 1882, type II	4,001
In 1883, type III	2,089
In 1883, type IV	2,090
In 1884, type V	11,680

And from 1885 to 1888, about 126,000 ties, types VI, VII, VIII and IX, making about 150,000 ties of ten different types (including Cosijns). Of each ot the types, trial lengths, under different circumstances of grades and curves, were put under special observation, every hour of maintenance work and every renewed piece being scrupulously noted. As a base of comparison 1,120 first-rate new oak ties were laid in the track, the rails being fastened with the ordinary spikes The plate shows the different types of ties used.

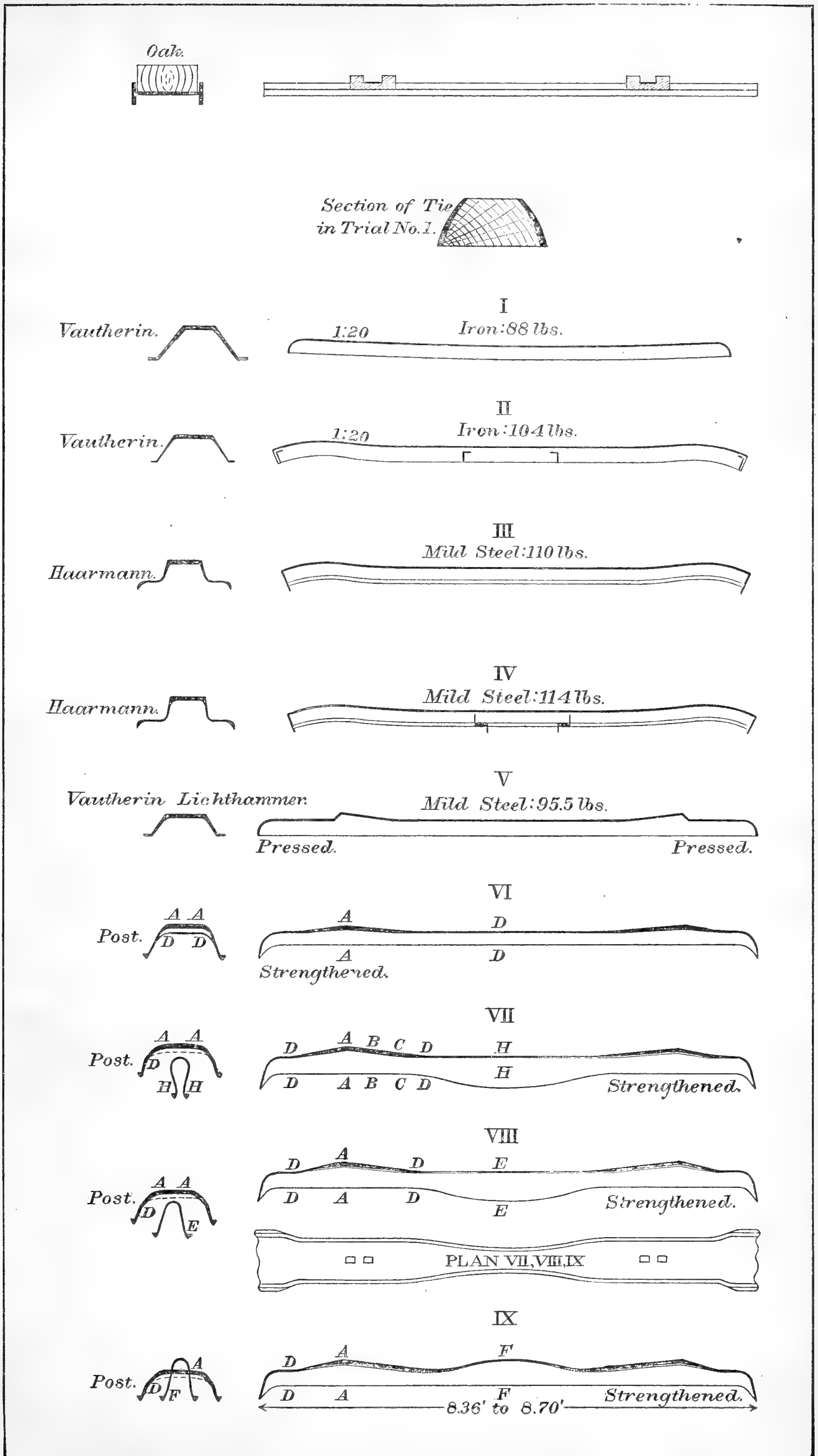
At the same time different systems of fastenings were tried on the metal ties.

By trying the best improvements in shape, material, and manufacture, and by eliminating every year the faults of the preceding types, Mr. Post gradually arrived at types of ties and fastenings which, having shown great advantage in every respect over the preceding types, have now been adopted as standards for this railroad.‡ (Types VIII and IX.)

* For methods of calculation see Bulletin I of Forestry Division; also the valuable report of the American Society of Civil Engineers, June, 1885, on the "Preservation of Forests."

† Many important improvements introduced since have increased the advantage of metal over timber.

‡ Other railroads have, to their great satisfaction, followed this example. A total of about 457,300 ties (about 23,800 tons) of the Post types VI, VII, VIII, and IX is now in service on different lines of Holland, Belgium, France, Germany, Switzerland,



DEVELOPMENT AND TYPES OF THE "POST" TIES.

Types VI, VII, VIII, and IX are in mild steel rolled to a variable section, strengthening at rail seats and tilt 1 in 20 being obtained directly by rolling, thus preserving the steel from damage at the vulnerable spot (rail seats) by bending or pressing. These ties weigh 50 to 55 kilograms each, corresponding to 57 to 63 kilograms per tie of uniform section BB (economy 15 per cent.). Type VI, without the narrow waist, like all preceding types, had not quite the same stability as the later types with narrow waist; indeed, this reduction of breadth in the middle causes the principal reaction of the ballast to work at the rail seats, eliminating the balancing action of the track which takes place when the support is in the middle, particularly on badly ballasted roads or with neglected packing. Moreover, the increased height at the center gives greater rigidity to the tie. The wedge waisted tie VII is, unfortunately, of difficult manufacture, and so types VIII and IX are practically esteemed the best, and all agree that they give remarkable results.

The ends are closed and project downward 2 inches into the ballast. The tests prescribed for inspection are very severe. The author executed a series of tests to ascertain whether annealing the ties after punching the holes does pay or not; his conclusion was, that with mild steel annealing is not necessary, but is desirable if it can be done at small expense.

The ties are tarred if they have to remain a long time beside the track. The price, including two years of guaranty, varies from $22 to $26 per ton.

The fastenings show the following improvements, gradually introduced and tried by Mr. Post. The surface of nuts and clips is roughened to facilitate the grip of the Verona nut-lock. The clips, if rolled (mild steel annealed), get three fillets for the same reason; if stamped (iron or mild steel), they are indented like the nuts. In both cases the clip has a large contact with the surface of the tie in order to reduce the wear. For the same reason the head of the bolt (iron or soft manganese steel) is large. The bolt must not be less than $\frac{7}{8}$ inch diameter. The collar of the bolt, which is eccentric, to enable widening of gauge on curves by turning the bolt 180 degrees, fits tight into the tie hole; this hole being rounded in the corners to avoid cracks, the bolt collar is rounded accordingly. The Verona nut-locks are of the very best quality, severely tested as to elasticity and sharpness of points, and are guaran-

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and Asia (colonies). About 272,700 more (about 12,700 tons), comprising the narrow-gauge and rack-road ties for Sumatra, are ordered and being manufactured now, making a total of about 730,000 ties (or 36,500 tons). See on this subject:

(*a*) Mr. Bricka's official report to the French minister of public works.

(*b*) Mr. Kowalski's official report to the Milan Railroad Congress, 1887.

(*c*) Report of Vincennes Exhibition, 1887, highest award to Netherlands State Railroad Company and to the writer.

(*d*) Annual Report, 1887, of the French Society for the Advancement of Industry; silver medal awarded to the writer.

teed. The price of these improved fastenings does not exceed 24 cents per tie.

The statistical results as to cost of maintenance gathered to January 1, 1888, on twenty-four trial lengths, are shown in the accompanying table. Columns 1 to 14 give the particulars of sections, condition of laying, types, etc., and columns 15 to 22 the expense of maintenance per day and per kilometre in francs.

The statistical data gathered to January 1, 1887, and the close and scrupulous observations of the trial divisions, allowed the company to report seventeen conclusions to the Milan Railroad Congress in 1887.

The service from January 1, 1887, to January 1, 1888, having fully confirmed the opinions of the company on these seventeen points, the following conclusions are still applicable to the statistical data gathered to January 1, 1888, as contained in the accompanying table:

(1) Trials 11 and 14 are on curves of 350 metres radius and 16 millimetres per metre grade. Oak ties occupying this place previously had to be respiked every year, causing great cost of maintenance; the rail flange cut the spikes 3 to 4 millimetres, thus giving every year a gauge widening of 6 to 8 millimetres. Several ties of type III, on the contrary, taken from the track for inspection after 1,553 days of service, showed only a widening of 2 millimetres, the exterior bolts (of the old type "A") being worn only 1 millimetre by the rail flange. The tie surface only showed a slight amount of corrosion, and the holes were not in any way enlarged or ovalized. Considering the unfavorable conditions under which these ties were, these are very good results; in no year did the expense amount to 2 francs per day kilometre, and the average day kilometre is only 1.39 and 1.40 francs (columns 18 to 22).

(2) Trials 3 and 9 being on marshy ground, the result may also be considered as favorable; in no year as much as 2 francs per day kilometre, and average day kilometre 0.95 franc and 0.88 franc (columns 15 to 22).

(3) As to consolidation (about 2,300 days), the only trials comparable to the base trial No. 1 (oak ties) are trials 2, 3, 4, and 5. Though two of these four trials are under unfavorable conditions, there is no sensible difference between the average day kilometre of trials 2, 3, 4, and 5, and the day kilometre (0.605 franc) of trial 1, a very favorable result indeed, considering the following facts:

(*a*) Type I is now considered a poor system, each of types II to IX being great improvements. Had one of the more perfect types been used on these trials, still better results would have been obtained.

(*b*) Respiking and re-adzing of the oak ties of trial 1 had begun in 1886, and has to be continued in 1888 and following years, increasing the cost of maintenance with the age of the wood.

(*c*) With the trials on metal ties, on the contrary, there is a tendency shown of a decrease of expense as the permanent way becomes set.

(*d*) On trial 1 only ten oak ties had to be replaced by new ones since 1881; this renewing, however, will go on increasing with the age of the wood, thus increasing, apart from the cost of purchase, the daily expense (work) of trial 1. The renewal of ties on the other twenty-three trials, on the contrary, was *nil* since 1881 (not one metal tie being broken), and will be *nil* for man y years.

(4) The day kilometre of trials 6, 7, 8, 12, and 17 does not exceed 0.88 franc; those of trials 10, 13, 15, 16, 18, and 19 are below 0.60 franc, though these eleven trials date only from 1883 and 1884.

(5) The time of observation for types VI, VIII, and IX (trials 20 to 24), has been too short to form any definite idea of the mean day kilometre; meanwhile everything tends to show that these types will give even better results than types I to V.

(6) The average expense for laying and maintaining the twenty-three trial-lengths 2 to 24, has not been greater than would have been occasioned by the timber ties laid on the same places. The supplementary expenditure for these trials, apart from the trouble of statistics, etc., is therefore *nil.*

The close observation of the permament way and of the manufacture of ties and fastenings led the company to the following conclusions:

(7) A part of the road near Liége, twenty-five trains daily, curve of 530 millimetres radius, 16 millimetres per metre gradient, after having been carefully pack ed, was left for forty months without any other work than occasional nut-tightening. This shows that a good road, with steel ties, once properly packed, requires no more scrupulous attention and maintenance than one laid with timber ties; on the contrary, it would have been dan gerous to have left a track situated as this was, and laid with timber ties, for a period of three and a half years.

(8) The diagrams of the self-registering gauge-measure show that the gauge is much more regularly kept on metal ties than on timber (even new oak) ties.

(9) The position of the rail, which often changes on timber ties, is not variable with the metal ties.

(10) The lateral displacement of the track is insignificant with metal ties, even on curves of short radius, providing that the tie is closed at the end.

(11) The breadth of the ballast bed may be made a little smaller with the narrow-waisted metal ties (types VII, VIII, and IX) than with ordinary metal or timber ties.

(12) The respiking and re-adzing of trial No. 1 necessitated to 1888 the replacing of two bearing plates and 1,081 spikes by new ones. The renewal of fastenings on the metal ties is insignificant, especially with the adopted type "C."

(13) Iron is not recommended for metal ties; mild steel is superior to it in every respect, viz. manufacture, inspection, rigidity, and durability.

(14) Alternating joints have given satisfactory results, especially in curves of short radius.

(15) Suspended rail joints have given the best results on metal ties, providing the angle splice-bars be strong and the distance between joint-ties small.

(16) Types VII, VIII, and IX fulfill all conditions for properly imbedding the tie in the ballast. If the packing is done properly, and does not exceed 1½ feet from each side of the rail, the track can never become balancing, through the ballast working towards the middle of the tie and leaving the ends unsupported, for the shape of the tie drives the ballast towards the rail seats, both transversely and longitudinally. Generally the ballast soon forms into a compact cake, adhering to the interior of the tie, thereby augmenting both the base and the mass of the track.

(17) The track men, who generally abhor novelties, have soon learned, owing to practical instructions, to appreciate the steel ties and to make an excellent track with them.

The company closed these seventeen conclusions by quoting at the Milan Congress the following statement from the annual report of Mr. Charles Renson, resident engineer of the Liegeois section, which will be received with great appreciation on account of the distinguished and impartial manner in which this engineer has organized the trials of metal ties on that section:

A single track with ties, Type VIII or IX (latest form), having twenty-five trains per day with curves, gradients, ballast, etc., as the Liege-Hasselt section, can be, after four years of consolidation, maintained in proper order at the rate of one hundred working days per year—kilometre. A gang of four men, working two hundred and fifty days a year, of which fifty days are given to other work, are able to maintain in good condition 8 kilometres of permanent way.

The Netherlands State Railroad Company, having experienced the great advantage of practical experiments made on trial sections of track, has continued experiments as follows, in order to gather information on other points:

Between Tilburg and Breda, four parts of equal length were laid in 1886 on the same track, to compare the cost of maintenance and of renewal between: (1) Ordinary steel rails (33 kilograms per meter) on timber ties. (2) Heavy steel rails (40 kilograms per meter) on timber ties with two Post's steel, toothed bearing-plates on every tie. (3) Heavy steel rails (40 kilograms) on heavy Post steel ties. (4) Ordinary steel rails (33.7 kilograms per meter) on ordinary Post steel ties.

The time of observation is yet too short for any conclusion.

Between Tilburg and Breda, four parts of equal length are being laid now in the same track to compare the cost of maintenance and of renewal between: (1) Ordinary steel rails on ten timber ties per 9 meters of track. (2) Ordinary steel rails on eleven timber ties per 9 meters of track. (3) Ordinary steel rails on twelve timber ties per 9 meters of track. (4) Ordinary steel rails on twelve timber ties per 9 meters of track, with alternating joints.

Between Weurne and Helmond the same four comparative trial lengths are being laid on ten, eleven, and twelve Post steel ties per 9 meters of track.

The information gathered by these methodical researches will be of great value, not only for the Netherlands State Railroad but for railroading generally; the best remedy for scanty net earnings being a reduction of the expenses of maintenance and renewal.

Cost of maintenance on trial tracks with wooden and metal ties, Netherlands State Railroad Company.

Trial number.	Trains per day.	Section of line.	From—	To—	Gradient in millimeters per meter.	Radius of curves in meters.	Length of trial in meters.	Number of ties.	Types. Ties.	Types. Fastenings.
1	2	2	3	4	5	6	7	8	9	10
			Kilom.	*Kilom.*						
1	25	Liége-Tongres	15. 620	14. 612	12. 0	500	1. 008	1. 120	Oak.	Spikes.
2	25	do	16. 666	15. 620	12. 0	750 / straight.	1. 046	1, 133	I.	A.
*3	25	Bilsen-Hassett	41. 093	40. 170	1. 2	straight.	0. 923	1, 000	I.	A.
6	25	Liége-Tongres	7. 946	7. 432	16. 0	1, 000	0. 514	600	II.	B.
7	29	Liers-Flamalle	1. 831	1. 393	level.	1, 000	0. 438	500	II.	B.
8	25	Tongres-Bilsen	25. 031	24. 570	8. 0	straight.	0. 461	500	II.	B.
*9	25	Bilsen-Hassett	43. 625	43. 349	4. 0	straight.	0. 276	300	II.	B.
11	25	Liége-Tongres	3. 790	3. 640	16. 0	350	0. 150	201	II.	B.
12	25	do	12. 707	12. 528	13. 0	500	0. 259	300	II.	B.
14	25	do	4. 002 / 3. 640	3. 790 / 2. 836	16. 0	350	1. 016	1, 328	III, IV.	A.
17	25	do	12. 528	12. 315	13. 0	500	0. 215	250	IV.	A.
21	25	do	4. 412 / 4. 765	4. 302 / 4. 748	16. 0	530	0. 117	200	VI.	C.
22	25	do	8. 000	9. 000	16. 0	1, 000	1. 000	1, 081	VI.	C.
4	14	Hassett-Wychmael	22. 238	21. 130	2. 9	straight.	1. 108	1, 200	I.	A.
*.	14	Wychmael-Achel	32. 673	31. 940	3. 4	straight.	0. 733	800	I.	A.
10	14	Hassett-Wychmael	8. 408	7. 301	3. 9	straight.	1. 107	1, 200	II.	B.
1	14	do	1. 562	1. 218	6. 5	500	0. 344	400	II.	B.
1	14	do	1. 218	0. 765	6. 5	500	0. 453	500	III, IV.	A.
1[illegible]	14	Achel-Eindhaven	47. 334	47. 795	0. 8	2, 000	0. 461	500	III.	A.
18	14	do	47. 795	48. 256	level.	straight.	0. 461	50[illegible]	IV.	A.
1	14	do	46. 868	47. 334	0. 8	straight.	0. 466	505	V.	A.
20	14	do	52. 709	52. 032	1. 0	2, 000 / straight.	0. 677	735	VI.	C.
23	14	do	57. 342. 50	56. 425. 9	1. 0	2, 000	0. 083. 40	93	VIII.	C.
24	14	do	57. 425. 95	57. 509. 10	1. 0	2, 000	0. 083. 15	9[illegible]	IX.	C.

* Marshy ground.

Cost of maintenance on trial tracks with wooden and metal ties, etc.—Continued.

Trial number.	When laid.	Date when observation commenced.	Days in service.		Cost of maintenance in francs per kilometer per day.							
			From beginning observation to January 1, 1888.	1887.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	Average from beginning observation to January, 1888.
	11	12	13	14	15	16	17	18	19	20	21	22
1	1881	July 1, 1881	2,375	365	0.159	0.217	1.226	0.396	0.493	1.101	0.423	0.605
2	1881	....do	2,375	365	1.120	0.423	0.576	0.195	1.086	0.538	0.842	0.650
*3	1881	Sept. 1, 1881	2,313	365	1.930	0.829	1.881	0.256	0.901	0.383	1.135	0.952
6	1882	Jan. 1, 1883	1,826	365	......	......	1.214	0.489	0.638	1.112	0.552	0.801
7	1882	....do	1,826	365	......	......	1.582	0.277	1.160	0.494	0.573	0.817
8	1882	....do	1,826	365	......	......	1.676	0.533	1.253	0.118	0.046	0.725
*9	1882	....do	1,826	365	......	......	1.687	0.861	0.953	0.278	0.625	0.881
11	1883	Oct. 1, 1883	1,553	365	......	......	0	1.084	1.974	1.187	1.660	1.389
12	1885	... do	1,553	365	......	......	0	0.891	0.465	0.264	0.746	0.587
14	1885	... do	1,553	365	......	......	0	1.647	1.792	0.867	1.610	1.392
17	1883	....do	1,553	365	......	......	0	1.132	1.111	0.498	1.000	0.879
21	1885	Apr. 1, 1885	1,005	365	......	......	......	......	0.036	0.078	0.983	0.495
22	1887	June 1, 1887	214	214	......	......	......	......	......	......	0	0
4	1881	June 15, 1881	2,390	365	0.6635	0.595	0.614	0.198	0.156	0.418	0.297	0.407
*5	1881	Sept. 1, 1881	2,313	365	1.584	1.027	0.790	0.326	0.536	0.569	0.227	0.632
10	1882	Jan. 1, 1885	1,826	365	......	......	1.077	0.475	0.329	0.503	0.595	0.596
13	1883	Sept. 15, 1885	1,569	365	......	......	0	0.433	0.438	0.879	0.583	0.543
15	1883	... do	1,569	365	......	......	0	0.246	0.412	0.258	0.429	0.313
16	1883	Mar. 1, 1884	1,401	365	......	......	......	0.311	0.143	0.329	0.802	0.421
18	1884	....do	1,401	365	......	......	......	0.290	0.372	0.553	0.651	0.471
19	1884	....do	1,401	365	......	......	......	0.551	0.897	0.277	0.492	0.554
20	1885–'86	June 1, 1886	579	365	......	......	......	......	......	0.144	0.252	.212
23	1887	Sept. 1, 1887	122	122	......	......	......	......	......	......	0	0
24	1887	....do	122	122	......	......	......	......	......	......	0	0

* Marshy ground.

REMARKS.—These trial-lengths are on single-track road. First group, 25 to 29 trains per day; second group, 14 trains per day. Rails, 38 kilograms per meter; steel angle splice bars. Ballast—gravel, sand, and cinder. Heaviest engine on these lines, 50 tons, with $13\frac{1}{2}$ tons on the heaviest axle; heaviest engine on other lines, 63 tons, with 13.9 tons on the heaviest axle. Speed up to 50 miles per hour (on some parts 60 miles per hour). A day's maintenance per man costs 2.19 francs; the results of columns 15 to 22 may be transformed into days by dividing by 2.19. The figures in columns 15 to 22 give the expense for work of maintenance, not the expense for purchase of new spikes, bolts, etc. Not one of the metal ties in this table, nor of the 124,000 steel ties in use on other lines of the Netherlands State Railroad Company, has broken in the track.

DISCUSSION.

E. E. Russell Tratman, Jun. Am. Soc. C. E.—Having received from Mr. J. W. Post, only a few days before the convention, the paper on "Maintenance Expenses of Track with Steel and Wooden Ties on the Netherlands State Railroad," which I have transmitted to the society by request of Mr. Post, I had not time to give as much attention as I would like to have done to this discussion.

The subject of metal railroad ties is one in which I take very much interest, and for some time past I have been engaged in making extensive investigations and collecting information with regard to practice and experience in foreign countries. In making my investigations I have been surprised at the great extent to which metal ties have been actually adopted for service, for while I knew that experiments had been made in many countries, in some cases on a quite extensive scale, I had no idea that, as a result of some of these experiments, many railroads had practically adopted these ties for regular use; this, however, I found to be the case, and several European railroad companies are now gradually substituting metal for wooden ties on their systems. I think few engineers who have not paid especial attention to this matter realize that metal ties are in actual service, the general impression seeming to be that while many experiments have been made and are still being continued, yet that no practical results have been obtained. To this lack of appreciation of the results of foreign experience may be attributed to a considerable degree, I think, the general indifference of American engineers to the question of metal track. The fact that the question of the future timber supply is one of serious import does not seem to be realized, although the reports of the forestry division of the United States Department of Agriculture show that use and waste are playing havoc with a supply that cannot, under the present system (or want of system) of forestry in this country, be renewed in proportion to the demand. It has always seemed to me surprising that American engineers, who are usually in the van of any great step in the profession, should have paid so little attention to this very important matter; important both as to the financial economy and the practical efficiency of the track. In my opinion steel ties should be used as the standard for first-class track, and not merely as a substitute for timber when the latter becomes scarce or expensive. For instance, on such a road as the projected New York and Boston Rapid Transit line, which is intended to be an independent line, and which will probably, when it materializes, start out with a heavy and rapid traffic, steel ties should be laid down in the first place. The same holds good for existing trunk lines, on which steel ties should be introduced, as an advancement in railroad engineering and a step towards economy.

Taken as a whole, the results of experience have been satisfactory, and the type which has been found to be the best is the cross-tie of the familiar reversed trough section. Cast-iron "bowl" sleepers are much used in new countries, and longitudinal iron sleepers are still used to some extent in Austria and Germany, but the cross-tie of trough section is the best type, as has been proved by experience and careful tests. In consequence this form of tie is being more and more widely adopted, numerous variations of section and various styles of rail fastenings being used, in accordance with the ideas of different engineers. In England several railroads are using steel cross-ties to a greater or less extent, but in consequence of the engineers keeping to the double-headed rail in chairs the track is very complicated and expensive, representing money wasted and lying idle in much useless metal, whereas with a good flange rail a metal track might be obtained more economical and more efficient than the present style of rails and chairs on wooden sleepers. Experience has shown that the ends should be closed, but in quite a number of cases open-end ties are used. With open ends, of course, the ties are more liable to lateral displacement, as they do not present the area of resistance presented by a wooden tie or a closed end.

As will be seen by Mr. Post's paper, the Netherlands State Railroad Company has made a systematic series of trials of different types of metal ties, and the very valuable and important result of these trials has been the designing of the mild steel rolled tie of trough section, with varying thickness, now well known as the "Post" tie, which has been adopted to a very considerable extent on European lines. Mr. Post has been fortunate in having charge of a road owned by a progressive and far-seeing corporation, which has grasped the economic purposes of metal track, and encouraged its engineer in his work of investigation. The comparisons of the different systems were gone into most thoroughly, account being taken of the amount of labor, time, and expense involved in maintenance, renewals, and repairs, and therefore Mr. Post has been able, gradually but steadily, to improve the form of tie, until he has arrived at the present form, which is correct in theory and successful in practice; it is easily manufactured, and has proved in service its advantages in point of economy and efficiency. The trouble experienced with early forms of ties was that they failed by cracking, generally between the holes for rail attachments, and if made thick enough to prevent cracking they were too heavy and expensive. With the "Post" tie the thickness is increased at the rail seat, giving ample strength where required, but without any undue excess of weight. This strengthening is secured in the operation of rolling by the use of special machinery, and in the same operation is secured the inclination of the ends which gives the rails an inward cant of one in twenty, in accordance with European practice. Many European steel works have orders on hand for "Post" ties.

The question of rail fastenings is one almost as important as that of the type of tie, and many different plans have been tried, some simple, but the majority very complicated. All riveting causes an extra expense, but a very favorite plan is to have a "clamp" or "crab" riveted to the tie to hold one side of the rail flange, the other side being held by a bolted clamp. Mr. Post, realizing that all extra shop-work is necessarily expensive, has adopted bolts exclusively, with entirely satisfactory results. It will be noted that the first type of metal tie experimented with had wooden blocks for the rails to rest upon, the idea being that the rail required an elastic seat. This seriously impaired the general efficiency of the tie, for the wood rotted and gave constant trouble, so that this form of tie was soon abandoned. It has been conclusively proved by experience with various types of ties in different countries that such a wood-bearing is not only unnecessary, but a positive disadvantage, and that the track is satisfactory to railroad men and travelers when the rail is fastened directly on the metal tie, and therefore no wood should be used at all, but a metal track should be entirely of metal. The introduction of metal ties has been hampered by the attempt to secure a "cheap" tie. The objects in using metal are to obtain economy in maintenance and efficiency in operation, and neither of these objects can be obtained by using a tie which is "cheap." Every desirable feature can not be combined in one piece of steel, and if the tie is to make the track safer, reduce the maintenance expenses, keep the road in better condition, and far outlast the wooden tie, it must have sufficient metal to insure these advantages. You need to have, and to pay for, enough metal to make an efficient tie; but you need not have, and need not pay for, extra metal that is mere dead weight. With ties, as with rails, the design and manufacture are equally as important points as the weight, and the rail fastenings no less important.

Two points need to be considered in designing or adopting a metal track, viz, economy and simplicity. Cheapness is very far from being economy, being in fact directly opposed to it. Simplicity is necessary, both for economy and efficiency, as the track which, while possessing ample strength, is the most simple in its construction, will give the least trouble, and consequently involve the least expense for maintenance. A good metal track, once well laid, is in itself a source of economy in maintenance and operation, and it is to be hoped that this type of track will soon be a feature of first-class American railroads.

In nearly every large country but America, and in many of the smaller countries, metal ties have been experimented with, and I would strongly urge that more practical attention should be paid to so important a matter by American engineers, railroad men, and steel manufacturers.

At the International Congress of Railroads, September 17 to 24, 1887, the following resolutions were the outcome of its discussions:

(*a*) The opinion of the Brussels Congress that iron ties are of equal value to wooden, has not been negatived during the last two years; the application of iron ties is rather on the increase.

(*b*) The question whether the use of wood or metal ties is cheaper depends on the local conditions and the state of the iron market.

(*c*) Regarding cost of maintenance and renewal, not yet sufficient data are on hand for lines with large and rapid traffic; for medium traffic and slow trains the iron ties offer advantages, especially when after some time the track has consolidated and the fastening has settled well.

(*d*) For the "Vautherin" form the use of a homogeneous metal is desirable.

PATENTS RELATING TO METAL RAILWAY TRACK.

By E. E. Russell Tratman.

The following list of United States patents relating to metal railway track will be found useful by persons interested in this subject. It could not practically be made anything more than a descriptive index, giving sufficient information to enable any one who wishes to investigate more fully to find the specifications.

No. 1,262; date, July 26, 1839; J. Stimpson.—Transverse frames resting on longitudinal timbers, with inclined braces to hold them in position, and sockets at the top to receive the web of a rail with a very narrow flange.

No. 16,898; date, March 24, 1857; H. Carpenter.—A short hollow post under each rail, connected by a tie-plate; T-shaped fastening fitting into hollow of post.

No. 18,494; date, October 27, 1857; S. A. Beers.—Continuous longitudinal structure with transverse tie-plates. Saddle rail of ∩ section.

No. 19,704; date, March 23, 1858; S. H. Long.—Cross-ties of channel ⊓ section or T section (the latter made of two angle irons). Continuous flat plate under ordinary rail.

No. 20,620; date, June 22, 1858; W. Bryent.—Combined longitudinal grooved rail and iron pavement.

No. 32,794; date, July 9, 1861; B. C. Smith.—Wide longitudinal channel sleeper and rail combined, with transverse rods. A raised rib lengthwise of the sleeper forms the rail.

No. 36,579; date, September 30, 1862; B. C. Smith.—Longitudinal cast-iron continuous bearing, of channel section, connected by transverse tie-rods. Rail secured to chairs.

No. 53,507; date, March 27, 1866; Franz Vester.—Flat cross-tie, with two deep corrugations along its whole length. Ends turned down.

No. 66,711; date, July 16, 1867; R. M. Holland.—Cross-tie of ⅄ section. Flange cut away for rails. Hinged wedge fastening.

No. 70,731; date, November 12, 1867; Henry McCan.—Broad flat transverse base-plates, with longitudinal girders held together by tie-rods. Rails resting on top of girders.

No. 71,063; date, November 19, 1867; Leonard Repsher.—Wrought-iron flat cross-tie, bent up at ends to embrace flange and web of rail, angle-clamp bolted to tie on inside of rail. Bolt through clamp, web of rail, and end of tie.

No. 83,880; date, November 10, 1868; J. Potter.—Flat transverse base-plate, with two uprights which support continuous stringers, to which flangeless T-rails are bolted.

No. 109,504; date, November 22, 1870; C. Fisher.—Cross-tie of inverted trough section, with closed ends. Two pockets for wooden bearing-blocks. Rail fastened by flat plates resting on tie and rail flange, screwed to the wooden blocks.

No. 112,805; date, March 21, 1871; S. M. Guest.—A railway joint chair, combined with an iron cross-tie of T section.

No. 121,956; date, December 19, 1871; J. Newton.—A rail fastening for iron ties. Flat tie with end turned up; wooden wedge between rail and end of tie; vertical gib and cotter fastening (with serrated cotter) on inside of rail.

No. 123,526; date, February 6, 1872; L. E. Towne.—Cylindrical cross-tie with a flat base plate at each end, and a rail chair on top at each end, secured by a strap passing round the tie.

No. 124,521; date, March 12, 1872; R. M. Upjohn.—Longitudinals under each rail, of ⊥ section with very high vertical web. The rail is of ⊓ section and rests upon the flanges of channel irons bolted to the vertical web of the longitudinals.

No. 134,418; date, December 31, 1872; James Calkins.—The continuous longitudinals of channel sections have lugs to hold the outer flange of rails; transverse plates project over the inner flange and are bolted to the longitudinals.

No. 136,067; date, February 18, 1873; J. W. Kern.—A continuous roadbed of Λ section, with the rails laid on the horizontal flanges. Transverse base plates at intervals. The bed to be of $\frac{1}{4}$-inch boiler-iron.

No. 139,518; date, June 3, 1873; W. Peck and H. C. Richman.—Two chairs connected by a horizontal flat tie-plate. Wooden bearing-blocks in the chairs.

No. 140,411; date, July 1, 1873; C. W. Gulick.—A flat wrought-iron cross-tie with ribs to form a channel for the flange of the rail. Fastenings of iron $\frac{4}{10}$ inch diameter under tie, passing up through holes in the same, with ends bent over rail flange. Ties about 5 inches wide and $\frac{1}{2}$ inch thick.

No. 143,407; date, October 7, 1873; P. S. Devlan.—A cross-tie made of two iron plates on edge, fastened together at the middle and widening out to hold a wooden block at each end.

No. 144,207; date, November 4, 1873; George Keech.—Longitudinal plates under each rail, with lugs to hold outside of rail flange. Tranverse tie-plates project over the inner flange and are secured by horizontal bolts passing through lugs on the base plate.

No. 145,991; date, December 30, 1873; H. L. De Zeng.—Wrought-iron cross-tie of ⊓, ⌐∪⌐∪⌐, or other section. A clip stamped out of the metal holds outer flange of rail; loose clip secured by vertical key or cotter holds inner flange. (See 155,369.)

No. 146,376; date, January 13, 1874; G. H. Blaisdell.—A cast-iron cross-tie of Λ section with wide, flat, deep ends, having sockets for wooden blocks. A bolt passes through both blocks and the whole length of the tie.

No. 147,563; date, February 17, 1874; P. Kendrick and J. Stokes.—A cross-tie made of two old rails laid parallel, with a wooden block between them at each end, and base plates if desired.

No. 148,242; date, March 3, 1874; George Potts.—Continuous bearing of wood held between two continuous iron stringers of ⊥ section, the top of the web being bent over to hold the rail flange. Bolts pass through the three pieces.

No. 155,369; date, September 29, 1874; H. L. De Zeng.—A cross-tie of inverted trough section, with open ends, but with projecting wings at ends to prevent lateral displacement. See No. 334,696.

No. 163,187; date, May 11, 1875; S. H. Hamilton.—An iron or steel cross-tie of square hollow section throughout, or only at ends. Fixed lugs hold the inner flange of rail, and bolted plates hold the outer flange.

No. 163,254; date, May 11, 1875; H. Reese.—A rolled iron cross-tie of T section; lugs stamped out while hot from the rolls. Bent clip and horizontal wedge fastening for outer flange of rail. (See 214,192.)

No. 164,793; date, June 22, 1875; Ramon Bañolas.—Cross-ties of I section, carrying longitudinal stringers of ⊥ section, to which flangeless rails of ⅂ section are bolted.

No. 166,625; date, August 10, 1875; R. E. Nichols.—A continuous hollow bearing, section similar to lower half of letter A; bottom closed; top open, with horizontal flanges to carry the rail flange; cross-ties of ⊔ section. Longitudinals and cross-ties filled with broken stone.

No. 171,422; date, December 21, 1875; John Quigley.—A cast-iron cross-tie with chair combined, for street railway track.

No. 172,041; date, January 11, 1876; E. E. Lewis.—A cross-tie of + section, with the top vertical flange cut away for the rails, which are secured by wedges. (See 183,766.)

No. 176,213; date, April 18, 1876; George D. Blaisdell.—A cast-iron cross-tie, with wide ends and loose bearing blocks, all held together by a bolt running through the whole length of the tie.

No. 182,984; date, October 3, 1876; Leonora E. Yates.—Cross-ties of , , or section, the latter being semi-cylindrical, with flanges. The rails are fastened by bolted clamps.

No. 183,766; 183,767; 183,768; date, October 31, 1876; E. E. Lewis.—A cross-tie of + section; rails of different forms. Also a joint tie of section. (See 172,041.)

No. 185,808; date, December 26, 1876; D. S. Whittenhall.—A cross-tie of section; the rails resting in notches in the top ridges.

No. 188,087; date, March 6, 1877; H. S. Wilson.—A cross-tie of I section, with fixed and movable rail clips.

No. 188,710; date, March 20, 1877; N. S. White.—A continuous bed-plate under each rail, with cross-ties.

No. 190,739; date, May 15, 1877; A. H. Campbell.—A cast-iron cross-tie, with sockets for wooden bearing-blocks.

No. 192,842; date, July 10, 1877; A. W. Serres.—A continuous bearing of section (in two pieces) under each rail, with transverse tie-bars. The web of a flangeless rail lies between the two vertical webs. (This track has been used in Europe. See Engineering News, New York, January 29, 1887, page 73; also Railroad Gazette, New York, August 19, 1887.)

No. 198,000; date, December 11, 1877; John B. Ward.—A longitudinal iron pipe (for conveying water) under each rail; the bottom of rail curved to fit pipe.

No. 198,464; date, December 25, 1877; E. E. Lewis.—A cross-tie consisting of an old rail with two notches cut to the level of the flange to admit the track rails. Two rails with wooden bearing-blocks used at joints. (See 172,041.)

No. 198,618; date, December 25, 1877; D. Horrie.—A transverse truss of cast or wrought-iron. Horizontal hook-bolt fastenings.

No. 201,667; date, March 26, 1878; H. A. Haarmann.—Continuous bearing for each rail, with cross-ties. This track has been extensively used in Europe. (See Engineering News, New York, January 29, page 74.) (See 219,856.)

No. 206,647; date, July 30, 1878; T. W. Travis.—A hollow cross-tie, with boxes at the ends open on top. The rails are held between two clips; the groove holds the rail-flange; the upper web lies against the rail web, and the lower web is wedged into the box.

No. 207,242; date, August 20, 1878; J. A. Bonnell.—An inverted trough cross-tie, with closed ends and corrugated top. Bolted clips or angle-bar fastenings for rails.

No. 207,320; date, August 20, 1878; J. H. Thompson.—A cross-tie made in two pieces, dove-tailed together in the middle. The rails rest on wood blocks.

No. 207,719; date, September 3, 1878; W. E. Curtiss.—A wrought-iron cross-tie of inverted trough section with flaring sides, having a brace of the same section inside under each rail. The ends are open. Rails secured by bolted clips.

No. 210,774; date, December 10, 1878 (patented in Germany, January 18, 1878); F. B. Freudenberg.—A wrought-iron cross-tie of somewhat similar section to the preceding one. Hooked clips are riveted on for the inside and outside flange on alternate ties, the rails being sprung into place. Long ties for double tracks.

No. 214,192; date, April 8, 1879; H. Reese.—A cross-tie of T section, with the ends of the horizontal table turned down at an angle. Clip and wedge fastening. (See 163,254.)

No. 215,675; date, May 20, 1879; H. Reese.—Improvements upon the preceding one.

No. 216,846; date, June 24, 1879; L. A. Gouch.—A cross-tie of section, the longitudinal web being the widest and having its edges turned up or down.

No. 218,559; date, August 12, 1879; S. Nicholls (of England).—A continuous broad bed-plate under each rail, for street railways. The rail is formed of two channels, leaving a space between for the wheel flange.

No. 218,603; date, August 12, 1879; A. P. Whiting.—A cross-tie of section, the top flange cut away for the rails. Bolted clips hold the inner flanges of rails.

No. 218,648; date, August 19, 1879; C. F. Wagner (of Austria).—A cross-tie composed of two parallel pieces of T section, fastened together by cross-strips. Bolted clip rail fastenings.

No. 218,878; date, August 26, 1879; C. Hanshaw.—A cross-tie made in two pieces lengthwise; on one piece are clips for the inner flange of one rail and the outer flange of the other, and on the other piece are clips for the outer and inner flanges, respectively. The two pieces are held together by a flat horizontal key driven between other clips in the middle of the tie.

No. 219,856; date, September 23, 1879; H. A. Haarmann, of Prussia, (see No. 201,667).—A cross-tie of inverted trough section with flaring sides, and a flat or grooved top table. The rail fastenings are ⊏-shaped, with a bolt passing under the rail.

No. 220,026; date, September 30, 1879; H. T. Livingston.—A tubular cross-tie of oval section with a flat surface under each rail. Rails fastened by bolts screwed into the tie. Interior of tie packed hard with straw, grass, etc.

No. 221,596; date, November 11, 1879; O. E. Mullarky.—A cross-tie of channel section ⊓ with wooden bearing blocks wedged inside under the rails. The rails are fastened by bolted clips.

No. 223,187; date, December 30, 1879; J. R. Sullivan.—Two separate cast-iron bearing pieces connected by a tie-bar. Each rail is secured by a cast-iron wedge.

No. 226,308; date, April 6, 1880; A. Greig (patented in England March 25, 1879).—Flat crose-ties with one or two grooves along the whole length. A brace or clip is riveted to hold the outside of the rail, and the rail is held against it by a hook bolt, the body of which lies in the groove and has a nut at the end of the tie. (This system is much used for portable railways manufactured in England.)

No. 227,602; date, May 11, 1880; D. S. Whittenhall.—Improvements on No. 185,808.

No. 9,292 (re-issue); date, July 13, 1880; H. Reese.—See original number 214,192 of April 8, 1879.

No. 230,826; date, August 3, 1880; Lewis Scofield.—A cross-tie of _⊓_ section. Riveted and bolted clips for rail fastenings.

No. 231,755; date, August 31, 1880; William Brown.—A hollow cross-tie of rectangular section, with concave bottom and open ends. A rib at the ends keeps the rail in position, and it is fastened down by hooked bolts with nuts inside the tie.

No. 233,528; date, October 19, 1880; W. C. Lutz.—A cross tie of ⊥ section, with the rails secured by flat hooked clips bolted to the side of the vertical web. (See 241,389.)

No. 235,078; date, December 7, 1880; G. H. Gilman.—A cast-iron cross-tie of rectangular section, with grooves to reduce the weight. The rails are held by fixed and movable lugs.

No. 235,321; date, December 7, 1880; F. A. Williams.—The two broad bearing plates on which the rails rest are connected by two transverse tie-plates, placed on edge.

No. 240,987; date, May 3, 1881; I. W. Fleck.—A cross-tie made of an ordinary rail, head down, with strengthening sections and a broad base plate bolted to it. It is curved into an arch form, high in the middle, with the ends level for the track rails.

No. 241,389; date, May 10, 1881; W. C. Lutz.—A cross-tie of cylindrical form, with flat-bearing surfaces for the rails; or with a vertical web on top, with notches for the rails. (See 233, 528.)

No. 242,850; date, June 14, 1881; H. Thielsen.—Cross-tie of T section; in two halves, one under each rail. Bent clips formed out of the metal of the tie. The two pieces keyed together at the middle. (See 317,244.)

No. 246,888; date, September 13, 1881; G. A. Jones.—A cross-tie of ⊥ section with the ends formed into a chair. The rail is held in the chair and spiked to a wood block.

No. 247,248; date, September 20, 1881; Levi Haas.—A cross-tie made of an old rail with the ends resting on wood blocks; the track rails are secured to the top of the tie. (See 257,572.)

Nos. 249,270, 249,271; date, November 8, 1881; E. H. Tobey.—Cross-ties of ⊔ or V section; the rails are held in chairs resting on wooden blocks.

No. 249,503; date, November 15, 1881; J. Clark.—A cross-tie of semicircular section , the bottom fastened to a flat bed-plate the whole length of the tie. The top of the arch cut away for the rail. (See 256, 199, 259, and 095.)

No. 251,251; date, December 20, 1881; C. F. Kreuz.—A flat cross-tie with thickened ends to hold the outer flanges of the rails; and a flat cross-tie with another flat piece resting on it to hold the inner flanges of the rails. These ties placed alternately. (See 263, 919.)

No. 254,892; date, March 14, 1882; J. Conley.—A flat cross-tie in two pieces, with the inner end of each turned up so as to be bolted together. Under the rails the sides are turned down. Clips are stamped out of the metal. (See 332, 384.)

No. 255,554; date, March 28, 1882; F. A. Williams.—A cross-tie of shallow inverted trough section, with broad ends. The rails are held against fixed clips by plates the whole length of the tie, placed on edge, underneath, with a hooked end to hold the rail flange. These plates are secured by a horizontal key in the middle of the tie.

No. 256,199; date, April 11, 1882; J. Clark.—Improvements upon No. 249,503.

No. 257,437; date, May 2, 1882; H. De Zavala.—A cross-tie of Λ section, with U bolts passing under the rail and having nuts screwed down on the rail flange.

No. 257,572; date, May 9, 1882; Levi Haas.—A cross-tie consisting of two cast-iron bed-plates, with bearing blocks to which the rails are bolted. A tie-bar connects the two bed-plates.—See No. 247, 248, 315, 771, 389, and 464.

No. 259,095; date, June 6, 1882; J. Clark.—Further improvements on Nos. 249,503 and 256,199. (See 270, 637; also August 5, 1884, and 358, 144.)

No. 259,823; date, June 20, 1882; A. L. Cubberlery.—A flat cast iron cross-tie, with concave bottom, and dove-tail grooves on top for sliding rail-fastenings into place.

No. 259,891; date, June 20, 1882; J. H. Meacham.—A cross-tie of ⊥ section, with end boxes for wood blocks, to which the rails are secured by hook bolts.

No. 260,231; date, June 27, 1882; J. Parr.—A cast-iron cross-tie with fixed and movable lugs for the flanges of the rails. (See 277,333.)

No. 263,919; date, September 5, 1882; C. F. Kreuz.—A cross-tie of ⊢⊣ section, the rails resting on the web and secured by wedges. An improvement on No. 251,251.

No. 265,760; date, October 10, 1882; M. I. Cortright.—A cross-tie with two grooves or corrugations in its length, and with notches to receive the flange of the rails.

No. 267,930; date, November 21, 1882; G. L. Putnam.—A cross-tie of square section, hollow or solid, with hooked spikes put in place from the bottom and tapering upwards. (See 285,842.)

No. 269,442; date, December 19, 1882; R. B. Meeker.—Cross-ties of T section, with broad table. Flat horizontal bars with turned-up ends, used alternately with the ties. The rail to be of extra height, bolted to chairs

No. 270,637; date, January 16, 1883; J. Clark.—A flat cross-tie with arched bearing plates and chairs. See No. 259,095.

No. 272,850; date, February 27, 1883; T. Breen.—A flat cross-tie twisted spirally in the middle and having the ends turned up. (See 294,191.)

No. 274,309; date, March 20, 1883; W. H. Gibbs and George Snook.—A cross-tie of ⊥ section, with supports for a rail-chair of inverted-trough section, with a wooden block, to which the rail is secured by hooked clamps.

No. 276,414; date, April 24, 1883; E. B. Hungerford.—A cross-tie of shallow channel section ⊔. The flanges are cut away and notched to hold the rail-flange, and the rail rests on a loose bed-plate with a clip to hold the other flange; the plate being held in place by a horizontal key driven through holes in the tie-flanges.

No. 277,333; date, May 8, 1883; J. Parr.—A hollow cast-iron cross-tie. The rails are secured to loose chairs, having long projections which run nearly through the tie and are secured by a vertical bolt at the middle of the tie. (See No. 260,231.)

No. 280,110; date, June 26, 1883; S. B. Wright—A cross-tie of inverted-trough section, with the inside of the top arched. (See 298,539.)

No. 280,200; date, June 26, 1883; J. Mahoney and D. W. Shockley.—A cross-tie of ⊥⊥ section, with wooden bearing-blocks. (See No. 370,634.)

No. 281,806; date, July 24, 1883; A. R. Spaulding.—A cross-tie of channel section ┌──┐ to which the rail is fastened by a series of flat horizontal keys or wedges in dove-tailed grooves.

No. 283,076; date, August 14, 1883; J. L. Chapman.—Cross-ties of shallow channel └──┘, or of two flat plates, one above the other, separated by distance-blocks. Each rail is secured by bolted clips to a bed-plate.

No. 283,230; date, August 14, 1883; H. F. Flickinger.—A cross-tie of I section, to which the rails are secured by ∩ bolts with the nuts on the under side of the top flange of the tie.

No. 284,157; date, August 28, 1883; J. W. Young.—A hollow, open-sided, elastic cross-tie of ⊐ section; to be filled with ballast or earth on surface lines. Two or more of these plates to be placed inside one another, with one side open, or to form a closed tie. It is claimed to be adapted to elevated roads.

No. 285,833; date, October 2, 1883; John Newton.—Channel-iron stringers ┌──┐ with flat cross-ties fastened to the top.

No. 285,842; date October 2, 1883; George L. Putnam.—A cross-tie of T section, depressed in the middle to hold a water-trough for supplying locomotives. The rails are secured by bolted clips. See No. 267,930.

No. 285,986; date, October 2, 1883; Clark Fisher.—A bent-plate cross-tie, of ∩ section in the middle, with flat ends. A U bolt passes under the rail, and washers are screwed down on the rail flange by the nuts.

No. 287,418; date, October 30, 1883; J. J. Clarke (of Peru).—A flat plate tie for portable railway track, with special joint fastenings. (Assigned to A. W. Colwell, New York.)

No. 289,806; date, December 11, 1883; T. J. Bronson and A. Armstrong.—An iron or steel cross-tie of approximately semi-cylindrical section ∩, with lugs struck up by means of dies.

No. 290,793; date, December 25, 1883; L. O. Orton.—A flat inverted trough cross-tie, with wedge-shaped boxes projecting above and below to hold the bearing blocks and fastenings.

No. 291,514; date, January 8, 1884; H. R. Holbrook.—A hollow cross-tie of oval section, with thickened portions under the rails; rails secured by bolted clips.

No. 292,421; date, January 22, 1884; J. J. Du Bois.—A cross-tie, with dove-tailed groove for rail and a wedge fastening.

No. 293,194; date, February 5, 1884; J. Reven.—A flat tie-bar to keep rails from spreading; one end bent up to hold rail, the other end having thread and nut, with movable clamp.

No. 293,302; date, February 12, 1884; George W. Bloodgood.—Bolted clips for fastening rails to ties of inverted-trough section.

No. 294,191; date, February 26, 1884; T. Breen.—A cross-tie made in two pieces, lengthwise; placed side by side, holding the rail-chairs and fastenings between them. (See 272,850.)

No. 296,725; date, April 15, 1884; W. T. Carter.—A hollow cross-tie, with flat top and bottom and concave sides.

No. 298,539; date, May 13, 1884; S. B. Wright.—Fastening rails to inverted-trough cross-ties by clips and T-headed bolts. (See No. 280,110.)

No. 299,557; date, June 3, 1884; J. Lockhart.—A clamp or tie-rod, to be used in connection with wooden ties. A tie-rod, running across the track, has clamps to hold the rail flanges, the inner clamps being held by set-screws. It is claimed that soft-wood ties can be used, as there will be no tendency for the rails to spread. (See 327,285.)

No. 302,965 and No. 302,966; date, August 5, 1884; C. S. Westbrook.—A cross-tie of ┌─┐ section, with parts of the horizontal table cut away. The rails are held by riveted and keyed angle plates.

Nos. 10,504, and 10,505 (re-issues); date, August 5, 1884; J. Clark.—Improvements in No. 249,503.

No. 303,373; date, August 12, 1884; E. G. Holtham (of England). Patented in England, December 22, 1883.—Broad longitudinals under each rail, with transverse tie-rods, and with additional side plates to increase the bearing on the ballast.

No. 304,746; date, September 9, 1884; G. W. B. Neal.—A cross-tie made of triangular section, with the rails carried in and bolted to chairs fastened to the apex of the tie.

No. 306,090; date, October 7, 1884; Robert Moffly.—A cross-tie made of three pieces the full length of the tie, bolted together so as to form a ⊥ slot along it, in which the rail fastenings slide.

No. 306,139; date, October 7, 1884; B. W. De Courcy.—A cross-tie of ∩∪∩ section, with the rails resting on the top and secured by hooked clamps bolted together below the rail.

No. 309,428; date, December 16, 1884; J. H. Williams.—A cross-tie of U section, with wooden blocks to which the rails are spiked.

No. 310,269; date, January 6, 1885; Abraham Gottlieb.—A cross-tie of inverted-trough section, with a groove along its top table. The rail is fastened by bolted clips or a special form of locking-plate or chair.

No. 312,566; date, February 17, 1885; W. H. Knowlton.—Cross-ties of different sections.

No. 312,717; date, February 27, 1885; E. N. Higley.—A flat cross-tie with sides and ends turned down and with a vertical rib along the middle. This rib cut away for the rails, which are fastened by bolted clips. General section thus, ⌒⌒. See No. 334,228. (Manufactured by the International Railway Tie Co., of New York. See Appendix B of report on metal track.)

No. 312,881; date, February 24, 1885; W. McVey.—A metal cross-tie in two pieces, mortised together at the middle and secured by a bolt.

No. 313,072; date, March 3, 1885; A. A. Harrison.—A combined flat longitudinal and cross tie; the cross-tie having plate at right angles and being laid so that these plates of adjacent ties meet.

No. 314,757; date, March 31, 1885; C. H. Van Orden.—A cross-tie of T section, with a rail chair at each end, the rails being secured by bolts which have hooked ends passing through the top of the tie.

No. 315,047; date, April 7, 1885; M. A. Martindale.—Longitudinals of inverted-trough section with rails forming a part of or bolted to the top table. Connected by transverse tie plates. Claimed to be adapted for laying along highways.

No. 315,771; date, April 14, 1885; L. Haas.—A cross-tie made of two pieces the full length of the tie, with the section of figure 1, having wooden-bearing blocks to which the rails are spiked. See No. 257,752.

No. 317,244; date, May 5, 1885; H. Thielsen.—A cross-tie of T section, the sides of the top table being turned down. (See No. 242,850.)

No. 317,763; date, May 12, 1885; M. A. Glynn (of Cuba).—Cross-ties of ⌐∩¬ or ⊥ section; also longitudinals of inverted trough section.

No. 319,010; date, June 2, 1885; A. J. Moxham.—A cross-tie made of two angle-irons, with distance-plates at the ends and middle ┌─ ─┐; the rails are bolted to high chairs. The tie is intended for street railways, and is shown with a center-bearing girder-rail.

No. 319,813; date, June 9, 1885; G. C. H. Hasskarl.—A hollow box cross-tie, with a Y-shaped web inside; the small middle space receiving the T heads of the track-bolts. It is also to be used as a longitudinal sleeper for street railways, the two large side spaces being used as conduits for telegraph wires, etc.

No. 320,231; date, June 16, 1885; E. D. Dougherty and George B. Bryant.—A cross-tie of rectangular section, with an opening in the top table to receive a smaller cross-tie to which the rails are fastened, and which rests on springs placed in the larger box.

No. 323,356; date, July 28, 1885; G. Murray.—A flat cross-tie thickened under the rail, and having a rib at the bottom under each rail, and in the middle; the rails secured by bolted plates.

No. 323,430; date, August 4, 1885; J. K. Lake.—A combined metal stringer and chair for street railways.

No. 323,809; date, August 4, 1885; William B. Henning.—A longitudinal plate lies under each rail; with cross-ties having deep ends with ⊥ slots to receive the web and flange of the rails. (See 376,884.)

No. 325,020; date, August 25, 1885; R. R. Shepard.—A cross-tie of channel section with one outer and one inner lug for each rail, and two slots for clips of -shape with eccentric heads.

No. 326,874; date, September 22, 1885; P. Kirk (of England).—A cross-tie with increased thickness at the rail seats, and with two lugs or clips punched up to hold the flange of each rail; the rail being secured by a wedge driven between the flange and one of the lugs (patented in England, France, Belgium, and Spain, in 1885).

No. 327,285; date, September 29, 1885; J. Lockhart.—An improvement upon No. 299,557.

Nos. 327,745 and 327,843; date, October 6, 1885; L. E. Whipple.—A cross-tie of X section, made of two curved plates placed back to back and having flat plate across top and bottom.

No. 328,632; date, October 20, 1885; J. S. Ammon.—A cross-tie of Λ section with rail chairs secured to the top ridge.

No. 329,429; date, November 3, 1885; G. E. Baldwin.—A pair of rail chairs of shape, resting on wooden blocks and tied together by a rod. The top table has a groove to receive the web of a rail of T section, having no bottom flange. Intended especially for city railways.

No. 329,821; date, November 3, 1885; P. Davey.—A cross-tie of channel section, to which the rails are secured by keys and Z-shaped clamps, the lower part of the latter lying inside the tie.

No. 332,384; date, December 15, 1885; J. Conley.—A fastening for attaching rails to metal ties, which have lugs to hold the outer flange of rail. The fastening is a bar inside the tie, with a hook at one end projecting through a hole and holding the rail flange, while the other end is bent up against the end of the tie. (See 254,802.)

No. 333,015; date, December 22, 1885; J. Howard and E. T. Bousfield (of England).—A cross tie of section, with a U-shaped depression for each rail, the rail being secured with a wooden wedge. (These ties have been used with the English double-headed rail; patented in England.) (See 335,523.)

No. 333,480; date, December 29, 1885; L. B. Prindle.—A steel cross-tie three-eighths to one inch thick; channel section ; at each end is a slot to receive a tenon at the bottom of a rail chair.

No. 334,228; date, January 12, 1886; E. N. Higley.—An improvement on No. 312,717. (See 353,028.)

No. 334,696; date, January 19, 1886; H. L. De Zeng.—An improvement in fastenings. (See Nos. 145,991 and 155,369; also 380,623.)

No. 335,523; date, February 2, 1886; J. Howard and E. T. Bousfield (of England).—A cross-tie made of a metal sheet or plate, with one or more corrugations lengthwise, the rails being held in chairs made by cutting away the corrugations. (See No. 333,015.)

Nos. 335,804 and 335,805; date, February 9, 1886; E. P. J. Freeman.—A cross-tie made of a sheet of metal bent to form a rectangular box. A wooden block is placed inside, under each rail, and a spike is driven into the wood through a hole in the metal. The spike may be split so as to flare like Λ when driven in combination, a guard-rail of a plate bent to Z shape, the rail lying on the bottom flange and all fastened to the tie.

No. 338,057; date, March 16, 1886; J. Gearon.—A continuous road-bed made of channel cross-ties placed alternately ⊓ and ⊔, with the vertical flanges overlapping one another.

No. 339,275; date, April 6, 1886; J. DeMott.—A cross-tie with a rail chair at each end. The end of the tie is rounded on plan, and is embraced by a ⊂ clamp with the ends turned up to hold the rail flange.

No. 339,938; date, April 13, 1886; F. F. Scott.—A cross-tie with a chair for each rail; one half of chair fixed, the other fastened by bolts. Pins driven through the web of the rail prevent vertical movement.

No. 340,118; date, April 20, 1886; H. Howard.—A deep channel ⊔ cross-tie for street railways. The rails are keyed to chairs resting on the top of the flanges.

No. 341,416; date, May 4, 1886; F. V. Greene.—For street railways. A continuous cast-iron hollow bearing (preferably 10 feet long and weighing 140 pounds per yard) under each rail. The rails are grooved, and are screwed to the top of the longitudinal.

No. 342,987; date, June 1, 1886; A. N. Warner and T. J. Deakin.—A cross-tie of channel section ⊔ with T-shaped rail chairs fitting into it. The rail secured to chairs by bolts with hooked ends, the nuts being under the flange of the chair.

No. 344,011; date, June 22, 1886; C. H. Sayre.—Flat or arched ⌒ cross-ties with pieces punched out of the top and bent to embrace the flange and web of the rail.

No. 344,185; date, June 22, 1886; W. Kilpatrick.—A cross-tie of ◡ section, with a slot along the flat top to receive the bottom of the rail chairs.

No. 344,826; date, July 6, 1886; I. F. Good.—A flat cross-tie thickened and widened at the ends to form rail chairs, and having flanges projecting down under the chairs. The rails secured by keys.

No. 345,733; date, July 20, 1886; C. Sailliez.—A cross-tie of channel section ⊓, with lugs to hold the rail flanges. The flanges are cut away at the ends to allow of wooden stringers being used under the rails.

No. 346,998; date, August 10, 1886; D. Kaufman.—Flat cross-ties with chairs at the ends, and longitudinal continuous flat plates beyond the chairs. The space between the rails is covered by a continuous arched plate.

No. 349,524; date, September 21, 1886; E. Schmidt (of Prussia).—A cross-tie made of two old flange rails laid flat, head to head, forming a tie of H H section. The rails rest on the web and are fastened by bolted clips. (Patented in Germany.)

No. 350,692; date, October 12, 1886; T. L. Mumford and H. Moore.—A cross-tie of inverted trough section, wider at the ends, with fixed lugs and movable clamps for fastening the rails.

Nos. 351,498 and 351,499; date, October 26, 1886; E. C. Davis.—A cross-tie made of two old rails placed side by side. Each track rail rests on a bearing-block in two pieces, with a lip at the end to engage the rail flange. The blocks are slid into place between the tie-rails and bolted through the tie.

No. 352,002; date, November 2, 1886; E. F. Reynolds.—A cross-tie of IΛΛΛI section. The rails rest in notches cut in the top, and are held by hinged clips and locking clips.

No. 353,028; date, November 23, 1886; E. N. Higley.—Improvements upon Nos. 334,228 and 312,717.

No. 353,691; date, December 7, 1886; S. D. Locke.—A channel cross-tie ⊓, with inclined ends and a transverse rib in the middle. The rails are fastened by bolted clips. (See 356,002.)

No. 354,250; date, December 14, 1886; R. S. Sea.—A cross-tie of T section with enlarged ends forming rail chairs. (See 379,005.)

No. 354,433; date, December 14, 1886; R. Morrell.—A cross-tie made of a plate bent to form a hollow rectangular box, with the top and bottom cut away at the middle. The rails are fastened to wooden bearing-blocks placed inside the tie. (See 365, 932.)

No. 356,002; date, January 11, 1887; S. D. Locke.—An improvement on No. 353,691.

No. 358,144; date, February 22, 1887; J. Clark.—A cross-tie of channel section, with chairs for the rails. (See No. 249,503, etc.)

No. 358,981; date, March 8, 1887; J. C. Lane.—An iron bridle-rod, made in two pieces, bolted together at the middle, to prevent rails from spreading at the curves.

No. 359,115 and No. 359,117; date, March 8, 1887; W. Wharton, jr.—A cross-tie of ⊥ or L section, with the bottom flange bent up to make a chair for the rails. To be used on street railways with girder rails.

No. 359,440; date, March 15, 1887; T. Gleason.—A cross-tie of trough section ⊔, with interior cross-pieces or webs to which the rail clamps are fastened.

No. 360,397; date, March 29, 1887; M. Y. Thompson.—A flat cross-tie, with a U shaped depression at each end to receive a wooden bearing-block. The rails are fastened by keys.

No. 361,199; date, April 12, 1887; H. P. Adams.—A cross-tie of T section, with chairs keyed to it.

No. 361,330; date, April 19, 1887; P. J. Severac, of Paris.—A cross-tie of I section, with the horizontal flanges bent at the ends. In some cases a broad plate is riveted to the bottom flange. The rails are fastened by clips or keyed to chairs. (This system is in use in Europe.) Patented in France, Belgium, England, Italy, and Spain, in 1884–'85.

Nos. 362,786 and 362,787; date, May 10, 1887; J. Riley (of Scotland).—A cross-tie of inverted trough section, with the rail chairs stamped or pressed by dies, the rails being secured by wedges. (Patented in England and Belgium; 1885–'86).

No. 363,020; date, May 17, 1887; L. Taylor.—A hollow-box cross-tie, with outward-flaring sides and concave bottom. The rails are fastened by hook bolts with the nuts inside the tie.

No. 365,350; date, June 21, 1887; A. Roelofs.—A cross-tie of channel ⊓ or inverted trough section. The rails are fastened by fixed lugs on the outside, and a tie-bar which is sprung into place on the inside. Also a flat tie with a rib under each rail and a slot along the middle for the bent tie-bar.

No. 365,511; date, June 28, 1887; F. X. Georget.—A cross-tie or longitudinal, of channel section ⊔, built up of a base plate and two concave side plates with the tops flanged outward horizontally. The ties or longitudinals are connected by tie rods. (See 381,125.)

Nos. 365,932 and 365,933; date, July 5, 1887; R. Morrell.—A hollow cross-tie, made of a plate bent to an oblong section, with straps around it at the rail fastenings. The metal is cut away to let the rails rest on a wood block inside the tie; the metal straps keep the spikes from working loose and allowing the rails to spread. Also a tie for elevated roads, made of two plates on edge, fastened together at the middle, and flaring apart to admit wooden bearing-blocks between them. See No. 354,433.

No. 366,546; date, July 12, 1887; N. S. White.—A cross-tie of channel ⊓ or inverted trough section, with a base plate at each end, with a bearing-block of wood or other material inside under each rail. The rails are fastened by locking clamps.

No. 367,325; date, July 26, 1887; John Splane.—A cross-tie of ⊓ channel section, with the bottom of the sides flanged outwards. The rails are let into apertures in the top and rest on the hooked ends of two tie-bolts, the inner ends of which are connected by a turnbuckle which is tightened by a wrench, there being a hole in the middle of the top table of the tie.

No. 367,383; date, August 2, 1887; J. Fitzgerald.—The rails are fastened to a cast-iron cross-tie by hook-headed spikes, which are secured by horizontal keys fitting into corresponding notches in the tie and spike.

No. 369,591; date, September 6, 1887; J. H. Coffman.—A solid tie with a groove along the top and lugs for the inner flanges of the rail; hooked rods hold the outer flange, and the inner ends of the rods are attached to a spring at the middle of the tie.

Nos. 369,755 and 369,756; date, September 13, 1887; William L. Van Harlingen, sr.—A box cross-tie made of an inverted trough fastened to a base plate; inclined and closed ends. It incloses a wooden tie or wooden bearing blocks. The rail is fastened by wood-screws with wide heads. Also a metal tie with end boxes to contain springs on which the rails rest.

No. 370,072; date, September 20, 1887; R. C. Lukens.—A cross-tie of T section, with slots in the web for attaching weights or anchors to keep the track in position. The rails are fastened by lugs and bolts.

No. 370,192; date, September 20, 1887; D. C. Heller.—A hollow box-tie of rectangular section, with the top cut away under the rails. The tie is filled with concrete and has two wooden blocks to which the rails are spiked.

No. 370,226; date, September 20, 1887; C. W. Yost.—A flat tie with lugs, and a separate bed-plate, with lugs, for each rail.

No. 370,634; date, September 27, 1887; J. Mahoney and D. W. Shockley.—A cross-tie of section, with a saddle plate for each rail seat. The plate has a lug for one flange and a clip is bolted on the other. See No. 280,200.

No. 371,110; date, October 4, 1887; W. H. Troxell.—A cross-tie with raised rail seat and outer lugs. Hooked bolts, with nuts on the outer side of the chair, hold the inner flange of the rail.

No. 371,780; October 18, 1887; J. Moser and E. Moeckel.—A cross-tie of T section, with a chair at each end; each chair has an inclined rail-brace and two hook-bolts.

No. 372,230; date, October 25, 1887; A. McKenney.—Cross-ties of channel section, with one end cut off at an angle to allow of a diagonal tie to the next transverse tie, each set of three ties making a letter N on plan. Arranged continuously.

No. 372,525; November 1, 1887; J. A. Dunning.—A hollow rectangular cross-tie, with open inclined ends; bottom and sides have corrugations, transverely and vertically. Bolted clip fastenings.

No. 372,703; date, November 8, 1887; I. A. Perry.—A cross-tie made of two old rails, with saddle chairs fitting over the heads of these rails. Track rails fastened by chair and sliding wedge, being held by flange and web.

No. 372,864; date, November 8, 1887; C. Netter.—A cross-tie of T section, with the ends beyond the rails bent down vertically and then horizontally. Rails fastened by bolts having hooks, which take hold of the bottom of the web of the tie.

No. 372,879; date, November 8, 1887; J. H. Stull.—A cross-tie made of a plate bent to a semi-circular form, and semi-cylindrical at the ends. Rails fastened by clamps. Open ends.

No. 373, 656; date, November 22, 1887; W. P. Hall and C. C. Barnett.—A cross-tie of semi-circular section, with open ends. Shoulders pressed out to prevent spreading. Rails fastened to saddles or straps. (See 375,996.)

No. 375,005; date, December 20, 1887; R. S. Sea.—A cross-tie of channel section, with closed ends. A strengthening plate is bolted to the under side of the top table, and the side flanges are deeply notched to give elasticity. A metal block is bolted under each rail, and the rails are secured by bolted plates.

No. 375,856; date, January 3, 1888; R. T. White.—A cross-tie of ⊥ section, with high chair at each end to receive the web of a girder rail. Intended for street railways. (See 385,395.)

No. 375,996; date, January 3, 1888; W. P. Hall.—A hollow cross-tie, made of a plate bent almost cylindrical, but with the bottom open and flat on top. The rails are fastened to saddle straps. (See 373,656.)

No. 376,214; date, January 10, 1888; J. W. Smith.—A hollow rectangular cross-tie, with holes in the top to admit the rail chairs, which rest on coiled springs inside the tie.

No. 376,884; date, January 24, 1888; William B. Henning.—A flat bar, bent up at the ends to embrace the flange and web of rail. Loose angle clamps on inside of rail. (See 323,809.)

No. 377,162; date, January 31, 1888; G. Kelton.—A cross-tie of channel section ┌─┐, with a separate bottom, having projections on its inner side to give a hold to the pulp with which the tie is to be filled. The rails are fastened by hooked bolts, with nuts inside the tie, cavities being left in the pulp filling.

No. 378,280; date, February 21, 1888; F. L. Barrows.—A cross-tie of inverted trough section, with clips struck up on the outside of the rail to hold its flange, and clips lengthwise on the inside of the rail to hold a rail fastening.

No. 378,930; date, March 6, 1888; J. Hill.—A flat cross-tie, corrugated lengthwise top and bottom. The rail is keyed to a chair. The inventor proposes to use a double-headed rail.

No. 379,312; date, March 13, 1888; S. B. Jerome.—A hollow rectangular cross-tie, made of a bent plate. It is to be filled with straw, sawdust, etc., and has a narrow bearing-block along the underside of the top, to which the rails are spiked. The ends are closed by wood or cement blocks.

No. 379,399; date, March 13, 1888; J. Jacobs.—A cross-tie of channel section └─┘ with closed ends; a top plate is bolted on by side clamps to form a rail seat. The tie is to be filled with concrete, etc.

No. 379,574; date, March 20, 1888; C. P. Hawley.—A cross-tie of I section, with the top flange bent to make a rail brace. A longitudinal bridge is used under the rail at joints.

No. 379,576; date, March 20, 1888; C. P. Hawley.—A cross-tie of ⊥ section, with slots for the web of a T girder, forming a rail seat, or which can be made a longitudinal bearing.

No. 380,623; date, April 3, 1888; H. L. De Zeng.—Improvements upon Nos. 334,696 and 348,550.

No. 381,125; date, April 17, 1888; F. X. Georget.—Improvements upon No. 365,511.

No. 381,860; date, April 24, 1888; E. R. Stiles.—A cross-tie of channel section └─┘, with a wooden block under each rail.

No. 382,134; date, May 8, 1888; W. H. Britton.—A cross-tie of T section, with the vertical web corrugated vertically. The rails are secured by lugs and clamps.

No. 382,394; date, May 1, 1888; J. B. Sutherland.—A cross-tie of approximately Y section; curved like the section of a yacht, and with the top edges bent in to form horizontal flanges for the rail chairs.

No. 382,855; date, May 15, 1888; F. Barhydt.—A hollow box cross-tie, with closed ends. There is a wooden block the full size of the face of the tie at the top, and another at the bottom; both inside. Coil springs are interposed between the top and bottom sections.

No. 383,118; date, May 22, 1888; M. Fitzgerald.—A cross-tie of channel section ┌─┐, with solid ends. Fixed lugs and hooked spikes are the rail fastenings.

No. 384,785; date, June 19, 1888; Jacob Reese.—A cross-tie of ∩ section, with a groove along its top table; rail seat bolted on top. The rail is secured by a bolt passing under it and through the chair, having ┌ washers to hold the rail flange. It is to be rolled from a plate of No. 7 steel 24 inches wide; bedded in ballast.

No. 385,395; date, July 3, 1888; R. T. White.—A channel cross-tie of U section, with rails secured to saddles by bolts and clips. (See 375,856 and 386,420.)

No. 385,492; date, July 3, 1888; D. Y. Wilson.—A cross-tie made of two angles ┘ └, with a base plate and channel plate for rail seat at each end. Rails bolted through top and bottom plates.

No. 386,119; date, July 17, 1888; R. W. Flower, jr., and S. L. Wiegand.—A hollow cross-tie of rectangular section, with part of the bottom cut away and turned down to prevent lateral movement. The rails are spiked to wood blocks inside the tie.

No. 386,156; date, July 17, 1888; J. A. Ogden.—A cross-tie of channel section ⊔, wide at the bottom, with bearing blocks and hook-fastenings for the rails.

Nos. 386,356 and 386,357; date, July 17, 1888; H. Shultzen.—A channel tie ⊔, with the middle part of the bottom cut away and turned up to prevent lateral movement. The rail is fastened to a wooden block by Z-clips and a longitudinal bolt under the rail, or by diagonal bolts. (Now being manufactured by the Standard Steel Tie Company, of New York.) (See Appendix B of the report on metal track.)

No. 386,389; date, July 17, 1888; A. Durand.—A cross-tie of inverted trough section, with clips and channels stamped in it. (See description on p. 25.)

No. 386,420; date, July 17, 1888; R. T. White.—Hollow box cross-ties of different sections, made of bent plates. Cross-section intended to give elasticity. (See 385,395.)

No. 388,277; date, August 21, 1888; A. J. Hartford.—A flat cross-tie, with end turned up, and a bent plate tie bridge, arched in the middle, bent to form a shoulder for inner flange of rail; the rail rests on this plate and the end is turned over the outer flange and secured by a bolt through both plates.

No. 389,464; date, September 11, 1888; L. Haas.—A cross-tie of rectangular section; top cut away at ends and middle. Wooden block under each rail. (See 391,704.)

No. 390,014; date, September 25, 1888; R. P. Faddis.—Wooden stringers, with flat iron tie plates across top and under rail, with U bolts embracing the stringers. For street and steam railways.

No. 390,370; date, October 2, 1888; I. G. Howell.—A cross-tie of channel section ⊓, with blocks under the rails. The top is cut away for the rail, and the rail clamps are fastened by hooks.

No. 391,492; date, October 23, 1888; W. J. Stifler.—A flat cross-tie with diagonal grooves on the under side near the ends to receive the heads of the bolts of the two plates, each with a lug, which form one rail seat.

No. 391,704; date, October 23, 1888; L. Haas.—A cross-tie of channel section ⊔, higher at the rail seats, with notched flanges for the rails. (See 257,752.)

No. 391,999; date, October 30, 1888; A. H. Ames.—A flat cross-tie, with flaring ends of channel section ⊓, having riveted and bolted clips for rail fastenings.

No. 392,849; November 13, 1888; J. Cabry and W. H. Kinch (of England).—A rolled steel cross-tie of inverted trough section, with lugs stamped out. Rails secured by keys driven between flange and lug. (In use on the Northeastern Railway, in England.)

No. 393,515; date, November 27, 1888; D. M. McRae.—A wooden or iron tie, with metal sockets at ends forming rail seats.

No. 394,738; date, December 18, 1888; G. W. Thompson.—A hollow cross-tie of rectangular section, with a metal bearing-block inside under each rail. Bolted clip rail fastenings.

No. 395,134; date, December 25, 1888; M. Hagarty.—A cross-tie made of two channels placed back to back][, inner lug on one, outer lug on the other. The bolt holes in vertical web are elongated to allow the channels to be shifted to let rail in.

No. 395,304; date, December 25, 1888; C. F. Yarbrough.—Hollow cross-ties of rectangular section, with open ends and openings at sides. Wood blocks may be used, or the ties may be filled with ballast.

No. 396,160; date, January 15, 1889; H. Hipkins (of England).—A stamped metal cross-tie of section, with lugs and rib stamped out of top table. (Patented in England, 1888.)

No. 396,473; date, January 22, 1889; C. P. Espinasse (of France).—A cross-tie of ⊥ section, with vertical web cut away for rail chair to which rail is secured by wooden wedge.

No. 398,004; date, February 19, 1889; S. U. Smith.—A cross-tie of channel section ⊓, with closed ends. The rails rest on the ends of a separate cross-plate, with fixed lugs inside, and bolted plates outside.

TREATMENT OF RAILWAY TIES IN ENGLAND.

The information given below is taken from a paper on "English Railroad Track," by Mr. E. E. Russell Tratman (Transactions of the American Society of Civil Engineers, June, 1888). The matter referring to the Great Northern Railway (of Ireland) was taken by Mr. Tratman from a highly interesting paper, "Description of a Creosoting Yard for Railway Purposes," by Mr. W. Greenhill, read before the Institution of Civil Engineers of Ireland, in May, 1886; the paper contains very full particulars, in detail, of the plant and process, results of tests, cost, etc., and is especially interesting in that it describes work done by a railway company in treating timber for its own use.

The ties are usually of Baltic red wood, 10 by 5 inches by 9 feet, spaced 2 feet 9 inches to 3 feet center to center. They are almost invariably creosoted, with about 7 pounds of oil per cubic foot. Some roads have the creosoting done by contract, others have their own plant for the work. Among the latter may be mentioned the Lancashire and Yorkshire Railway and the Great Northern Railway (Ireland), both of which have very large and complete plants, and pay careful attention to the important point of tie preserving. [See also paper by Mr. John Bogart, M. Am. Soc. C. E., entitled "The Permanent Way of Railways in Great Britain and Ireland; with Special Reference to the Use of Timber Preserved and Unpreserved," and read November 20, 1878.*] I do not think enough practical attention is paid in this country to the question of preserving railroad ties, and some points in the matter may be learned from English practice.

Usually the ties are of rectangular section, but on the Midland Great Western Railway (Ireland), they are preferred of half-round section, except where the bearing-plates (bed-plates) are used. Mr. Price says that for heavy traffic he would prefer sleepers 11 by 5½ inches; he uses, however, sleepers 10 by 5 inches, 8 feet 11 inches long, always creosoted. The following is from the company's specifications: The timber is to be of good sound Baltic redwood, free from shakes and other defects, well seasoned and dry; 90 per cent. of both rectangular and half-round sleepers to have not less than 7½ inches diameter of heart-wood, and 10 per cent. not less than 7 inches at both ends. On one side the rectangular sleepers to have 50 per cent. sharp edges down to 9 inches surface, and 50 per cent. not less than 8 inches, and on the other side all edges to be sharp. The rectangular sleepers are to be grooved and bored and the half-round sleepers to be grooved, in accordance with the templates which will be supplied by the engineer. After being grooved and bored they are to be placed in a receiver and thoroughly impregnated with the best creosote oil (an equal mixture of light brown and black oil) under such pressure and for such time as shall entirely fill the pores with the liquid. The sleepers are not to be creosoted till they have been stacked in the contractor's premises for at least three months after inspection by the engineer.

* Transactions, Vol. VIII, page 17, January, 1879.

The engineer will reject, either before or after delivery, any sleepers which do not comply with the above conditions, or any sleepers the sap-wood of which has not been fully creosoted.

(1) Lancashire and Yorkshire Railway.

The ties, after being well seasoned, are passed through a combined adzing and boring machine, which first cuts out a seat about one-sixteenth of an inch deep for the chairs, in order to give them a uniform bearing, and then simultaneously bores the eight holes required for chair fastenings in each tie. The machine will seat and bore about one hundred ties per hour.

The ties are then placed on small iron trucks and drawn on a tramway of 3-foot gauge into the cylinder, which contains eight trucks with forty-seven ties each, or three hundred and seventy-six ties in all. The cylinder is 77 feet long, 6 feet internal diameter, built of one-half-inch wrought-iron plates and having egg-shaped ends. When the full number of ties has been put in, the doors or covers are put on and hermetically fastened by means of dog-bolts and screws, and the air exhausted by a steam ejector. The creosote is then introduced, heated to a temperature of from 100 to 120 degrees Fahrenheit; the air-pump then ceases to work and the pressure pump is put into operation, the full pressure of 150 pounds per square inch being obtained in about ten minutes; this pressure is maintained for about fifty minutes and is then withdrawn. The spare creosote is allowed to run back into the reservoir under the cylinder, the cover is removed, and after the ties have been left to drip for about fifty minutes, they are taken out of the cylinder. About 3 gallons of creosote are allowed for each tie, or 9½ pounds per cubic foot of timber. The efficiency of the process is ascertained by weighing three or four ties out of every charge, both before and after the operation, the additional weight showing the quantity absorbed, which averages about 30 pounds per tie:

	Pounds.
Average weight of tie before creosoting	128
Gain in weight during process	30
Average weight of creosoted tie	158

The whole operation for one charge of ties occupies about one hundred and thirty-two minutes, as follows, but varies slightly, however, according to the moisture in the timber:

	Minutes.
Ejection vacuum	13
Pumping commenced and tank filled	9
Full pressure obtained in	10
Full pressure maintained for	50
Spare creosote allowed to drip from ties	50
Total	132

From the creosoting cylinder the timbers are run back into the chairing shed, where the chairs are attached to the ties by a machine (somewhat on the style of a steam hammer) which, at one stroke, drives the four fastenings for each chair. This machine will "chair" about seventy ties per hour.

The time occupied in seating, boring, creosoting, and chairing three hundred and seventy-six ties is as follows:

	Hrs.	Min.
Stating and bering	3	40
Running trucks into cylinder	0	20
Creosoting	2	12
Withdrawing charge from cylinder	0	20
Chairing	5	14
Total	11	46

or 1 minute and 53 seconds per tie.

The cost of the operations, not including the value of the machines, is as follows:

Loading white ties	per 100	$0.36
Adzing and boring	do	.62
Tanking,	do	.64
Creosote, 300 gallons	do	6.75
Chairing and spiking	do	2.44
Total		10.81

or 10.81 cents per tie.

The whole of the work is done at the company's store yards at Castleton and Knottingley, and is let piece-work at the above rates.

(2) GREAT NORTHERN RAILWAY (IRELAND).

In 1876, when a number of railways were amalgamated to form this system, the new company decided that all the ties should be creosoted, and that to insure the work being efficiently performed, it would erect a suitable plant of its own for sawing, grooving, and creosoting the timber to be used for ties. After being sawed, the ties are taken to the grooving-machine, which forms a groove or seat for the base of flange rails by means of cutters making 2,000 revolutions per minute. Boring machinery, with twisted augers, was used for a short time, but the adoption of the improved ragged spike, which cuts its own way without splitting the tie, enables holes to be entirely dispensed with, and insures a tighter fit of the spike. After being grooved the ties are run out into the yard on a tramway of 30-inch gauge, and stacked to a height of 14 feet, alternate tiers on edge and on flat.

The cylinder is 60 feet long (6 tie lengths), 6 feet diameter, built of three-eighths-inch plates. The safety valve is set at 110 pounds, but seldom rises; it is, however, sometimes lifted to release air and water when the pressure pumps are working. There are six tanks, of such a size that a vertical inch of the six tanks represents 156 gallons; a float is connected with a gauge and scales, which show the gallons or pounds of creosote forced into the cylinder. There are 1½-inch pipes in the cylinder, through which the steam is forced to heat the creosote to 120 degrees Fahrenheit, thus dissolving the naphthaline, etc., and rendering the creosote quite fluid. There is an air-pump, 6½ by 10 inches, which exhausts the air from the cylinder, and the creosote enters by the atmospheric pressure on the tanks; the partial vacuum does not extract the sap or affect the timber. When the cylinder is nearly full the valve is closed, air-pump stopped, and the two force pumps, 3 by 4 inches, put to work. Three hours of steady pressure are required. The consumption of oil varies from 140 to 180 casks of 36 to 38 gallons each, per week, and the quantity used annually is about 250,000 gallons. The average quantity of creosote injected is 2.35 to 2.57 gallons, or 25 to 27 pounds per tie. About nine months' seasoning is customary, but a longer period is considered desirable so as to insure dryness.

"Little or no creosote can be forced into a thoroughly wet sleeper, even at high pressures, and a thoroughly dry sleeper will readily absorb a large quantity of oil which, when solidified by exposure to the air, no moisture, either from air or wet ground, will succeed in removing."

CIRCULAR IN REGARD TO CHESTNUT-OAK TIES.

FOR INFORMATION OF RAILROAD MANAGERS.

U. S. DEPARTMENT OF AGRICULTURE, FORESTRY DIVISION,
Washington, D. C., December, 1887.

GENTLEMEN: Hoping that you have appreciated the manner in which the Forestry Division of this Department has, by its first Bulletin, attempted to call the attention of railroad managers to the need of economy in the use of forest supplies, allow me, in furtherance of such economy, to present the following statements, which may be of interest to you.

In the use of oak for cross-ties, the specifications of most roads, especially those of the South, call for white oak (*Quercus alba*), a timber which is sought for also by almost every industry employing oak, and which is therefore rapidly decreasing and approaching comparative exhaustion. Meanwhile, millions of feet of tan-bark or chestnut oak (*Quercus prinus*) are rotting in the forests, after being stripped of their bark, because their value for cross-ties is not known or is underestimated in many regions.

This lack of appreciation of the value of this wood causes not only waste of the wood itself, but waste of the bark also, as without ready demand for the wood it does not pay to peel the larger limbs.

From information furnished by Dr. Mohr, of Mobile, Ala., an expert in forestry statistics and agent of this Department, it appears that from the line of the Louisville and Nashville Railroad, south of the Tennessee River, between 5,000 and 7,000 cords of bark are shipped annually, involving the felling in that district alone of from 10,000 to 13,000 trees which are consigned to useless destruction, while capable of yielding not less than 100,000 first-class railroad ties.

As to the lasting quality of the timber of chestnut oak, experiences are reported from Cullman, Ala., to the effect that posts of this oak outlast those made of white oak, partly, probably, because the timber is peeled. One reliable report states that tan-bark-oak posts were found to be sound after twelve years, while those of white oak in the same construction had to be replaced several years sooner. Reports from railroad companies where this wood is used for ties give their life as from five to ten years, while the reports for white oak give from three to twelve years. In the average, all the oaks which are known as "white oaks," named below, last between seven and eight years in the road-bed.

That the oaks of this class may be used for railroad construction interchangeably, and do not offer any appreciable differences in the qualities most essential for a good railroad tie, the following table, compiled from the Census Report, may serve to show. The column of specific gravity will allow an estimate in regard to adhesion of spikes, while the column of indentation allows an estimate as to resistance to cutting of rail.

The position as to quality, in comparison with the other kinds mentioned, is indicated by numbers in parentheses.

Description.	Range.	Weight per cubic foot.	Specific gravity.	Resistance to indentation.	Elasticity.	Transverse strength.
White oak (*Quercus alba, L.*).	East of the Rocky Mountains.	46.35	0.7470 (4)	3388 (6)	97089 (2)	905 (4)
Chestnut or rock-chestnut oak (*Quercus prinus, L.*).	Northeastern and in Kentucky, Tennessee, and Alabama.	46.73	0.7499 (3)	3688 (5)	125473 (1)	1031 (2)
Basket or cow oak (*Quercus Michauxii, Nutt.*).	Southeastern	50.10	0.8039 (2)	3725 (4)	96373 (3)	1118 (1)
Burr, mossy-cup, or over-cup oak (*Quercus macrocarpa, Michx.*).	Northern United States.	46.45	0.7453 (6)	3730 (3)	92929 (4)	982 (3)
Post or iron oak (*Quercus obtusiloba, Michx.*).	East of Rocky Mountains.	52.14	0.8367 (1)	4415 (1)	83257 (5)	872 (6)
California white oak (*Quercus Garryana, Dougl.*).	Pacific Coast	46.45	0.7453 (5)	3846 (2)	81109 (6)	879 (5)

From these figures it would seem that, contrary to the accepted notion, the white oak, par excellence, is inferior in all particulars to the chestnut oak, and in general not superior to any of the others.

Trusting that the above information will be of value to you, and that, so far as your conditions enable you to make use of it, you will do so, and thus to some extent aid in economizing timber supplies.

Yours, respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

NOTE.—The objection to the injurious influence on their durability of cutting trees in the sap, which is done to obtain bark, is met by leaving the trees full length, with limbs and leaves untrimmed for a fortnight, when by the action of the leaves a more thorough seasoning will be accomplished than can otherwise be obtained.

This practice is common abroad wherever summer felling is a necessity, and has proved itself so satisfactory that preference is given to cutting timber in the leaf.

CORRESPONDENCE IN REPLY TO THE CIRCULAR ON CHESTNUT-OAK TIES.

Louisville, New Orleans and Texas Railway Company.—My own experience confirms fully the facts stated in your circular. (James M. Edwards, vice-president and general manager.)

Richmond and Allegheny Railroad.—I have ranked chestnut oak with white and post oak for thirty years past, and in the middle sections of the State the impression is that, cut under similar conditions, it rather outlasts the white oak. (R. D. Whitcomb, chief engineer.)

Cincinnati, New Orleans and Texas Pacific Railway Company.—I have seen your circular concerning the value of chestnut oak, and am glad that you called attention to the subject.

We have had its use specified for our cross-ties on the Cincinnati Southern Railway since the first construction of the track, in 1876. (G. B. Nicholson, chief engineer.)

Nashville, Chattanooga and Saint Louis Railway.—Please accept my thanks for your circular letter with reference to chestnut oak for cross-ties. Our chief engineer advises me that he classes it third best for this purpose, and considers it but little inferior to white oak for cross-ties. (J. W. Thomas, president.)

Saint Louis and San Francisco Railway Company.—Ninety-five per cent. of the timber fit for ties on our lines is composed of white, burr, or post oak. We have occasionally obtained a few ties made of what is called chinquapin oak, which is a variety of chestnut oak, and has long been recognized to be one of the best varieties of timber for cross-ties. (James Dun, chief engineer.)

Philadelphia, Wilmington and Baltimore Railroad Company.—We have bought several thousand of *Quercus prinus* in the Virginia counties bordering on the Chesapeake Bay this last season. I consider it every way equal, if not superior, to the *Quercus alba* ties. If you can direct me where the bark of the *Prinus* is being used, I will at once send our agent to see what we can do towards getting the cross-tie in the spring after the trees are barked. (J. N. Mills, superintendent.)

Mexican Central Railway Company.—We are using on our railroad now, so far as we draw from the United States, for the main line, cedar grown in northern Michigan and southern Canada, and we have already contracted for 1,000,000 ties for next year's supply.

We have also bought 25,000 white-oak ties. These are the only oak ties that have been purchased in the three and a half years of my presidency, with the exception of some small lots of bridge ties. So, as you see, we have not been very great sinners in the matter of the use of white oak.

The 25,000 oak ties were for use in curves; heretofore we have used on curves mesquite ties grown in Mexico; the supply was never plentiful, and it had materially diminished.

The information you give us, therefore, may become of great importance. (Levi C. Wade, president.)

SPECIFICATIONS FOR WOODEN CROSS-TIES.

PROPOSED GENERAL SPECIFICATIONS FOR CROSS-TIES.

TIMBER.

Cross-ties will be accepted of the following varieties of timber: Oaks of the various kinds known as "white," "black," "yellow," "rock," or "chestnut," "burr," and "post," red oak, black locust, second-growth white chestnut, beech, red elm, cherry, maple, butternut, tamarack, and yellow pine of the long-leaved Southern hard pine variety cut from untapped trees, white and red cedar. Hemlock may be accepted but only under special contracts.

SIZE.

First class. Eight and one-half feet in length, 7 inches in thickness, and not less than 7 inches width of face on both sides at the small end.

Second class. Eight feet in length, 6 inches in thickness, and not less than 7 inches width of face on both sides at the small end; and in each class there must be at east one-fourth of the whole number that will be not less than 10 inches in width of faces.

MANUFACTURE.

All ties must be made from sound, thrifty live or green timber, free from loose or rotten knots, worm-holes, dry-rot, wind-shakes, splits, or any other imperfections affecting the strength or durability of the timber.

Not more than 1 inch of "sap wood" will be allowed on the edges or corners, and none at all on either face of the ties; they must be hewed or sawed with the faces perfectly true and parallel, of the exact thickness specified; the faces must be out of "wind," smooth, and free from any inequalities of surface, deep score marks, or splinters; they must be cut or sawed square on the ends to the exact lengths given and be generally straight in all directions, and will not be accepted if more than 3 inches out of straight in any direction; and must be peeled or stripped entirely free from the bark before being delivered.

No "square ties," either hewed or sawed, will be accepted excepting under special contracts. No split ties will be accepted under any circumstances, and "culls" only at the option of the company, and at such prices as may be agreed upon from time to time.

DELIVERY.

All ties delivered along the line of the railway must be stacked up in neat square stacks of fifty ties in each, with alternate layers crossing each other, and on ground, wherever possible, as high or higher than the grade of the railroad, and in such position as to admit of being counted and inspected with ease and facility. Ties delivered at suitable and convenient places, acceptable to the company, will be inspected, and bills made for all received and accepted up to the last day of each month, and payment will be made for same on or about the —— day of the succeeding month.

—— ——,
Chief Engineer.

SPECIFICATIONS FOR CROSS-TIES USED BY NEW ORLEANS AND NORTHEASTERN RAILROAD.

The timber shall be either white, post, burr, or chestnut oak, mulberry, black locust, red cypress, or long leaf yellow pine, cut in any month of the year of delivery except February, March, April, May, or June, from young, sound, living trees. It must be free from rotten or loose knots, worm-holes, dry-rot, wind-shakes, or other imperfections affecting the strength and durability of the wood.

The cross-ties must be 9 feet long and straight in all directions, not less than 7 nor more than 7½ inches in thickness. They must have not less than 7 inches of heart face.

The hewn surfaces must be parallel, free from objectionable score-marks, and not winding. The ends must be cut square and all bark removed. No sawed ties will be accepted.

The ties must be delivered on the right of way of the railway, not lower than the grade, and not higher than 8 feet above grade.

They shall be scattered for inspection in such a manner that all parts of every tie can be seen and measured by the inspector.

All accepted ties must be arranged in piles formed of layers separated by two ties.

PROPOSAL.

The undersigned hereby propose to furnish, according to the foregoing specifications ——— cross-ties. Said cross-ties to be delivered as aforesaid at ——— ———, at the rate of —— cents per cross-tie.

The undersigned further propose to commence work within —— days from date hereof, and complete the delivery of ties on or before —— ———, 18—.

Signed this —— day of ———, 18—.

Name of firm : ——— ———,
By ——— ———,
——— ———,
——— ———.

Reference : ——— ———.
Post-office address : ——— ———.

REPORT OF EXPERIMENTS IN WOOD SEASONING.

CHEMICAL LABORATORY,
Aurora, Ill., January 9, 1889.

Mr. G. W. RHODES,
Superintendent M. P., Chicago and Burlington R. R. Co.:

DEAR SIR: Herewith is submitted a report on a second series of "experiments in the fluctuation of moisture in wood during seasoning," a report on first series having been submitted March 2, 1887. Accompanying this are diagrams showing the weekly fluctuation of the moisture for every piece used during the experiments, based upon the exact percentages of moisture in the tables given herein. In the diagrams the nearest to a whole per cent. was taken.

The object of this second series was to corroborate, if possible, the conclusions of the first series, viz: (1) To determine the time that outdoor seasoning begins and ends as indicated by the moisture; (2) to ascertain whether the wood will again take back moisture during the wet seasons of the fall and spring; (3) effects of size of wood; and (4) whether one season is sufficient to season wood.

To determine these questions, fifteen pieces of unseasoned timber, as wet as could be obtained, were placed out of doors in a latticed shed, and loosely piled with cleats between and a board topping, all to protect from direct dripping and rain, and yet to be under the same conditions as outdoor seasoned lumber.

All of the oak was from Kentucky, the pine from Michigan, ash from Arkansas, white-wood from Tennessee, and elm from Michigan.

The first lot of lumber, including all but the pine, was received Wednesday, December 29, 1886, and the first determination of moisture made Monday, January 3, 1887. The four pines were received later, the first moisture determination being made April 18, 1887. The following are the determinations and the kind of material:

Letter.	Kind.	For what used.	Cross dimensions.	Length.
			In. *In.*	*Ft.* *In.*
A	Oak	Draw wood	$4\frac{3}{4}$ by 14	17 0
F	do	do	$4\frac{1}{2}$ by 8	8 2
D	do	End plate	$3\frac{1}{2}$ by $12\frac{1}{2}$	9 3
E	do	End sill	5 by $9\frac{1}{2}$	9 6
J	do	do	9 by $9\frac{1}{2}$	10 0
K	do	Corner post	4 by 5	7 4
G	do	Draw beam	$9\frac{1}{4}$ by $9\frac{1}{2}$	12 2
I	do	Side brace	3 by $4\frac{1}{2}$	7 0
B	Ash	Corner post	4 by 9	16 0
C	White-wood	Outside	3 by 12	16 0
H	Elm	Brake beam	$4\frac{1}{2}$ by $6\frac{1}{2}$	12 0
L	Hard pine	Flooring	2 by 10	18 0
M	Soft pine	Roofing	1 by 6	16 0
N	Hard pine	Side sill	5 by $9\frac{1}{2}$	30 0
O	do	Side plate	$2\frac{1}{2}$ by 5	30 0

There are yet running two pieces of pine (N and O), and when they are finished a third report will be made on "fluctuation of moisture in wood and miscellaneous experiments in wood seasoning."

On every Monday morning the amount of moisture was determined. Following is the method employed in the estimation: From the same end of each piece, exactly 3 inches was sawed, and from this piece on the end freshly sawed, and exactly in the center, borings of the wood were obtained, using a $\frac{5}{8}$-inch bit. These borings or chips were transferred, as quickly as they left the bit, to a previously weighed drying tube, and when about $2\frac{1}{2}$ inches had been bored, the tube is quickly and securely stopped and again weighed. The amount of chips of the wood is then known. This tube containing the chips is placed in an air-oven for one hour, at a temperature of 230 degrees Fahrenheit; then taken out, cooled and weighed. This is repeated, drying fifteen minutes each time, until the weight begins to increase (due perhaps to oxidation of the resinous matters), when the lowest weight obtained is taken as the correct one. The determinations were all made by the same person, except a few during March and April, 1888, and thus any "personal error" avoided that might arise from different persons doing the work.

COMMENTS.

Oak.—It will be noticed in the tables of percentages of moisture that determinations were made in eight pieces of oak of different dimensions, only one of which (A) was of sufficient length to last more than one year. In this piece the moisture fluctuated very much, although there is noticeable decrease commencing in April, and being the lowest the latter part of November, when it increased from 30 per cent. to 35 per cent., and then went down again until it ended in March. I do not attribute the 5 per cent. increase in December to the wood absorbing moisture, but to the fact that the per cent. of moisture in the center or heart of green oak would amount to this difference. An experiment was made on oak to determine this point, a report of which will be given in the third series. In oak G (dimension 9½ inches by 9½ inches by 12 feet 2 inches), the moisture at start in January was 43 per cent., and commenced to drop in March and April and in the following months until the end in November, fluctuating between 38 per cent. and 41 per cent. The remaining oak (K, F, I, D, J, and E) all commence to decrease in percentage of moisture during March and April, and show a continual decrease toward the end of the pieces. Unfortunately these pieces were not of sufficient length to allow the moisture to reach the lowest limit, but from them we can tell the spring months which the seasoning begins.

Pine.—Experiments with the pines were not commenced until April 18, 1887, and two test pieces (N and O) are still under observation. In these there is an almost immediate decrease in percentage of moisture. In N, the moisture dropped from 28 per cent. in April to 12 per cent. October 1, when it increased to about 16 per cent., remaining at that through the full winter and spring, and in the following May again began to decrease until 13 per cent. was reached, where it remained with slight variation. In O, the moisture in April, 1887, was 20 per cent., and by the following August, 1887, had dropped to 9 per cent., then increased to about 14 per cent., where it remains with the exception of a slight drop in the summer.

Months of 1888: The piece of roofing, 1 inch thick, had 14 per cent. of moisture in April, 1887, and which decreased to 10 per cent. by August, but the following fall and winter months it increased to 16 per cent., and did not decrease during the winter and spring months, until August, 1888, when it commenced to drop, and by June, 1888, the percentage was about the same as the summer of 1887. This piece took up moisture during the wet seasons.

The pine L (2 inches by 10 inches by 18 feet) when first commenced in April contained 18–20 per cent. moisture, but immediately began to decrease and reached the lowest percentage of moisture in the following July and August, then increased during the fall and winter, amounting to 17 per cent. during February and March of 1888, and again beginning to decrease in April and continuing to do so until the piece ended in the middle of July. The piece also took up moisture during the wet seasons.

Ash.—Only one piece of ash was used during the experiments, which contained about 22 per cent. of moisture during the months of January, February, and March, but during April the percentage began to decrease, being the lowest in August (11 per cent.) and remained at about 12 per cent. during the following fall and winter months, and until March, 1888, when the piece ended.

Elm.—The one piece of elm, H, showed a steady decrease of moisture from 29 per cent. in January, 1887, to 16 per cent. in November of the same year, when the end of the piece was reached.

White-wood.—This wood, C, had 16 per cent. of moisture in January, 1887, and began to decrease in April, reaching the lowest (10 per cent.) in July and August, and varied but 1 or 2 per cent. during the remainder of the period of observation, which ended the middle of November of the same year.

Percentages of moisture.

Date.	Oak.	Ash.	White wood.	Oak.			
	A.	B.	C.	D.	E.	F.	G.
1887.							
Jan. 3	33.66	19.79	16.21	46.56	44.23	38.75	43.21
10	36.53	22.31	14 80	46.09	45 07	40.00	42.94
17	38.72	22.35	15.78	46.83	45.60	40.37	42.22
24	40.73	22.42	15.52	46.25	45.41	40.28	42.68
31	40.56	22.60	14.31	43.33	43.90	40.08	44.32
Feb. 7	41.85	22.44	15.11	45.57	43.90	39.18	43.51
14	42.99	22.37	15.72	46.47	43.79	41.03	42 92
21	43.13	22.59	15.89	46.38	42.92	39.29	42.30
28	43.78	22.49	15.03	46.20	43.31	39.48	42.80
Mar. 7	42.11	21.67	15.45	43.64	42.88	38.47	42.10
14	42.81	20.84	15.33	43.04	43.19	38.20	40.29
21	42.63	21.02	15.32	45.11	43.82	38.44	40.28
28	43.14	21.24	15.54	46.62	44.08	37.82	40.97
Apr. 4	43.61	21.26	15.21	44.57	43.38	37.37	40.05
11	42.85	23.26	13.98	45.56	42.26	38.50	39.62
18	41.83	19.08	13.36	43.77	42.27	38.61	39.62
24	43.02	20.61	14.06	40.53	41.57	39.37	40.30
May 2	40.08	18.76	12.26	40.03	41.85	38.04	38.81
9	40.65	18.32	12.01	40.43	41.84	38.40	38.38
16	39.80	17.31	11.51	39.59	42.11	38.21	39.45
23	39.95	16.88	11.10	40.68	41.34	36.82	38.34
30	39.52	16.42	11.78	41.45	41.81	37.24	37.61
June 6	45.44	16.34	12.47	42.62	41.31	37.38	38.70
13	35.96	15.87	12.19	40 97	41.01	37.71	38.94
20	39.39	14.30	11.19	40.50	40.15	37.06	36.66
27	40.10	13.91	10.40	40.49	40.41	37.28	35.39
July 4	39.78	13.31	11.34	35.51	41.12	36.56	39.03
11	40.67	13.21	11.05	34.70	41.72	35.52	38.60
18	37.76	12.61	10.46	32.47	41.22	35.89	40.65
25	41.40	13.00	10.95	34.19	41.68	34.93	40.06
Aug. 1	40.81	11.32	9.26	31.57	39.66	31.46	39.21
7	37.81	13.15	9.81	33.42	39.67	21.17 End.	40.31
15	39.15	12.69	10.55	30.56	39.68	......	40.58
22	40.49	12.36	11.56	29.50	38 92	......	40.44
29	38.43	12.45	11.22	25.66	36.38	......	41.29
Sept. 5	38.65	11.37	10.73	23.77 End.	36.88	......	40.52
12	37.37	12.23	10.80	......	34.70 End.	......	40.67
19	34.94	11.18	10.35	......	......	......	38.68
26	36.11	12.43	11.11	......	......	......	40.02
Oct. 3	36.37	12.69	12.84	......	......	......	40.42
10	35.51	12.43	12.44	......	......	......	40.86
17	35.66	12.10	11.81	......	......	......	39.34
24	34.32	12.25	11.93	......	......	......	38.46
31	34.07	12.34	11.81	......	......	......	38.58
Nov. 7	32.77	12.04	11.29	......	......	......	35.09
14	32.28	11.95	11.50	......	......	......	36.68
21	33.44	12.23	8.39 End.	......	......	......	37.11
28	30.26	16.68	......	......	......	......	32.36 End.
Dec. 5	31.43	12.70	......	......	......	......	......
12	33.03	13.03	......	......	......	......	......
19	33.60	12.80	......	......	......	......	......
26	34.46	12.80	......	......	......	......	......
1888.							
Jan. 1	34.21	13.09	......	......	......	......	......
9	34.81	13.56	......	......	......	......	......
16	34.82	13.71	......	......	......	......	......
23	34.22	13.23	......	......	......	......	......
30	33.58	12.69	......	......	......	......	......

Date.	Elm.	Oak.		
	H.	I.	J.	K.
1887.				
Jan. 3	28.51	47.23	37.75	42.90
10	28.21	44.33	37.98	43 00
17	28.59	44.67	38.74	43.07
24	27.83	41.63	37.77	43.26
31	27.12	43.80	38.99	42.17
Feb. 7	27.35	44.50	35.99	42.17
14	28.03	44.69	37.89	42.66
21	27.51	43.93	37.93	42.18
28	27.39	44.59	38.85	42.69
Mar. 7	26.85	42.70	39.00	41.36
14	25.57	42.31	37.23	40.65
21	24.46	42.61	37.56	43.83
28	24 42	42.85	35.87	40.31
Apr. 4	24.28	41.65	35.74	40.48
11	23.60	40.76	37.09	40.22
18	23.47	40.57	36.03	40.18
24	23.14	41.49	38.15	40.52
May 2	22.67	39 87	36.55	39.62
9	22.91	40.97	38.19	39.55
16	22.34	39.9[illegible]	38.72	39.41
23	21.69	38.94	38.42	39.51
30	22.12	39.06	37.67	39.19
June 6	21.58	38.44	36.95	38.93
13	21.23	36.63	36.11	38.22
20	20.50	34.71	34.20	38.16
27	20.16	33.11	33.63	37.07
July 4	20.20	32.56	34.65	35.57
11	19.48	31.28	36.56	32.32
18	19.23	24.43	34.76	24.57 End.
25	18.94	29.48	34.83	......
Aug. 1	17.64	21.98	35.13	......
7	18.50	21.98 End.	37.72	......
15	17.92	......	36.80	......
22	17.31	......	36.09	......
29	17.65	......	37.32	......
Sept. 5	16.93	......	36.94	......
12	16.38	......	35.96	......
19	16.25	......	30.60	......
26	16.61	......	26.00 End.	......
Oct. 3	16.53	......	......	......
10	16.12	......	......	......
17	16.75	......	......	......
24	16.26	......	......	......
31	16.36	......	......	......
Nov. 7	16.25	......	......	......
14	15.15	......	......	......
21	15.58	......	......	......
28	12.70 End.	......	......	......
Dec. 5	......	......	......	......
12	......	......	......	......
19	......	......	......	......
26	......	......	......	......
1888.				
Jan. 1	......	......	......	......
9	......	......	......	......
16	......	......	......	......
23	......	......	......	......
30	......	......	......	......

Date.	Pine.			
	L.	M.	N.	O.
1887.				
Jan. 3	......	......	......	......
10	......	......	......	......
17	......	......	......	......
24	......	......	......	......
31	......	......	......	......
Feb. 7	......	......	......	......
14	......	......	......	......
21	......	......	......	......
28	......	......	......	......
Mar. 7	......	......	......	......
14	......	......	......	......
21	......	......	......	......
28	......	......	......	......
Apr. 4	......	......	......	......
11	......	......	......	......
18	17.58	13 58	23.37	21.21
24	19.56	14.11	29.18	21.27
May 2	17.09	12.52	28.61	18.34
9	15.47	12.42	28.32	16.32
16	13.56	11.22	26.27	14.11
23	12.69	12.64	22.77	14.22
30	13.88	8.99	27.42	14.32
June 6	15.21	14.25	25.19	15.15
13	14.65	12.17	24.24	13.29
20	13.29	11.71	19.00	10.06
27	12.72	11.36	19.82	10.52
July 4	12.79	12.54	19.05	11.25
11	12.48	12.70	20.80	9.61
18	11.50	10.31 (*)	16.67	9.43
25	12.43	10.82	21.28	9.98
Aug. 1	10.89	9.70	19.47	8.64
7	11.01	9.88	19.59	8.82
15	11.92	11.63	17.73	10.55
22	12.60	11.12	15.83	10.58
29	13.02	11.86	16.65	10.89
Sept. 5	12.03	11.10	15.84	10.40
12	12.62	11.83	14.79	10.92
19	11.90	11.10	13.44	10.16
26	12.90	12.01	14.18	11.29
Oct. 3	13.86	16.26	12.25	13.38
10	14.01	15.43	15.04	12.98
17	16.62	13.72	14.34	12.07
24	13.14	13.94	14.91	12.95
31	13.29	13.26	14.00	13.01
Nov. 7	12.70	12.54	13.73	15.03
14	12.99	12.43	14.78	12.64
21	14.48	13.12	14.93	9.39
28	13.23	13.59	14.94	13.79
Dec. 5	13.09	13.77	14.88	13 58
12	14.00	14.73	15.12	14 67
19	13.64	14.78	14.78	13.57
26	13.99	14.26	14.47	13.48
1888.				
Jan. 1	14.46	14.53	13.30	14.00
9	14.97	16.10	15.56	14.78
16	15.11	16.32	15.38	14.59
23	15.43	15.81	15.39	14.25
30	15.42	16.31	15.79	14.17

Percentages of moisture—Continued.

Date.	Oak.	Ash.	White wood.	Oak.				Elm.	Oak.			Pine.			
	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.
1888.															
Feb. 5	33 30	12.97	......	......	......	......	......	......	......	......	......	16.20	16.35	15.72	14.04
13	32.65	13.20	......	......	......	......	......	......	......	......	......	16.61	16.48	16.26	14.25
20	32.01	13.20	......	......	......	......	......	......	......	......	......	15.95	11.48	13.58	13 98
27	30.66	12.85	......	......	......	......	......	......	......	......	......	16.17	15.78	15.89	14.16
Mar. 5	30.08	12.57	......	......	......	......	......	......	......	......	......	16.65	15.19	16.14	14.08
		End.													
12	28.69	......	......	......	......	......	......	......	......	......	......	16.47	14.65	15.79	13.89
19	22.32	......	......	......	......	......	......	......	......	......	......	16.01	15.80	15.41	13.43
	End.														
26	......	......	......	......	......	......	......	......	......	......	......	16.13	15.22	15.61	13.79
Apr. 2	......	......	......	......	......	......	......	......	......	......	......	......	15.03	16.18	15.26
9	......	......	......	......	......	......	......	......	......	......	......	15.85	13.51	15.29	12.80
16	......	......	......	......	......	......	......	......	......	......	......	15.84	13.38	14.95	12.62
23	......	......	......	......	......	......	......	......	......	......	......	16.00	13.50	15.54	12.95
30	......	......	......	......	......	......	......	......	......	......	......	14.19	11.00	15.22	14.07
May 7	......	......	......	......	......	......	......	......	......	......	......	15.04	11.80	15.79	13.47
14	......	......	......	......	......	......	......	......	......	......	......	15.07	12.27	15.95	12.72
21	......	......	......	......	......	......	......	......	......	......	......	14.64	11.71	15.90	12 82
28	......	......	......	......	......	......	......	......	......	......	......	13.99	12.18	15.49	12.53
June 4	......	......	......	......	......	......	......	......	......	......	......	13.81	11.46	14.23	12.14
11	......	......	......	......	......	......	......	......	......	......	......	13.86	11.36	14.29	12.29
18	......	......	......	......	......	......	......	......	......	......	......	12.97	10.30	13.39	11.38
													End.		
25	......	......	......	......	......	......	......	......	......	......	......	14.42	......	13.14	11.25
July 2	......	......	......	......	......	......	......	......	......	......	......	12.63	......	13.16	11.44
9	......	......	......	......	......	......	......	......	......	......	......	12.95	......	13.98	12.32
16	......	......	......	......	......	......	......	......	......	......	......	12.73	......	12.71	11.87
23	......	......	......	......	......	......	......	......	......	......	......	11.93	......	12.30	11.46
30	......	......	......	......	......	......	......	......	......	......	......	12.11	......	12.56	11.92
Aug. 6	......	......	......	......	......	......	......	......	......	......	......	12.21	......	12.32	11.57
13	......	......	......	......	......	......	......	......	......	......	......	11.24	......	13.25	11.52
20	......	......	......	......	......	......	......	......	......	......	......	11.68	......	12.67	11.54
												End.			
27	......	......	......	......	......	......	......	......	......	......	......	......	......	12.90	11.91
Sept. 3	......	......	......	......	......	......	......	......	......	......	......	......	......	11.79	10.84
10	......	......	......	......	......	......	......	......	......	......	......	......	......	11.34	10.84
17	......	......	......	......	......	......	......	......	......	......	......	......	......	12.63	11.16
24	......	......	......	......	......	......	......	......	......	......	......	......	......	12.70	12.60
Oct. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	11.87	12.04
8	......	......	......	......	......	......	......	......	......	......	......	......	......	12.69	12.70
15	......	......	......	......	......	......	......	......	......	......	......	......	......	15.53	11.89

NOTE.—In the "starred" percentage on y. pine "M," the cut was made 1 foot from previous one on account of knot. Pieces "N" and "O" have 10 feet yet to be cut. The diagrams were made on percentages up to October 29, 1888.

CONCLUSION.

Out door seasoning depends a great deal on the character of the weather during the year, that is, as to an early or late spring or fall, hot or cold summer months, or severe winter, etc., but during the experiments it may be considered to have been average Illinois weather.

The result of this series of experiments shows that the month during which the seasoning begins varies with the kind of wood.

(1) That for oak the seasoning commences in March or April; with pine the exact month can not be decided, as they were not placed under observation until late (April), but all test pieces showed a loss of moisture within a fortnight after being exposed.

Ash and white-wood commenced to lose moisture in April, and elm immediately on being exposed in January.

No law can be deduced from the experiments as to the exact time that seasoning ends, as the woods all vary, but as a general rule it may be stated that in all woods (except perhaps elm) seasoning virtually ends with the end of the summer months.

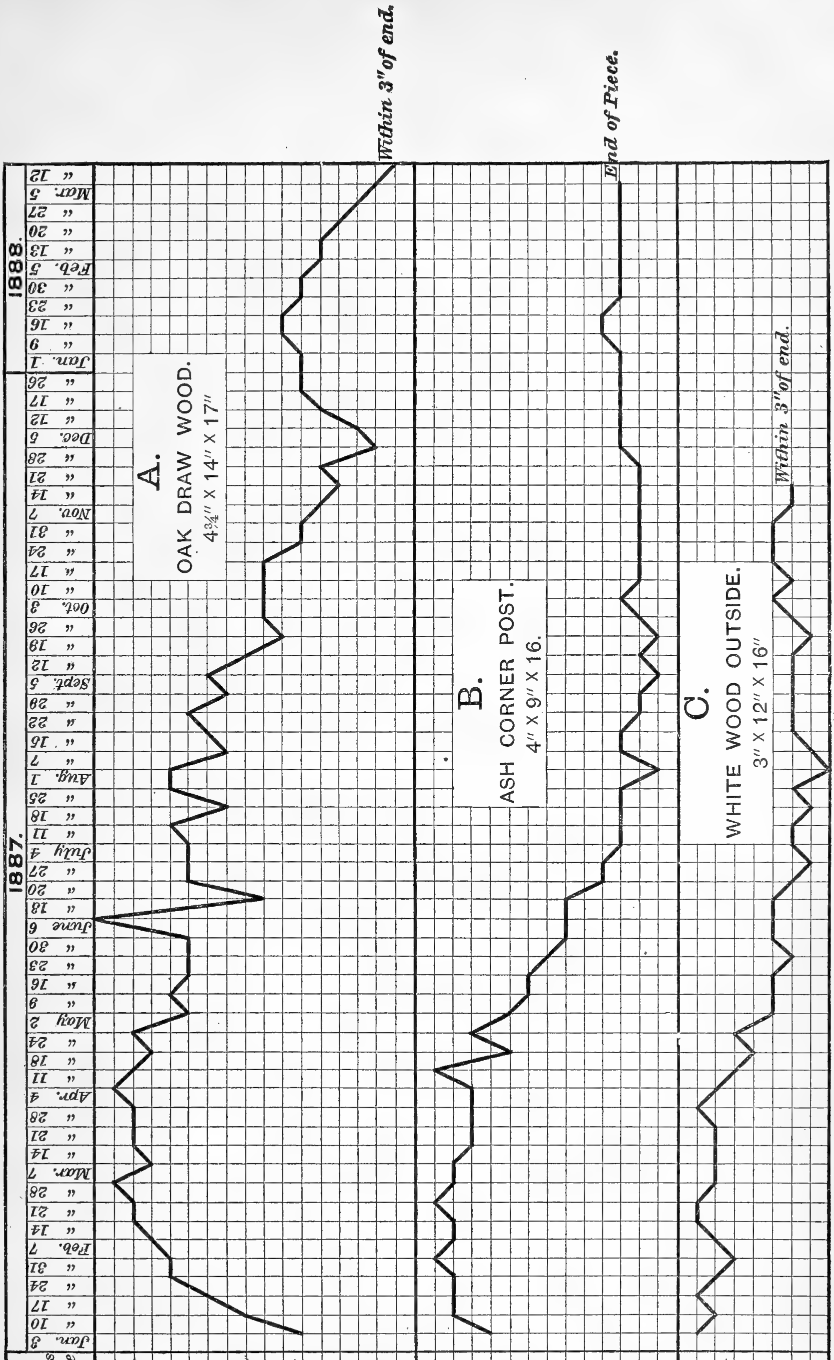
(2) All woods take up moisture in slight amounts during wet weather of the fall and winter months.

(3) Pine of small dimensions (such as 1 inch flooring " M ") will absorb moisture during the wet months. Other woods of small dimensions were not experimented with.

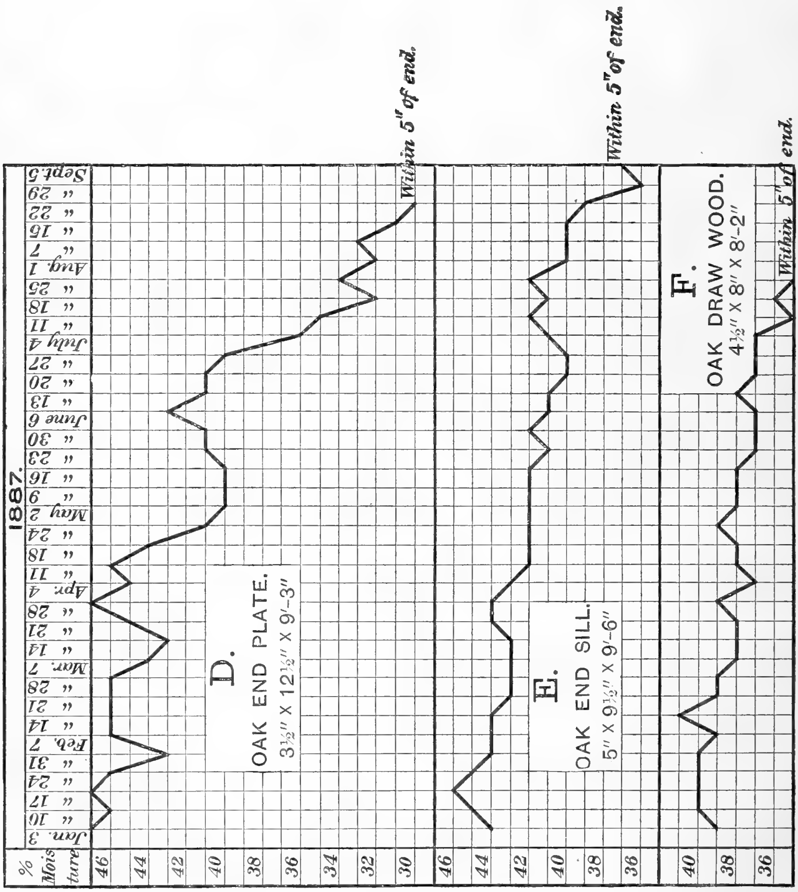
(4) As shown by these experiments one season of average weather is generally sufficient to season woods for purposes of construction.

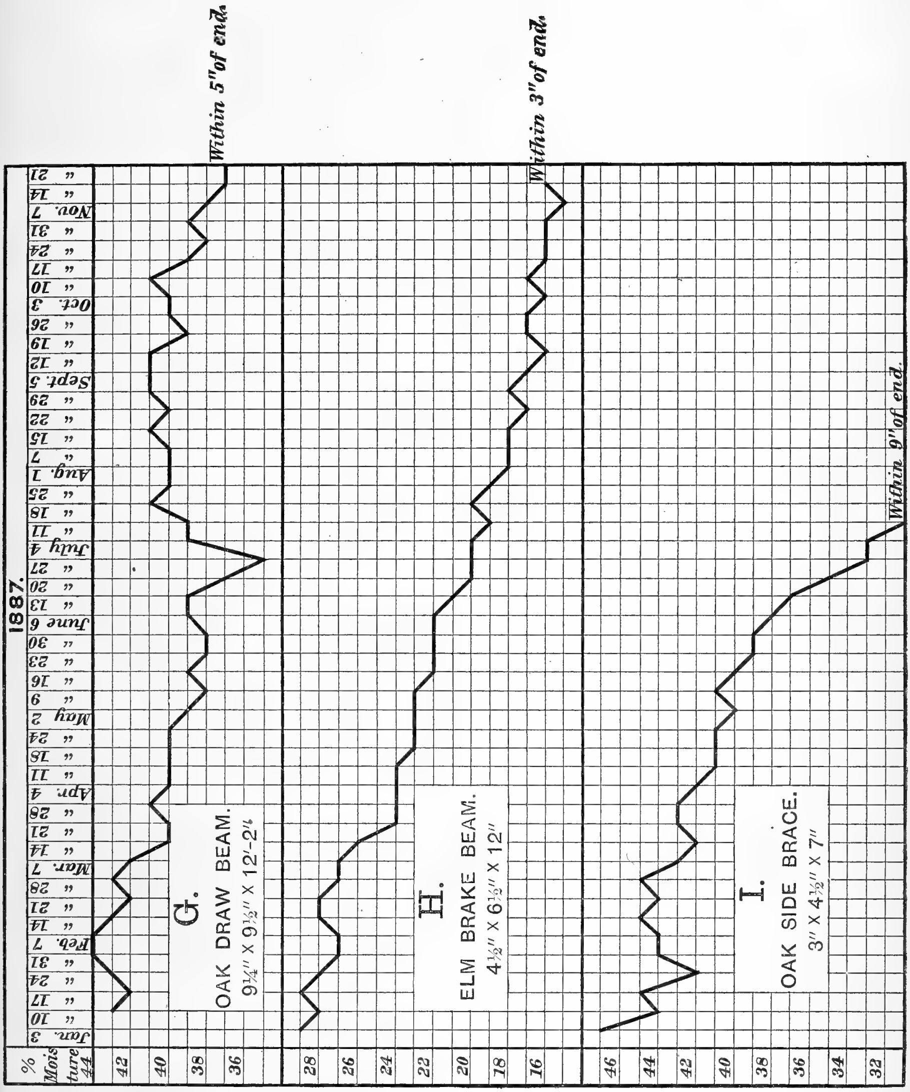
Yours truly,

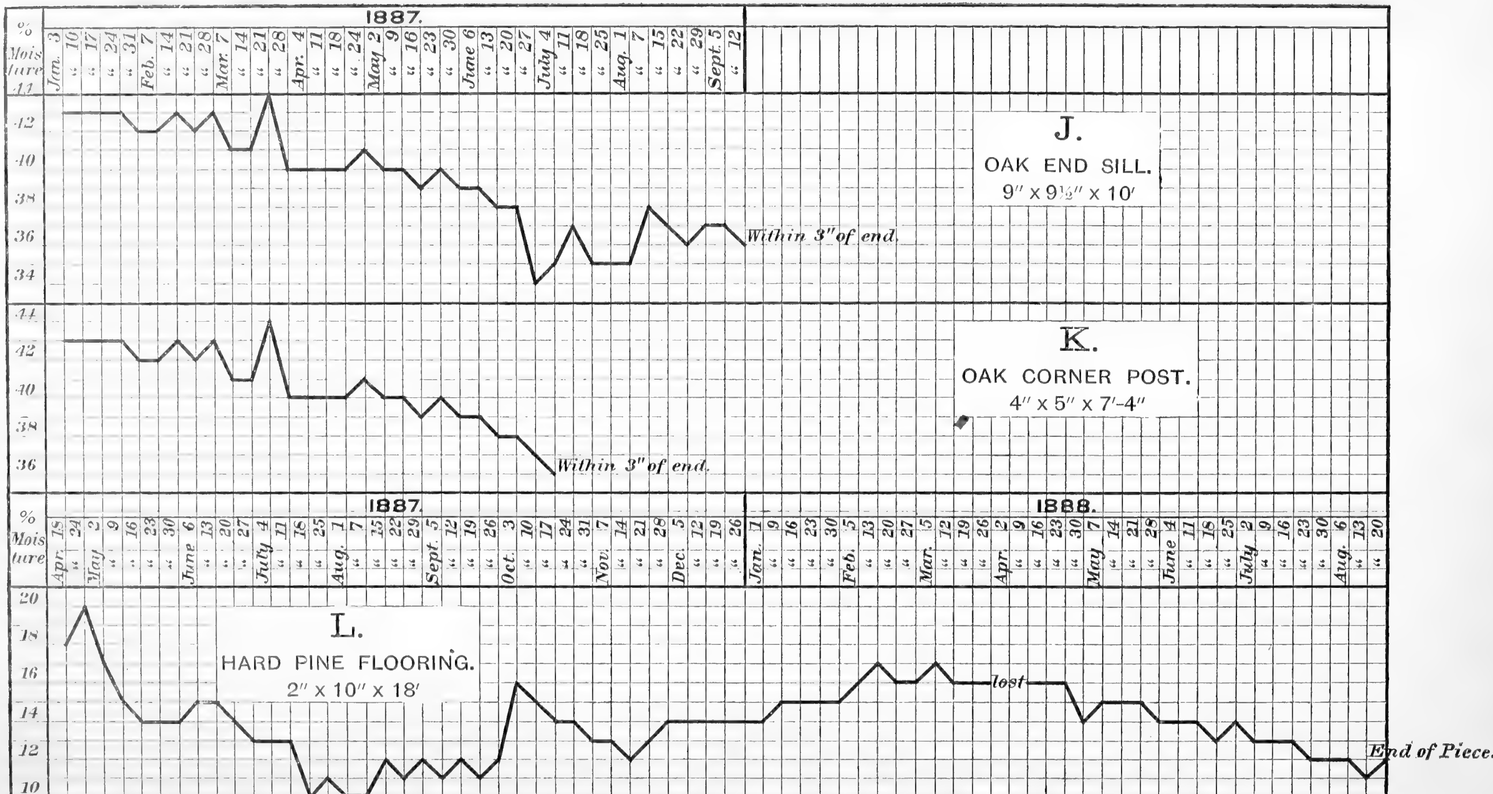
G. H. Ellis,
Chemist.

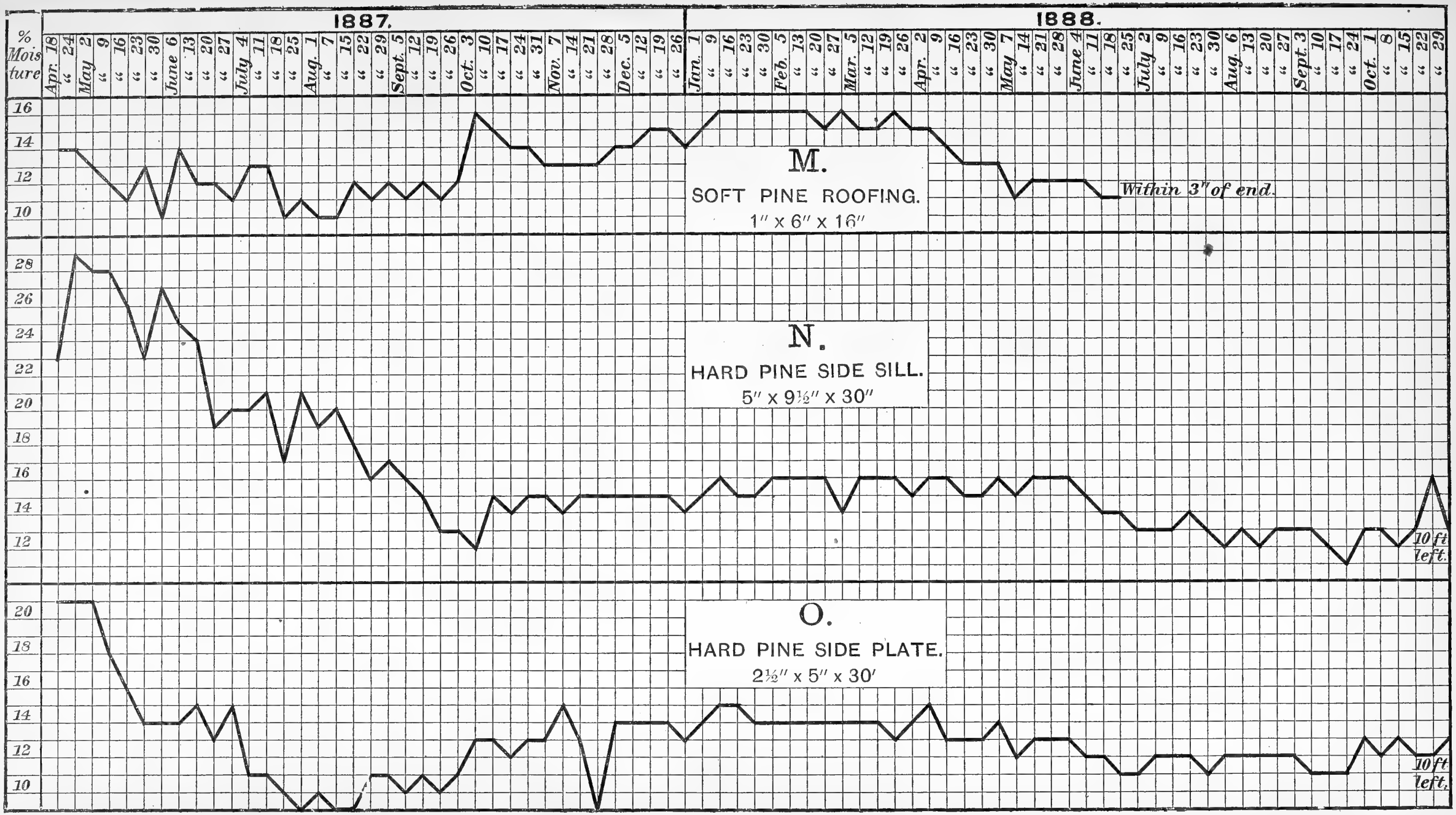


% Moisture
1887.
1888.
A.
OAK DRAW WOOD.
4¾" X 14" X 17"
Within 3" of end.
B.
ASH CORNER POST.
4" X 9" X 16.
End of Piece.
C.
WHITE WOOD OUTSIDE.
3" X 12" X 16"
Within 3" of end.


1887.
% Mois ture
Jan. 3
Feb. 7
Mar. 7
Apr. 4
May 2
June 6
July 4
Aug. 1
Sept. 5
D.
OAK END PLATE.
3½" X 12½" X 9'-3"
Within 5" of end.
E.
OAK END SILL.
5" X 9½" X 9'-6"
Within 5" of end.
F.
OAK DRAW WOOD.
4½" X 8" X 8'-2"
Within 5" of end.


1887.
% Moisture
Jan. 3
Feb. 7
Mar. 7
Apr. 4
May 2
June 6
July 4
Aug. 1
Sept. 5
Oct. 3
Nov. 7
G.
OAK DRAW BEAM.
9¼" X 9½" X 12'-2"
Within 5" of end.
H.
ELM BRAKE BEAM.
4½" X 6½" X 12"
Within 3" of end.
I.
OAK SIDE BRACE.
3" X 4½" X 7"
Within 9" of end.


1887.
% Moisture
J.
OAK END SILL.
9″ x 9½″ x 10′
Within 3″ of end.
K.
OAK CORNER POST.
4″ x 5″ x 7′-4″
Within 3″ of end.
1887.
1888.
L.
HARD PINE FLOORING.
2″ x 10″ x 18′
lost
End of Piece.



1887.
1888.
% Moisture
M.
SOFT PINE ROOFING.
1″ x 6″ x 16″
Within 3″ of end.
N.
HARD PINE SIDE SILL.
5″ x 9½″ x 30″
10 ft left.
O.
HARD PINE SIDE PLATE.
2½″ x 5″ x 30′
10 ft left.

THE RELATION OF RAILWAYS TO THE TIMBER RESOURCES OF THE UNITED STATES.

By E. E. Russell Tratman, C. E.

(*Read before the American Forestry Congress, at Atlanta, Ga., December* 8, 1888.)

The report of the Commissioner of Agriculture for 1887, recently published, contains an interesting but brief report from the Chief of the Forestry Division, and this report refers to the Government interest in the development and maintenance of the forests; a matter which is of far greater importance than is generally understood, and which is especially important on account of the rapid destruction of forests through the legitimate demand for timber, through reckless use, and through wasteful practices of burning, herding, etc., while very little practical attention is paid to the question of forest planting or reforesting, although the forest under proper management is capable of furnishing continuous crops. The question considered is, "What is the first duty of the General Government in regard to the forestry question?" It is stated that the natural forests are being rapidly reduced by an increased demand for timber and by reckless use and wanton destruction, and that the annual consumption of wood and wood products is at least double the amount reproduced on our present forest area. The national interest in this question is shown from four points of view: (1) Because the forests properly managed would be the source of a constant supply of timber; (2) because a sound land policy demands attention to forest management to prevent the deterioration of forests and forest lands; (3) because a rational forest policy demands attention to the disturbance of the distribution of water flow by forest devastation and by the denudation of mountains and hills; and (4) because forest planting is a means of ameliorating climatic conditions and making certain regions more habitable.

Other nations have recognized the importance of the forestry problem and have the matter under State administration; for private interest is not sufficient to protect the forest property, since to the individual it is the existing timber alone that is valuable, and he has no care for any but pecuniary considerations. Consequently the State must undertake the management and protection of the forests.

The General Government of the United States owns about 50,000,000 to 70,000,000 acres of forest area, principally in the far West and on the Pacific ranges, and mostly on land not fit for agricultural purposes. The water supplies for the valleys and the agricultural areas of these regions are regulated and influenced to a great extent by the forests, and it is therefore obvious that the matter of preservation and protection of the forests is one of importance to the national prosperity; whereas, in fact, the timber is recklessly used and wasted, while the attempts to prevent the waste are practically ineffectual. A bill to protect the Government forests has, however, been submitted to Congress. The report referred to shows very forcibly the need of legislation in this direction, and of proper management to regulate the cutting, to attend to the maintenance and protection, and to undertake the planting of new forests to furnish a future supply of timber.

Of course these remarks apply to the consumption in total, but the railways are responsible to a considerable extent, both on account of the immense amount legitimately consumed for ties, bridges, trestles, buildings, etc., and on account of their waste and the amount improperly acquired. The report states as follows:

> Every land-grant railway, in addition to its share of the land grant of 75,000,000 acres and the right of way, is permitted to cut timber "for first construction, adjacent to the line of its road." But the railways do not consider "construction" and "adjacent" exactly in the sense in which the lawgivers did, and they have cut wherever, whenever, and for what purpose they chose.

Railway men as a rule do not give much attention to the sources of supply for ties, but, with others, believe blindly in "inexhaustible" forests, or if they do look forward at all to a diminished supply, they usually consider it as too far in the future to require any special attention now. In point of fact, however, this is even now a very important matter, which becomes more serious every year. Forests, although they can be made to furnish regular annual crops, can not be grown in a year, and while present resources are being recklessly drawn upon, few steps are being taken to provide future resources.

There are four ways in which the railways may help to economize the present supply: (1) By taking more care in the selection, cutting, and storing of timber; (2) by the more general use of iron, steel, stone, brick, concrete, etc., for bridges, trestles, buildings, and other construction works; (3) by the introduction of some efficient and economical preservative process; and (4) by the introduction of metal cross-ties. These four methods of economizing will be considered separately.

1. *By taking more care in the selection, cutting, and storing of timber.*—Sufficient investigation has not been made of the availability of different kinds of timber for railway work. For instance, there are probably other kinds of timber besides those now used which are suitable for ties, and, in fact, a circular was issued some months ago by the Forestry Division* showing the advantages of the hitherto unused chestnut

*See Circular on p. 52.

oak, a species of timber of which the bark was used, but the wood itself left to rot, its value for railway ties not being known or appreciated. As a result of this circular, large numbers of ties have now been made from this wood. Certain specifications for ties which have been published name only the following varieties:

> Oaks of the various kinds, known as "white," "black," "yellow," "rock," "burr," and "post" (no red oak will be received), second-growth white chestnut, red beech, red elm, cherry, maple, butternut, tamarack, and yellow pine of the long-leaved, southern hard pine variety, cut from untapped trees and grown not north of South Carolina. Hemlock may be accepted, but only under special contracts.

But it has been suggested that red oak, black locust, and white and red cedar might be added, and probably others, besides the chestnut oak already referred to. This part of the question is important also in connection with the third part, as the use of preservatives may enable other kinds of timber to be used. It is sometimes specified that there is to be no sap-wood on the face of the ties, which excludes all ties cut from such trees as give only one tie, often the best. With regard to cutting, although over this the railway has often no control, except in the case of new roads through timber country, there is undoubtedly much timber wasted in high stumps and by careless felling, etc., which with a little care might have been available for ties or lumber. In storing, the ties are often stacked up in close piles, without any air-spaces between adjacent ties, and left till wanted, by which time many will probably be found, especially at the bottom of the pile, to be rotten and useless. If they were thrown into a pond or brook, of course under proper supervision, their life when put in the track would be longer than if they had been stacked. Bridge timbers and other lumber should also be properly cared for in storage.

2. *The more general use of iron, steel, stone, brick, concrete, etc., for bridges, trestles, buildings, and other construction works.*—On this point much need not be said. Iron and steel are becoming more and more generally used for bridges and trestles, and many large and some small stations are now built of masonry. There is, however, room for very much greater economy yet to be practiced in the use of timber for railway structures, and it will be practiced more as companies grasp the idea that a heavy outlay in the first place is often economical. This, of course, applies only where the heavy first cost can be afforded; but it applies extensively to wealthy corporations, which continue to spend money and use timber in building and repairing timber trestles, sheds, wharves, etc., instead of laying out a good round sum on permanent works. In this respect much might be learned from European practice.

3. *The introduction of some efficient and economical preservative process.*—Numerous preservative processes have been experimented with and large quantities of preserved ties, piles, and lumber used; but considering the enormous quantity of timber in use on the railways of this country, the step towards economy in this direction is a very insignifi-

cant one. The trouble is to find a good process and to get it thoroughly carried out. Different species of timber and different pieces of the same timber absorb different quantities of the preservative, thus producing an undesirable want of uniformity. This is specially troublesome in the case of ties, some ties lasting for years and others having to be replaced in a short time, which means considerable expense for maintenance of the track. In England, where the creosoting process is generally adopted for ties, some railway companies have their own plant and creosote their own ties, sometimes also sawing their own ties from logs delivered by contract. Some of these plants were described in my paper on "English Railway Track," read at the annual convention of the American Society of Civil Engineers at Milwaukee, Wis., in June, 1888. Too little practical attention has been given to this question, though it seems as if some slow progress was being made. Creosoting is very generally used in England and is very successful, but the kind of creosote used is more expensive in this country. Some very valuable and useful information on this subject is contained in the report of the committee on the preservation of timber, American Society of Civil Engineers, June, 1885, and in Bulletin No. 1 of the Forestry Division for 1887.

4. *By the introduction of metal cross ties.*—This subject, one of the most important in railway matters, from the point of view of the economy and efficiency of the track for operation and maintenance as well as from that of economy in timber, is not given much practical attention in this country. Comparatively little is known in detail of what has been done and is being done in other parts of the world, though it is usually understood that quite a number of experiments have been made in foreign countries. Experiments certainly have been made and are still being made, but the matter, on the whole, is beyond the experimental stage, and metal ties have been regularly adopted on hundreds of miles of track, with most satisfactory results. The reason why the matter has been so neglected in this country, may probably be found in the undeniable *cheapness* of so many of our railways; the fact being frequently overlooked that cheapness is expensive, and that what is saved in construction is paid out over and over again in maintenance and expenses. By this it is not meant to suggest that every road should at once put down metal ties, because there are many cases in which this would be inexpedient if not impracticable, since many Western roads must of necessity be built at as low a rate of first cost as possible; and as the construction of these roads (I refer here only to legitimate enterprises) is absolutely necessary for the development of certain districts, for the benefit of those districts, and incidentally for the benefit of the country at large, there are cases in which, for the present at least, wooden ties may be used and their use put under the head of "legitimate consumption." But there are other classes of railways: there are the roads which, having been cheaply built in the first place,

have built up the district they serve and are being improved to meet the requirements of increased traffic—on many of these roads metal ties might be laid to advantage; then there are the wealthy trunk lines, which instead of consuming great quantities of wooden ties every year for maintenance and renewals, should gradually introduce metal ties on their tracks; and finally there are the new roads in busy parts of the country, which are built in a first-class manner to accommodate a heavy traffic from the beginning—these lines should be laid with a metal track in the first place.

In these four ways the railway systems of the country might aid greatly in economizing the present supply of timber, but, in addition, they might help to restore the forests by establishing plantations and encouraging forestry. This has been done to a small extent, but the length of time necessary for the growth of a "crop" is a hinderance to any movement of this kind. In Pennsylvania, railways already have to go outside the State for their oak ties, and the mining industries in the once heavily timbered coal regions of the same State have to import the props, etc., for the workings. In Europe, steel is coming into extensive use for mines, both for props and beams, and for ties.

Some idea of the consumption of timber by railways may be gathered from the following particulars, which are abstracted from a Report on the Forest Condition of the Rocky Mountains (Department of Agriculture, Forestry Division, Bulletin No. 2), by Col. E. T. Ensign, forest commissioner of Colorado:

Union Pacific Railway.—During 1886 there were used in Idaho, Montana, Wyoming, and Colorado, 686,827 ties and 8,450,969 square feet of dimension timber.

Denver and Rio Grande Railway.—The following native timber was used in Colorado and New Mexico in 1886: 60,000 broad-gauge ties, 740,000 narrow-gauge ties, 3,000,000 feet, B. M., of dimension lumber. The approximate amount of timber required for annual renewals and repairs was 1,023,376 ties, and 5,625,000 feet, B. M., of sawed timber.

Colorado Midland Railway.—The number of ties for the construction of 250 miles of main track and the sidings, was estimated at 900,000, and the number of feet of timber for bridges and other construction work at between 6,000,000 and 7,000,000.

Atlantic and Pacific Railway.—During 1885 the consumption of native pine was 937,240 feet in New Mexico, and 2,028,959 feet, B. M., in Arizona. In 1886, 47,456 ties of native pine and 298,755 feet of native pine dimension lumber were used in New Mexico.

Another form of timber destruction, and one for which the railways are largely responsible, is that of fires; on many lines through tracts of timber there is abundant evidence of this fact in strips of charred stumps and logs along the track, sometimes spreading off into large patches. The spark arresters on many locomotives, especially on lines of minor importance, are very inefficient, and on some little lines in New England over which I have traveled, the wood-burning engines, although fitted with spark arresters, throw out continuous showers of sparks. Some interesting notes in respect to forest fires may be gathered from the reviews of the forestry interest in each State and Territory—given in the annual report of the Division of Forestry for 1887, by Mr. B. E. Fernow, Chief of the Division, which report, as well as other publications of the Division, I recommend for perusal to all persons interested in this important question of our timber supplies. In most cases there are laws and penalties relating to starting fires, etc., but the laws seem generally to be a dead letter; they are rarely enforced, and consequently little heed is paid to them. In New Jersey, the loss from fires for the last fifteen or twenty years is said to have averaged, on a low estimate, $1,000,000 a year, an amount which would nearly pay the entire taxes of the State. In Maryland, the loss by fires, "largely from locomotives," is estimated at between $30,000 and $40,000 a year. The total losses by fire form in the aggregate an enormous amount of timber, representing a wicked waste of material, and consequently of money. On the other hand, the steps taken towards planting are few and insignificant, being almost invariably on a very small scale.

Street railways, too, consume a great amount of timber, and it is probable that the ties, from their being covered up but not protected from moisture, have a short life compared with that of ordinary railway ties. When we reach that station of progress when we shall begin to follow the European precedent of building city railways of iron and concrete, we shall materially reduce one item of consumption of timber. But proper street construction must come before, or at least with, proper street railway construction.

In conclusion, the close relations of railways to the timber supply of the country have, I think, been clearly outlined in this paper, and I sincerely hope that at no distant time the railways will, in effect, cooperate with the Government in the conservation and protection of the timber resources, while at the same time they greatly improve the efficiency and value of their own works.

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