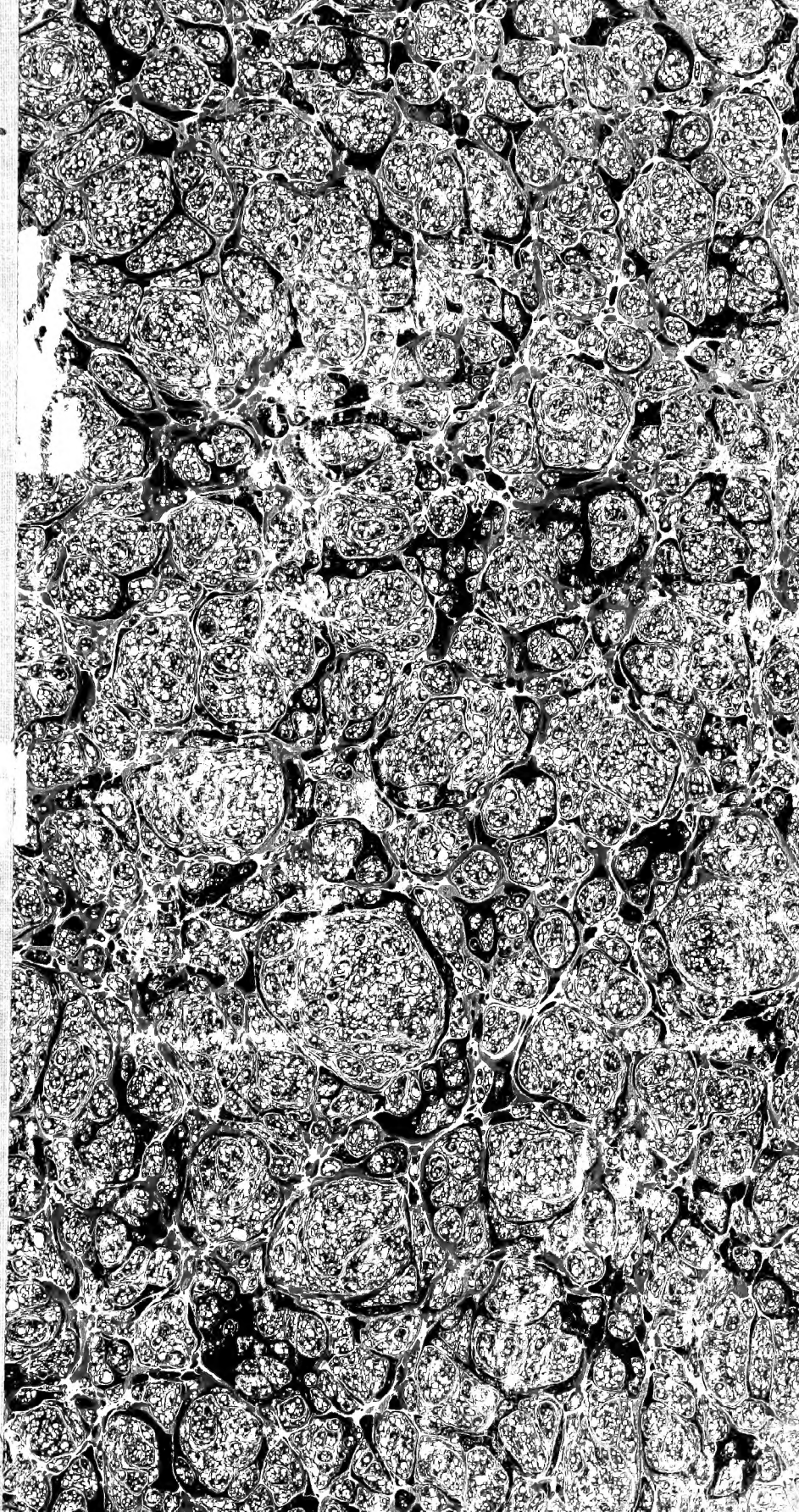

REPORT

ON THE

NECESSITY OF PRESERVING AND REPLANTING FORESTS.

COMPILED AT THE INSTANCE OF THE GOVERNMENT OF ONTARIO,

BY

R. W. PHIPPS, Toronto.

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1883.

To the Honourable S. C. Wood,

Treasurer of Ontario,

Sir,—Agreeably to the instructions of the Ontario Government, I have prepared a report on the important subject of the forests of the Province. The object of the Government, as I have understood and endeavoured to carry it out, has been to circulate the information procurable in so popular a form as to ensure its being generally read, and thereby to enlist the understanding and sympathies of all in the valuable work contemplated—that of preserving such portions of forest as are necessary for our future supplies of timber, and for that still more important result, which the maintenance of forests secures the great climatic and agricultural benefit derived from regular supplies of moisture, whether in river, spring, or rainfall.

The subject has long been one of my favourite studies, my first writing thereon in the *Canada Farmer* and other journals dating thirteen years ago, while I have had myself much personal experience, which I have found useful in preparing the report, a work which, I may remark, has occupied me several months.

I have concerning the matter actually presented, followed the plan generally observed in other countries in drawing up such documents, namely, that the first Report should present the scientific aspect of the case as applicable to the country in question, together with statements of what steps have been taken by other governments in such matters, the results which have attended their efforts, as well as the causes which led to their action; accompanied by such additions to the stock of facts as personal knowledge enabled me to supply, and compilations, in as concise a form as possible, of such evidence touching the subject as is on record from the pens of gentlemen well acquainted with Canadian affairs, and such quotations as bear most directly from the most celebrated writers in America and Europe, concerning the advisability of action in the care of and reproduction of forests, and their explanation of the great principles on which such advice is based. Such reports have generally been preparatory to a more exact personal examination of the country, and the obtaining of evidence from individuals in its different localities, which, the writer would suggest, should now be undertaken.

It may be added, that of the various scientific explanations adduced, none has been given except on the highest authority, nor without consulting numerous authorities, of some of which I now append a list. Of those authorities to which I am chiefly indebted, I may mention the various reports presented from time to time to the American Government, the valuable report compiled by the Commissioners of the Ontario Government concerning the Forestry Congresses at Montreal and Cincinnati; the Montreal press reports of the former; the numerous excellent writings of Prof. Hough, U.S. Forestry Department; some very useful and exhaustive reports concerning the examinations made by the East Indian Government in the system of European Forestry (for which I have to thank Hon. M. Joly and Prof. Goldwin Smith); Le Traitement des Bois, par Ch.

Broillard; Les Bois, par Dupont et La Grye; Les Arbres, par Schacht; Brown on Forests and Moisture; and Reboisement in France, by John Crombie Brown, LL.D., Edinburgh; The Forester, by James Brown, LL.D., Stirling; Bagneris on Sylviculture; The Earth as modified by Human Action, by Zeo. P. Marsh; The Trees of America, by D. J. Browne, New York; the far-famed meteorological works of Herschel, Flammarion, Glaisher, Humboldt, and others; the reports of the various conservators of forests in Australia, New Zealand, and India; Lasett's Timber and Timber Trees; Chapman's Geology of Canada; Vallis' Influence of Forests, etc., etc.

It may be remarked that this report, with the same or even less labour, might easily have been made much more bulky. But I have rather chosen to reject as much as possible, so as to leave, in the present form, an amount of information more likely to secure perusal than if further extended.

INTRODUCTION.

As a preface, perhaps I cannot do better than ask the reader to peruse, I need not ask him to admire, the following beautiful piece, from "Nature, or the Poetry of Earth and Sea," by Madame Michelet :—

"Alas, in how many places is the forest, which once lent us its shade, nothing more than a memory. The grave and noble circle, which so befittingly adorned the mountain, is every day contracting. Where you came in the hope of seeking life, you find but the image of death.

"Oh, who will really undertake the defence of the trees, and rescue them from a general and senseless destruction? Who will eloquently set forth their manifold mission, and their active and incessant assistance in the regulation of the laws which rule our globe? Without them, it seems delivered over to the blind destiny which will involve it again in chaos! The motive powers and purificators of the atmosphere through the respiration of their foliage; avaricious collectors, to the advantage of future ages, of the solar heat, it is they, too, which arrest the progress of the sea-born clouds, and compel them to refresh the earth; it is they which pacify the storm, and avert its most disastrous consequences. In the low-lying plains, which had no outlet for their waters, the trees, long before the advent of man, drained the soil by their roots, forcing the stagnant waters to descend, and construct at a lower depth their useful reservoirs. And now, on the abrupt declivities they consolidate the crumbling soil, check and break in the torrent, control the melting of the snows, and preserve to the meadows the fertile humidity which in due time will overspread them with a sea of flowers.

"And is not this enough? To watch over the life of the plant and its general harmony, is it not to watch over the safety of humanity? The tree, again, was created for the nurture of man, to assist him in his industries and his arts. But on this immense subject I cannot dwell. Only, it is our very emancipation. It is owing to the tree, to its soul earth-buried for so many centuries, and now restored to light, that we have secured the wings of the steam engine.

"Thank Heaven for the trees! In this book, and with my feeble voice, I claim for them the gratitude of man. Let other writers of greater authority come to their assistance, and restore them to the earth, before she is utterly stripped, before she becomes an arid and uninhabitable desert.

"One day, as seated before a forest of firs already marked for the axe, I was lost in a sad and silent dream. Another dreamer, who could well interpret my thoughts, told me that he came from the Engadine, the most elevated and the coldest region of Switzerland, where the fir ceases to grow, where the larch can barely live, but where the arolla prospers, and hardily plants its roots on the edges of the glacier. It is a hero! I exclaimed; we are in Switzerland, and should we not see it?' 'You must make all possible haste,' replied the stranger. 'In the war which man has declared against the Tree, the last of the arollas will soon have disappeared.'"

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WHEN the paddles of the Frenchmen first broke the clear waters of Toronto Bay, and their canoes grated on the bright beach of sand which then surrounded that harbour, Ontario, from the Detroit to the Ottawa, was under the roof of the forest. It contained at that time, as has been well remarked by one of the best qualified judges in the United States, perhaps the most valuable masses of timber which ever existed in a region of its size. There were hundreds of thousands—nay, there were millions of acres of magnificent maples, two feet—three—four feet through, their rugged trunks rising clear, separate, distinct, to the lofty arches of the forest, like the pillars of some great cathedral, overshadowing and crushing out by their ponderous vitality all inferior growths, so that below a carriage might have been driven for many miles in any direction, unimpeded through the park-like woodland. There were vast sections of beech timber, their clear blue-grey stems standing far away in the indefinite perspective of the forest, and here and there reflecting from their shining surfaces the occasional rays by which the sun was able to penetrate the mass of foliage overhead—great trees—three, or even four, fourteen feet logs to the trunk, a reservoir of plane-wood which would have lasted all the carpenters of the world for a century. There was white-oak, would have ribbed the navies of Europe, and ash sufficient to plank them all to the water-line. There are many perfect works in the forest, there is none more perfect than the white ash. Its shaft, round and perpendicular, sheathed in serrated bark of clear cut channels unique in their beauty, forms a picture the very axe might be loth to destroy. There were hickory trees by millions, the shaggy outer-covering hanging in strips from the huge red-brown trunks, had kept the world in axe-handles till doomsday. There were miles upon miles—there were hundreds of miles of wide-spreading cedar flats, where the traveller's foot might all day long press the mossy covering of their protruding and gigantic roots, while around him still arose on all sides the upright shafts, the curious leaning branches of that most picturesque of trees. There were dark and apparently illimitable forests of hemlock, of which axe and fire have long since found the limit, as the tanners are learning to their cost. There were millions of silver-skinned birches, and iron-woods in countless numbers.

And above all others in use—above all others in money value, everywhere piercing the hard-wood foliage roof, rising to double its height above it; lofty, dense, sombre, fully exposed to, but almost immovable by, the tempest, stood in far-spreading masses the giants of the forest—the great Canadian pine.

It is not to be supposed that the forest of that day stood in clearly defined sections of different woods. Trees of other species from the predominant always intermixed, but in many sections to so slight an extent that those who saw that vast woodland can well remember where, every here and there, all appeared maple, all beech, or all hemlock, far as eye could discern. "What kind of land is it?" asks Cooper's Major of the Indian. "All sugar-bush; what you want better?" is the reply.

If the lord of these servants should at any time return from a far country, and demand to know the use the Canadians had made of his talent of timber, we should be puzzled to extricate it from the napkin of fire in which we had wrapped it. For the advance of the Anglo-Saxon across the North American region has been, so far as the trees are concerned, like that of Attila, who boasted that no grass ever grew where his charger's feet had trodden. No destruction was ever more ruthless, more injurious, more lasting in its effects, or more difficult of repair, than that to which Canadians, for the past hundred years, have cheered one another on. Among all the politicians who have in turn saved our country, few of them have thought it worth while to attempt to save the timber. And yet much might very easily, very valuably, have been done towards that end. But the Genius of Preservation was absent, while that of Destruction filled the land with his voice. Here might have been seen a rustic, placidly destroying a grove of white pine, worth a million of dollars, in order to uncover a barren waste of sandy land, which at first gave but little wheat, and has since pastured but a few cows; there another, devoting to the flames a district of red oak, would have kept Malaga five years in wine puncheons, that he may bare a piece of hard red clay on a mountain slope, which he shall try to cultivate for a few years, and shall abandon when the winter torrents have washed the scanty humus away from the hard pan which all impenetrable lies below. Here is yet another who, to advance himself a little by burning in June a fallow which should have lain till fall, and thereby save a matter of ten of twenty dollars, has let fire run through five hundred acres of good hemlock bush, killing the young trees, girdling the old, and half ruining the soil for future agricultural purposes. Here you might have seen one rolling together and burning great logs of black walnut (a wood invaluable for furniture, of which the Canadian supply is long since exhausted, and the United States supply almost so), in order to make a farm, all the profit of which for forty years would not reach one-tenth of the sum the walnut, if left standing till now, would easily have drawn. Nay, an item which will be more comprehensible by every one, I have myself seen, on the sandy lands near Toronto, great heaps of almost clear pine, worth to-day forty dollars a thousand, given over to the flames.

All old residents of Toronto can well remember the days before the railways—the old wharves piled high with pine for steamboat fuel—the long procession of wood-waggons, two cord on each—down Yonge street, and from the Kingston and Dundas roads. I fancy the pine so used would now sell for a good deal more than all the steamers and all the freight they ever carried.

"We must have the land," said the settlers, "we don't want any boards, and there's no sale for it in town." A hundred miles north of Toronto, and within fourteen of a railroad, I have known heap after heap, acre after acre, square mile after square mile, till the forest was gone, where the splendid and massive rock elms, three to even six feet through at the butt, the long clear basswood, good for many a use, the straight logs of valuable cherry timber, and equally valuable red oak, with beech and maple, hemlock and ironwood, uncounted and uncountable, arose in smoke, a sacrifice to the Goddess of Ignorance throughout the length and breath of the land.

But one will say, "The land has to be cleared." Yes, and no. It was necessary indeed to obtain land for the plough, but what I shall endeavour to shew in these pages, is that, had great reserves of the inferior lands, and of the mountain lands, been spared the axe, in proper and intermediate positions, good and constant succession of trees, and large supply of timber might have been obtained therefrom, while the land which was cleared would not only have yielded larger crops than the present much broader acreage affords, but would have yielded them at a much smaller cost of anxiety and labour. This point once demonstrated, we shall probably obtain some valuable ideas as to the road to be travelled in utilizing the forests which yet remain to us.

In the settlement of woodlands, such as Ontario was once entirely, it would be well that those entrusted with the duty of choosing the sections to be occupied by new comers, should reserve large portions of inferior land for forest purposes. The settler here, in many cases, cleared, much to his own injury, hill, swamp, sand and hard pan which might well have been left untouched, while there was, at no great distance, plenty of excellent land. That poor land, left in forest, would have, by its climatic influence, rendered much more easy, and consequently, much more lucrative, the production of crops on the other, and would also, if fairly used, have continued an inexhaustible reserve of timber, of firewood, and of fence.

Allow me to give an instance of my own experience in this matter, illustrative of the way in which heights of land, which should above all have been kept in forest, have been carelessly deforested in Ontario. On one of my expeditions many years back, undertaken in company with some other young men for the purpose of choosing farms among the vast forests then existing in the Province, after travelling a good many miles, we came to a district where there was evidently much good land, none of which, however, seemed at that time to be in the market. It was a broad and a splendid forest, dense with vast elm and heavy oak. There on all sides rose the mighty maple, rich in promise of sap and overflowing trough, intermixed with many a lofty basswood not unsuggestive of futures even sweeter, for amid the blossoms thick among its massing foliage, high overhead in buzzing millions the wild bees toiled and sang. Here and there, perhaps miles apart, a settler had cleared a limited rectangular space, his small log barn and smaller house half hidden by the waving luxuriance of his little patch of Indian corn, his field of wheat, his bit of meadow, where, tall, interweaving with each other, and covered with dull red flowers the clover and timothy, vigorous from the untired soil, climbed high against and even overtopped the four-foot fences. All here was deep and loamy clay. Travelling through continual and overhanging forest, we were not aware of the elevation, but in fact the country through which we were passing was the gradually arising slope of

a mountain range. We passed on further, the land did not now appear so rich. It was still strong and fertile clay, but not at all the equal of that we had left. The oaks were smaller, the maples harder of trunk, and dying at the top, dark masses of hemlock frowned perpetual from the glade, and every here and there the spectre-like balsam, high, gaunt and spire-crowned, pointed his warning branches to the hard, red soil below. However, persuaded by settlers, who at any risk wished to bring other settlers around them, we bought land, cleared it and built on it. Other settlers came and did likewise. Then a while afterwards, when our road and clearings had introduced daylight for many a mile, we understood what we had done—we had occupied the height of land. The rich slope we had passed on one side was equalled, had we gone that far, by a slope of equal richness on the other side of the mountain. But we had halted, and many had halted, on the watershed, the summit of the mountains, a great table-land of many thousand acres, rich in its uncleared state with springs of water (on my hundred acres I had six or eight which promised to be never-failing), but of far inferior land to that which lay below. There was the great mistake. The authorities of that day knew nothing of it, the settlers knew nothing of it; and those great slopes, extending many a league, are now cleared of trees from highest ridge to far-distant valley on hither and farther slope, or showing every prospect of becoming so. The inevitable consequences will as surely follow. The land, even before I left that part of the country, was washing rapidly from the top. I have seen it gather eighteen inches deep against the fence on the lower side of a field. As for floods, since the leafy guardians of the height have been dislodged, I have seen a creek which would have flowed in full volume between one's joined hands, with two hours' rain roll down a red torrent which bore a ten pound stone some distance on its surface before it sank. The old forest, left above, would have held the rain in bed, leaf, and tangled brushwood for days, and sent it forth in gentle and gradual streams to the slope below. The summit land should never have been sold for settlement. With proper care in thinning and reproduction of trees, fenced against cattle and managed by foresters, that wide extent of tree-crowded height might have stood for ever a valuable forest, furnishing yearly lucrative supplies of saleable timber, and a far greater benefit, giving a continual fertility—by attracting rain, by preserving its former steady and numerous water-courses (seven-eighths of which are now dried up), and by preventing the now perpetual washing away of the soil—to all the far greater extent of far more easily cultivable land below. Let any one who knows the district I speak of think how scarce barn timber and even firewood now is there, and consider how valuable a large reserve on the height would have been to the whole country. This opportunity exists no more. The land is in private hands or it is cleared. But we have many mountain ranges still unsold which might be better managed.

Perhaps I may be permitted to refer again to my remembrances, and to remark that, a life-long resident of Ontario, and in my day largely engaged in clearing the forest, besides having had continual occasion to observe the work done in the same line by many of my relatives, who, coming to this country in the earlier part of the century, were mostly farmers, and what was long synonymous, choppers, I necessarily know something of the process and results of clearing. Their axes rung in many an Ontario forest—in the dense bush near Chatham, among the heavy beech of the old Trafalgar survey, on

the pines of the Yonge street line, away north in the Gwyllimburies, farther yet to the right and left of the Georgian Bay, in the woods where now stands Whitby town, and in many another forest glade, now forest glade no more. I have seen vast districts around me, where from elevated points we could once overlook many thousand square miles of forest and of lake, changed in a few years from leafy shades to sunny fields. In all my experience, though I have known many farmers who, believing that "ther'll allus be wood," cleared off every stick, and have now for many years bought wood, and in some cases coal; and though I knew some (myself included) who made spasmodic and ignorant attempts to preserve some forest, yet I never knew one who seemed at all likely to secure to his successors enough timber on their own land. No doubt there are such; but I have not been aware of them.

This arose from many causes. Some cared little so their turn was served, and I have seen a farmer point to his ten or twenty acres of wood yet uncleared, with the remark, "Well, I guess that'll last my time. I didn't own no bush to begin with, nor no land neither, and my sons'll be better off than I was, for they'll have the land anyhow. Besides, there'll always be lots of wood in this here wooden country." Then, the pressure of poverty was sometimes severe, and men sometimes driven almost to starvation point, had little scruple in destroying a hundred dollars' worth of timber to procure five dollars' worth of wheat, when they knew they could get the five dollars, could not get the hundred then, and were by no means sure that they ever would. Again, ignorance was very general. Few of us knew that, in destroying the forests, we were, in effect, pledging ourselves to pay a heavy rent for our farms. There is nothing now better known to the world of science, than the fact that any deforested country will cost the cultivator at least four or five dollars more per acre, to obtain the same crops which nature would have assisted him to procure, had a proper interspersion of forest reserves remained to continue the natural moisture and preserve the original fertility of the soil. And I may remark that it was impossible that this should be then known, as it is known in the present day. The knowledge, or rather the proof of the knowledge, had not been arrived at. It is only of late years that even the older nations of Europe have attempted carefully to investigate the matter. For instance, when, in 1870, I took occasion to write in the "Canada Farmer," and other journalistic literature of the day pretty extensively concerning this matter, I found no such stores of knowledge, or of reference, as at present exist.

Even in that short interval of twelve years great progress has been made. Fresh experiments have been carried out, and new and valuable information obtained, in American, European and Asiatic countries. The American Government, warned by the rapid decrease of their forests, and consequent and evident injury to the productive power of their soil, have for some years past had in operation a Forestry Bureau, which, under the efficient management of Dr. Hough, is doing excellent service, and has now issued its third volume of reports. France and Switzerland, convinced by recent experience of the injurious results of deforesting their mountain districts, are replanting at great expense the most elevated plateaux. In the case of the former country, vast additional outlay has been incurred, and with the most gratifying success, in establishing along the sea coast great plantations of valuable timber, a benefit to the climate, a source of profit to the proprietors, and a complete remedy for, and prevention

against the wind-carried waves of sea sand, which previously every adverse gale scattered in masses far inland, to the utter destruction of the arable soil. In both these countries, within the same period, as well as in Germany, in the far distant region of Australia, and, indeed, in most civilized lands, schools of forestry have been improved or have been established, provision made for the drawing thence annually a body of trained foresters for the service of the State, and governmental machinery created, whereby their services will be at once and continually available for the preservation of existing and the planting of fresh sections of woodland.

But of all this, while the chief mass of Ontario timber was destroyed, little was known to the world, and less to the destroyers. If, here and there some one had more skill in natural philosophy than his brethren of the log heap, he also had skill to see that he alone could not impress the masses in such a matter, and that his efforts would do but little to preserve the naturally assisting relation between forest leaf and ear of grain. Some few I heard of as having enclosed, thinned and protected from fire and cattle their modicum of woodland ; but so few and far between were these that I never knew personally one. I knew thousands who did not. Those few who had means and will lacked experience and teachers.

I remember, when little over twenty years of age, I made my first experiment in clearing a hundred acres. I left ten acres of solid, lofty timber in a strip along the north side as a shelter against the coldest wind. It was for ultimate, not for immediate service, for behind it stretched, broad and untouched, the forest of many miles in depth. The strip, when its border stood fully exposed by my clearing operations, formed a pretty picture. Thick with dense young trees below, and great hemlocks, red oaks of mighty size, waving beech and heavy maple nodding their leafy heads, above, it stood (for my fires had not touched it), from ground to summit twigs, a wall of living green ; which, when the cool daybreak air of June, purified beyond the imagination of city dwellers by many a charcoal heap, had covered the great leaf masses, the branches, the angular rail fence below, and every forest weed around, with myriads of bright and glancing drops of dew, shone, flashed and waved along its whole emerald length, and down a thousand opening and closing vistas, like the wall of Fairy-land itself. "These other country fellows," thought I, "chop down everything, but I shall preserve this beautiful growth, at least, whatever happens."

Well, time passed on. Next year was a dry summer, and an English gentleman who knew considerably less than the little we knew, cleared at one fell swoop a hundred acres behind mine, and burnt the soil of half his farm beyond redemption in the process. I was many miles away, and what shall hinder his fires from, by way of a gentle commencement, running all around the border, and some forty feet into my pretty reserve. Down went my young maples by the thousand ; my little hemlocks, their roots burnt from under them, stood in blackened and spectre-like rows. The beauty of the strip was gone. Next year, a poor settler lived near with some cattle he could not feed, so turned them loose. They did not leave a young tree nor a green branch they could reach in my ten acres. The result of these combined attacks was that the moisture seemed to leave the strip. The vegetable coating of massing roots and rotting leaves was swept away, and the great trees which

fire and cattle could not destroy, seemed to dry, perish and fall of pure desiccation. In five years the green bit of fresh forest was a desolation of dry and rattling stalks, fit for nothing but the axe, and scarcely for that. But (and here was our lack of knowledge) had fire and cattle been excluded, the green bush had, with care, been green to-day.

Throughout Ontario clearing has been largely similar. It has been pursued without plan or system, utterly oblivious of the great and vital principle that, in this country, as in all others, there were certain portions which should be left as forest, because the ground would be valuable for that purpose, and scarcely for any other; and certain portions which should also be so left, as elevated above the rest, they form the natural conductors to attract rain, store-houses to preserve it, and slopes down which, in driest weather, the refreshing streams still carry the reserved moisture from the wooded hill top, to the arid and parching soil at a distance, but below. Then, as for reserves on each farm of timber and fire-wood; let us consider how these have been provided for:—

On each one, two, or three hundred acre lot as it happened, the original proprietor left generally "some bush," here, there, or anywhere in that part where it would least interfere with the cultivation of his cleared land.

Well, fire would run in some of these reserved portions and it would blow down, fill with weeds, become an eyesore and be cleared off and "cropped."

Or, the farm would be divided and sold; the bush lot buyer would have too much bush, and would clear most of it, so that now the two or three hundred acres would have but ten or twenty acres of forest.

Or, the whole would be cleared; the cultivators saying to one another, "Oh, there's lots of bush down on the sandy flats that never will be cleared (and here comes in the saving clause) in our time; we can always get wood hauled to our own doors in winter at one or one and a half dollars a cord. Let us clear off all the plaguy trees and crop the land!"

Or, a demand for cordwood for railroad or other purposes would spring up, and the farmer would be induced to sell his bush to the choppers. Notice how this would affect the one who had cleared. He had said, "So-and-so has hundreds of acres of wood; he can always sell to me." Others say so of others; but the demand carries off the very woods they had been depending on. Then they must cut down the small groves they had been intending to keep "no matter what happens;" or they go to others and say, "Well, wood's very scarce round here; I don't want a twenty miles' hauling job; tell you what, if you'll let me have some out of your ten acre block, I'll give you a dollar and a half a cord and cut for myself. There!" The offer seems large to one who has been used to pay for having the wood destroyed, and he takes it. Others offer more, and the ten acre lot goes, and is in grass.

Then the masses of woods, bounding his vision on every side, here a solid wall bordering his farm, there a strip along the horizon, were at first apt to deceive the settler into a belief of the continuance of the forest. I mentioned one a few lines back as saying, "There will always be wood on the sandy flats." I will give here a little bit of experience showing how such expectations have been dissipated.

Along the low shores of a great lake stretched a forest, wherein stood cedar trees, good enough and many enough for Solomon's Temple, if he had been contented with

white instead of red, intermixed with many a solid acre of the largest and tallest beech, maple and basswood I have ever seen. We used to look from our more elevated region upon this great carpet of tree-tops covering the valley with intermingling foliage, and many of us thought we need keep no timber, we could always buy it or own it there. Well, I was a boy, and must needs go raspberry picking one dry summer day, when we had had no rain for six weeks, and we must, of course boil our tea-kettle, or rather big tin can, and apparently the fire went out; and I am afraid in fact, we cared very little whether it did or not, for it was either long before the days, or far beyond the scope of the three months fire regulations, though they now are in full force in that district. Well, we went home, and about a week after, a column of dense black smoke could have been observed to the northward, and somebody said, "There's a big fire along the shore." There was indeed. The column of smoke broadened and blackened, and extended for weeks, nor did it subside until the heavy September rain, nor was utterly quenched before the winter snow. The devastation was melancholy to behold. The forest had fallen before it like grass before the scythe. Our tea-kettle had cost thousands of acres. Cedar and beech, oak and maple, were no more, and in their place, many summers after, a vast white carpet of close standing Canada thistles used to overspread the land. No more reserve of timber for us along the lake. But some will say, "At all events, the loss of the forest gave room for crops." Unfortunately, it could not. Nature had planted and cultivated there the only crop such soil could grow.

The trees, by protection and careful use, could have been continued a source of income for infinity; but its burning took the top soil of a few inches of black earth from off a carpet of pebble stones and boulders. The best of the soil was gone, and nothing less than three centuries of rest, or the income of a Rothschild could restore it.

The settler, too, can never fully realize the vast power of the settlers who are coming. He sees indeed, the sixty or a hundred acres on which he has abolished the forest; but still he sees everywhere the embowering shade; he drives to the village through avenues of trees; he visits the next farmer across five miles of dense wood; nearly every hundred acres he sees is a hundred acres of timber, but he does not so well understand, at first, that for each there is an owner, and that each piece of good and many of poor land will as surely, in a few years, find some one prepared to clear it, as that each separate snowflake in a January field will before June meet a sunbeam to disperse it into air.

If we look from end to end throughout the settled portion of Ontario, we shall find what the foregoing observations have led us to expect. There are as yet, on many farms, portions of forest remaining, generally of small extent. But, as a rule, little care is taken to exclude cattle or to continue in its efficacy the timber plantation as a perpetual source whence many sturdy trees can every year be taken without injury to the continuance of the grove. On the contrary, all over our older districts, as any one who has travelled them as I have for the last forty years is well aware, the patches of reserved timber are every year becoming smaller and smaller, nor is there any replantation observable, at all calculated to fill their place.

It must be thoroughly understood that unless powerful efforts be made in the direction of replanting, the cultivated portions of Ontario will become almost denuded of trees. The whole force of circumstances and nature point inflexibly in that direction. Portions

of the forest left standing will not, without care, continue many years in a state productive of timber or beneficial to the climate.

These trees have grown, root and trunk, in the shade. The outside rows, exposed to the sun, wither gradually, decay, and are easily uprooted by the force of the wind, injuring the inner and younger trees in their fall. Then, if cattle are allowed entrance they will kill every young tree, a process which, as far as my observation extends, dries up the soil in small blocks of forest, and precipitates windfalls of large trees in all directions. In fine, the forest in most sections of Ontario, if left to itself in isolated patches, rapidly deteriorates. When we add to this the continual pressure in all directions, inducing owners to sell their wood and clear their lands, we must admit that if no active movement be made for their preservation, the forests which once overspread Ontario will soon give place to a bare and denuded surface, broken only by the low branches of an occasional orchard or the few trees which some one, here and there, has set in line along his fences or around his house.

That there is cause for much apprehension in the matter is a fact which can be well proven by contemporary experience, and it would be impossible to find a better method of obtaining such than by examining what has happened in those portions of Canada settled previously to our own. Let us look to old Lower Canada, the present Province of Quebec. Let us first consider the character of its inhabitants. The Lower Canadians are industrious, thrifty and home-loving. Their climate is a severe one. So far as the habits of their ancestors may be thought to influence, it may be remarked that no other nation were so careful in the preservation of their forests as, when they settled Quebec, were the French. There is, then, every reason to suppose that Quebec has been as well treated in that respect as Ontario is likely to be. May I, then, ask the attention of my readers to the condition of the older settled portions of Quebec, a state of affairs which any one travelling in that Province can verify, and which no one aware of the character of the witness whose testimony I am about to quote, will for a moment doubt. I allude to the Hon. H. G. Joly, of Quebec, from whose valuable report on "Forestry in Canada" I shall elsewhere quote further. With reference to the matter at present before us he says :—

"As far back as the year 1696 the attention of the French Governors of Canada was drawn to the wasteful destruction of the forests, and they were called upon to check it. Nothing, however, was done by them, and little has been done since. The result stares us reproachfully in the face, especially in the Province of Quebec, the oldest in the Dominion. The old settlements are painfully bare of trees; you can sometimes go miles without seeing any trees worth looking at, and the passing stranger fancies himself in a country more denuded of trees than the oldest parts of Europe. There is a large district of very good agricultural land south of Montreal, where the scarcity of firewood, which is a matter of life and death in our climate, has compelled many a farmer to sacrifice a fine farm and leave the country. There are many other spots in the Province nearly as bad, and unfortunately the process of destruction is going on even now in more places than one."

There is no reason to suppose that the residents in our Province of Ontario will be, if left to their individual guidance, more careful of their wooden reserves than have been our French Canadian friends. If on the one hand the Lower Canadian habit of partitioning their farm lands among the members of a family was likely to create a demand

for more fuel and more timber from each hundred acres than is our own, it is to be remembered that in their rigorous climate they had greater cause to fear a scarcity, and had every necessity to practise the art of replanting and of husbanding their woodlands. Nor had they at the time most of their clearing was performed an excuse for carelessness in reservation of timber, which has to a great extent prevailed in Ontario, namely,—the certainty of being able, by means of the number of railways, which in every direction chequer the surface of the latter Province, to purchase coal at reasonable rates. The Province of Quebec had been sixty years in the hands of the British before coal was even to any extent used in New York city. On the other hand, to my own knowledge, many an Ontario farmer has cut down his last tree, sold off the timber from his last five or ten acres of bush, with the consoling reflection, "Well, if the wood does run out, I can get coal, and folks say it's hotter and cheaper." Taking all this into consideration, no reasonable observer can doubt that the settled portion of Ontario is on the high road to becoming as destitute of woodland as Mr. Joly's pamphlet pictures any part of Quebec.

And here I will ask my readers to consider a point which might, perhaps, better come later, as more connected with what will then be introduced, but which may be now mentioned as concerning the Province just spoken of. We will remark, before we lose sight of this very important feature, the injurious effect this over-clearing has had on the Province of Quebec.

It is well known to every person of ordinary information that in times past quantities of wheat were raised in and sold by the Province of Quebec. Certain valleys drained by great rivers there, covering vast areas of land, were thought to be the very home of the wheat plant. Before 1830, the yield of wheat in Lower Canada is said to have been enormous; between then and 1865 it sank to an insignificant fraction; since then better farming has to a certain degree restored it, though to nothing approaching its old fertility. It has been usual to call the process which caused the injury "over-cropping." No one doubts that with good farming and favourable seasons the land might, as much land has, have stood the cropping without deterioration. But if it could be proved that, on the contrary, the process of clearing the forests tended to carry away the fertile portion of the soil, and had done more, had even prevented the possibility of seasons continuing as favourable as formerly, would it not do much to account for the falling off? What if we can discover by undoubted testimony that this is so? We shall, I think, in the course of this book find proof of these two important points.

First.—That gentle, frequent and refreshing showers, where a country is to a proper extent retained in forest, are likely constantly to occur throughout the summer months, giving their well-known and powerful stimulus to all the growths of the field.

Second.—That when such proportions of forests are not retained the showers are not equally distributed; they do not descend at the especial time, nor in the manner beneficial to the plant, and being precipitated in floods, the result is:—

That they do not frequently, and therefore not nearly so advantageously give moisture to the earth. That, coming in floods, they bear away, in discoloured overflow, much of the richest earth of the fields. That extended areas of pasture, meadow and plough land thus rendered comparatively infertile, cannot yield the means of keeping

much cattle or obtaining much manure, and the land thus again, from this secondary cause, yet further deteriorates.

If we take into consideration what has occurred as previously stated, concerning the destruction of forests in the Province of Quebec and its results, and remember that the same state of affairs exists in many of the older settled States of the adjoining Union, and remember also how little isolated and individual action can do in the way of remedy, there is no avoiding the conclusion that, in our own Province of Ontario, unless the strong hand of Governmental assistance is brought into operation, even the small reserves of woodland which here and there dot the surface of our present cultivated territory will disappear, and their absence will produce the same results as have in other countries invariably been found to follow similar losses. In the eastern portion of the United States the same deterioration of soil is observable, and has proceeded step by step with their disforesting. Many once fertile farms there are now abandoned through sterility; while, as if to point out more clearly cause and effect, as will be shown by quotations further on, the operations of replanting which have been in progress for thirty or forty years in certain districts there, have not only produced new forests but improved growth in the adjacent cultivated lands. This is especially the case in Massachusetts.

Speaking of Massachusetts tree planting, we may remark that that whole easterr coast, following the French success, is conquering the sand drift with the pine tree. Numerous instances are given where these artificial plantations are now yielding merchantable timber, and some where the original woodlands, preserved for that purpose and properly managed, had yielded larger returns than money devoted to the purchase of lots afterwards forming part of the most flourishing cities, and of course paying well. It should be noticed here that Nature, always benevolent, has offered a remarkable inducement here. The very lands most useless to the agriculturist—the light and almost barren sands—are those on which, according to French, German and American experience, we may hope for most success in planting the most desirable, the most rapidly disappearing of all our timber, the great Canadian pine. Sombre, indeed, as that dark tree passed by Æneas on the downward way.

> "Ulmus opaca, ingens, quam sedem Somnia vulgo.
> Vana tenere ferunt, foliisque sub omnibus hærent;"

or, we may translate freely,—

> Vast elm, impervious to daylight's beams,
> Where live the Visions and where haunt the Dreams.

But no tree of all the forest will serve Ontario so well as these tall, gloomy guardians of the soil, valuable for the timber they yield, doubly valuable for the climatic influence their giant height and dense foliage exert, forming a link as they do in the transmission of moisture between the heavens above, the earth beneath, and the waters under the earth.

Already a great number of the smaller streams which formerly flowed continuously throughout the length and breadth of Ontario are dried up, or only run during the floods produced by spring thaws or autumn rains. With the utter disappearance of our forest reserves, those which yet remain will more and more entirely disappear.

Formerly the interspersing belts and large masses of yet untouched forests held, in a manner afterwards to be explained, during the summer period of vegetation, great reservoirs of moisture, which causing a continual flow of water-courses throughout and under our fields, watered and fertilized the land, and was in itself, as we shall hereafter see, at once the cause and the result of the frequent spring and summer showers which so greatly aided the labours of the husbandmen.

It is noticeable, I may remark at this point, that in many parts of Ontario where formerly portions of newly cleared forest ground could be reasonably expected to yield a large crop per acre, adjoining land as well wooded and of precisely the same constituents, so far as soil is concerned, will not now when cleared and cropped give anything like the same amount. It is also observed that ploughed land some years under cultivation, in similar localities, compared with ploughed land of many years back, although now worked with the advantage of improved implements, far greater care in the rotation of crops, and the application of a quantity of manure quite unobtainable in the old days, frequently fails to yield an equal return to that formerly secured with rougher cultivation and infinitely less labour.

The old settler remembers the once spontaneous growth, and is apt to say with Hood in the "Haunted House":—

> "A merry place it was, in days of yore;
> But something ails it now; the place is curst."

The land is haunted by the spectre of its former fertility; the fertility which in our greed we slew. We were not satisfied with the golden egg of the field, we must, to get all at once, kill the goose—the woodland which nurtured the field; and we have neither fair forest nor fat meadow. We said with the fabled rebellious members, "What is the good of feeding this useless stomach? The limbs are the valuable parts." "What," said we, "is the value of this woodland? The field it is which gives the crop." But as the stomach got thin the limbs got thinner; as the forest grew small the field returns grew smaller. We had destroyed the regularity of the summer rain, that for which Virgil bids his husbandmen pray:—

> "Humidæ solstitia atque hiemes orate serenas,
> Agricolæ,"—

or, if you accept my translation of the first part:—

> "That moist and warm arrive the spring,
> That frequent showers the summer bring;
> Still, farmers, ask when vespers ring
> Ask in your matin prayer."

As I have just remarked in the case of Lower Canada, we have been too apt to believe that over-cropping alone has occasioned the evil. It has no doubt had something to do with the matter, but there is too much reason to believe that an equally powerful factor is to be found in the far less favourable distribution of moisture which our careless disforesting operations have brought about; and if this be the case even at present, what have we to look forward to as our present scanty interspersing reserves disappear, except a still more unfavourable climatic condition and one becoming worse much more rapidly

than in the commencing years of its progress, as the stone rolling down hill at first slowly, flies faster and faster as it continues to move. Much of our valuable soil has already been washed away from the uplands; many pastures formerly moist and green the summer through, now dry and bare, furnish but scanty picking in most years to one or two cows and a few sheep, and a very large proportion of our arable land, plough it and manure it as we will (as just observed) smiles not with the promise of former days, when, as the proverb says, "If you tickled it with a hoe, it laughed into a harvest."

The prospect is that if no governmental actions be taken (and I am now speaking of our counties which have been long settled) as soon as the disforesting process is as complete as it threatens to be, much of our higher plateaux, together with the long and sometimes steep slopes which, facing towards their nearest river beds, form so large a portion of our best land, will lose fertility in the course of a few years to a marked extent. For the rain will fall, the snow will descend, and will lie; but where disforesting is general, instead of being deposited—the first in refreshing and growth-producing showers, the latter, by its slow melting in the woods feeding our thousand springs and rivulets, passing in all directions under and through the cultivated fields, and yielding to them that moisture which is to plants what the blood is to the human frame—will come the rain in heavy torrents, which, instead of soaking into and manuring the cultivated land, will rush violently across it, melting the snow in violent floods during thaws, and both carrying away millions of cubic yards in solution of the cultivated earth that, had forests been left in proper extent, would have remained, and not only would have remained, but would have been enriched by the slow and beneficial passage across and through it, of those very waters which now remove it from our fields. Nor do the lower grounds escape, for none are so low as the bed of the rivers which drain them, though the fall may be less steep thereto.

The reckless disforesting, so strongly condemned by many American writers, which has been practised by their countrymen, is now bearing its fruits in the terrible spring and autumn floods which of late years have affected large portions of the United States. The Americans might spare much of their care for the channels of the Mississippi if they would restore the groves cut from the hills which fed its sources. To disforest a mountain slope is to devote the height to barrenness, the valley to flood, and both to parching drought when drought is most injurious, when

"Exustus ager morientibus æstuat herbis."

Added to this absolute abstraction and loss of soil—and to a much greater extent richness of soil—the loss by cropping, so to speak, in spite of nature, of taking from the soil without allowing the recuperating influence which Providence has placed in position to assist the farmers to perform their work, there is but too much reason to believe that we shall in Ontario, unless care be taken, find ourselves in the position in which too many countries now find themselves—compelled in order to grow crops and feed cattle, to give double the labour, and yet not receive the return we might for half the work, had we allowed the assistant forces of nature to remain in sway, and not destroyed the woodlands through whose agency they benefited the region wherein we dwell. To those who have not considered the matter, these statements may seem overstrained. If my readers

follow me I will endeavour to show them how well they are based on facts, and how deep our need in Ontario of action before the evil increases to a much greater extent, and while the means of prevention are within our reach.

I have spoken of the cultivated region of Ontario, which has been formed from our best lands—our deep clay loam, and rich limestone country. But close to us is a far greater danger in our inferior lands.

The province of Ontario is not a broad limestone bed. When we go north a couple of hundred miles, say as far as Muskoka, or a line running from it south-east to near Kingston, we came to a region of far less fertility, because based on a rock far less favourable to decomposition into fertile soil—here all is based on granite. There is no limestone, there is no lime. You will find yourself as you go through Huntsville, Bracebridge, Magnetawan, and all the great Nipissing region, considering how cold the country, rather startled to see that very few of the houses are plastered inside, but all wainscoted with thin pine. You will find many large hotels without an atom more lime about them than just built their chimneys; and that drawn a great distance at much cost. There is no lime, it is a granite land. Be respectful, for you stand near the very framework of the world, the great Laurentian rock. For my part, I had as soon my earthly station were somewhere else. The land is not that of the old Home District. The rich clay of the other is not here; it cannot be; there was no lime to make it,

> "Ere yet the little rills began
> To feed thy bones with lime, and ran
> Their course till thou wert also man."

There is clay; but it is whitish, soapy, sandy: and there is a vast preponderance of soft, peaty, powdery soil. There is much good humus in this, if it could be preserved until a thick clover bed overlies it (and it will grow excellent clover), but it is, above any land I have seen, that in which, when dried and thinned by partial settlement, I should fear the ravages of fires. I have passed over many of what are called balsam flats, which cover a vast part of that land, and though I heard some were richer, yet it was always my luck to be able to dig the tomahawk in the earth a foot deeper than its fifteen inch handle, and find nothing but grey powdery soil resting on powdery soil, and that on red sand or poor white clay. There is much birch timber, but largely dying at the top—the sign of weak soil. There are, left by the lumbermen, many poor or young pines; there are good beech and maple, but not the beech and maple of the old Ontario woods. There is, where the lumberman has not wrought, much fair pine; but this taken away, it will not be a heavily timbered forest, and it is one which will dry, especially as soon as the settler cuts gaps in it here and there, and thousands of cattle are let loose to do more damage than hide and horn, beef and tallow will ever pay for or begin to pay for. I say what a life's hard won experience has taught me,—that they will dry the land, that fire will run there, and that it is the very soil, and that it is the very timber where fire will do much damage. On the high ridge lands it will burn to the bone. Let anyone go a few miles north of Rosseau (many of our tourists yearly do so) and look at the forests they will see there, or what were forests where the fire has passed, and the bare white rock is visible as far as eye can see, with the ghosts of trees standing, gaunt, black, and charred, in long and hideous rows. Yet this was forest protective of springs and

moisture, creative of rivers and streams. It might have been kept in forest, but replanting is scarce possible in many places there.

"All the king's horses and all the king's men
Couldn't put Humpty together again."

However, in the softer soils, fire will not reach the rock, but it will surely run fast and far, and burn deeply and most injuriously into the life of the land (the vegetable humus on which in such a soil, the only hope of the agriculturist lies). And yet here is the region, the very region which, above all, we should endeavour to keep wooded, green, and flourishing.

Here we are near the height of land, the great water-shed which crosses the east of Ontario, on this side of which our streams flow into the lakes, while on the other they run into the Ottawa River. This height of land stretches from north-west to north-east, from near Nipissing till it strikes the St. Lawrence near Kingston. If you look at the surveyor's details of townships surveyed, you will find all this to be described much as land is pictured in the Nipissing and Muskoka districts. It is at present emphatically a land of moisture and of streams. There are numerous and beautiful lakes, there are rivers and water-powers right and left which would delight the heart of a manufacturer; there is the water, the very water he wants to aid the production of woollen and cotton goods—the water free of lime. The housewife may there boil her tea-kettle for years, no rock will form inside.

The great slope leading to this watershed, and stretching to and past the Ottawa, bordering the north-east of the settled portion of Ontario, is, so far as fire has yet spared them, clothed with woods. Partly the lumberman has here and there taken out timber, partly they are untouched by his axe-blade. While in forest they are for all Ontario east of Toronto our reservoir of moisture, our mother of waters, our feeder of streams, the streams which flow from this water-shed across our Province. But civilization is reaching them in its most destructive mood, and all along the southern border of this mass of forest the sturdy agriculturist frets its edge with fire and steel. He pierces it with roads, he clears his isolated farms deep within its solitude, the forest falls before his axe, it dries and shrivels beneath the hoofs of his cattle; and still, as clearing operations penetrate farther and farther from its outward trees, this great forest becomes drier and yet more dry. It is not a rich and deep-rooted forest such as existed in former days near

"Wild Ontario's boundless lake."

It is a forest, the outer edge of which, dried by clearing operations, may be relied upon to burn in dry summers, and not unlikely to burn terribly and devastatingly, and for many miles. My readers may remember the fires three years ago, in the Muskoka district, where it may be said, we had just commenced to attack the corner of the great wood clothed watershed slope of which I speak. If they had travelled, as I happened to, forty miles by stage through that district then, the clouds of smoke obscuring all around us, the glare of the fires visible right and left in many directions along the darkened horizon, the snapping and crackling of the giant trunks continually sounding in our ears, and occasionally passing near some great roadside tree, clothed in a mass of fire, threatening to precipitate itself in destruction on coach, horses and passengers below, they would

have some slight, though even then, but an outside and superficial idea of what a forest fire means.

If fire should obtain any serious headway there, Ontario with Æneas may well say,

"——— Jam proximus ardet
Ucalegon."

It is frequently said, "Ontario has plenty of forests; there is yet fifty per cent. remaining; let us attend to more important affairs." Most of the fifty per cent. remaining might, so far as it is likely to benefit the older portions of Ontario, as well be in Greenland. Much of it is in Algoma—much more far in the Parry Sound or the North-West territory, where it will have little climatic influence here. Or, it is said, "Some day; there is yet no need." Now, in August is wheat harvest; what would we think of one who said, "Oh, we don't need wheat till August; we shall look after it then, and sow some!" But all agree that we shall some time need to grow forest in Ontario. If so, now is late enough to plant, for before we reap *that* crop, with some trees twenty, some forty, some seventy years must pass. And it is agreed that some time we shall regret more forest was not preserved. If so, it is none too early to see about it, for in a few years all worth preserving will be far beyond the reach of such an effort. Are we to sit down to make our musket when the enemy is charging up the slope?

In a word, the great forest to the north and north-east of Ontario, our principal forest reserve, as the one which feeds the sources of most of our streams east of Toronto, is likely under present conditions to disappear much more rapidly than did the more heavy and more deciduous woods in our older land. Thus, it appears to me, as one who has had considerable experience in clearing land, and much opportunity to observe the effects, and who has since given much study to the question of loss by over disforesting, and possibility of replantation, that the whole of Ontario is in great danger of heavy loss, unless action be in time taken by some authoritative and powerful hand. There is yet time to take this action, and the following pages are intended to present in order :—

1. The scientific aspect of the case.
2. Corroborative evidence from other lands.
3. Measures being taken elsewhere in pursuance of the same object.
4. Some suggestions as to the action necessary.

The Mechanism of a Tree.

A tree (and I will beg my readers to follow this attempt at explanation closely—all depends on it) receives its nourishment from the roots. These correspond to the mouth in the human frame. Now, as in the human frame the nourishment received is, after being supplied to the blood, exposed to the operation of air in the lungs before it is fit to give fresh material to the body, so in a tree, the nourishment taken in at these tree-mouths, the roots, passes to the lungs of the tree, and there, by contact with the air, is rendered fit to supply fresh material to the tree. These tree lungs are the leaves.

This operation is effected by the passage upward, from the soil around the roots, through the trunk, the branches, and every twig of the tree, to the leaves, of a large

quantity of water, containing in solution the nutriment for the tree. Arrived at the leaves, a process takes place which separates, by means of contact with the air, most of the water the roots had taken in, from the valuable nutriment, and throws off, in vapour, the surplus water into the air. At this same time certain constituent portions of the air are utilized and mingled with the nourishment retained. This all, now a small portion in comparison with what had arisen from the roots, yet retaining enough water to serve as its vehicle back, is returned towards the roots, depositing in its way, in leaf, bark and root, what is needed there for the growth of the tree. In these they undergo, especially in the bark, further fitting and digesting processes, before they assimilate with the substance of the tree. The water which was retained to carry them down, being now needed no longer, passes out at the roots.

If the reader choose to peruse the three following paragraphs, he will find from the pen of the learned Mr. Brown, a more scientific and exact description of this process :—

"The water thus absorbed by the several cells composing the spongioles of the root is by a similar process absorbed from them by cells behind them; and by continuous repetition of it by those beyond the moisture absorbed from the soil is passed on and on, from the extremities of the rootlet to the extremities of the smallest twigs, and to the furthest and the loftiest extremities of the branches of the trunk. There, through the leaves, a part, and that a large portion of it, is given off into the atmosphere, while a part, comparatively a small portion, is returned by the same duplex process of exosmose and endosmose by the same cells, and others, their progeny, towards the root. By the way is deposited, by exosmose, nutriment for the tree, the leaf, the flower and the fruit; and the residuum is in part deposited by the same process in the leaves, the bark, or the root, and passed off into the soil by the exosmosic action of the cells composing the spongioles of the root."

"In the back of the leaf are numerous stomates, or mouths. The structure of these differs in different plants, but what may be considered the typical structure is two elongated cells, resembling a microscopic black pudding or thick sausage, so built into the structure of the skin of the leaf, that this will not admit of their being further elongated; each of these is, along one side, attached to that skin, but on the sides along which they are in contact they are free. When moisture is in excess, they become distended, but the structure of the skin of the leaves is such that they cannot be elongated, and they bulge away from each other, leaving a wide opening between them through which the vapour with which the air surrounding the cells in the interior of the leaf is charged, finds an open exit. When the pressure is relieved, they, having lost some of the moisture or water with which they were filled and distended, collapse to such an extent as to diminish the opening; and in this way, exactly to the degree required, they vary and regulate that aperture—varying it, it may be, I shall not say twenty times in the day, but, if necessary, twenty times in the minute; and if drought become such as to render it desirable that every drop of moisture in the plant should be preserved, under the influence of that drought they become flaccid and completely close the aperture."

"Of the extent of the provision made for this evaporation some idea may be formed from a consideration of the number of the *stomata* or stomates to be found in the leaves of plants, often symmetrically disposed. The number varies in different plants, for

which variation a reason may be found in the different conditions of growth to which they are subjected in their several natural habitats. In the back of the leaf of the apple tree, there are about twenty-four thousand stomates to the square inch. In the leaf of the lilac there are a hundred and sixty thousand of them to the square inch. Sixty thousand have been reckoned in a square inch of the under surface of the white lily and three thousand in a square inch of the upper surface. In the leaves of the cherry-laurel there are none on the upper surface of the leaf, but ninety thousand have been counted on the lower surface of the leaf. In the true lilies they are so large that they may be seen with the aid of a simple lens of an inch focus. In the water lilies and other plants having leaves which float upon water, all the stomates are on the upper surface, where alone evaporation can take place. Leaves of plants which grow entirely under water, where there can be no evaporation, have none."

The quantity of water drawn up from the soil by the roots is very great. It is not well known how much passes back to the roots, or how much passes through the leaves into the air, but all experiments show that very much more passes off through the leaves into the air, than runs back through the roots into the ground again, as is shewn above. The provision made for evaporation when necessary, and for absorption when necessary, in leaves is immense. In the leaf of the lilac for instance, as elsewhere noticed, there are one hundred and sixty thousand openings for the purpose to the square inch. By these, when the tree needs it, it throws off; by them, when it needs, it obtains moisture from the air again. It may be well here to say that, as regards the amount of water absorbed, in case of need, by leaves, science has not as yet been able to give us such clear proof as it has furnished concerning the amount given out by them. The last is certainly immense. The former exists; but is as yet unmeasured. In some trees the upward rush of moisture from the roots is very powerful. The workmen in shipyards frequently find in the centre of a teak log a core of sand fifty or sixty feet long, an inch in diameter, and hardened to a marble-like consistency, which has been carried and deposited there by the sap in its upward course. One main conclusion, we will, for our purpose at present, notice—that the volume of moisture passing into the air from the leaves of trees must be extremely large.

How Moisture is Retained in Forests.

The whole forest, in its natural state, forms a reservoir admirably fitted to receive large supplies of moisture, to hold it for a lengthened time, and to part with it at intervals well calculated to benefit the vegetation of the surrounding country. The bed of the forest is a widely spread surface, piled thick with leaves, twigs, pieces of fallen branches and remnants of decayed logs, covering another layer of the same substances, in a state of partial decomposition, overlying yet another strata completely decomposed, altogether forming a deep porous hollow framework, penetrated with a myriad of pipes, tubes, and aqueducts, and interpersed with millions of miniature cisterns. Then, every hollow on the surface is obstructed by fallen and rotting logs, blocking and holding in position the flow of water until the humus below fully absorb it, while the whole surface of the earth is crossed, recrossed and crossed again by a chequer-work of partially elevated roots, the box-like openings between which perform the same function. If we go below

the surface we shall find the solid earth beneath the mass of vegetable decomposition pierced everywhere with upright and porous pillars of wonderful tubular structure—the large and perpendicular tap-roots which many trees possess, passing deep into solid clayey strata otherwise impermeable, and sending through the triturated earth which surrounds them, a slow and steady supply of water to a thousand subterranean and spring-feeding channels, which, travelling away from the forest and under the cultivated fields, supply the great lower bed of moisture, that continually rising, fertilizes the upper soil, and finally passes off to find in brooklet, lake or river, their course to ocean again. On this great natural bed and reservoir, rain may fall in torrents, only to be held there in suspension till it gradually, and in such degrees as are best fitted to promote the beneficient work of nature, flows away in curving creek, in rippling rivulet, nourishing and feeding the thirsty earth as it goes. On this same great bed, vast mountains of winter snow may pile themselves, protected by the overhanging branches and dense thickets of underbush, against too rapid thaws in Spring, thoroughly moistening and soaking the whole great mass of humus and roots, and furnishing a vast field for evaporation ready to part with its watery treasures to the surrounding atmosphere, at the fervent bidding of the warm sunbeams of April or of May, the period when vegetation needs them most—the period for which nature has stored them and at which she delivers them, and the period, if you notice, at which she takes care no dense foliage obstructs the action of the sun. Then, reversing the process, when in times of drought, the forest bed has parted with its surface treasure of moisture, the deeper roots can and do draw, from the subterraneous and concealed channels, a vast supply for the trees themselves, which again passes through the leaves into the air, and falls in rain or dew.

Let us view the forest under a different aspect from that which is open and apparent to the natural eye. Let us consider that great portion of its actual being, life and functions which are carried on by means of water. This forest, with all its ponderous trunks standing around us, solid, firm, impermeable, has been in its day, from root to leaf, but water, gases and vapour, and is still but a channel for their passage, the passage by which its existence is continued, its growth fostered, its death in due time obtained and its reproduction secured. The forest is a river; deep around its interlacing roots the joining waters fill everywhere the land, they separate, they mount in every trunk continually in upward flowing streams, they separate again in their course to every branch and every leaf, they again separate in their passage to the outward air through the thousand openings in these; they join the air, they form a dense and vapour-saturated atmosphere above the forest top, above the whole far-spreading and wind-tossed sea of glittering leaves, and they rise perpetually a body of innumerable tons of invisible water, cool and damp from the forest depths, to meet the coming south-west wind bearing its liquid treasures fresh from the warm equatorial region, treasures of moisture rich as that of the forest exhalation, far more extensive but far more heated than their's. They meet, and the junction of the differently heated masses necessarily precipitates both in rain; it falls to the ground; it may pass by innumerable channels to the distant ocean, it may rise to the nearer atmosphere through wheat, through grass, through forest leaf again. Every forest is an immense fountain of water rising perpetually from earth to sky, falling ever from sky to earth again.

Moisture Supplied to the Air by Forests.

The forest land being always shaded, by the dense masses of foliage above, from the summer sun, is then much cooler than the surrounding earth of the open country, a coolness increased by the damp atmosphere within and surrounding it, produced by the exhalations of the leaves, by the droppings of the great accumulations of dew, which collect on its great extensions of leaf surface in the course of the night, and by the evaporation from the ground itself, which, as before observed, is almost a perpetual bed of moisture. The amount transpired by the leaves, as shewn in the preceding paragraph, is enormous. The forest then is continually sending out and sending upwards, dense accumulations of vapour. It necessarily sends them upwards, the vapour of water being the lightest and most inclined to rise of all vapours. Therefore, there will be above the forest a large stratum, or it may be a column of air holding in solution as much vapour of water as it can bear, without forming cloud, and ready, when the proper natural cause occurs, to form a cloud, and thereafter in due time to be precipitated in rain. What may occasion this we will speak of further on.

Moisture Increased by Prevention of Winds.

Another cause which adds to the moisture in the field surrounding a forest is the great influence it exerts in modifying the force of the wind. When the stratum of air immediately above the fields has, in drying the fields, taken up a portion of its moisture, that moisture will pass off slowly to the stratum of air above, and that in turn to the next above; but if the stratum of air next to the ground be rapidly moved across the ground by the wind, it is no longer simple evaporation into one stratum, that portion of stratum moves off immediately with the wind, and is immediately succeeded by another portion of the same stratum, and that by another and another as rapidly as they can pass over the ground, each in turn, taking what moisture it can rapidly imbibe. Therefore, a portion of country protected by an adjoining forest from rapid winds, may remain, although exposed to sunshine, for weeks, in good moist and growing condition, while a rapid drying wind passing over it for even one day, might have taken from the ground much more moisture than it could spare, and have very injuriously affected the crop. To prevent this is one great use of even very thin lines of trees.

The great Natural System which gives Rain in due Season.

Providence gives man the means, if he choose to avail himself of them, of procuring all through the growing season, frequent growth assisting showers. The means are given him of continuing and preserving to himself thousands of rivulets, "the upper springs and the nether springs," so that few good sized farms need be without a creek or spring in some corner or another, where you may always be sure of water for your cattle, without having to spend hours a day pumping it from a well, and not getting then a constant supply, or one nearly as healthy as the stream; without having, when wells dry, to drive your cattle across your neighbour's fields, meeting his black looks, because he is sure it is you who leaves his bars down, and moreover he don't calculate he'll have more water than

he wants, and "doesn't believe he contracted to supply the country," without, worse still, having to tramp after your beasts three or four miles along the dusty roads to a creek. Or, if you have plenty of water, and your neighbours none, it is hard to say whether you are much better off. If you supply them you are a thoroughfare without a toll-gate. If you refuse, you are a tyrant, and are informed over your fences that "there will be water when you're dead and maybe you'll want it yourself before you die."

More, the water which supplies moisture for the crops comes largely from below. It is not because the rain fell on the herb of the field that growth chiefly proceeds, though that does good; but it is because the earth received the water, and the great underground system of natural pipes and channels has obtained its due supply. If, during the shower, some malevolent giant should hold his umbrella completely over your farm, his spiteful intentions would be, in large measure, frustrated, for the whole network of channels, which everywhere tunnel the soil—millions invisibly small—millions conveying vast quantities—would have all over the land received their share, and your land would receive from below some compensation for what the overgrown gentleman had kept off above. It is this underground store, which, in a dry time, sends moisture up to the roots, and thence to leaf and twig. The dry board lying on the ground will split and crack in the sun—the pitch will boil out of the seams of the upturned boat—the rock will glow till it will nearly burn your finger; but the plant will not—it is cool, green and moist long after all around is parching. It has had no rain; it may not flourish, but it does not die. It has other means of obtaining moisture, and one of them is by drawing through its roots from below, water, which, it may be, fell in rain two months before, has been preserved on forest floor or subterranean cavity till now, has now in its turn passed on its course to the sea, and in its way preserves from death the growing herbage till the rain from above give it of life a new and a firmer hold.

If my readers will travel with me a little way on a very dusty road of dry technicalities, we will endeavour to find a clear explanation of what brings rain, and what causes the winds which bear the clouds along. Let us here remark that when we see a cloud apparently come with the winds, we need not be sure it came at all. That cloud may have been above us in *propria persona*, but we could not see it. The air may have had much water in it which we could not see; the wind may have brought sufficient cold to condense the moisture, when we could see it at once. The *cloud* in that case did not come. The means of changing it into visible form came.

A writer says in relation to a certain storm in India:—"Previous to such a downpour of rain the heavens were perfectly clear, without a cloud to be seen; yet there, it may be, the whole of that moisture was suspended, dissolved in the air. The rain cloud may have appeared to proceed from beyond the horizon, and to come thence, advancing with resistless force, borne forward by the gust of wind, more like a tornado than aught else; but there are reasons, and these satisfactory ones, to warrant the conclusion that the cloud had not been blown thither by the blast, but had been formed at the various points of its advance by the wind suddenly cooling down the air below a temperature at which it could hold the moisture in solution, very much as is the case with the sand and dust filling the air immediately before the falling of the rain; whatever proportion of these may have been brought from a distance more or less remote, most of it may have been seen raised from the ground on the spot as the mighty rushing wind passed on in its course, and the little lapse of time between the appearance of this precursor and the precipitation of the rain was only such as was occupied in the aggregation of the rain

particles into the larger drops which fell, and the precipitation of these by gravitation and by the blast, aided, it may be, by the co-operation of electric force, the process being essentially the same whether the blast have come on as an onward moving cold wave or have advanced as an advancing whirlwind which raised the air through which it passed to an elevation at which, it may be in consequence of sudden expansion, the temperature was too low to retain all the moisture in solution.

"With the copious evaporation going on from the leaves of a forest, there is nothing surprising in any change of wind producing a cloud or mist above a forest, where formerly the air had been perfectly transparent, and everything known in regard to such phenomena makes it probable that in general, if not invariably, the cloud is produced there, and not attracted thither by the forest."

Let us go on with the explanation, premising that it is founded on the one given by Herschel, and published in the "British Encyclopædia;" that it has been adopted by Flammarion, one of the leading French meteorologists, who published an exhaustive work containing it in 1879; and that this work is edited by Mr. Glaisher, one of the leading British authorities of to-day.

It is as follows:—At the equator, where, as we all know, it is always very warm, the broad heated ocean sends up, as is the nature of water when heated, vast quantities of itself in the form of vapour. At the same time the air there is always being heated, and rises as the vapour does, with great force, but not with nearly so much as the vapour. Vapour of water is the lightest of all known vapours, and except hydrogen and ammonia, the lightest even of gases. How much lighter than air it is you can see for yourself, if you notice how fast it climbs through the air from the pot to the ceiling. True, the air has not quite its chance; it, too, would climb fast if it were hot. But heat it as you will it could not climb like that. Now, the quantity of water sent into the air in the tropics by evaporation is immense. It is calculated that throughout the whole great equatorial region there rises thus annually a body of water sixteen feet deep. That is over half an inch a day. That does not sound large, but it will sound larger when you think how it grows. Turned into vapour, even at only fifty degrees temperature, it takes a space many thousand times larger than before, or some thousand feet high over the whole region. Add to this that the air it has been forced into when thrown upwards from the ocean is itself expanding largely, and therefore becoming lighter and rising also, you will see that there is an immense body of air and vapour being sent upwards very rapidly and constantly over the whole great equatorial region. Now this uprising leaves no large vacuum of its own size, as a body of that dimension would if sent upward in some circumstances. There is no vacuum left whatever, for the water is below and continually affords fresh vapour. But north and south there is abundance of air; air, too, which has not been heated as has that of our central body which is going up; and as the central body over that vast space—remember we are speaking of a belt round the world thousands of miles wide—as it gets heated, rarefies and rises, the great cooler and more solid bodies of air north and south rush in, themselves become dilated in the scorching heat, and rise upwards in their turn along with the immense volume of vapour, which being still more inclined to rise than they are, hurries them aloft; so that at the equator, or rather in the great equatorial regions, are two great masses of air rushing from the temperate regions, north and south, towards the equator, meeting, rising, and going upwards together with the vapour arising from the sea.

We will here pause to take into our calculations another item. These winds (these two north and south coming masses of meeting air, form the tradewinds, as they are called. These winds, though starting to go from north and south towards the equator, do not get there as north and south winds; for the earth keeps turning round from west to east, so that on the north the tradewind is a north-east wind, and on the south its meeting tradewind is a south-east wind. These came, we remember, from the temperate zones, leaving of course a space there which is instantly occupied by another mass of air rushing in from the polar regions north and south.

Now we will follow our meeting tradewinds upwards from the equator. Forced upwards above the surrounding strata of air, beyond the levels of equilibrium, they flow over to north and south towards their respective polar regions. These are the anti-tradewinds, and they are acted upon by the earth's rotating movement as are the tradewinds before mentioned, so that these returning currents blow from the south-west in our northern hemisphere, and from the north-west in the southern hemisphere, always, however, towards the poles and from the equator. Near the poles, they approach the point whence the polar air started to move towards the equator, to fill up the gap occasioned by the rising equatorial air (or rather, there is no gap, but to prevent the gap which would have been had they not pressed in). Well, at this point near the poles they, as fast as the polar air starts towards the equator, press into its place, follow it, go to the equatorial regions in the tradewinds, rise up there and come back again to the poles in the anti-tradewinds, and the current is complete.

Now, at first the anti-tradewinds coming back towards the poles keep high in the air, so that they and the tradewinds below, going towards the equator, are quite separate; but once past the tropical circle they come down near the earth and blow towards the poles on the same level as the tradewinds coming from the poles. They are therefore upon the same level, and kept asunder only by the rotating action of the earth. There are, to quote Flammarion, "points at which these two currents come together, and their different qualities cause numerous and sometimes disastrous atmospheric disturbances. Their beds get shifted over the surface of the globe, and the succession of one after another in the same place produces sudden variations in the state of the sky." To avoid confusion they are, from the point at which they flow on the same level (where, I mean, the anti-tradewind above flowing towards the poles, comes down to the same level as the tradewind below blowing from the poles), called no more trade or anti-tradewinds. The anti-tradewind is from here to the poles called the equatorial current of air, and the tradewind the polar current of air.

You will remember that in our northern hemisphere the anti-tradewinds returning from the equator blow from the south-west; the tradewinds coming from the poles blow from the north-east. We will remark, therefore, in passing that the equatorial current must, as being laden with moisture risen from the tropic seas, be humid, warm, and bring much moisture with it, while the polar current, coming from the arctic regions, will be cold and dry. But these two currents are varied in their moisture-bearing capacities by many local and other circumstances; great mountains condense their moisture; the warm Gulf Stream has much to do with evaporation in its course; great stretches of prairie and of woods cause differences. Here, for instance, in Toronto our Observatory records would

give the humid winds as ranging from east round to south-west, largely south-east. This is explained by some who have given thought to the subject as being caused by much moisture passing from the equatorial current, high above us, into lower currents blowing other ways, by the fact that the Rocky Mountains deprive the west wind of much moisture, and by the passage of moisture here across the Atlantic States from the warm Gulf Stream and the Gulf of Mexico. Many acute observers, however, hold strongly to the south-west wind being the rain-bringer. Still from the equator, one way or another, but of course from the south, most of our moisture comes. It may be here remarked that in order clearly to comprehend the motion of the winds, it is well ever to keep in mind the fundamental law, that all movements of the atmosphere are in consequence of the property gases possess of being expanded by heat, and that the heat of the sun keeps all in motion.

Here is an instance, from the meteorologist Spang, of the meeting of these two winds forming whirlwinds :—

"The polar current, in its course towards the south, held in suspense by the equatorial or warm current, may be compared to a body of water confined by a dam, except that the dam has here also a positive force, and if released, a motion of its own. If this aerial dam is broken at some point on the surface of the earth, the air of the polar current above the break will sink into it, and there will be formed in its upper region a depression or trough corresponding to the break. That portion of the equatorial air which has opposed the sunken polar air will rush with great force into the depression, and produce an eddy or whirl, and cause a rotary storm and a cloud to be formed which assumes the form of an inverted cone. This cloud is formed by the sudden and profuse condensation of the moisture contained in the air of the equatorial current, which is thrown suddenly into higher and colder regions, and sometimes the temperature is so greatly reduced that the vapour, after being condensed freezes, and hail is formed by the centrifugal force of the rotary storm."

The two winds just described may be said to be the only two winds in the world. All the rest are but modifications of these, occasioned by what may in comparison be considered local causes. The different divisions and apportionments of land and water here and there cause many inferior rarefactions and condensations, which produce all the varied phenomena of tempests, hurricanes, gales hither and thither, which continually take place. This forms a chief part in the great plan of Nature. By this many movements necessary in fitting this world for the habitation of beings like ourselves, are set in operation. One very important one, which we shall frequently have occasion to notice, is that by this means is borne upwards from the equatorial seas and towards the poles that vast mass of moisture previously described. It does not of course all go as far as the polar regions, though a great portion does. Much falls back in rain in the tropics, and much on the way north and south. It may be here observed that no doubt large evaporation of water is continually occurring elsewhere, on ocean, lake and river, and on land as well as in the tropical zone. But the last is the chief source of supply. We will now leave this part of the subject and go on to another intimately connected therewith, which is necessary to be considered before we can make further headway.

The Production of Rain.

To quote from the excellent author I have just mentioned, "The water is not motionless either in the depths of the oceanic basin, in the solid ice, or in the atmosphere. Thanks to the always active power of the sun, to the aerial currents, the water rises vertically from the depths of the seas to its surface, becomes vaporized at all temperatures, ascends in the shape of invisible vapour through the ocean of the air, becomes condensed into clouds, travels across continents, falls again in the shape of rain, filters through the surface of the soil, passes along the strata of impermeable clay, springs up as a source or fountain head, descends by the streamlet into the river, and falls from the river back into the sea again."

The vapour of water, as we have seen, rises from the ocean, mingles with the dilating and arising air, and in immense quantities ascends into the higher regions of the atmosphere.

Will my readers now for a moment study this little table. It is but nine lines :—

At 14 deg.	a cubic foot	of air	is saturated	with water by the weight of	1 grain.
30	"	"	"	"	2 grains.
41	"	"	"	"	3 "
49	"	"	"	"	4 "
56	"	"	"	"	5 "
66	"	"	"	"	7 "
80	"	"	"	"	11 "
88	"	"	"	"	14 "
100	"	"	"	"	20 "

When we thoroughly comprehend the effect of the fact stated in this table, we understand why two clouds or two currents of air more or less saturated with vapour of water, coming into contact at certain temperatures, produce rain. It occurs in the following manner :—

We will notice that a foot of air at a temperature of one hundred (the heat of a very hot day indeed) will hold twenty grains of water. If it were only at thirty degrees it would hold but two grains of water. Now let us suppose a mass of a thousand cubic feet of air at 100 degrees, and holding twenty thousand grains of water. Well, a cold current of air comes along, meets our cubic mass, and cools it down to thirty degrees. It can only hold two thousand grains now ; the cold current has served an ejectment on the odd eighteen thousand grains, and they must fall out. They would fall out first into cloud, then into rain, and that is a rough sketch of the way in which rain is produced.

But we will go more slowly, and first show how a cloud is formed. Here are the words of an excellent writer on the subject, so concisely put and so clearly, that we cannot do better than copy them :—

"The *invisible* vapour of water spread through the atmosphere becomes *visible* when a decline in the temperature or an addition of moisture brings it to the point of saturation. Suppose, for instance, that a certain quantity of air at eighty-six degrees contains 478 grains of vapour of water, this air will be quite transparent. If by some cause or other this air descends to seventy-seven degrees, or receives an accession of moisture (either will do) it will become opaque. If it is done by the lowering of the temperature, a diminution of nine degrees of heat will cause 108 grains of vapour of water to be condensed and to become visible. This is what a cloud really is : vapour of water which the

air, being saturated, is no longer able to absorb, and which becomes separated from it by passing into the state of small vesicles."

This is the way clouds form, and, as you will see by the following, it is but by a continuation of the same process they are precipitated in rain. If the cold current which has produced them from the warmer atmosphere continue to exert its condensing force, or if a more saturated current arrive, the process goes on, and now becomes molecular; that is, the larger particles rapidly come together in still larger ones, the force of gravitation begins to be felt, and the whole process is described by that great meteorologist, Herschel, as follows :—

"In whatever part of a cloud the original ascensional movement of the vapour ceases, the elementary globules of which it consists being abandoned to the action of gravity, begin to fall. By the theory of the resistance of fluids, the velocity of descent in air of a given density is as the square root of the diameter of the globule. The larger globules, therefore, fall fastest, and if (as must happen) they overtake the slower ones, they incorporate, and the diameter being thereby increased, the descent grows more rapid and the encounters more frequent, till at length the globule emerges from the lower surface of the cloud, at the vapour plane, as a drop of rain, the size of the drop depending on the thickness of the cloud-stratum and its density."

Now, if my readers have but followed these learned gentlemen through their technicalities they have grasped this plain fact :—Rain is the precipitation from the air of moisture which was more than it could, at the degree of heat to which contact with a colder stratum of air had reduced it, hold in solution. And to show how elevations, especially if wood-crowned, produce rain, any one can also easily see that if a saturated current of air arrive at a mountain chain or other height, and have to rise into the colder atmosphere above, getting colder one degree, according to the season, as they rise 200, 250 or 330 feet, as the air is the colder the higher we ascend, it must in consequence part with, as rain, much of the moisture it carries. Let us remember, too, that rain differs from cloud only in being formed of drops produced by the mutual attraction of lesser drops, which rapidly fall by force of gravitation to the earth instead of floating, as the smaller particles of moisture composing the cloud had been, in the air.

Dew.

We will now travel onwards to another important point, and will do our best to observe the operation of dew. To understand this we have simply to remember that the earth's surface is heated in the day by the sun, and gets much colder at night, the heat it has obtained being what is called radiated off. Some objects cool in this way much more than others, some leaves of plants more than others. Whatever it may be which cools these, these cool the air next to them, and produce the same effect as the cold stratum of air we have just been speaking of in connection with clouds; (when it strikes the warmer stratum, that warmer stratum is cooled so much that it cannot hold all its moisture, and cloud is formed, and afterwards, if the process be continued, rain); so the grass, the leaves, paper, glass, wood, all these cool quickly by radiation, form the cool stratum here and compel the air close at hand to part with its moisture to them. We see it in the morning covering them in the form of drops and call it dew.

Let us for a moment consider what the dew point is, a thing frequently mentioned in relation to this. It is the point at which the air is saturated with moisture to the extent of all it can hold at its then existing degree of heat. If it be cooled it must lose moisture. Now our knowledge of dew on the forest leaves is principally given us by a learned gentleman called Meguscher, who says :—

"Whenever the temperature of the air is above sixty-seven degrees Fahrenheit, the temperature of the tree will be, to the extent of the excess, lower. If the temperature of the atmosphere be ninety degrees, and the dew-point seventy-five degrees, there will be a copious deposit of dew, and if the lower temperature be the consequence of radiation, the deposit may be expected to take place over the whole of the upper surface of the leaves, in the aggregate, according to Humboldt's measuring, several thousand times the area of the ground they cover."

Baron Humboldt's statement, to which this refers, is so clear, concise, and yet elaborate, that I cannot refrain from giving my readers, in full, at least this one small gem from the innumerable brilliancies of this great traveller's writings. He was one of those always successful writers who are successful first that they see, at any cost of travel, all that is possible concerning they mean to tell of, and next, know how to tell it. He says :—

"The forest region acts in a threefold manner—by the coolness induced by its shade, by evaporation, and by the cooling process of radiation. Forests uniformly composed in our temperate zone of 'social plants' belonging to the families of the Coniferæ or Amentaceæ (the oak, beech and birch), and under the tropics composed of plants not living socially, protect the ground from direct insulation, evaporate the fluids they have themselves produced, and cool the contiguous strata of air by the radiation of heat from their leafy appendicular organs. The leaves are by no means all parallel to one another, and present different inclinations towards the horizon, and according to the laws established by Leslie and Fourier, the influence of this inclination on the quantity of heat emitted by radiation is such that the radiating power of a given measured surface a, having a given oblique direction, is equal to the radiating power of a leaf of the size of a projected on the horizontal plane. In the initial condition of radiation of all the leaves which form the summit of a tree, and which partially cover each other, those which are directly presented towards the unclouded sky will be first cooled.

"This production of cold (or the exhaustion of heat by emission) will be the more considerable in proportion to the thinness of the leaves. A second stratum of leaves has its upper surface turned to the under surface of the former, and will give out more heat by radiation towards that stratum than it can receeive from it. The result of this unequal exchange will then be a diminution of temperature for the second stratum also. A similar action will extend from stratum to stratum till all the leaves of the tree, by their greater or less radiation, as modified by their difference of position, have passed into a condition of stable equilibrium, of which the law may be deduced by mathematical analysis. In this manner, in the serene and long nights of the equinoctial zone, the forest air which is contained in the interstices between the strata of leaves, becomes cooled by the process of radiation; for a tree, a horizontal section of whose summit would hardly measure two thousand square feet, would, in consequence of the great number of its appendicular organs (the leaves) produce as great a diminution in the temperature of the air as a space of bare land or turf many thousand times greater than two thousand square feet."

Taking this and the preceeding paragraphs together, we must be aware that the forest absorbs much moisture from dew, which will either fall in drops on the ground, or be disseminated in the whole atmosphere within and above the forest. All that falls within or stays within is safe from the sun's drying power. So with whatever rain may

fall on the forest, it soaks into the spongy bed of the ground, renewing that deposit of moisture which in winter the snow had kept fully supplied. The snow was kept there in the partial shade of the branches, the water melting from it kept by the peculiarities of the surface—that soil of the forest already described, with its roots, logs, and inequalities—till spring was advanced and yet a good supply of moisture remained for summer. Then comes the rain, and is stored like the former, while night after night the dew adds its share and assists in maintaining the great forest bank, on which the thirsty fields for miles round perpetually draw, and perpetually, too, return back honestly that moisture which they have borrowed. So long as the forest is left in fair amount, field and wood act, in reference to supplies of water, like a great self-regulating and compensating machine. But when we destroy one part of the engine, we do not find it to work (and no wonder) so beneficially or so smoothly as before.

The moisture in forests is further increased by that obtained from mists, which are, in fact, clouds forming near the earth. The particles in these are not yet large enough to form drops of rain, and are, till further condensed by change of temperature, kept apart by the nature of their present support in the air. But, as when one is passing through a fog, the water collects on the beard and on the clothes, so with trees, though the particles of moisture in the fog be so small that a heated wind (rising the temperature, which, as before explained, renders the air capable of taking in more vapour of water) might have absorbed and carried it all away again. Yet all which touch the innumerable leaves stay there, coalesce there, run together, and fall to the ground.

It must be remembered with relation to dew on forest leaves, that there is a vast transpiration frequently going on from them, which must interfere somewhat with the deposit of dew on the same leaf. This transpiration, which will be shortly described, takes place while the tree is warm, that is, uncooled by radiation, and continues till far on in the night. It becomes more feeble, as various writers state, from the leaves of plants of all species, when covered with dew. This is inevitable; the leaf must cool to form dew; it is before cooling that transpiration is most active. It must also be remembered that except in case of leaves such as water-lilies, which float, the openings—the *stomata* —are largely on the *under* surface, thereby interfering less with the operation of dew-forming.

The reader will find it worth while to study these three or four paragraphs by an acute writer relating to the same subject:—

"The clouds occasionally seen over woods, while the atmosphere around is compararatively clear, are consequent on the condensation of the humidity occasioned by the evorporation from the leaves."

"There is always moisture existing in the atmosphere; it is reckoned one of its constant constituents, but it varies in quantity. The quantity is minute compared with that of the oxygen and nitrogen of the air; but it is never absent. There it is, on the highest mountain and in the deepest mine; on the ocean's surface and on the dry land a thousand miles away."

"The quantity of moisture passing into the atmosphere from the leaves of a forest in active vegetation must be considerable. Calculate the number of *stomata*, or stomates, on a leaf, multiply this by the number of leaves on a branch, the product by the number of such branches on a tree, and the product of this by the total number of trees in the clump, or the total number of trees in the forest, and the final product will indicate the

provision made for evaporation from the forest. There are similar stomates on every verdant plant on the dry land; but the evaporating surface supplied by the leaves, rising tier above tier, far exceeds in extent that supplied by the herbage and the grass growing elsewhere; and in many places these may be found growing as luxuriantly on the soil of the forest as in the fields beyond, or perhaps more so, and adding their quota of evaporation to the evaporation from the trees."

"Of the moisture thus raised by the tree, and no longer required when the sap has been elaborated in the leaf, the air will only take up what quantity it can, at the temperature at that time and place, dissolve and hold in solution; and cases have been cited in which the excess is so great that the leaves seem to act as alembics, distilling water which falls in great drops to the ground.

"Where this does not take place, what the air dissolves it will hold in solution so long as the temperature is maintained at the same or a higher point; but if the temperature fall below the point at which it can do this, what it cannot sustain as invisible vapour, will be deposited or suspended in the form of mist, or cloud; and such a reduction may follow the setting of the sun, or even the decline of it in the afternoon and towards nightfall; or if there come over the trees a wind in any degree colder than the air in which they are enveloped, the air is thereby cooled down, and a quantity of the moisture which it held in solution may be deposited in the form of fog, or of dew, or of rain."

The same writer shows us another remarkable effect of the soil of forests:—

"A distinction has been drawn between the effects produced on the ground by the shade from sunshine, and by the shelter from drying winds afforded by trees and forests. It is necessary further to distinguish between the effects produced by shade and by vegetable mould, which exists always in greater or less quantity in forest soil, in consequence of the decay and decomposition of fallen leaves and fallen twigs, and broken or decaying rootlets.

"In the soil of a forest there generally exists more moisture than can be attributed to shade, or to shade and shelter combined; and much of this is attributable to the attraction of moisture manifested by this vegetable mould.

"In this effect of vegetable mould we see how forests may exercise a third influence, over and above and distinct from both shade and shelter, in maintaining a humidity of soil."

From what has been so far stated concerning the forest, my readers will have seen that it is a great storehouse of moisture, so long as its natural bed and foundation be preserved from the injuries occasioned by cattle and running fires, and while it is reserved in sections of sufficient depth and width, to thoroughly maintain its forest character, and establish decided variations between its temperature and that of the cleared land. They will have seen that that moisture will in such case be continually renewed from the depths of the earth to which the tap-roots pierce, in addition to the larger supply received from the clouds above. They will have seen that the sun's rays cannot again carry off this moisture when it is once within the forest wall. They will have seen that the wind, which dries faster than the sun, and extremely fast when it has the sun to help it, cannot dry the land in the forest. That the moisture thus kept in the forest is used to feed the rivers, streams, creeks, and springs, and to keep up the whole underground system of water below the fields; and also, and in very great part, to carry up nourishment from the roots to the leaves, escaping in vast volume thence to the higher atmosphere through the not innumerable altogether, for they have been counted; but through the wondrously numerous openings in the leaves (160,000 sometimes to the square inch; the most

complete little contrivances imaginable, with a door and hinges to each, and full power to shut or open them, all as the tree needs). Stop one moment, and notice that when the leaves are cool, and dew is forming on them, as it would on any dead substance which cools by radiation, these doors can be shut. When the tree is warm with life from the sun again, they can open, and transpiration (as the out flow of vapour from the leaves is called), or absorption of moisture if the tree need it, go on in full vigour. We cannot do better, to interest ourselves in the operation, than to read the description written by a distinguished gentleman of France (the Marshal Vaillant), who made it a special study, and gave much time to experiments connected therewith. He says:—

"Even the most humble plants, such as chickweeds and meadow grasses, evaporate considerable quantities of water.

"If from herbaceous plants or modest shrubs we turn to our large forest trees, we may expect that, compared with the weeds of which we have just spoken, they will transpire a large quantity of water, which is probably in proportion to the number of leaves and their extent of surface; and it is our belief that this summer function of the leaves is carried on by the trunk and branches during the whole year.

"From whence comes the water so rapidly transpired by the foliage? Certainly from the soil.

"I placed in a large jug of water, tightly closed up to hinder the natural evaporation of the water, the end of an oak branch, five feet long and nearly an inch thick at the butt. It was cut from a tree eighty feet high and three feet thick. In three days it had lost thirty ounces of water.

"If we believe that all the leafy part of a tree will act, as regards the faculty of transpiration, like the leaves of the above-mentioned branch, we arrive at the astounding result that an oak like the one described will in a summer day cause the evaporation of more than 440 gallons of water.

"I am not decided as to the value of my experiment, and see that my deductions are not free from objections; but it must be allowed that supposing even half or one-quarter of the estimated quantity be omitted, the quantity must greatly exceed what might have been expected."

Let us use the excellent Marquis's experiment, and draw our own inferences, which will put us, probably, in a position a step farther advanced. The branch with its leaves, no doubt, sent off this vast proportion. But branches on trees probably do not. If my readers will remember what is previously stated about the mouths of a tree (the spongioles, as they are called, at the ends of the roots), they will notice that these take in as much water as the tree needs to carry up its nourishment and act as its vehicle to the leaves, where all water not needed is sent off by transpiration into the air. Now the leaves, it may be supposed, having no such functions, not being the sentinels at the root gates, may transpire while they live as much water as is sent up to them, and we may suppose the transpiration machine working furiously, when the Marquis had cut off the connections with the roots, as a steam engine with the regulating valves left unattended.

They would, no doubt, take it in at the severed end of the branch, and send it off by the leaves. But though the forest draws much up, and transpires it, this experiment does not prove that it draws up the enormous quantity spoken of.

Taken with this understanding and qualification, however, we can well believe the rest of the Marquis's comments, which are in fact generally adopted as correct by meteorologists, and of which Mr. Crombie Brown, a high authority, thus speaks:—"With

regard to the main fact, that the emission of moisture by the leaves of the forest is very great, we are at one."

The Marquis's views thus largely corroborated are:—

"It is an accepted fact, and not without reason, that the neighbourhood of forests is cold and damp. This is far from astonishing when one thinks of the enormous volume of water transformed by forests into vapour, and the quantity of heat absorbed in this transformation. This heat must have been obtained somewhere, perhaps from the soil of the forest and that of the neighbourhood.

"In the same way there should be great damp in the neighbourhood of forests, especially when the temperature is high, and it cannot be otherwise, on account of the enormous amount of water in the form of vapour which is discharged by forests into the adjacent atmosphere.

"This vapour is emitted in much greater abundance during the day than during the night. Towards night, a little after sunset, when the general temperature begins to fall, the transpiration not yet having time to slacken, and ascending into a colder air changes into visible fog, like our own breath in like circumstances, and this fog in its turn becomes a cloud on the following morning, when the sun warms its particles; but whether clouds or fogs, they will be carried away by the first breeze to descend in showers.

"If these details as to the formation of forest fogs be correct, such fogs should be more frequent in calm weather, when the air is naturally more moist and especially when the contract is greater between the cool of the evening and the heat of the day. The test of conditions for the formation of thick fogs is especially complete, at least in our climate, towards the end of summer and the first half of autumn; and it is during this period that the phenomenon is most frequent and noticeable.

"If the transpiration carried on by the leaves were coloured and perceptible, it would be a grand sight to see great columns of vapour ascending majestically into the air, diminishing by their heights the distance between the tops of the trees and the stormy clouds; and as this vapour facilitates the passage of electricity, by increasing the moisture of the air with which it mingles, the facility with which isolated trees are struck with lightning can be accounted for."

If my readers have followed me, and we have succeeded in arriving at a clear explanation, we will now have had:—

1. A short account of the manner of growth of a tree.
2. The system of the winds and their method of conveying moisture.
3. The causes of the moisture being precipitated and falling to the earth as rain.

We will now proceed to notice:—

The Connection of Forests with the Production of Rain.

We have observed that the winds returning, charged with heat and moisture, from the equator in their course to the north pole, bear with them an immense quantity of water. As has been said, the torrid seas send their surface, sixteen feet deep, to the skies in the form of vapour in a year. Of this it has been computed that six feet are discharged in rain in the tropics, the remainder sent towards the poles, towards the north pole about six feet—a tremendous mass of water. In addition, we must remember, vast though lesser amounts of water, are taken up from the rest of the surface of the world, both land and sea, and though the south-west winds, evident or concealed by changing currents, must be our chief supply, yet water-charged clouds from other sources pass over in all directions as well.

From abundant proof and many observations, as well as from the natural reasoning concerning what must be the case under such circumstances, it is evident that there is arising from forests a vast amount of vapour of water, which, as we have seen, is the lightest of vapours. This vapour will necessarily be cool, as is the forest region from which it comes.

The winds bearing moisture coming from the south will not be generally as cool. These, meeting the ascending streams of cool and moist air arising from a forest region, must be deprived thereby of their power of holding a great part of the water they carry, which must shortly descend in rain near the place of conjunction, according to the temperature of the approaching wind, and the amount of water it bears.

Thus we have the chain of proof, and the direct influence of forests in securing rain during summer given in its completion. Spring and summer are the seasons when the internal functions of trees are in their greatest activity; then is transpiration most active; then rise from them most columns of humid air towards the clouds. Spring has not so many leaves, but then the sun pierces the forest, and draws from the ground—the bed of moisture, as before explained—an amount of vapour many times greater than the fields can afford. This cool vapour, rising and meeting the south, south-east, or south-west wind forms rain. And these seasons, spring and summer, are those in which rain is most needed by the thirsty fields and the growing vegetation. This is the value of woods to the farmer.

We have now gone over the complete system of transpiration of moisture by wind throughout the atmosphere from equator to poles and back to the equator again. But it was also remarked that there were many important circumstances of local origin which produced local results in the distribution of moisture and the arrangement of climate. To us in the Province of Ontario there are existing very important local circumstances indeed, which undoubtedly have a great influence, that is to say, the presence of the great lakes. Our chief reservoir of moisture, as is that of all the world, is the equatorial ocean. But our lakes also greatly help, and there is no doubt that their presence largely contributed to the establishment of the splendid forests we have destroyed, and to the accumulation of the layer of rich land on which those woods rested. We cannot do better than now to call to our assistance the aid of a gentleman who has given, as far as I can find, the best explanation of these local phenomena, Dr. P. H. Bryce, M.A., of Toronto.

But before reading this it would be well to study carefully the few pages following, here, after which the other as connected with these great principles, will be much better comprehended. The article is from the world-renowned pen of Herschel, and is fully in accord with the explanations of writers of a late date:—

Of Land and Water as Recipients and Communicants of Heat.

"Of the solar heat which actually reaches the surface of the globe, that which falls on water penetrates it to some moderate depth and is absorbed internally, while that which is incident on land is wholly absorbed superficially, or within a very minute thickness. Water, moreover, is eminently a non-conductor of heat, so that once received into its substance, it is only diffusible by agitation; and since this, however violent at the surface of the ocean, diminishes rapidly with the depth, the ultimate communication of heat downwards to any considerable depth is a very slow process. By far the greater portion of the

daily supply of heat to water, then, may be said to float within a moderate depth of the surface, forming a kind of reservoir of heat. On the other hand, water is a *good radiant*, and as such is continually, both day and night, giving off radiant caloric, which is absorbed by traversing the air, and thereby tends to raise the temperature of the latter medium. Hence, it is most probable that much of the heat so radiated off is detained in the lower strata of air. Meanwhile a balance is struck in the water itself of the quantities received and parted with, by the preponderance of one or the other of which it gains or loses in average temperature in the twenty-four hours. Thus, in the warm season, when days are long and nights short, the general temperature of the air is slowly rising above its annual average, and *vice versa* in the opposite season. Below a certain depth, however, the temperature of the ocean would appear to be determined by other causes, and to be very little dependent on its superficial amount or fluctuations. It results from the observations of Kotzebue, Beechy, and Sir James C. Ross as a general fact ascertained by thermometric soundings that the deep sea water below a certain level, determined by the latitude, is of invariable temperature throughout the globe, and that a very low one; the calculations of Lenz founded on Kotzebue, results, giving 36° F., and those of Ross, 39°.5 (which last is the temperature at which pure water attains its maximum of density). The depth at which the fixed temperature is attained, is about 7,200 feet at the equator, diminishing to latitude 56° on either side of that line, where it attains the surface, and the sea (superficial currents apart) is of equal temperature at all depths. Thence, again, the upper surface of this uniform substratum descends, and at 70° of latitude has already attained a depth of 4,500 feet. Thus the ocean is divided into three great regions; two polar basins in which the surface temperature is below 39°, and one medial zone above it, attaining 82° at the equator, and at the poles of course the freezing point of sea-water. It is within these respective regions only then, that superficial currents can act as transporters of meteorological temperature.

"The habitudes of dry land with relation to incident heat are very different. There is no mobility of parts, and the communication of heat downwards is therefore entirely a process of conduction. But what is most influential, is the fact that the absorption is performed strictly on the exposed surface, which therefore in the instant of absorption fixes upon itself within a very minute depth all the heat which, falling upon water, would in the same instant be disseminated through many feet or yards of its substance. The mere superficial film then becomes much more heated, and since it is a law of radiation that its intensity increases rapidly with the temperature of the radiant surface, it radiates out on the very instant a much larger fraction of the total incident heat, than in the case of water, besides imparting to the air, by contact communication a proportionally greater amount. In water, the absorbed heat is for the most part withdrawn from the radiant action, enveloped and husbanded. In dry land it is instantly and wholly exposed to such action in its most intense form. It is no uncommon thing in dry and light (*i. e.* badly conducting) soils, in hot climates to find a superficial temperature of 120° to 140° F., or even more.

"That portion of the heat which enters the soil is conducted downwards, and so long as the surface is gaining in temperature a wave of heat is continuously propagated downwards into the earth. When the surface, however, by the decline of the sun, begins to lose heat, this ceases, and (the radiation still continuing) what may be called a wave of cold (less comparative heat) begins to be propagated, and so on alternately during the day and night. These waves as they run on spread forwards and backwards, and so by degrees neutralize and destroy each other. Thus the diurnal fluctuations of temperature beneath the surface grow continually less as the depth increases, the rate of diminution depending on the "conductibility" of the soil. In ordinary soils, the difference between the diurnal and nocturnal extremes becomes imperceptible at four feet below the surface. In like manner the general increase of heat due to the summer season, and of cold during winter are propagated in similar, but larger and fuller annual waves, which, in their turn neutralize each other at more considerable depths and become imperceptible at forty or fifty feet. Prof. Forbes has shown in an elaborate memoir on this subject that at depths varying from fifty-seven to ninety-nine feet according to the nature of the soil, the annual variation does not exceed 0°.01 C.

"The absorption of incident heat as *solar heat* and its radiation outwards as terrestrial heat (*i. e.* heat of a much more absorbable nature) by the solid surface depends very much on the nature of its substance; but if the ground be covered with vegetation, the whole of the incident heat is returned back either by radiation or contact communication, to the air; and the soil receives no heat where so covered otherwise than circuitously through the medium of heated air. All these causes acting together, produce a vast difference as respects the temperature of the air in regions of the globe covered by the ocean and those occupied by dry land. In the former, the fluctuations both diurnal and annual are confined within very much narrower limits than in the latter; and this contrast which theory indicates, is confirmed by universal observation as the expression of the distinction between an *insular* and a *continental* climate, or that of a small island remote from all other land and of the central regions of an extensive continent. If there be one general feature in meteorology more prominent than another it is the uniformity of temperature over large bodies of water, as compared to that under similar exposures to the sun on land."

Terrestrial Radiation.

"The theory of radiant heat promulgated by Prevost, which all experimental enquiry into the subject, has tended to confirm, lays it down as a principle, that a mutual interchange of heat is continually taking place between all bodies freely exposed to view of each other, the hotter radiating more than the colder, in the ratio of some function increasing with the temperature. The experiments of Dulong and Pefit on the radiation of bodies in vacuo have shown that this function, within the limits of their experiments is of the exponential form, or in other words, that the force of radiation in vacuo increases in geometrical progression as the excess of temperature of the radiant body above that of its envelope increases in arithmetical. Hence when a hot body is placed in presence of bodies, some colder, some hotter than itself, an equilibrium will rapidly be established, in which its momentary gains and losses of heat to and fro among them all will balance each other, and its temperature will thenceforward be unchanged.

"The mean temperature of the earth remaining unchanged, it necessarily follows that it emits by radiation *from* and *through* the surface of its atmosphere, on an average, the exact amount of heat it receives from the sun; *i. e.* as much as would melt 0.01093 inch thickness of ice per minute over one of its great circles, which is equivalent to 1-40th inch of water per hour over its whole surface, condensed from its dewpoint. Taking this as the measure of the total average radiation, one-third of it, or 1-120th inch, may be taken as radiated off from the atmosphere without even reaching the earth, and the remaining two-thirds, (1-60th inch), may be considered as got rid of by radiation from the surface of the earth. Let us now consider the manner in which this takes place, supposing a clear sky to prevail:—

"Conduction through the soil is a very slow process, radiation a very rapid one. So soon, then, as the sun has sunk so low as not to counteract the earth's radiation, the immediate surface begins to part with its heat, at first slowly, but as night advances more rapidly, and at length faster than it can percolate from the interior to supply the waste. The surface therefore becomes greatly chilled, and a wave of cold is propagated downwards, neutralizing and destroying the heat wave rising to meet it, a process which goes on leisurely, and takes its own time. Meanwhile the chilled surface now borrows heat from the air also, to supply its waste; 1st, by contact communication; 2nd, by downward radiation; and 3rd, by condensation of vapour when the temperature of the surface air is reduced to the dewpoint, and thus attains that state of equilibrium which the circumstances admit of."

We will now consider the facts adduced by Dr. Bryce, premising that although correctly expressing the author's views as to facts and figures, it is (as is too often the case with newspaper reports), not nearly as well worded, and not as connected as the original paper. The only full copy, however, unfortunately wandered into that Slough of Despond,

the Ottawa Dead Letter Office, and from that bourne few travellers return. I therefore give it as it appeared in the newspaper :—

Forest and Rainfall.

The following abridgment of the paper on this subject, read by Mr. P. H. Bryce, M.A., of the Ontario School of Agriculture, before the Canadian Institute, will be found interesting:—

"That there is an estimate relation between forests and rainfall, and that the destruction of forests produces aridity and finally sterility, seems to have been long understood, the Greeks recognizing the truth of it by considering it unpardonable to cut down the olive trees in an enemy's country. The opinion of Bernard Palissey and the prediction of Mirabeau, as regarded the destruction of forests in France were sustained, and in other countries the voice of warning has been heard against this evil.

"The remark of Governor Hant, of Denver, Colorado, "I am convinced that farming in Colorado resolves itself into a question of water, and its judicious application," the reader held to be largely true concerning various branches of farming in Ontario. In Canada, however, it was more a question of regulating the supply, or of obtaining it at the proper periods. That the Canadian climate has undergone great changes in the last forty years is looked upon largely as an inexplicable fact, while the scientist regards it as an effect dependant on physical causes known or hidden.

"The whole area of Ontario is 121,260 square miles, while that of the lakes about it is 100,000 square miles ; a large portion of the Province must, therefore, be affected by this large body of water. In the autumn, when the earth's position causes a declination of the sun's rays, the surface of the treeless land becomes very rapidly cooled by radiation, and with this cooling vegetable growth largely ceases. The lake waters, however, which during the summer have been slowly storing up heat, do not radiate it thus rapidly, while experiment shows that in September the temperature of the water, at least in Lake Ontario, is higher than that of the land. In November, 1837, the water according to Professor Dewey, averaged forty-six and the land thirty-six degrees. The land begins to feel the influence of the growing sun by January, when the water has radiated most of its heat. During the whole of this period, however, the land has had sweeping over it, currents of air with their temperature elevated by contact with the warmer surface of the waters in the regions lying to the north and north-west. These, carrying moisture, come in contact with the cold land, and mists and rains are precipitated.

"Not only does the cold land cause precipitation of this moisture, but the much higher level of much of the land over that of the lakes increases the cold at about the rate of one degree for every 430 feet, and, therefore, increases precipitation. Add to these causes the influence of the north-east winds, cooled by passing over great extents of land surface, and some idea is had of the principal causes which conduce to the great snow falls of the central plateaux of this Province, while the lower and more southern countries obtain the same amounts of moisture largely as rain. Another set of phenomena mark the progress of spring, the advent of which is marked by the great prevalence of northerly winds, of which, on the whole, we seem to have more now than thirty years ago. The reasons for these northerly winds seems evident. By the 20th of March the sun's rays are beating powerfully upon the earth for twelve hours per diem, rapidly elevating its temperature. The atmosphere over the land, becoming heated, rises, and its place is supplied by cold winds coming in from the lakes, especially from the ice-cold waters and ice-fields of Georgian Bay and Lake Huron. Conditions the opposite of those of winter now exist. Instead of the moisture of the winds from the lakes becoming condensed as the winds blow over the land, the wind becomes drier, because warmer, and only when a cold north-east current meets these moist currents from the lakes will the moisture be precipitated. In the summer months we find long days, and also the perpendicular rays of the sun, elevating to an enormous extent the temperature of the treeless surface, while from the surrounding lakes currents of cooler air are continually rushing in to supply the place of the ascending heated column. These cooler lake breezes, while keeping our climate more

pleasant and moist than inland regions less favourably situated, are at the same time elevated in temperature by passing over the heated land, thus being enabled to retain the moisture which, passing over a cooler surface, they would precipitate. This condition of the air continuing throughout the whole summer season, the natural consequence would be that the summer would be drier than where the surface is protected by trees. With a bare, treeless surface, therefore, there would be:—1. An autumn warm and moist. 2. A winter with much snow, falling irregularly and much cold wind from the north and north-west. 3. A spring raw and cold, with prevailing north-west winds, with necessarily a large precipitation of moisture. 4. A hot and comparatively dry summer.

"Interposing among these phenomena the influence of trees, the relative rate of cooling between the water and the land greatly changes. With the sun's rays beating down on the ground it will frequently rise to ninety or ninety-five degrees; but a tree intercepting the sun's rays prevents the high temperature of the ground. Now, though the intercepting tree does become elevated, the rise is slower and never reaches the same height as that of the bare soil for several reasons:—1. The green foilage is not so good an absorbent of heat as, say a dark soil. 2. Since the tissues of the trees are full of sap, and since the specific heat of water is about four times as great as that of the soil, the sap will not rise in temperature so rapidly as would the soil. 3. On account of the circulation of the sap, successive portions are being continually presented to the heating influences of the sun's rays, but as the rapidity of circulation is increased with heat, and as the sap, coming up from the deep portions of the earth surrounding the roots, must have a comparatively low temperature, the elevation in temperature of the whole volume of sap must necessarily be slow. 4. The much greater amount of evaporation taking place from the leaves and branches of the tree than does from the soil, produces a greater degree of cold than would be produced by less evaporation. 5. The greater amounts of moisture in the air surrounding trees will prevent a rapid rise in temperature. These causes combined prevent the tree from attaining to the maximum temperature till evening. Radiation from its surface then setting in will be much slower than in the case of the soil. Hence the temperature does not sink so low as that of the unprotected soil.

"He proceeded to explain the effect over a whole country clothed with forests, contending that while the slower decrease of the trees temperature in autumn augured a higher temperature, the moderating influences of forests on the winter were beyond question. In spring, the sun's rays being intercepted cannot melt the snow so rapidly, and on this account spring floods are largely prevented, the winter grains and clover are protected for a longer period from the effects of thaws by day and frosts by night. Slower radiation prevents so many night thaws, and the baneful chilling influences of cold raw winds are much mitigated. Among other things, the trees, becoming elevated in temperature but slowly, act as condensers to the vapours swept over them from the surface of the lakes, thus supplying frequent showers to the growing plants, while at the same time, by preventing so rapid evaporation, they aid the rains in effecting their fructifying influences.

"The reader then proceeded to consider at length Canada's present condition, and in doing so remarked that where settlement has existed for at least twenty-five years, three-quarters of the forest has been destroyed, while in few cases is the preserved wood distributed over the surface with any regard to its protecting influences, so it may be said, that three-fourths of the influences that would be exerted in our climate under a treeless surface are at work. 1. A cold, raw spring, with high winds and frequently much dry weather during germination. 2. A hot summer, with but little rain, the dryness increasing regularly from May to August. 3. An irregular winter, with frequent high winds, irregular snow falls, etc. These conclusions would be borne out by the following statistics:—

The total precipitation of moisture has decreased. Thus the

TOTAL SNOW AND RAIN.

1840-44	216.57	inches.
1850-54	164.684	"
1860-64	160.387	"
1870-74	152.62	"

or, between the 1st and 4th periods there was a total decrease of 63.95 inches, or a yearly difference of 12.79 inches.

The total moisture is divided as follows :—

TOTAL RAIN FALL.

1840-44	191.020 inches.
1850-54	137.999 "
1860-64	131.706 "
1870-74	113.150 "

or, between the 1st and 4th periods there was a total decrease of 77.87 inches, or a yearly difference of 15.35 inches.

TOTAL SNOW FALL (12 inches snow, 1 inch rain).

1840-44	322.70 inches.
1850-54	320.10 "
1860-64	344.38 "
1870-74	473.83 "

or, between the 1st and 4th periods there was a total difference of 151.13 inches, or a yearly increase of 12.59 inches.

These calculations agree exactly with theory. In comparing the individual quarters of each period, he arrived at the following results :—March has remained much the same still; with April is found a decrease of more than ½ inch, a decrease that increases with each month until September. Thus :—

	April, May, June.	July, August, September.
1840-44	48.55	68.101
1850-54	40.195	48.625
1860-64	32.742	45.617
1870-74	34.670	35.14

The significance of this unpleasant change must be evident to all. The average temperature of the two months of germination is lower now than it was forty years ago. Thus:—

	March.	April.	May.
1840-44	29.88	42.62	51.22
1850-54	30.24	40.06	50.68
1860-64	29.02	40.80	52.86
1870-74	27.24	40.18	53.36

This undoubted fact causes what is termed a late spring, the period for growth and development of the plant being shorter than formerly. The temperature of May, the first month of real growth, is now warmer than formerly, by an average of nearly two degrees. The growth is thus apparently forced unnaturally to make up for loss in April, but the attempt is rendered futile by an undue dryness, the rainfall in May having been:—

1840-44	15.015 inches.
1850-54	13.675 "
1860-64	14.055 "
1870-74	8.640 "

"The dryness increasing, the growing plant has neither the means nor the time for its perfect development, while the dryness of the last months of summer has become so extreme as to cause entire uncertainty as to the existence of good pastures. The young clover is frequently "burnt up," and general failure results.

"Mr. Bryce discussed at considerable length the causes of the wholesale destruction of our forests; the action of our Indian and Australian Governments regarding forests; the extent and condition of forests in Britain, Germany, France, Austria, Hungary, and the means adopted for preservation there.

"The remedies he suggested were reconstruction of at least part of what had been destroyed, and replanting in an intelligent manner. Another remedy was irrigation. He argued to show that cultured woodland is the most profitable form in which land can be held, and quoted the produce of an acre in seventy years to have been £469. 15s. 6d. Such facts he adduced to combat the idea of non-practibility of any organized system of tree-planting as a source of profit. The remainder of the paper was devoted to suggestions for legislation on the subject."

The Lessons of History and some Contemporary Evidence.

We have now studied the scientific aspect, let us have a word on the results historically and geographically noticed, where forests were destroyed.

The progress made by Germany in tree-planting is but part of her general progress. The credit is given to the great Frederick; it was part of the National policy of his day, which raised Prussia from a small power to a great one, and to the energetic continuance of that policy, Germany owes Sadowa and Sedan. By this forethought vast armies have been maintained where once the sandy deserts would not nourish a flock of goats, and successive regiments of hardy soldiers have poured forth from the fertile soil where, two hundred years ago, the ruggid debris of winter torrents, the thorn and the thistle, overspread a thirsty and an impoverished land.

In France, the aristocrats, not unwise in all, had preserved the forests. But when Jacques Bonhomme, not wise in all, had overthrown their tyranny, he bethought him that no good policy could flow from so bitter a fountain, proceeded straightway to emulate with the axe the ravages of the guillotine, and succeeded in no long time in almost staying crop growth in field or meadow adjacent to where he had heaviest laid his grove-destroying hand. Wiser councils now prevail; experience has borne its fruits, and the French forests, particularly those near the sea, bear witness how readily Providence assists a liberal, how sternly she repays a greedy and a grasping cultivator. There is a deep lesson in the old verse, "Thou shalt not reap the corners of thy field."

It may be said of a large part of Italy, of Spain, and of Turkey, that, owing to the injudicious clearing of the forests from their most elevated portions—the watersheds, in fact, which fed the nether springs, bubbling spontaneous up, the source and feeders of many a river through all the lower land—fully one-third of those countries are in a state of infertility and insalubrity as unnecessary as it is complete. The tourist of to-day, full of Cervantes and of Le Sage, passes through Spain in wonder whither have gone the umbrageous forests, the pleasant groves, the cool fountains which, however few their other comforts, never failed to the philosophic Gil or the chivalrous Don. In Turkey, too, he can well see why the crescent pales, when he observes vast pachaliks, once sending many thousand strong sons of Islam to the horse-tail standards, now desert and barren, despoiled of their forests, and necessarily, thereafter, stripped by the elements of the soil

those woods alone preserved. It is not the mere absence of men. Turkey has many subject territories, and many means of retaining recruits. It is that there has been an absence of thinkers—of leaders—of men who had minds to understand the sources of fertility and national strength, and energy to impress them on their countrymen. When we read of the great armaments sent out, in former days, by the Ottomans, by Spain, by Greece, we should remember that these great efforts—now represented by a rusty anchor, some broken armour on the hall pillars, or a few time-shattered towers, and perhaps three lines in a history—augured and indeed implied broad harvests, industriously worked mines, industries of many cities, vast store of cattle and of horses, and all that goes to fill the cup of national strength. Now, long deserted shores, deserts where once the well-kept fences for a hundred leagues carefully divided the rich land among its proud proprietors; grass-grown mounds where rose the myriad sounds, where flourished the countless industries of great cities, meet the traveller's eye. Why? They destroyed the protecting forests; the land parched into sterility; the strength of the possessors faded in a few generations away.

Throughout the North American continent, where winter's frost and summer's heat, with fervid alternations elsewhere unknown, try the temper of the soil, there is every reason to believe that the process of destruction, once the forests are withdrawn, will be more rapid and more thorough than in other lands. This has already, in Wisconsin, Minnesota, New York, Kentucky, and nearly all the settled states, been a source of deep uneasiness to reflective minds. The north-western waters, it is said, have now lost half their draught-power, and the whole wide-draining tributaries of the great Mississippi are losing their steady depth, while in spring and fall, those terrible inundations we have lately seen carry off the waters—then as injurious as they might have been beneficial. An Ohio man, at the Cincinnati convention said, "Let the hills be deprived of the rest of the protection which the forests afford, and half of the area of the State will be sterile in less than fifty years. The rain will wash the soil from the hill-tops first, then from the slopes; the limestone, which is now covered with productive humus, loam and clay, will be laid bare; the naked rocks will reflect the rays of the sun and increase the summer heat, the north storms will blow unhindered over the country, and every change of the wind will cause an abrupt change in the temperature. The rainfall will be diminished and become irregular. Snow and rainwater will at once run down in the valleys and cause periodical freshets, which will ultimately carry away the best part of the soil, even from the valleys. Such will be the unavoidable results of further devastation of the timber." Mr. Clay, of Kentucky, remarked at the same gathering: "I move in the sphere of experience with more certainty. I remember when the forests were hardly broken here that springs of water were very frequent and perennial. The rivulets and creeks and rivers had a perpetual flow; these have now changed. The rivulets and creeks are now dried up in summer, and the fish so often caught by me in earlier years are now gone. Not one spring in a thousand remains." I would beg my readers to note what follows particularly; it is also my own experience here. Mr. Clay goes on:—"Indian corn was generally planted in March, and the rains and exhalations of moisture from the surroundings made crops successful every year. Now, the destruction of the forest has lost to us that bed of leaves which was a perpetual reservoir of water for springs and for

evaporation; aided by the treading of the hard surface, the rainfall, if the same as of old, rushes off at once, sweeping the soil into the Mississippi delta. The dry winds absorb not only the ancient humidity of the air, but drink up the subsoil evaporation. So that our winters are longer, more changeable, and unendurable. Corn can hardly be planted safely till late in April, and drought too often ruins our best efforts. Now, trees do influence rainfall in a State like Kentucky, where the rain is not precipitated by mountain heights, but by the meeting of warm, moist, and cold winds. Here one neighbour has plenty of rain, another scarcely any. And even if the rainfall should be the same for the whole State, the owners of forests have reason to believe that these windbreaks are favourable to rain eddies and rain-bearing currents of air." Prof. Sargent, of Harvard University, who has given perhaps as much study to this question as any one in America, remarked that, "As moderators of the extremes of heat and cold, the benefits derived from extensive forests are undoubted, and that our climate is gradually changing through their destruction, is apparent to the most casual observer. Our springs are later, our summers are drier, and every year becoming more so; our autumns are carried forward into winter, while our winter climate is subject to far greater changes of temperature than formerly. The total average of snowfall is perhaps as late as ever, but it is certainly less regular, and covers the ground for a shorter period than formerly. Twenty years ago peaches were a profitable crop in Massachusetts; now we must depend on New Jersey and Delaware, and our apples now come from beyond the limits of New England. The failure of these and other crops in the older States is generally ascribed to the exhaustion of the soil, but with greater reason it can be referred to the destruction of the forests which sheltered us from the cold winds of the north and west, and which, keeping the soil under their shade, cool in summer and warm in winter, acted at once as material barriers, and reservoirs of moisture."

Statements Collated from the Works of Distinguished Writers on the Subject.

We have now gone over the influences which connect the presence of forests with the climate of a country, first considered in a general, and then in a local sense. I will now, by way of corroborative proof, quote a number of passages from those authors who have made this question their special study. In Europe, where, within the last ten or twelve years especially the subject is creating very great interest, from the evident decrease in moisture and corresponding fertility, much is being done to examine into the evil and remove its causes. One of the first to move in the matter was a distinguished European gentleman of both theoretical and practical experience. Herr Gustav Wex, Counsellor of State and Director-in-Chief of Works undertaken for the regulation and flow of the Danube. He says:—

"Having in foregoing statements given indisputable evidence that in the five principal rivers of Central Europe,—the Danube, the Rhine, the Elbe, the Vistula and the Oder, the basins of which embrace an area of 26,860 (German) square miles,—the lowest and the mean annual water levels, and consequently also the quantities of water delivered by these rivers, during a lengthened period of many years, has been continually decreasing, we may from this draw the following conclusions:—

"1. As the aforesaid rivers are fed mainly by the brooks and streams which flow into them, there must have been also in these a continued decrease in the quantity of water delivered by them for a great many years, from which we may further conclude that if observations had been made on the levels of the different feeders, similar to those which have been made on the five large rivers named, and these had been compared, they would have supplied results similar to those at which we have arrived concerning these.

"The correctness of this allegation receives confirmation from the fact that many manufactories, etc., which have been built during the last fifty years, on rivulets and streams, have experienced a marked diminution in the quantity of water coming through their water-leadings, and it has been found necessary to employ steam-engines to meet the deficiency of their water-power, which was originally sufficient for the work they had to do.

"2. As it is possible that the causes which have produced the effect of the lowering of the water level, and diminution of the quantity of water delivered in these five river basins, operate equally in the basins of the other rivers and streams in Europe, and not only so but in the most populous and cultivated districts of the other three quarters of the globe—it may be assumed that in most of the streams and rivers on the surface of the earth, a similar lowering in the lowest and mean levels of the body of water delivered by them has taken place; while the high floods in the same, reaching a higher point, and becoming of more frequency, discharge a greater quantity of water, and produce more extensive devastating inundations than previously was the case.

"3. If the causes which have operated in producing the decrease in the usual water flow of the streams and rivers, with the rapid overflowing of them in times of flood, in the course of the last 140 years, were to continue to operate also in the future, it is evident from what has taken place that in brooks, and streams, and rivers, the lowest and the mean level of these may be expected to be lowered still further in the future. And the question forces itself upon every one involuntarily to what degree may this diminution in the quantity of water thus delivered by the several streams and rivers be carried?

"A consideration of the three rivers—Weser, Elbe, and Oder—makes clearly manifest a reduction in the quantity of water delivered by them, and a silting up of the river-bed with sand. It has been calculated that if the Elbe continue to diminish in the future at the same rate at which it has been diminishing up to this time, it will soon be impossibe for heavily laden ships to pass by it. Nor is it otherwise with the Oder; in the very dry year 1858, there were only *eleven* days in which the navigation of the Oder in Silesia could be carried on with full force. The Weser delivers the smallest body of water of the three. One principal reason for this is the destruction of forests which has taken place on the heights which are found alongside of the river, and which the Government have latterly taken steps to prevent; but still more than what has resulted from the destruction of forests has been the consequence of the rectifications of the river-bed, which it has become a general practice to carry out.

"After weighing fully the collected observations on the water level, and consequences deduced from them in the foregoing treatise, I think no Hydrotechnik will venture to call in question the correctness of the allegations advanced by the distinguished hydrographer Dr. Berghaus, in the year 1835, which allegations have been confirmed and established by myself, that in the brooks, streams, and rivers in Central Europe, within the period of observations, extending over about 140 years, high floods now appear and attain a greater height; on the contrary, the lowest, and the *mean* levels of the rivers are falling, and consequently the delivery of the water by these streams and rivers is being continuously diminished to a very great degree."

There follows an expression of the views of the author on the great practical importance of the fact brought to light. In the second chapter he describes the reduction observed in the flow of springs and in the quantity of water yielded by them, and after citing numerous facts, illustrative of these points, he thus concludes:—

"In regard to the diminishing of subterranean waters, we can adduce the following evidence:—

"As we have in the preceding chapter shown, from observations on the water level continued through long series of years, that there has been seen in later decades a lowering of the level of the lowest and of the *mean* annual flows, while the high floods consequent on storms of rain, have become of more frequent occurrence—from which it comes to pass that a greater quantity of water is thus carried away at such times than formerly—it follows as a consequence that if the quantity of the rainfall remains the same, the proportion of this flowing away on the surface of the earth in such circumstances has increased. On the other hand the proportion sinking below the surface must be less; and from this it comes to pass that the quantity of the subterranean water supply, the drainage and superficial waters, and with them the springs which are fed by them must have been reduced; and the correctness of this conclusion can be established by the following facts:—

"From these long continued observations on river levels we have further proved that on brooks, streams, and rivers, in these later times, the lowest and *mean* levels, and also the quantity of water delivered, have been being continuously reduced, and that to a marked degree; and that in the very months during which the water courses have been fed almost exclusively from subterranean flows of water and from springs the diminution of the water delivered has been greatest. Whence it may with all justice be concluded that in these later times the water supplies in subterranean reservoirs and the water bearing strata have decreased, and also that drainage waters and the springs in a river basin in their collective contributions now furnish smaller water supplies to the feeding of the river course than was the case at an earlier period."

Herr Wex goes on to say:—"I consider that I have satisfactorily proved, by the foregoing observations, deductions, and examples, that in recent times the supply of water in subterranean reservoirs, and in the water-bearing strata of the earth, is being diminished; further, that many of the drains and springs of to-day have become some quite dry, and others yield a comparatively small supply of water; and finally, that through these changes the lowest and the *mean* water-levels in brooks, streams, and rivers are being continuously lowered, and the quantities of water delivered by them continuously diminished.

"If this continuous diminution, which has been going on for the last 140 years, is to go on continuously still, then will these results and changes on the surface of the earth entail on coming generations evils, and evils of incalculable extent and magnitude. Through the lowering of the level, and reduction of the rivers and of the subterranean drainage, and also through the alternation of very wet and very dry years,—such as is shown by the diagram referred to, to be prevailing,—will the fertility and productiveness of the land be reduced in no inconsiderable degree, and not a few lands now covered with luxuriant vegetation will become veritable deserts, cheerless and desolate.

"After the drying up of many brooks and streams, and after the conversion of streams and rivers into torrents, in consequence of these changes, men would have to go for their water supplies for drinking and for domestic use, and for other purposes, either to the deeper-lying water-bearing strata of the earth, or to a greater distance from their dwelling; whereby the cost of the water consumed would be increased, while many industrial establishments and manufactories would be deprived altogether of the supply of water indispensably necessary to their operations, and would have either to adopt expensive means of providing a substitute for what has been lost, or remove to some remote district where brooks and rivers have not as yet been deprived of their water supplies.

"Finally, by the continuous diminution of water in streams and rivers, the former would become quite dry through the greater part of the year, and the latter would become unnavigable.

"As, through the consideration of what has been advanced, it may thus be seen that, through the continuous diminution and lowering of the flowing water on the surface of the earth, there is imperilled—and that to a great extent—not only the prosperity and the health, but also the existence of future generations, it is desirable that numerous

students of physical science should be incited to further research into the cause of these intimately connected phenomena, and then to devise measures to avert the impending calamity, in so far as it may be within the scope of man's power to do so."

The author adds :—"I have given myself also to an attempt to a solution of this difficult problem, and I give the results of my researches in this study in the two following chapters, in the hope that distinguished *collaborateurs* in the same calling, and men of scientific attainments may prosecute further the researches I have been privileged to commence, and that the results of their study may bring great good to the generations yet unborn.

The chapter which follows is occupied with a discussion of the cause or occasion of a diminution having taken place in the quantity of water flowing in streams and rivers, which he thus concludes :—

"When we fully realise what is implied in the opinions expressed by men of science, and practical men expert in such matters, in various countries, and in very different parts of the world, after long experience, observation and research, we find that forests effect to a very great extent the quantities of water coming from springs and flowing in rivers ; that they affect the climate ; and that they have a good effect upon the fertility of the lands in which they exist ; and that thus :—

"1. The deposit of rain from the atmosphere is greatly increased by the amount of woods in a district, inasmuch as mists and clouds passing along the surface, striking upon the forests, have the moisture of which they are formed condensed and precipitated as rain. Further the temperature within the woods is cooler by day, and, on the contrary, warmer by night than it is in the open fields and meadows ; and by reason of this, there is a continual circulation of air in the vicinity of forests whereby mists and clouds are precipitated and led to discharge themselves of their contents. This happens not through the forests in and for themselves, nor as a consequence of the forests of themselves, but through the difference between the forests and the open fields ; and on this depends the abundance of the rain. It is also very manifest that the forests exercise an attractive influence upon the clouds, by their attracting from them electricity with which they are charged, and with this the water of which they are composed, increasing thereby the rainfall. It is also an ascertained fact that a great part of the water precipitated as rain remains on the leaves of the trees, one part of which falls to the ground, but another portion of which evaporates into the atmosphere, and is again precipitated as fog, mist, dew, or rain,—whence it comes to pass that rain water is kept longer within forest lands, and may be precipitated oftener than once, whereby the rainfall is increased.

"2. Through the abundance of forests will the copiousness of the subterranean drainage flow, and springs be increased, while the rainwater retained by the foliage of the forest trees, falling slowly to the earth, is kept by the spongy character of the ground in woods, from flowing quickly away, and is in part absorbed, or is left to permeate the mineral strata, which is considerably facilitated by the numerous spreading roots of the trees penetrating cracks, fisures, and canals in the superficial ground, by which means the rainwater reaches a greater depth, and this in a much greater quantity in forest ground than in the open field. Further, by numerous experiments, it has been established that the evaporation of the humidity in the open country is at least from four or five times as great as it is in woodlands ; from all which it appears that the moisture absorbed in forests is not so readily evaporated, but it is retained and directed to the feeding of drainages, springs, and brooklets.

"3. If forests be uprooted, more especially in mountainous regions, or even in somewhat hilly country, the raindrops, falling upon the exposed ground with some force, tear it up, and then, flowing down the declivity with considerable rapidity carry with them earth and stones towards the brooks, and streams, and rivers, by which these water courses are suddenly filled up, and experience much higher and more devasting overflow-

ings and inundations, than was the case while the woods stood, as is explicitly testified by the aforementioned tabulated observations of river levels.

"4. Through the extensive clearing away of forests the heat of the summer months and the desiccation of the ground becomes increased, then, as a consequence of this, the duration of droughts is prolonged, and from this there follows naturally a diminished productiveness of the land.

"These most disastrous effects of the clearing away of forest show themselves in a very marked degree in these countries, once blessed with a luxurant vegetation, Palestine, Persia, Greece, Sicily, Spain, and the Canary Islands."

Mr. Marsh in his treatise on "The Earth as Modified by Human Action," in writing of the influence of forests on the flow of springs, says:—"It is an almost universal and, I believe, well-founded opinion, that the protection afforded by the forest against the escape of moisture from its soil by superficial flow and evaporation insures the permanence and regularity of natural springs, not only within the limits of the woods, but at some distance beyond its borders, and thus contributes to the supply of an element essential to both animal and vegetable life. As the forests are destroyed, the springs which flowed from the woods, and, consequently, the greater water-courses fed by them, diminish both in number and volume. This fact is so familiar in the American States and the British Provinces, that there are few old residents of the interior of those districts who are not able to testify to its truth as a matter of personal observation. My own recollection suggests to me many instances of this sort, and I remember one case where a small mountain spring, which disappeared soon after the clearing of the ground where it rose, was recovered about twenty years ago, by simply allowing the bushes and young trees to grow up on a rocky knoll, not more than half an acre in extent, immediately above the spring. The ground was hardly shaded before the water reappeared, and it has ever since continued to flow without interruption. The hills in the Atlantic States formerly abounded in springs and brooks, but in many parts of these States which were cleared a generation or two ago, the hill-pastures now suffer severely from drought, and in dry seasons furnish to cattle neither grass nor water."

Effects of Forests and of the Destruction of these on Rivers, and Streams, and Springs, by John Croumbie Brown, LL.D.

"It is a somewhat prevalent opinion that as rain proceeds from the clouds, rivers have their primary source in springs; and along with this opinion it is held by many, that the primary function of rivers is to carry moisture to lands which otherwise would be barren, and there to diffuse fertility. But, in point of fact, no water springs from the ground which has not previously been deposited from the atmosphere; and the primary function of streams, brooklets, and rivers, is simply to carry off surplus moisture in excess of what the soil can retain.

"As rain is produced by the gravitation to the earth of surplus moisture in the atmosphere in excess of what the air can contain suspended in a state of invisible vapour at the temperature to which it has been reduced, rivers are produced by the gravitation to a lower level of the surplus water so precipitated in excess of what is absorbed by the earth or evaporated again into the atmosphere.

"The popular phraseology in regard to many things is far from being in exact accordance with scientific conceptions. We speak of catching cold, of the rising sun, and of the new moon. And so we speak of the little spring of water at the greatest distance on the highest elevation from the mouth of a river as its source; but no one supposes that the whole of the waters of the river come from this. It may be that there is not an inch of its course, or of the courses of its numerous tributaries and affluents, which does not pass many of its sources, channels of capillary dimensions, through which, from time to time, such excess of rainfall has drained off, or may drain off, into its bed, by which the accumulated drainings are drained off into the sea, if they be not absorbed or evaporated by the way.

"It is under this aspect of springs, and streamlets, and rivers, we should look at them while considering the local effect upon them of forests, or of the destruction of these."

Mr. Marsh says:—"With the extirpation of the forest, all is changed. At one season the earth parts with its warmth by radiation to an open sky; receives, at another, an immoderate heat from the unobstructed rays of the sun. Hence the climate becomes excessive, and the soil is alternately parched by the fervours of summer, and seared by the rigours of winter. Bleak winds sweep unresisted over its surface, drift away the snow that sheltered it from the frost, and dry up its scanty moisture. The precipitation becomes as irregular as the temperature; the melting snows and varied rains, no longer absorbed by a loose and bibular vegetable mould, rush over the frozen surface, and pour down the valleys seawards, instead of filling a retentive bed of absorbent earth, and storing up a supply of moisture to feed perennial springs. The soil is bared of its covering of leaves, broken and loosened by the plough, deprived of the fibrous rootlets which held it together, dried and pulverized by sun and wind, and at last exhausted by new combinations. The face of the earth is no longer a sponge, but a dry heap; and the floods which the waters of the sky poured over it hurry swiftly along its slopes, carrying in suspension vast quantities of earthy particles, which increase the abrading power and mechanical force of the current, and augmented by the sand and gravel of falling banks, fill the beds of the streams, divert them into new channels, and obstruct their outlets. The rivulets, wanting their former regularity of supply, and deprived of the protecting shade of the woods, are heated, evaporated, and thus reduced in their former currents, but swollen to raging torrents in autumn and spring.

"From these causes there is a constant degradation of uplands, and a consequent elevation of the beds of water-courses, and of lakes, by the deposition of the mineral and vegetable matter carried down by the waters. The channels of great rivers become unnavigable, their estuaries are choked up, and harbours which once sheltered large navies are shoaled by dangerous sand-bars.

"The earth, stript of its vegetable glebe, grows less and less productive, and, consequently, less able to protect itself by weaving a new net-work of roots to bind its particles together, a new carpeting of turf to shield it from wind, and sun, and scouring rain. Gradually, it becomes altogether barren. The washing of the soil from the mountains leaves bare ridges of sterile rock, and the rich, organic mould which covered them, now swept down into the low dank grounds, promotes a luxuriance of aquatic vegetation that breeds fever and more insidious forms of mortal disease by its decay, and thus the earth is rendered no longer fit for the habitation of man."

Mr. Marsh also states in regard to a forest:—"By its interposition, as a curtain between the sky and the ground, it both checks the evaporation from the earth, and mechanically intercepts a certain portion of the dew and lighter showers, which would otherwise moisten the surface of the soil, and restores it to the atmosphere by exhalation. While in heavier rains the large drops which fall upon the leaves and branches are broken into smaller ones, and, consequently, strike the ground with less mechanical force, or are, perhaps, even dispersed into vapour without reaching it.

"The vegetable mould, resulting from the decomposition of leaves and of wood, seems as a perpetual mulch to forest soil by carpeting the ground with a spongy covering which obstructs the evaporation from the mineral earth below, drinks up the rains and melting snows that would otherwise flow rapidly over the surface, and perhaps be conveyed to the distant sea, and then slowly give out by evaporation, infiltration, and percolation, the moisture thus imbibed. The roots, too, penetrate far below the superficial soil, conduct water along their surface to the lower depths to which they reach, and then by partially draining the superior strata, remove a certain quantity of moisture out of the reach of evaporation.

"The meteorological effects produced thus by forests resolve themselves into the prolongation and consequent increase of the evaporation of water falling in the forms of rain, snow and hail, effected in two distinct operations; first, the absorption and renten-

tion of a large portion of the rainfall, and second, the retardation of the flow of the remainder towards the great reservoir and source of all, in accordance with the observation of the Hebrew preacher, 'All the rivers run into the sea; yet the sea is not full; for unto the place from whence the rivers come thither they return again.'"

There is another operation, noticed by Becquerel, to which sufficient importance has not, until very recently, been generally ascribed, namely, the mechanical action of roots as conductors of the superfluous humidity of the superficial earth to lower strata. "The roots of trees," says he, "often penetrate through subsoil almost impervious to water, and in such cases the moisture, which would otherwise remain above the subsoil, and convert the surface earth into a bog, follows the root downwards, and escapes into more porous strata, or is received by subterranean canals or reservoirs. When the forest is felled the roots perish and decay, the orifices opened by them are soon obstructed, and the water, after having saturated the vegetable earth, stagnates on the surface and transforms it into ponds and morasses. Thus, in La Brenne, a tract of 200,000 acres, resting on an impermeable subsoil of argillaceous earth, which ten centuries ago was covered with forests, interspersed with fertile and salubrious meadows, has been converted by the destruction of the woods into a vast expanse of pestilential pools and marshes. In Sologne the same cause has withdrawn from cultivation and human habitation not less than 1,100,000 acres of ground, once well-wooded, well-drained and productive."

From the Report of John Ednie Brown, Esq., Conservator of Forests, to the Parliament of South Australia:—

That large bodies of trees have a direct influence on the atmospheric changes of a district or country is, I think, in these days of so much statistical and other reliable information, now a recognized fact. If we look back and examine ancient, mediæval, and modern history, we there find many very noted examples of decrease of rains, dried up rivers, extended deserts and depleted populations, simply from the clearing of extensive forests; while again, on the other hand, it has been observed that where large tracts of country have been laid under a crop of trees, and which previous to this having been done were designated dry and comparatively unproductive parts, small streams of water have been found where none formerly existed, and the general nature of the districts has been improved to such an extent that they have become highly favourable for agricultural purposes, and hence more able to sustain an increased population."

1. "*Trees give Shelter*:—In the agricultural parts of this colony, especially in the northern areas, where extensive tracts of most excellent country are open to every blast of wind that blows, it is self-evident that the planting of belts of trees in different directions through them would have a most beneficial influence on the crops which are produced upon the ground. The direct results of such belts would be that the hot winds, which at present are the very scourge of the country so far as their effects upon vegetation are concerned, would, if they were not in time subdued altogether, be at all events considerably softened by coming in contact with the cooler atmosphere arising from the damper surface of the ground shaded by trees, and therefore pass harmlessly over the country; and thus the crops would not only be more certain, but would grow more luxuriantly, and consequently the yield would be proportionately larger. Again, another important result which would arise to the agricultural community from the planting of trees on the plains would be, that shelter would be given to stock, both from the hot winds of summer, and the storms and cold blasts of winter."

2. "*Forests Prevent Evaporation*:—It is, perhaps, almost superfluous to remark that very great evaporations take place all over the colony at all seasons of the year, from the thoroughly exposed character of the country generally to the full power of the sun's rays. In consequence of this, what rain falls upon the ground is, almost as soon as it reaches the ground, again taken up into the air by evaporation, without being retained in the soil for the use of the crops growing upon it. Even on those parts of the country which are under indigenous forests, from the scattered and generally sparse crop of trees constituting these, together with the peculiarly characteristic feature of the Australian trees, affording but little shade to the ground—owing to upright habit of the foliage—

evaporation goes on in a very rapid manner. It is chiefly to these causes alone that I attribute the fact of their being so few never-failing creeks and rivers in this colony. Now, were there judiciously laid out plantations all over the country, and the trees constituting these being at such distances apart, and of such kinds as would effectually shade the ground from the sun and prevent evaporation to a certain extent in these parts, or at least in a much slower manner than is done at present, the rain would have time and opportunity to be absorbed into the ground, and by percolating to considerable depths, come out again at a lower level, and thus cause streams of water where none exist at present, and so on from place to place, keeping up a general degree of humidity to refresh and encourage the growth of vegetation.

3. "*Forests have a Tendency to Equalize Rainfall*:—In this colony, the climate of which is considered very dry, nearly as much rain falls within the twelve months as there falls within the same period in some countries which are nearly humid ones. In moist climates we find that on nearly three-fourths of the days of the year, rain falls more or less. In this country, again, there are at least three-fourths of the twelve months which are entirely cloudless. And still the rainfall in both instances is not in like manner disproportionate so far as the total amounts for the year are concerned. These appear somewhat contradictory statements, but yet they are approximately correct for many cases which could be cited. The reason of the difference is not that the one country lies perhaps in the northern hemisphere, and the other in the southern, or that the one may be fifteen degrees nearer the equator than the other. No; the grand secret is that the country which has its rainfall spread over the whole year is thickly covered with trees, while in the case of our own colony there is a very small proportion of its area occupied by forests. In two or three hours in this country as much rain will fall as would occupy two days steady drizzling in Great Britain.

4. "*Forests Attract Rainclouds*:—That this is the case is now a very well ascertained fact. I do not, however, hold myself to the opinion of some writers that *the trees themselves* abstract the rain, but rather that the *results* flowing from a large body of trees have this tendency. To put the matter in a scientific form we find (1) from the shade given by the trees the temperature of the earth is lowered; (2) the atmosphere hovering immediately above the trees is in consequence lower than that in part of the country adjoining which may be clear of vegetation; consequently it follows (3) that if hot clouds flow over a plantation they will be cooled down and their moisture condensed upon coming in contact with the cold, humid atmosphere hanging about the trees, and as their power of holding water in a condition of vapour is sensibly diminished in a certain ratio according to the fall of temperature, the result is a deposit on the ground of either rain, mist or dew; and again, (4) clouds containing vapour, which have blown over dry ground heated by the sun, where the air is in consequence highly rarefied and warmer than the clouds, these dissolve themselves and vanish; but should these clouds come in contact with the cooler air above masses of trees, they become overcharged with moisture, and rain is the result.

5. "*Forests Subdue Aridity*:—We have seen that the planting of large bodies of trees has the indirect influence of attracting rainclouds to the sites occupied by them, and that the atmosphere generally about woodlands is in a continual state of moisture by transpiration from the pores of the leaves, and by a certain amount of evaporation from the ground by the heat of the sun. From this, then, it will at once be seen that by planting arid tracts of land with properly proportioned belts of timber here and there through them, the result is (1) lower temperature; (2) arrest of hot winds; (3) shelter; (4) more frequent rains; and (5) a more humid climate generally, thus making such tracts of country suitable for agricultural purposes.

6. "*Forests make Climate more Humid*:—This is a result and contiguous part of the whole system of the different influences of trees upon climate which have already been explained. Water is sucked up from the soil by the roots of the trees, and is exhuded again in the form of vapour from the stomates on the back of the leaves; this rises into the air and forms itself into clouds, and, if not deposited again on the ground as rain by some counter-balancing atmospheric influence, is wafted across the country, cooling the air and keeping up a supply of heavy dews which refresh and invigorate vegetable life.

While again, the humidity of the climate is maintained from the simple fact that the green, moist foliage of the trees constituting the forests has the well-known tendency of preventing the increase of the sun's rays by radiation, and thus reducing the chances of evaporation.

"The Count de Gasparin has found that soils covered with low vegetation or with woods, and in which the soil is composed of humus, mingled with sand and lime or clay, absorb more water than those which contain no humus, and consequently retain it longer than the latter. These effects vary, according to the proportions of the various elements of which the soils are composed. The infiltrations are greater in wooded lands than in those covered with sod. The roots penetrate deeper, and thus facilitate the passage of waters, which would be only stopped by an impervious stratum.

"The branches of trees in leaf not only oppose the evaporation of the water in the soil, but the leaves themselves are constantly yielding a vapour from exhalation, and which tends to reduce the evaporation of waters, so far as the moisture exhaled goes to saturate the air, the infiltration at the same time going on into the soil. Herbaceous plants, not in masses, do not produce similar effects; in fact, whoever has been in places partly wooded and partly sodded must have observed, after a rain and a rest of some duration, that the sodded grounds were dry, while the wooded soil was always damp.

"We will now speak of the water absorbed by the roots, and that which is exhaled into the atmosphere.

"The roots of trees, as shown by the experiments of Hales and others, absorb a large amount of water, charged with various elements constituting the sap. The surplus water is evaporated from the leaves, which are constantly surrounded by a humid atmosphere. The water thus evaporated is drawn, not only from the upper strata, but likewise from the deeper layers of the soil into which the roots penetrate, and which supply little or no water to herbaceous vegetation. These lower strata are fed by subterranean sheets of water that often come from a distance. Furthermore, this water remaining in these lower strata, being thus given to the atmosphere, fall again as fog, dew or rain, and thus increase the quantity of water that the surface of the soil receives from some distance away.

"The amount of water absorbed by the roots is so great that it is practically difficult to make much of it remain near the trees, several reasons for preventing it occurring. The soil in contact with the roots, and for a little distance away, is in a certain state of desiccation; little by little it loses its nutritive properties, the lime, etc., and when these elements are gone, the soil contains little but sand and clay, which then becomes permeable. It is, therefore, well demonstrated—

"(1.) That a difference exists between the evaporation from a naked soil and a soil covered with sod.

"(2.) That there is a like difference between a soil covered with sod and one that is wooded, with the further advantage of the latter in facilitating the infiltration of water.

"(3.) That the amount of water absorbed by the roots does not produce drought in the soil, since it is returned after evaporation in the condition of fog, dew or rain. The drought does not take place till the soil is exhausted."

The thermal influence of forests has been established by Humboldt as follows:— "They shelter the ground against the sun's rays, they maintain it in a greater degree of humidity, and facilitate the decomposition of the leaves and litter, which they change into humus; and they act as a cooling cause by producing active aqueous transpiration from the leaves and by multiplying in the expansion of their branches, the surfaces warmed by the solar heat, and the surfaces cooled by nocturnal radiation. In regard to the action last mentioned, positive experiments show that the layer of atmosphere in contact with a meadow or a field covered with herbage or vegetable leaves, becomes cooled by nocturnal radiation, other things being equal, several degrees below the temperature of the atmosphere at some meters above, while nothing of this kind takes place over a naked soil, which becomes warm or cool according to the nature of its component parts. We will add, as we have demonstrated, that the leaves as well as the trunk and branches become warmed by solar heat, and retain into the night a portion of this acquired heat. This effect should counterbalance the cooling from nocturnal radiation. We have not thus far

taken account of the fact that the warming of the trees by the sun has a considerable effect upon the temperature of the atmosphere outside the woods as well as within them."

Influence of Woodlands upon Springs, Rivers, and Streams, and in Causing Droughts.

Professor Hough says:—"It is a matter of common remark that our streams diminish as the woodlands are cleared away, so as to materially injure the manufacturing interests depending upon hydraulic power, and to require new sources of supply for our State canals and for the use of cities and large towns. Many streams once navigable are now entirely worthless for this use.

"The mode in which this influence operates will be readily understood when we consider the effect of forests upon the humidity and temperature of the air.

"A deciduous tree during the season when in foliage is constantly drawing from the earth and giving off from its leaves a considerable amount of moisture, and in some cases this amount is very great. This change of state from a fluid to a gaseous condition is a cooling process, and the air near the surface, being screened from the sun and from the winds, becomes by this means so humid that a rank, succulent vegetation springs up and thrives, which in an open field would wither and perish in an hour. The air being thus charged with moisture and cooled, does not take up by evaporation the rains which fall, and the soil being more open readily allows the water from melting snows and from showers to sink into the earth, from whence a portion appears in springs and in the swamps, which give rise to rills and streams.

"The air at all times holds more or less watery vapour in suspension, and its capacity for doing so is increased as the temperature is raised, not by a steadily gaining rate, but more rapidly as the heat is increased. There can be no evaporation when the air is saturated with moisture, and no deposit of water in any form until the temperature is reduced to the point of saturation. It is not yet determined as to how far the cooling and moistening influence of a grove may extend. It must depend upon many circumstances, and especially upon the slope of the surface and the direction of the winds. The effect is often apparent to the eye from the freshness of the herbage in adjacent fields for many rods in width."

He also says:—"Woodlands are well adapted to hinder the waters from running off and to favour their passage into the soil. This they do with better effect when they are more densely covered. It is, moreover, certain that the leaves of trees pump up and absorb a large amount of water, and although the soil on which they grow is uncultivated, it is much more susceptible of absorption of rains than bare and uncultivated land.

"Forests contribute so effectually to the detention and preservation of the waters, that springs in some countries flowing through the year have entirely disappeared after the woods had been burned, nor did they reappear until after the verdure had been restored, their existence being closely dependent upon its presence."

I will give a quotation on a very important subject, the amount of moisture evaporated by leaves of trees:—

"The leaves of plants impart by evaporation during the growing season a certain amount of watery vapour to the air. The amount of this evaporation differs, not only in the different kinds of plants, but it also depends in the same plants upon external conditions—the temperature of the air, the intensity of light, and on the amount of moisture in the air and in the soil. The greater the warmth of the air, the more intense the solar light, the drier the air, and the moister the soil, by so much more will plants give off moisture from their leaves, the transpiration under these conditions being more active. In this respect light affects plants to such a degree that even passing clouds will lessen the evaporation. The result of all the observations thus far has been to show that under like circumstances the transpiration is greatest in the direct light of the sun; that is, less in common daylight, still less in the shade, and least in the night. Risler found

by his investigations that in the lucerne the amount of water evaporated in the sun is four times greater than it is in the shade. The difference of evaporation in the two conditions is with this plant considerably greater than with corn. In some plants, as in the willow, it is, however, very slight. This is no doubt the reason why some plants will thrive better in the shade than others. Transpiration is also diminished by a fall of temperature and an increase in the humidity of the atmosphere. With the decrease of warmth and the lessened influence of light, the transpiration of plants becomes less in autumn, and finally stops entirely, causing the falling of the leaves. The evaporation of the leaves is very slight in a damp or foggy atmosphere, and when the leaves are wet by dew or rain. In the damp air of our hot-houses, and under glass vases, often placed over weakly plants, the amount of evaporation is very slight. It is correspondingly lessened in the shade of trees in the cool and damp air of dense forests and under artificial coverings.

"In order that the leaves of plants may remain fresh and plump, as much water must be taken up by the small fibres of the roots as is lost by transpiration. A constant circulation of water is going on from the roots through the trunk to the branches, and through these and the stems into the leaves. The plants remain in a normal condition whenever the supply of water by the roots and loss by evaporation correspond. Under some circumstances it will occur that the supply of water received through the root is greater than the loss through the leaves, or that the loss is greater than the supply. Instances of the former case are presented in the plant which during the night evaporates less water than it receives from the ground through the roots. The surplus is deposited on the leaves in small drops, which, upon examination, may be found early in the morning even in the hot-houses, which precludes the idea that they are gatherings of dew. Another instance is shown in our deciduous trees in autumn after the fall of the leaves, when, from a relatively warm soil the roots maintain their activity, and continue to receive moisture from the soil, which will remain in the body of the tree, as the organs of evaporation are gone. This explains the reason why there is a greater amount of water in the body of the tree in autumn than there is in summer. It is oftener the case, however, that the amount of water lost is greater than that received, which occasions in herbage and young plants a withering of the leaves. Larger trees are not materially affected by this interruption, as the body of the tree acts as a reservoir of water, from which the trees are supplied for some time. The withering and drying up of plants is not always the result of an insufficient amount of moisture in the soil, but it may occur when, in consequence of a lack of activity in the roots the absorption of water from soil is not proportioned to the loss by transpiration."

Here is a word from California. The *Nevada Enterprise* says :—"It will be but a very short time before we shall be able to observe the effect that stripping the fine forests from the sides and summit of the Sierras will have on the climate of this State and California. In a very few years every accessible tree, even to such as are only of value as firewood, will be swept from the mountains. Even now this has been done in some places. It is to be hoped that a new growth of pines or timber trees of some kind may spring up on the ground that has been cleared, but we do not hear that any such growth has yet started.

"Already one great change has occurred that is evident to the most ordinary observer, which is the speedy melting away of the snow on the mountains. It now goes off at once, in a flood, with the first warm weather of spring, whereas formerly, lying shaded and protected by the pines and other evergreen trees, it melted slowly, and all summer sent down to the valleys on both the eastern and western slopes of the Sierras constant and copious streams of water. Instead of a good stage of water in our streams throughout summer, as in former times, there is a flood in the spring, and when this is passed by our rivers speedily run down, and being no longer fed from the mountains, evaporation leaves their beds almost dry when the hot weather of summer comes on.

"The mountains being stripped of their trees, there will be nothing to shade the rocks and earth, and both will absorb a sufficient amount of heat from the rays of the sun during the fall, and even until far into the winter, to melt any light snow that may occur.

The result will be that our autumn weather will reach further into winter, until at last we shall have no winter worthy of the name. On the California side of the mountains the effect will be much the same. The hot weather of the valleys will extend over the foot-hills and gradually reach up into the mountains."

The desolation of mountain regions by the clearing of forests and by pasturage of flocks is also strikingly illustrated in the Pyrenees. This region in the last century was almost entirely out of account in the agricultural and commercial reports of France. The slopes were timbered with forests of great extent, which, from wants of markets and ways for transportation, remained unproductive and to some extent unknown. On the top, where forest vegetation ceased, sufficient herbage was found for the pasturage of flocks in summer. The plains were poorly cultivated and inundations were much less frequent and less destructive than now-a-days. As roads came to be opened the profit from sheep and cattle became greater, and the clearing of forests was begun to make room for pasturage, and to some extent for timber, until by degrees the slopes of the mountains were denuded, and the rains having nothing to hinder began to form eroding torrents, the south slopes suffering most because first cleared and directly exposed to the sun's heat. The extremes of flood and drought became excessive, and extensive tracts have been ruined for present occupation from this source.

The Island of St. Helena, the well-known scene of Napoleon's banishment, furnishes a remarkable illustration of the connection that exists between forests and rainfall. When first discovered in 1502 it had heavy forests. The introduction of goats and other causes destroyed these woodlands until the island was almost denuded. The consequences were that in the records of the last century we find accounts of repeated and almost periodical visitations of very severe drought, occasioning various losses to cattle and crop efforts. Toward the end of the last century, however, the governor saw the need of strenuous efforts, gardeners were sent for, and trees from all parts of the world were planted, without regard to their character. The "Pinas Pinaster" was sown very extensively, and several plantations of this still exist. The consequences of this were discovered a few years since as follows :—"For many years past, since the general growth of our trees, we have been preserved from the scourge, and droughts such as were formerly recorded are now altogether unknown. We have no means, however, of otherwise comparing the rainfall of the two periods, as no tables or even estimates of the rainfall can be had for the earlier dates. Our fall of rain now is equal to that of England, and is spread almost evenly over the year. The showers fall more heavily in two or three months of the year. But this period, though called on this account the rainy season, is in no way to be compared to what is understood by an inter-tropical rainy season."

The Island of Ascension furnishes another remarkable instance. This island, some seven and a-half miles long and six wide, was entirely barren when first occupied in 1815, and so destitute of water that supplies were brought from England and the Cape of Good Hope. Means have since been taken to plant trees and introduce agriculture on the island, though not to any great extent, the effect has been most remarkable. The island grows forty kinds of trees, where but one tree grew in 1843, owing to want of water. The water supply is excellent, and the garrison and ships visiting the island are supplied in abundance with vegetables of various kinds.

In Ceylon the planting of tea and coffee a few years since became an object of active and to some extent speculative enterprise, the soil and climate being alike adapted to both and with more profit to any other vegetable products previously grown. This led to the extensive cutting off of forests, to such extent that there was reason to fear that districts hastily cleared under these inducements might be so changed that there could not be a few years' cultivation. Dr. J. D. Hooker, of the Royal Kew Gardens, to whom reports had been sent, in a letter dated May 27, 1873, to the Earl of Kimberley, calling special attention to the consequences likely to follow this improvidence, says :—

"It is principally on climatic considerations that the cutting down of forests seems to require Government supervision. There is good reason to think that in tropical countries the removal of wood operates effectively in reducing the rainfall. There can at any rate be no doubt that the presence of forests plays a most important part in storing the rainfall and yielding up gradually to the streams a continuous supply of water, a thing, I need hardly say, in a hot country, of primary importance. Moreover, the rain is retained by forests on the surface of the ground ; it gradually permeates to the subsoil, and so feeds the underground water-bearing strata upon which springs and wells must eventually depend. If the forest is indiscriminately removed the rain runs off as fast as it falls, and washes away the superficial and fertile soil with it.

"The mischief already done in Mauritius and various West India islands is so widely spread (being in some, indeed, irreparable), and the feeling of the colonists against any interference on the part of the Government is apt to be so determined that I venture to press upon your lordship my own opinion as to the urgency of active steps being taken in the case of an island so beautiful and at present so fertile as Ceylon. I have lately received an account of the deterioration of the climate of some of the leeward islands, which affords a melancholy confirmation of what I have urged above.

"The contrast between neighbouring islands similarly situated is most striking. The sad change which has befallen the smaller ones is without any doubt to be ascribed to human agency alone. It is recorded of these that in former times they were clothed with dense forests, and their older inhabitants remembered when the rains were abundant and the hills and all uncultivated places were shaded by extensive groves. The removal of the trees was certainly the cause of the present evil. The opening of the soil to the vertical sun rapidly dries up the moisture and prevents the rain from sinking to the roots of the plants. The rainy seasons in these climates are not continuous, cloudy days, but successions of sudden showers, with the sun shining hot in the intervals. Without shade upon the surface, the water is rapidly exhaled, and springs and streams diminish.

"It is not, however, simply to the restriction of the removal of existing forests that I would venture to direct your lordship's attention, but also to the object, no less important, of making new plantations of forest trees useful for timber and in the arts. Such plantations would serve the double object of retaining the desired humidity and of yielding a revenue to the island."

The Khanate of Bucharia presents a striking example of the consequences brought upon a country by clearings. Within a period of thirty years this was one of the most fertile regions of Central Asia, a country which when well wooded and watered was a terrestrial paradise. But within the last twenty-five years a mania of clearing has seized upon the inhabitants, and all the great forests have been cut away, while the little that remained was ravaged by fire during a civil war. The consequences were not long in following, and have transformed this country into a kind of arid desert. The watercourses are dried up and the irrigating canals empty. The moving sands of the desert being no longer restrained by barriers of forest are every day gaining upon the land, and will finish by transforming into a desert as desolate as the solitudes that separate it from Khiva.

In the calculations concerning the influence of forests on the rainfall and vegetation of a country, the world has suffered from a lack of scientific observations, no country having for a number of years in succession employed meteorologists to make the requisite observations. In this matter of late years Bavaria has moved to great purpose, and has secured already a large amount of valuable data. From these I make the following quotations, which if carefully read will give my readers valuable facts lately ascertained by the Bavaran Government :—

"By direct observation, it being shown with certainty, that the evaporation in forests covered with litter is very much less than that of naked soil under like circumstances, there can be no longer a doubt that not only forests, but also the litter that covers the surface, contribute largely to the retention of moisture in the earth and to the feeding of springs. The total mean loss of moisture in litter-covered forest soil during the months from April to October inclusive, 1869, was sixty-two per cent., and in 1870, fifty-eight per cent., less than in soil free from litter. If we compare these percentages with the preceding, we find this most interesting result; that the litter covering contributes as much to the retention of moisture in the soil as forests themselves. In very rainy seasons this influence is less than in dry years. From this it is seen how important it is to retain a protecting covering of moss or leaves on the soil especially upon mountain slopes, where, without litter, or even without woods, but very little water penetrates the soil, the water for the most part running off into the valleys.

"A knowledge of the amount of precipitation (rain, snow, fog, and dew) during the year has a practical as well as a scientific interest, because not only is the height of mean water in our rivers governed by the amount of rain and snow, but also the yield of our crops is largely dependent upon the amount of moisture in the earth. Each plant during its life, uses a considerable amount of water as compared with its weight, and this is derived mainly from the soil. In great drought the plant either dies, or is developed but poorly, forming few roots and few leaves and seeds. In fertilized soils it may thrive better, but without sufficient moisture its vital powers decline. According to the careful investigations of Hellriegel it appears, that in sandy soils and in dry regions, the size of our crops depends more upon the amount and distribution of rain than any other factor. Although generally a greater warmth of the air acts favourably upon the development of plants, it certainly does no service unless the soil receives a corresponding amount of rain.

"The action of the water begins with germination and continues till the formation of the fruit. In the early summer months the grass will wither in the meadows, the herbs and young plants will dry up, the leaves and blossoms of trees will droop, and the half-ripe fruit fall. But how suddenly plants will revive when a long-delayed rain falls on the arid earth! The forester knows from experience the injuries caused by drought. He knows that forest vegetation demands a certain minimum of yearly precipitation, which must be relatively greater in warmer and drier climates and soils. He also knows that the growth of wood is greater in moist and moderately warm years than in hot and dry seasons; in fact, the growth of forest trees and their propagation is governed in a very large degree by the distribution of moisture.

"The great claims which trees make upon the moisture in the soil are explained by the circumstance that they contain a large amount of water, which forms the principal part of their sap, and a part of the wood fibre, cells and other organic parts. Starch, chlorophyl, etc., are saturated with water. It is by its agency that the functions of nutrition and growth are carried on. This want is greatly increased by the enormous evaporation constantly going on through the leaves, etc., during the growing season especially in the day-time, which passes off into the air as an invisible vapour, and must be replenished from the soil through the agency of the roots, or they wilt and die. The tree is, in one sense, a stream of water, which, during the growing season is moving from the fibres of the roots, through the outer body of wood into the limbs and branches and into the leaves. The forests thus withdraw a great amount of water from the soil and give it off as vapour. In winter the process is partially suspended, but still there is a

certain degree of activity in the roots. They lay up a supply of aliment in the wood, which serves to keep them alive at a time when grass and herbs would die, and from the depth to which the roots penetrate, they are able to draw water from deeper strata which never become dry, and may thus be able to endure the driest seasons. The amount of water which plants and trees need to sustain life, depends mainly upon the growth and evaporation. The latter differs in the same plant according to age, size, and location, as well as conditions of soil, amount of light, and motion of the air. We have as yet no reliable results as to the amount of water which different forest plants and trees under various circumstances lose by evaporation. This is a subject which deserves our attention in the highest degree, and furnishes a rich subject for forest experimental stations. While Unger found that water would evaporate three times the amount of a plant of the same surface, Schleiden concludes that a forest evaporates at least three times as much water as a water-surface of like area. According to Hartig, a forest evaporates less than free water or wet earth. In hot summer days some plants will evaporate their own weight. In fact, forests afford, and some species of trees, more than others, a kind of vertical drainage of water from the soil.

"With respect to the relative amount of water falling in the fields and forests, it was found uniformly greater at the surface of the earth in the former than the latter, for the manifest reason that a part was intercepted by and evaporated from the foliage of the trees. The percentage in the woods as compared with the fields, varied in different years, by seasons, from forty to ninety, being on the general average of all stations, and, for the whole period least in spring and most in winter. These results will be found to agree with those obtained at other stations, and the rule would doubtless apply to all countries and to every period of time.

"The foregoing statements show how closely related in a country, are its wealth in forests and water (as shown by the great influence of the former), and the litter that covers the surface, to the evaporation and moisture. It therefore need not surprise us that springs and brooks dry up or flow only periodically, and that the mean height of water in rivers and large streams lessens when large surfaces are cleared up, or that springs flow more abundantly and regularly when, by replanting, the extent of forests is increased. The influence of forests, and of litter-covering on the moisture of the soil, founded upon these observations, may be expressed not only in percentages, but we may be allowed to draw conclusions from small to great, as they afford the means for estimating the loss of water in the soil, caused by large clearings and the taking off of litter from any given surface."

As I am endeavouring to present in this compilation as good an idea as is available of what has been done in this matter of late years, in different countries, (for the world in general appears to be becoming aware of the loss of its timber), I will now give an opinion relative to the Indian forests from a source which should command attention. It is from a valuable work entitled "India in 1880," by Sir Richard Temple, Bart., G.C.S.I., C.I.E., D.C.L., late Governor of Bombay, Lieutenant-Governor of Bengal, and Finance Minister of India (a work with which, by the way, I was furnished by the kindness of Mr. Goldwin Smith):—

Of his qualifications for writing such a work, the author says:—"If, in undertaking to give such a description from my own knowledge, I shall seem presumptuous, I may state that the demands of public duty have compelled me to visit every part of the Indian Empire, from Thibet to Ceylon, from the Khyber Pass to the frontier of Ava, from the valley of Asam to the city of Candahar. It has been my fate to serve in the three Presidencies of Bengal, Madras, and Bombay, and in every province of the empire with one exception, to be brought in contact with the Native States and the North-West frontier, and to be employed in some capacity or other under all the departments of the State. These circumstances are mentioned in order to show how the materials have been acquired upon which this volume is founded. I have, with trifling exceptions, not only beheld, but

made sketches of every scene which is described in these pages. I have been from first to last concerned in, or otherwise personally cognizant of almost all the affairs which are here discussed." Concerning the forests of India, Sir Richard says ;—

"The forests of India were vast according to tradition, and have been considerable even during periods of authentic history. During some few centuries they have been shrinking in size and importance, until they are at present inconsiderable for so great an empire as India, which possesses so many ranges of mountains and hills. If the hill-sides generally had slopes which could be cultivated, then the forests as they were gradually cut down and up-rooted, would give place to crop-bearing fields. But the hills are steep, the soil, lying upon rocky strata, is thin, and is speedily washed away by the rains descending violently at certain seasons. The forest is destined by nature to bind the soil with roots, and so to support the lesser vegetation on the ground. Consequently, when the hill-side is denuded of trees, the shrubs, plants, and herbage fail to sustain themselves, and barrenness ensues. The unrestrained clearance of the forests has affected the climate unfavourably, and lessened the supply of moisture in a country already subject to aridity. It has caused wood, a necessary article, to become dear and scarce, and compelled the people to use for fuel substances which ought to be used for manure. It has reduced to a low ebb some valuable portions of the national wealth, and cut off beyond recovery some branches of the imperial resources. For many generations the forests have been felled whenever firewood had to be gathered for the consumption of the villagers, or new lands reclaimed from the hilly slopes, or towns built with styles of architecture in which wood is largely used, more particularly when cantonments for troops had to be formed, or civil edificies constructed. The felling used to be carried on indiscriminately, without any thought of leaving some parts of the forests, or even a few trees here and there, for reproduction in the future. This destructive process was continued under British rule, and became even aggravated under various circumstances. Timber was needed for the building of barracks, and the officers of the public works' department used to make contracts with capitalists for its supply. These officers were unwilling to interfere with the operations of the contractors who, having no abiding interest in the forests, cleared them to the last logs, without regard for the consequences of such denudation. The forests had been so little explored that the local authorities seldom became aware of the mischief that was being done. When railways began to be constructed, sleepers were not, as they now often are, obtained from Northern Europe, but were procured from local forests, through the agency of contractors, who denuded the forests according to the custom which had unfortunately been established in such cases. The Government theoretically deplored the evil so far as they knew its existence; but its real proportions remained long unknown by reason of the ignorance which prevailed in respect to the sites, value and stock of the forests.

"Within the present generation, scientific attention has been awakened, the Government has bestirred itself, and an effective management of forests has been inaugurated. Mischief, practically immense, has been done already, of which some parts are irreparable, or can be repaired only after the lapse of a long time, while others may be remedied within one or two generations. Of the primeval forests there remains several, still intact, enough to constitute a national resource.

"In the lower ranges of the Himalayan mountains, in central India, in the valleys of the Vindhya and Aravali ranges, in the northern and western portions of the Deccan, and in many districts of the Madras Presidency, the forests have been for the most part so long destroyed that their restoration is hardly to be anticipated. But in the higher ranges of the Himalayas, in the central tracts of the Punjab, in the Satpura range, in that hilly region where the Vindhya and Satpura ranges join, in the Eastern and Western Ghat ranges, they are either preserved, or else but partially destroyed, and may still prove very productive. In some parts of the Bengal Presidency, and in many parts of the Presidencies of Madras and Bombay, the remnant of them is still being invaded bit by bit. Many authorities apprehend that the western and southern provinces of India are, owing to the destruction of the forests, threatened with a danger which is feebly checked, and which, if not arrested, may seriously affect the best interests of the country.

"The woods and forests of India from the Himalayas to Cape Comorin comprise, as

might be expected, trees of European kinds; the cedar, the pine, the fir, the mountain cypress, the juniper, the yew, the oak, the ilex, the elm, the ash, the maple, the plane, the holly, the laurel, the birch, the walnut, the alder. The Asiatic sorts are the acacia, the terminalia, the ebony; the ficus order including the banyan and the india-rubber tree, the mango, the sandal-wood, the cane, the bamboo, the toon, the neem, the blackwood, the sal; and greatest of all, the teak. To these should be added the palms, including the feathery date-palm, the palmyra with its fan-like leaves, and the betel-nut palm. The lesser products of the forests, such as myro-balans, and other articles, are also considerable.

"Many believe that the rainfall is copious and seasonable or otherwise, according as the woods and forests, and the vegetation subsidiary to them, are preserved or destroyed, while others disbelieve this view, which at all events must admit of much qualification. But, after all due abatements have been made, the view is generally held to comprise some truth. The total rainfall of the whole country cannot possibly be affected by the existence of forests. The average quantity of vapour must come from the ocean and must be condensed somewhere; if it be not changed into rain as it passes across the plains, it will pass on to the mountains and be transformed there. This, indeed, is a matter of common experience; moisture-laden clouds float over the Deccan, leaving it arid, and move on to the Satpura range, and, being condensed there, fill the torrent-beds with rain-water which rushes into the rivers and returns ultimately to the plain in the shape of inundations. Similarly, clouds sweep over the thirsty plains of Hindostan, and being condensed in the Himalayas, return in the form of floods in the great rivers. The hope is that, if forest tracts were distributed over the plains, there would be cool surfaces to attract the clouds and to arrest them, as it were, on their way. There are many tracts where forests, if preserved, would grow up in a short time. Thus it is anticipated by many that the climate would be improved, and that the early and the later rains would descend more seasonably than at present. It is remembered that, throughout the world, those regions which possess rich vegetation receive abundant rains, while those which are denuded of vegetation are rainless. It is remarked, too, that those regions in India, which ordinarily receive rain, but have been parched by a long drought, are plagued afterwards with immoderate rain.

"At all events the forests, and their subsidiary vegetation, husband and store by a natural process the exceeding moisture of the rainy season, for the benefit of the country during the dry season. The streams become better filled and more available for the use of the people; the springs are less likely to run dry, the wells less liable to failure. This consideration becomes peculiarly important in those regions where the canals for irrigation are drawn from rivers having their source in mountains which depend on the annual rainfall for moisture. Near the springs and along the upper courses of these rivers the vegetation needs especially to be preserved for the sake of the canals.

"The economic considerations relating to the forests are manifestly important, as wood is used largely in the construction of the houses and cottages in most parts of the country. In northern India, where trees are few, the earth, indurated by the sun, affords good material, and the earthern walls are durable, but elsewhere the earth does not always possess a like degree of consistency. For these reasons it is essential that the timber markets should be well supplied. Without interposition by the State, the wood and timber would become scarcer and dearer from time to time, as the forests became exhausted. As coal is not available, the people require wood for fuel; if they cannot obtain wood they will use cow-dung cakes for burning. The practice of consuming for fuel that which ought to be used for manure in a country too, where artificial manure is not available, extensively prevails, is most injurious, and tends to exhaustion of the soil. The only means of lessening this practice is by preserving the forests to provide a cheap and plentiful supply of wood for fuel.

"Thus the policy of preserving the forests rests on two grounds, first the improvement of the climate and the retention of moisture; secondly the husbanding of the national resources in timber and fuel for the use of the people. This policy is of much consequence to the well-being of the country and the nation."

Mr. Marsh says that, concerning the influence of the forest, considered as inorganic matter on temperature :—"The evaporation of fluids and the condensation and expansion of vapours and gases are attended with changes of temperature ; and the quantity of moisture which the air is capable of containing ; and of course, other things being equal, the evaporation rises and falls with the thermometer. The hygroscopical and the thermoscopical conditions of the atmosphere are therefore inseparably connected as reciprocally dependent quantities, and neither can be fully discussed without taking notice of the other. The leaves of living trees exhale enormous quantities of gas and of aqueous vapour, and they largely absorb gases, and under certain conditions, probably also water. Hence they affect more or less powerfully the temperature as well as the humidity of the air. But the forest, regarded purely as inorganic matter, and without reference to its living processes of absorption and exhalation of gases and of water, has, as an absorbent, a radiator, and a conductor of heat, and as a mere covering of the ground, an influence on the temperature of the air and the earth, which may be considered by itself.

"*Balance of Conflicting Influences of Forest on Atmospheric Heat and Humidity.*

"We have shown that the forest, considered as dead matter, tends to diminish the moisture of the air, by preventing the sun's rays from reaching the ground and evaporating the water that falls upon the surface, and also by spreading over the earth a spongy mantle which sucks up and retains the humidity it receives from the atmosphere ; while, at the same time, this covering acts in the contrary direction by accumulating in a reservoir not wholly inaccessible to vaporizing influences, the water of precipitation which might otherwise suddenly sink deep into the bowels of the earth, or flow by superficial channels to other climatic regions. We now see that, as a living organism, it tends, on the one hand, to diminish the humidity of the air, by sometimes absorbing moisture from it, and, on the other, to increase that humidity by pouring out into the atmosphere, in a vaporous form, the water it draws up through its roots. This last operation, at the same time, lowers the temperature of the air in contact with or proximity to the wood, by the same law as in other cases of the conversion of water into vapour.

"As I have repeatedly said, we cannot measure the value of any one of these elements of climatic disturbance, raising or lowering of temperature, increase or diminution of humidity ; nor can we say that in any one season, any one year, or any one fixed cycle, however long or short, they balance and compensate each other. They are sometimes, but certainly not always contemporaneous in their action, whether their tendency is in the same or in opposite directions, and, therefore, their influence is sometimes cumulative, sometimes conflicting, but, upon the whole, their general effect is to mitigate extremes of atmospheric heat and cold, moisture and drought. They serve as equalizers of temperature and humidity, and it is highly probable that in analogy with most other works and workings of nature, they, at certain or uncertain periods restore the equilibrium, which, whether as lifeless masses or as living organisms they may have temporarily disturbed.

"When, therefore, man destroys these natural harmonizers of climatic discords, he sacrifices an important conservative power, though it is far from certain that he has thereby affected the mean, however much he may have exaggerated the extremes of atmospheric temperature and humidity, or, in other words, may have increased the range and lengthened the scale of thermometric and hygrometric variations.

"*Special Influence of Woods on Precipitation.*

"With the question of the action of forests upon temperature and upon atmospheric humidity is intimately connected that of their influence upon precipitation, which they may affect by increasing or diminishing the warmth of the air and by absorbing or exhaling uncombined gas and aqueous vapour. The forest being a natural arrangement, the presumption is that it exercises a conservative action, or at least a compensating one, and consequently that its destruction must tend to produce pluviometrical disturbances as well as thermometrical variations. And this is the opinion of perhaps the greatest number of observers. Indeed, it is almost impossible to suppose that, under certain conditions of time and place, the quantity and the periods of rain should not depend, more or less, upon the presence or absence of forests ; and without insisting that the removal of forests has

diminished the sum-total of snow and rain, we may well admit that it has lessened the quantity which annually falls within particular limits. Various theoretical considerations make this probable, the most obvious argument, perhaps, being that drawn from the generally admitted fact, that the summer and even mean temperature of the forest is below that of the open country in the same latitude. If the air in a wood is cooler than that around it, it must reduce the temperature of the atmospheric stratum immediately above it, and, of course, whenever a saturated current sweeps over it, it must produce precipitation which would fall upon it, or at a greater or less distance from it.

"We must here take into the account a very important consideration. It is not universally or even generally true that the atmosphere returns its condensed humidity to the local source from which it receives it. The air is constantly in motion—

> —— howling tempests scour amain
> From sea to land, from land to sea;

and, therefore, it is always probable that the evaporation drawn up by the atmosphere from a given river, or sea, or forest, or meadow, will be discharged by precipitation, not at or near the point where it rose, but at a distance of miles, leagues, or even degrees. The currents of the upper air are invisible, and they leave behind them no landmark to record their track. We know not whence they come, or whither they go. We have a certain rapidly increasing acquaintance with the laws of general atmospheric motion, but of the origin and limits, the beginning and end of that motion, as it manifests itself at any particular time and place, we know nothing. We cannot say where or when the vapour, exhaled to-day from the lake on which we float, will be condensed and fall; whether it will waste itself on a barren desert, refresh upland pastures, descend in snow on Alpine heights, or contribute to swell a distant torrent, which shall lay waste square miles of fertile corn-land; nor do we know whether the rain which feeds our brooklets is due to the transpiration from a neighbouring forest or to the evaporation from a far-off sea. If, therefore, it were proved that the annual quantity of rain and dew is now as great on the plains of Castile, for example, as it was when they were covered with the native forest, it would by no means follow that those woods did not augment the amount of precipitation elsewhere.

"The whole problem of the pluviometrical influence of the forest, general or local, is so exceedingly complex and difficult that it cannot with our present means of knowledge be decided upon *à priori* grounds. It must now be regarded as a question of fact which would probably admit of scientific explanation if it were once established what the actual fact is. Unfortunately the evidence is conflicting in tendency, and sometimes equivocal in interpretation, but I believe that a majority of the foresters and physicists who have studied the question are of opinion that in many, if not in all cases, the destruction of the woods has been followed by a diminution in the annual quantity of rain and dew. Indeed, it has long been a popularly settled belief that vegetation and the condensation and fall of atmospheric moisture are reciprocally necessary to each other, and even the poets sing of

> * * * Afric's barren sand,
> Where nought can grow, because it raineth not,
> And where no rain can fall to bless the land,
> Because nought grows there."

Dr. Schacht, Professor at the University of Bonn, says in his well-known work, "Les Arbres":—

"The snow and ice which accumulate during the winter on the mountains, melt rapidly under the spring sunshine—thus swelling the torrents whose mass of water makes its way into the valleys with resistless force. But when the mountain sides are covered by forests, or where the arable plains are bordered by woods, the scene changes its aspect. The greater part of the snow is deposited on the trees or falls between them, and the water which results is absorbed by the soil formed by the accumulation of vegetable matter; but wherever the forests have disappeared, the spring inundations of the rivers have

acquired a frequency unknown before. It cannot be disputed that the terrible destructive effects of the inundations of the Loire and the Vistula of late years must be in great part attributed to the excessive denudation of the forests.

"A mountain cliff, a wall, or a forest are the natural protections against the wind. In this respect the forest cannot be without beneficial effect on the adjacent country; the young growth of trees flourishes, screened from the force of the wind, the arable land develops itself better, the shifting sands meet an impassible barrier, and the noxious influence of the dry winds is turned aside.

"It is, then, indisputable that the forests exercise a salutary influence on the temperature of a country. The sanitary condition of man and of domestic animals, as well as the growth of cultivated plants, immediately depends on the climate of the locality. Epidemics, unknown before, may perhaps be attributed to a climatic change brought about by the destruction of forests.

"The fertility of a country depends on its supply of forest land, for on this depend the foundation of soil, the precipitation of dew, and fall of rain, the steady current of rivers, the mitigation of the evil influences of unhealthy winds, and the growth of vegetation in the fields and meadows. The great fertility of certain tropical regions, as we have shown with respect to Madeira and the Canaries, is in great part due to the extension of forest land.

"Cultivated plains and forests are by no means so opposed to each other as that they cannot exist together. The kind of land where one flourishes is by no means always suitable to the other. For example, at a certain altitude of mountains of a rocky nature, cultivation cannot well be carried on, while yet the ground is well suited to forests. Much elevated ground, now covered with crops which scarcely pay for the labour expended in producing them, was formerly wooded. The bed of soil produced by the shade and *debris* of forests has disappeared with them; each new fall of rain has carried away some of its soluble constituents, in each a new loss to the soil which, thus impoverished, becomes at last sterile.

"We are far from asserting that we can do without arable lands any more than forests, it is clearly right to cut down woods when in need of land for culture. But the destruction of forests ought never to exceed its necessary limits, never should some temporary need decide on the fall of a forest, nor should this ever be allowed when wheat is incapable of growing; and wherever a forest is felled, we should always replace it with a new plantation of trees. The prairies, fields of wheat and of other grain, like all vegetables, do exercise an influence both on the soil and in the atmosphere. Nay, more, these would yet further improve the soil, if the harvest and the rotation of crops did not each year remove their supply of organic and mineral nutriment. With these the fields ought to be manured, as the forests are each year, by the fallen leaves. The action of arable fields and meadows on the atmosphere is the same as that of forests, but within much weaker limits, and with a gentler surface of exhalation and absorption. Fields and arable lands cannot supply the place of forests, they cannot retain in as complete a manner the moisture in the soil, or impress in the atmosphere so active a circulation. The proportion between arable lands and forests ought to be based on the special conditions of the soil and climate of a country. This question is one of the most difficult, as it is one of the most interesting problems of political economy, and on its solution depends, to no slight degree, the development and well-being of nations.

"Since Julius Cæsar and the other Roman historians, Germany has been covered by vast forests. It was the same in Spain according to Diodorous Siculus, in Greece according to Herodotus and Thucydides. Under the Roman Empire the forests were banished to the mountains, and were in fact reduced to the condition of plantations. Green oaks and cork trees abounded as did pine along the Guadalquiver.

"*How to reconstruct the forests:*—By culture and care, by well-chosen replanting, by the plantation of new woods. One should never cut down woods excepting when there is need of lumber, or when beneficial to the forests themselves. Trees which have not yet attained the full growth of their development should never be cut down but from absolute necessity. The plantations of old trees should be sacrificed; their development is at an end, and the soil will profit more by a new plantation. When woods are cut

down the ground should never be left unoccupied. There is no difficulty in establishing a new forest on ground of good quality and well protected; but this is hard, if not impossible on soil impoverished or exposed to the heat of the sun or violence of wind. Yet it is the plantation of such land as this which is generally undertaken by Governments. The difficulty is three-fold:—1. Absence of soil. 2. Want of shade in summer. 2. Cold winds in autumn and winter. Against the first of these, our principal resource is to plant in sufficient quantity those plants which, like the sand grass, by the interlacement of their root-fibres, prevent the nutritive elements of the soil from being drained away by the rains. It is probable that the net of mesh-work formed by their roots will at last solidify the soil, which will also profit by the continuous deposit of clay. After these preliminary operations, one can begin to plant trees.

"The pine, birch, aspen, alder, are well able to bear the heat of the sun, and should be planted first, then the oak, witch-elm, etc., in their shade."

It will be valuable for our purpose to notice Mr. Marsh's statement respecting snow:—

"Whenever the humidity of the atmosphere in contact with snow is above the point of saturation at the temperature to which the air is cooled by such contact, the superfluous moisture is absorbed by the snow or condensed and frozen upon its surface, and of course adds so much to the winter supply of water received from the snow by the ground. This quantity, in all probability, much exceeds the loss by evaporation, for during the period when the ground is covered with snow, the proportion of clear dry weather favourable to evaporation, is less than that of humid days with an atmosphere in a condition to yield up its moisture to any bibulous substance cold enough to condense it.

"In our Northern States, irregular as is the climate, the first autumnal snows pretty constantly fall before the ground is frozen at all, or when the frosts extends at most to a depth of only a few inches. In the woods, especially those situated upon the elevated ridges which supply the natural irrigation of the soil and feed the perennial fountains and streams, the ground remains covered with snow during the winter; for the trees protect the snow from blowing from the general surface into the depressions, and new accessions are received before the covering deposited by the first fall is melted. Snow is of a colour unfavourable for radiation, but, even when it is of considerable thickness, it is not wholly impervious to the rays of the sun, and for this reason, as well as from the warmth of lower strata, the frozen crust of the soil, if one has been formed, is soon thawed, and does not again fall below the freezing-point during the winter.

"The snow in contact with the earth now begins to melt, with greater or less rapidity, according to the relative temperature of the earth and the air, while the water resulting from its dissolution is imbibed by the vegetable mould, and carried off by infiltration so fast that both the snow and the layers of leaves in contact with it often seem comparatively dry, when, in fact, the under surface of the former is in a state of perpetual thaw. No doubt a certain proportion of the snow is given off to the atmosphere by direct evaporation, but, in the woods, the protection against the sun by even leafless trees prevents much loss in this way, and besides, the snow receives much moisture from the air by absorption and condensation. Very little water runs off in the winter by superficial water-courses, except in rare cases of sudden thaw, and there can be no question that much the greater part of the snow deposited in the forest is slowly melted and absorbed by the earth.

"The immense importance of the forest, as a reservoir of this stock of moisture, becomes apparent, when we consider that a large proportion of the summer rain either flows into the valleys and the rivers, because it falls faster than the ground can imbibe it; or, if absorbed by the warm superficial strata, is evaporated from them without sinking deep enough to reach wells and springs, which, of course, depend much on winter rains and snows for their entire supply. This observation, though specially true of cleared and cultivated grounds, is not wholly inapplicable to the forest, especially when, as is too often the case in Europe, the underwood and decaying leaves are removed.

"The quantity of snow that falls in extensive forests, far from the open country, has

seldom been ascertained by direct observation, because there are few meteorological stations in or near the forest. According to Thompson, the proportion of water which falls in snow in the Northern States does not exceed one fifth of the total precipitation, but the moisture derived from it is doubtless considerably increased by the atmospheric vapour absorbed by it, or condensed and frozen on its surface. I think I can say from experience—and I am confirmed in this opinion by the testimony of competent observers whose attention has been directed specially to the point—that though much snow is intercepted by the trees, and the quantity on the ground in the woods is consequently less than in the open land in the first part of the winter, yet most of what reaches the ground at that season remains under the protection of the wood until melted, and as it occasionally receives new supplies, the depth of the snow in the forest in the latter half of the winter is considerably greater than in the cleared fields. Careful measurements in a snowy region in New England, in the month of February, gave a mean of thirty-eight inches in the open ground and forty-four inches in the woods.

"The general effect of the forest in cold climates is to assimilate the winter state of the ground to that of wooded regions under softer skies; and it is a circumstance well worth noting, that in Southern Europe, where nature has denied to the earth a warm winter garment of flocculent snow, she has, by one of those compensations in which her empire is so rich, clothed the hill-sides with umbrella and other pines, ilexes, cork-oaks, bays, and other trees of persistent foliage, whose evergreen leaves afford to the soil a protection analogous to that which it derives from snow in more northern climates.

"The water imbibed by the soil in winter sinks until it meets a more or less impermeable or saturated stratum, and then, by unseen conduits, slowly finds its way to the channels of springs, or oozes out of the ground in drops which unite in rills, and so all is conveyed to the larger streams, and by them finally to the sea. The water, in percolating through the vegetable and mineral layers, acquires their temperature, and is chemically affected by their action, but it carries very little matter in mechanical suspension.

"The process I have described is a slow one, and the supply of moisture derived from the snow, augmented by the rains of the following seasons, keeps the forest ground, where the surface is level or but moderately inclined, in a state of approximate saturation throughout almost the whole year.

"It may be proper to observe here that in Italy, and in many parts of Spain and France, the Alps, the Appenines, and the Pyrenees, not to speak of less important mountains, perform the functions which provident nature has in other regions assigned to the forest—that is, they act as reservoirs wherein is accumulated in winter a supply of moisture to nourish the parched plains during the droughts of summer. Hence, however enormous may be the evils which have accrued to the above-mentioned countries from the destruction of the woods, the absolute desolation which would otherwise have smitten them through the folly of man, has been partially prevented by those natural dispositions by means of which there are stored up in the glaciers, in the snow-fields, and in the basins of mountains and valleys, vast deposits of condensed moisture which are afterwards distributed in a liquid form during the season in which the atmosphere furnishes a slender supply of the beneficent fluid so indispensable to vegetable and animal life."

An elegant French writer upon forest economy, Jules Clavè, in a work entitled "Ètudes sur l'Economie Forestière," thus clearly describes the processes of nature by which forests maintain and equalize the flow of waters:—

"*Rains.*—The first phenomenon that offers for our inquiry, in the study of the regulation of the waters, is rain. It is this that gives rise to springs and rivers, and that in certain conditions of continuance occasions inundations.

"Rain is caused by the precipitation of the vapour held by the atmosphere, and this precipitation is commonly caused by cold and humid winds. When these winds come to us (in France) from the ocean or the Mediterranean, and pass over a place where the temperature is too low to hold these vapours in suspension, they condense and fall as rains.

"It has been claimed that the presence of forests, like mountains, have the effect of lowering the temperature, and by this means of increasing the abundance of rains as well as of diminishing their violence. It cannot be doubted that forests have the effect of sheltering the surface from solar heat, and of causing a cutaneous exhalation from the leaves, while they multiply, by the spreading of their branches, the amount of surface cooled by this evaporation, and thus have a cooling effect; but this, in fact, is far from being general, and especially in our climate it is often marked, and even neutralized, by local circumstances, such as the physical properties of the soil, the topographical situation of the place, the direction of prevailing winds, etc. If it is certain that the mean temperature of our country is higher than was in Gaul in the days of Cæsar, when it was covered with forests, we must nevertheless admit that while a forest protects the surface from cold winds it does not tend to raise the temperature, and that if cut away a refrigerator would not be thereby necessarily produced. Thus, for example, it has been proved that the department of *l'Ardèche*, which is now without a single considerable piece of woods, has shown during the last thirty years a perturbation of climate, of which late spring frosts, formerly unknown in the country, are among the saddest effects. A similar remark may be made in the plains of Alsace, since the denudation of several of the crests of the Vosges."

"*Tropical Forests.*—On the contrary, in countries within the tropics, where the nights are usually very serene, the radiating power of plants is sensibly increased, and the energy of other frigorific causes are developed in the same proportion, so that the presence of forests tends uniformly to reduce the temperature. This fact was proved by numerous observations given in M. Boussingault's work on the region included between the eleventh degree of north and fifth degree of south latitude, and it effectually explains the reason why America is not so hot as Africa within these latitudes.

"The action of forests upon rainfall, through the influence which they exert upon the temperature, is therefore very difficult to determine in our country; but it is distinctly marked in warmer climates, as proved by numberless examples. M. Boussingault reports that in the region comprised between the Bay of Cupica and the Gulf of Guayaquil—a district covered with immense forests—*the rains are almost continual*, and that the mean temperature of this humid country is scarcely above 79° F. M. Blanqui, in his travels in Bulgaria, mentions that at Malta the rains have become so seldom, since the trees have been cut away to make room for cotton, that at the time of his visit in October, 1841, not a drop of rain had fallen during three years. The fearful dryness which has desolated the Cape Verde Islands may be, in like manner, attributed to the cutting off of forests. On the island of St. Helena, where the wooded surface has considerably increased within the last few years, they observe that the amount of rain increases in the same proportion, and it is now double that which fell annually at the time of Napoleon's sojourn there. Lastly, in Egypt, the recent plantations have brought rains where they were almost unknown before.

"In the midst of this uncertainty in which our climate is left, by the study of meteorology—for the hygrometrical operations made at different points in France have yielded results too diverse to serve as the foundation of any theory—we will come to limit our study of the action of forests to the regulation of the water courses in the single point of view which their mechanical and physical laws present."

"*Rains, how disposed of in Forests.*—The rains which fall upon our continents are disposed of as follows:—A part runs from the surface into the streams that carry it back to the sea. Another part is evaporated soon after its fall and returns to the atmosphere, and another part is absorbed by the ground. The first and third of these exclusively go to feed the springs and rivers, while the second is wholly withdrawn from our calculation. This feeding of the water courses is more or less regular or constant, according as it finds a superficial or underground passage-way, and therefore depends not only on the physical properties and the topographical contours of the soil, but also upon the vegetation with which it is covered.

"Under ordinary circumstances, the superficial flow produces no effect except upon soil where the slope is considerable and quite impervious to the water, such as denuded

rock or compact clay. It contributes, only in a very irregular manner, to the feeding of rivers and streams, as it delivers considerable volumes at certain times, and becomes nothing as soon as the rain ceases. But, on the contrary, when the soil is permeable, it absorbs all the water that falls, and does not deliver it again at the surface until some days after the rain, if completely absorbed. It is then that the action of forests begins to be felt. But if, in fact, the soil is uncovered, the liquid volume descends with a velocity proportionate to the slope, and brings with it the materials of every kind that obstruct its course, at the same time increasing its volume and destructive power. If these form torrents of limited ravage when the rainfall is local, they become fearful inundations when it is more general in extent. But, on the contrary, if the soil is covered with woods the flow is more gentle. Being arrested at every point, broken by the trees, their branches, and the mosses which it encounters on the way, the water arrives at the bottom of the valley much slower, without erosions, and without bringing with it any foreign substances. The forest, therefore, in hindering the delivery of the water, lessens the chances of engorgement."

"*Evaporation.*—We know that evaporation is going on at all temperatures, with greater or less rapidity, whenever the surrounding air is not already saturated with moisture. All other things being equal, it is greater when the ground is cleared than when covered with forests, because the latter arrest the action of the winds and prevent the masses of air, when saturated, from being renewed, and keeps the temperature lower by shielding the surface from the sun's heat. In lessening the amount of water evaporated, it by so much increases the quantity that is absorbed. It is, moreover, needless to insist upon a fact which everybody knows—for no one can be ignorant of the fact—that the soil in a forest after a rain remains wet much longer than where the surface has been cleared.

"Evaporation can only take place when, at a given temperature, the air is not saturated with moisture. But the rains themselves prove that there is an excess of saturation in the air at the time, and therefore there can be no evaporation when it rains. They can, therefore, have no very serious influence upon inundations properly so-called, and in this regard cleared lands present no advantage over others."

"*Absorption.*—A part of the water which falls is absorbed by the soil. Some of this is used by the vegetation, and serves to carry into the tissues of plants their soluble mineral elements, and is then returned in a certain degree to the atmosphere by the exhalations of the leaves. Another portion filters slowly into the soil till it meets an impervious stratum, and then flows along this bed, following its undulations, till it appears at the surface in the form of springs, unless it is drawn down into the depths of the earth's crust. It is this part alone, which is absorbed by the earth, that feeds the springs and furnishes the aliment of rivers. Every cause which tends to increase, to its detriment, the evaporation or pure loss of water, or to augment the superficial flow, has to this extent an influence upon the regulation of the water flow, and in this regard forests exercise a most important influence. All soils are not equally permeable. Some, as in the oölitic formation, absorb nearly all the rain that falls upon their surface. Others, like the primary rocks and liasic soils, allow rain to penetrate only so far as they are covered with vegetable mould. It is implied, therefore, that these vegetable beds should be preserved at the highest points, since they tend to increase the subterranean contingent of a part of the water, which, without its presence, would flow off upon its surface. But forests serve marvellously the functions of fixing the soil upon the steepest slopes. There will be no need of conviction upon this point to one who shall pass over the Alps or Pyrenees, where every peasant knows that to consolidate the banks of the brooks that cross his fields, and to prevent the gullying of the slopes of the roads, he has only to plant a few trees. Who does not, moreover, know the cohesive power of grass turf in fostering the roots of plants? The forests are turf upon a large scale, in which the blades of herbage are replaced by trees, of which the roots strike two or three yards into the soil. They can, therefore, oppose an invincible resistance to this washing away of the soil. According to M. Brougniart, the roots of trees contribute to augment the permeability of certain soils by offering a kind of vertical drainage."

"*Clay Soils.*—Nor is this all. When the soil is carried away, it confines a certain proportion of clay, which, when moistened to a depth which, according to M. Becquerel, does not exceed six times the depth of the sheet of falling water, it forms a natural cup, its pores being obstructed mechanically by the rains which harden them. It is then impermeable, and free to deliver, by superficial flow, all the liquid that has not been absorbed. But when, on the contrary, the surface is covered with forests, the dome of foliage breaks the force of the rains, which only reach the soil in a state of minute division, and this impervious condition cannot then take place to hinder effective absorption. Finally, by the humus which they produce, forests increase the absorbent qualities of different soils, and consequently the amount of liquids with which they may be charged. This absorbent quality is about twenty-five per cent. in weight in sandy soils, and varies from fifty to ninety per cent. for argillaceous soils, and in humus it rises to one hundred and ninety per cent.

"We must admit," says M. Hun, "that the sheet of water produced by the heaviest rains scarcely exceeds 3.9 inches in depth. But the bed of soil in a well-stocked forest comprises a layer of humus over a great part of the surface of more than double this depth. In speaking of forests I do not refer to the thin and ruined woods to which this name has been improperly applied; but to the timber lands like the forests belonging to the state, and to all the communal forests in the eastern departments, where the soil has a capacity for absorption greater than the volume of water yielded by the heaviest showers. From this we may explain the fact that after a deluging rain, the water-courses issuing from a well-stocked forest, show only a moderate increase in their volume, and that they keep this up for quite a time, their transparency being scarcely affected."

"*General Conclusions:*—Thus, to resume our subject, forests hinder the superficial flow, or delay its progress; they hinder evaporation, and in a rain of given amount they tend to increase the portion that is absorbed by the soil, and to diminish the surplus flow, which is lost without profit.

"The data of the problem being stated, it is easy to adduce the conclusions. If we assume that the mean annual number of rainy days is 120 and of dry days 244, it follows that, in order that the rivers shall always keep at a constant level, the time required for the flow of their waters should be nearly three times greater than that in which they fell as rain. It would be necessary, therefore, that they should be stored in a reservoir of which the outlet should only be one-third as great as the inlet, thus allowing the waters to escape in a time three times as long as that in which they are received. If the flow takes place more rapidly, the reservoir will be dry for a season, after having flowed in excessive abundance, which might cause either a local or a general inundation. If, on the contrary, the flow is not so fast, it will not discharge in a proper time all the liquid mass, and there will be an engorgement producing marshes, and finally inundations. Thus, an undue excess of rapidity or of slowness in the discharge of rainwater will cause, as we shall hereafter see, either from an absence from an extreme abundance of forests, the same results.

"*Forests retard the flow of waters:*—Forests, by favouring absorption, allow only the minimum of waters to be liberated. Moreover, in prolonging the discharge of the liquid absorbed, they extend the time required for its flowing off, and serve like a reservoir, of which the springs are the outlets, and thus insure the regular feeding of the water-courses. Denuded soil, on the contrary, allows a part of this water to escape both by evaporation and by superficial flow, retaining only imperfectly what it absorbs, and allows the sun's rays to pump up the moisture from the lower beds. For these reasons the springs become dry in summer and the rivers engorged in winter.

"*Examples near at home:*—But why should we seek so far away for the proofs of phenomena that are renewed daily under our eyes, and of which any Parisian may convince himself without venturing beyond the Bois de Boulogne or the forest of Meudon? Let him walk out, after some days of rain, along the Chevrence road, bordered on the right by the forest of Meudon, and on the left by cultivated fields. The amount of rain

that has fallen is the same on both sides, and yet the ditches by the roadside along the edge of the forest will be still filled with water, proving the infiltration going on from the wooded soil, while, already for some time, those on the other side, adjoining the cleared fields, will have been dry, after having served their purpose by a sudden flow. The ditch on the left will have emptied itself in a few hours of all the water, which the one on the right will take some days to convey to the bottom of the valley.

"*Direct effect of Forests Illustrated*:—To those examples we may add another which appears to us to be characteristic. It is due to the observations of Mr. Cantegril, sub-inspector of forests, and was communicated by him to the *Ami des Sciences*.

"Upon the territory of the commune of Labrugniére there is a forest of 1,834 hectares, (4,524 acres), known as the forest of Montant, and owned by the commune. It extends northward on the Montagne-Noire, and the soil is granitic with a maximum altitude of 1,243 meters, and a slope of from fifteen to sixty in one hundred. A little water-course, the Caunan brook, rises in this forest and drains the waters of two-thirds of its surface. At the entrance of the forest, and along this brook, will be found several fulling mills, each requiring eight horse-power, and moved by water-wheels which work the beaters of the machines.

"The commune of Labrugniére had long been noted for its opposition to the forest regulations, and the cutting of wood, together with the abuse of pasturage, had converted the forest into an immense waste, so that this great property would hardly pay the cost of guarding it, and afford a meagre supply of wood for its inhabitants.

"While the forest was thus ruined and the soil denuded, the waters after each heavy rain swept down through the valley, bringing with them great quantities of gravel, the *débris* of which still encumbers the channel of this stream. The violence of these floods was sometimes so great that they were compelled to stop the machines for some time. But in the summer time another inconvenience made its appearance. Little by little the drought extended, the flow of waters became insignificant, the mills stood idle, or could be run only occasionally for a short time.

"About 1840, the municipal authorities began to inform their population relative to their true interests, and under the protection of a better supervision, the work of re-planting has been well managed, and the forest is to-day in successful growth.

"In proportion as the replanting progressed, the precarious use of the mills ceased, and the regulation of the water-courses was totally modified. They now no longer swelled into sudden and violent floods, compelling the machines to stop; but the rise did not begin until six or eight hours after the rains began. They rose steadily to their maximum, and then subsided in the same manner. In short, they were no longer obliged to stop work, and the waters were always enough to run two machines, and sometimes three.

"This example is remarkable in this, that all the other circumstances had remained the same, and therefore we could only attribute to the reforesting the changes that occurred, namely, diminution of the flood at the time of rain, and an increase in its flow during common times.

"We may readily from the preceding account for the part which forests act in heavy and long-continued rains as to the floods then produced. Before reaching the soil and being completely absorbed, the rain must pass through the dome of verdure formed by the leaves, which they wet, thus causing the first appropriation of the waters. Then we must add the results of great permeability of wooded soil, and the great absorption of which the humus of forests is capable, so that until these demands are supplied no water can run from the surface.

"The flow will be slower and with less destructive force than in cleared fields, on account of the obstacles of every kind which the liquid mass meets in its course, so that it will not reach the bottom of the valley until after the rain which fell in the lower parts shall have been discharged."

"*Review of M. Vallès' Book*:—In a very remarkable work entitled, "*Étude sur les inondations, leurs causes et leurs effects*," published in 1857, M. Vallè an engineer of *ponts et chaussées* contradicts the efficacy of reforesting as a means of preventing inundations.

In giving an account of this work in the *Annuales forestiéres*, M. A. F. d' Héricourt combats these assertions in a victorious manner, and proves conclusively that the reforesting of a portion of the upper basin of the Loire would have prevented the inundation of 1846.

"Accepting," says he, "the data of M. Vallés, who has analyzed with much care the various phenomena which characterized the flood of October, 1846, in the upper basin of the Loire, I will admit with him, that if we could have held back 175,000,000 cubic meters of water, the inundation which proved so sad a calamity to France would not have presented so painful an event. The upper basin of the Loire, as far as Roanne, comprises an area of 640,000 hectares, (158,080,000 acres) of which at least a third say 213,000 hectares (52,693,000 acres) might be profitably reforested. This inundation was caused by a rain which lasted sixty hours, and poured upon the soil a sheet of water 153 millimeters (about six inches) in depth. This portion of the basin of the Loire, therefore, received 979,200,000 cubic meters of water. On the hypothesis of M. Vallés, 244,800,000 cubic meters were absorbed. There accordingly remained for superficial flow 734,400,000 cubic meters.

"But, let us suppose that in 1846, the 213,000 hectaries above mentioned to have been covered with massive woods, and then let us calculate what would have happened. These 213,000 meters would have received as their share 290,000 cubic meters. The absorbent qualities of the soil are increased forty per cent. by reforesting, and this operation would have withdrawn 130,116,000 cubic meters from the superficial flow, which would have reduced the amount upon the retimbered portions to 195,174,000 cubic meters. But this liquid mass would have been hindered in its course down the valley, as we have above explained, by the passive resistances of every kind which the forest presents, and a half, at least, would not have arrived until the other half, which had fallen in other parts of the basin had passed off. We may, therefore, conclude that the superficial flow would not have exceeded 500,000 cubic meters, and that the calamities occasioned by the inundation of 1846 would have been completely prevented by reforesting."

"*Snows Retard the Flow of Waters*:—This hindrance in the flow is very apparent at a time when the snow is on the ground. When a part of a valley is wooded, the snows that fall there lie much longer than in other parts, and while diluvial rains, which ordinarily cause inundations, would be quickly followed by a rise of waters in the cleared region, and suddenly augment the liquid mass in that portion, the same rains would affect but slowly the snows that lie in the wooded portions. The swell would come by slow degrees, and the flood would give no special cause of alarm.

"*Mountain Torrents*:—But it is especially upon mountains formed of slaty or marly rock that the utility of forests is shown in a remarkable degree. When the slopes of these lands, which have but slight powers of resistance, are denuded, the rains wear them into ravines with the greatest facility, forming partial excavations which extend from below upward, and end by forming a vast ravine, into which the lateral rills enter and which are themselves ramified in every direction. At every shower the waters plunge from every part of the mountain into the channels they have worn, producing a torrent that brings down with it masses of rock and scatters them over the plains. When the slopes are wooded, nothing of this kind can happen, for the trees protect the soil from the shock of the flood and by retaining it with their roots they guard it against erosions. They, moreover, break up the waters and hinder them from flowing too rapidly toward the valley, and thus, by this double effect, they oppose an invincible obstacle to the formation of these devastating torrents. The most effectual obstacle that can be opposed to these inundations is, therefore, reforesting, and of all preventive measures this is the cheapest, besides offering, above all others, the inestimable advantage of maintaining and of multiplying itself. We need not think that these effects will require a long time to be felt, for it is not necessary to wait until the woods have come to their full size, and in four or five years their effects will begin to be observed. Every replanting on these slopes

or plateaux is, in some degree, a conquest over the dominion of the floods, and a reduction of the ravages that they may commit.

"*Forests in Excess:*—But, carried to too great an extent, this operation will work precisely against the end which we desire to obtain. If the forests cover too great an extent of country, we may fear that the springs or subterranean water-courses may not be able to deliver all the rain that falls in a given time before other rains fall, which will cover the country with stagnant water. This was the condition of Gaul at the time when it was covered with forests, and such is still the condition of certain parts of America, which are wooded in this excessive degree. By this means we explain the apparent contradictions of which the partisans of reforesting are accused.

"*Reforesting where Needed:*—It will be necessary, before coming to the desirable conclusion as to where the true proportion lies, and which cannot now be known with precision, that we should be able to show for each river-basin how much of a reservoir a forest should furnish that shall discharge, freely and with regularity, the rains that it receives only at intervals. However the case may be, it is evident that the reforesting should be carried on upon the mountainous parts of the different basins. It is there, practically, that the humid winds condense the vapours that they contain, on account of the lower temperature which there prevails, and from thence comes the superficial flow of waters, the absorption of which we wish to increase, and make to appear in the springs, whose number and volume we would regulate. It is from thence, in short, the torrents begin, which become the forerunners of the inundations, which it is our wish, if possible, to control.

"*Certain Changes Beyond our Control:*—It may be asked as to whether, these investigations being ended, 'shall we always be able to guard against these inundations?' Probably not; for it is not in the power of man to prevent atmospheric perturbation, and we have never yet found the remedies against the return at times of the warm and humid currents of air from the Atlantic, to which the diluvial rains are due which cause these damages. But at least, if we do not by reforesting entirely allay these evils, we may, peradventure, considerably reduce their magnitude, and enhance the efficacy of other means of defence which have until now been held as quite illusory.

"*Dikes and other Structures:*—At the present time most of the works constructed for the preventing of these evils, in fact, only increase them. It is held by a great number of engineers, that transverse dikes, in order to be of service, should be built in the lower parts of the valleys and near the mouths of affluents; but the first result of this would be to cause inundations in these parts which are usually fertile and well-cultivated, and where, if they had not been built, they might not have been felt. We might have to pay damages for the property injured, and the sums, although considerable, would not always be compensated for by the advantages claimed. This system, moreover, amounts only to transferring the evil to another place, without escaping it, and it is at best but a secondary, not a radical, remedy. As for longitudinal dikes, not only are they frequently unable to withstand, in time of flood, the power of the waters, but they tend to erode the river bed, and to create obstacles which stop the materials carried down. Rivers, therefore, become for the country which they traverse a permanent source of danger, for, by a moderate flood the plains are often overflowed. Reforesting quite removes this peril, and by hindering the erosion of torrents they check the wearing out of the channels of the rivers and the obstructions at their mouths from accumulations of sand and gravel. They also tend to favour the construction of longitudinal dikes, at points where their utility is recognized.

"*Denuding Power of Rains:*—In the torrid zone the degradation of land is generally very rapid, but the waste is by no means proportioned to the superior quantity of rain, or the suddenness of its fall, the transporting power of water being counteracted by a greater luxuriance of vegetation. A geologist, who is no stranger to tropical countries, observes

that the softer rocks would speedily be washed away in such regions if the numerous roots of plants were not matted together in such a manner as to produce considerable resistance to the destructive power of the rains. The parasitical or creeping plants also entwine in every possible direction, so as to render the forests nearly impervious, and the trees possess forms and leaves best calculated to shoot off the heavy rains, which, when they have thus been broken in their fall, are quickly absorbed by the ground beneath, or when thrown into the drainage-depressions give rise to furious torrents."

An eminent English writer says :—

"When plantations and strips of wood of considerable extent are so arranged as to obstruct the wind in its course, shelter is afforded both to cultivated and pasture land, and in appearance as well as in productiveness the character of the estate undergoes a thorough change.

"It cannot be doubted by any one acquainted with the losses which are frequently sustained on high-lying farms from nipping frosts and withering winds, that in cold, late districts, shelter is of the greatest value to the farmer. Various kinds of crops are liable at the time of flowering to be seriously injured if exposed to strong winds, and frequently cereal crops, which are just beginning to ripen, suddenly assume a premature whiteness after being loosened about the roots by severe wind storms ; the crop is imperfectly developed and the farmer is the loser. Shelter will, to a very large extent, prevent this evil. Then, at harvest, it has been found that a line of plantations running transverse to the wind, though at a distance of half-a-mile, has materially diminished the loss from shedding. Along the eastern coast of Great Britain, a proper increase of shelter would not fail to add several bushels of grain to the yield per acre ; and in Caithness and Orkney, where, simply from the want of shelter at first, ordinary timber trees rarely ever become more than stinted bushes, the increase would be a great deal more.

"The only way in which either forest or hedge plants can be started into growth in these northern countries is to afford them at once the shelter of a stone wall or earth embankment, and often when their tops appear above the upper surface of the protecting dike, they are cut over by the winds as by a knife. This shows in its extreme aspect the importance of that shelter which, in all exposed situations, must in a greater or less degree promote the development of crops.

"The value of shelter for pasture stock is no less deserving of careful consideration. It is well known to veterinary practitioners that cattle grazing in high and exposed situations are generally more predisposed to consumptive and cutaneous diseases than animals pastured on low and sheltered farms. In cold, backward springs, the shelter conferred even by a very small plantation is to the sheep-farmer in the highland districts of the greatest practical service. On grazings much exposed to withering winds the large number of lambs deserted by their mothers in late seasons, in consequence of a scarcity of milk, is sometimes a severe loss to the flock-master. But it is well known that on the hill farms partially sheltered by growing timber, the percentage of deaths from this cause is considerably reduced. The pasturage, when sheltered even in a very partial manner, is both earlier and more nutritive than if exposed to the full effects of unchecked winds, and in their haunts, flocks rarely fail to indicate the situations which are really benefited by plantations, either near at hand or at a considerable distance. It is a well-known principle of animal nutrition that the radiation of heat from the system is greater in a cold than in a warm temperature, and that more food is necessary in the former situation than in the latter to maintain vital heat. If it is practicable, therefore, in the formation of plantations to elevate the mean temperature of any particular district two or three degrees, it follows that its grazing will not only be improved, but that, in proportion consumed, fattening animals will make greater progress than under less favourable circumstances.

"It appears conclusive, therefore, that the relation that exists between forestry and agriculture is a very intimate one ; and yet while great exertions are being made to develop the agricultural resources of the country, the inactivity which has long prevailed in respect to the management of timber continues the same, and presents, in some respects, an aspect hopeless enough."

"*Enhanced Value of Farms from Tree-planting*:—In almost every instance in which a farm is to be let on lease the offerers are influenced, in a greater degree than they themselves are aware of, by the first general appearance which it presents. If the exposed parts are partially under thriving, well-enclosed wood, the whole fields, within the range of vision, have such a look of warmth and fertility that, as if by intuition, a few shillings more per acre are put upon the land than would otherwise have been given. The amenity and value of landed property are so linked together, that in ordinary cases the one cannot be increased without a greater or less addition being made to the other also. It has been proved by experience that in proportion as well-laid-out plantations are extended on an estate, up to but not beyond a certain point, the yearly value of its farms advance. I know property, which, eighty years ago, did not yield more than half the rental derived from it now. It was then, according to the testimony of old men in the district, little more than an open waste; but the proprietor began about then to plant extensively, and as the plantations increased in number and age, the rental of the estate advanced with them, though the farm was anything but good. With right management the same result may be expected on every exposed property."

The following article upon the forests of Europe and America is from J. G. Lefebvre (du Hâvre) who has long been intimately acquainted with the practical details of the timber trade in France:—

"One of the most important questions that presents itself to the attention of the principal producing and consuming countries in the article of wood, is beyond doubt that which relates to forests.

"It is an unfortunate fact, and becoming more and more true, that the clearing of woodlands is encouraged, and we may say, stimulated by the formidable and continually-increasing general consumption, which leads to proportions vastly exceeding the normal annual production, as we shall presently show. There evidently results a most threatening danger, which has already been often pointed out with energy, and against which the general welfare requires us to adopt on every side the most effectual and decisive measures, which should be executed with activity and perseverance, if we would seasonably avoid the consequence of a lamentable crisis.

"Taking a general review of the immense areas of ground, which various statistical works admit to be still covered with forests, it might at first sight appear that our fears were taxed by groundless apprehensions of exaggerated evils; but we feel assured that, considering the innumerable quantities of trees cut every year, the number prematurely destroyed, and the number wasted, it must be admitted that we should lose no time in trying to remedy, as speedily as possible, a condition of affairs so much to be deplored.

"We ought not to forget that in addition to the economical value of the forests, taken as a part of the wealth of the country, and in the welfare of its inhabitants, their protection in a climatic relation becomes a necessity of the first importance. No one is so ignorant as not to know that the inconsiderate destruction of trees reduces the water-courses, and causes disastrous inundations. We believe that the multiplied benefits derived from the presence of forests are not enough appreciated, such as the sanitary improvement of marshy places, the moderation of the temperature, the protection of open plains against violent winds which have their force broken and their currents divided by the trees; and, finally, the prevention of prolonged droughts, which too often desolate regions of country where the wood has been taken off, as has been frequently proved by examples down to the present time.

"We should also not fail to remark that we often find tracts of land masked by a thick covering of verdure, that are in reality nothing but immense wastes occasioned by fires or storms, and which contain little but the wrecks and remnants of trees, and are sometimes overrun with wood insects, some species of which in a little while may destroy whole forests, as was lately seen in Bohemia, where a million of cubic toises of wood were entirely destroyed.

"If we now approach the question of production and consumption in the principal countries of Europe that are now occupying our attention, we shall find conditions of a

nature to convince the most incredulous as to the duty of the state foresters to seek without further delay for such remedies as the situation demands, so great is the actual peril."

A most valuable paper bearing on this point was read at the Cincinnati Congress, by the Hon. V. Colvin, Superintendent N. Y. S. Adirondack Survey. I wrote to Washington for this paper, but it was not in print. I can therefore only give my readers the abstract given by the Forestry Congress Commissioners sent from Ontario :—

"The influence of forests upon the water supply of any given drainage area is directly proportional to the rainfall, and it is from the standpoint of evaporation and rainfall that the effect of forests must be considered.

"The data for the investigation must be searched for in the east, where the destruction of forests has been great. Here, rather than on the frontiers of civilization, we should look for traces of climatic change, if the destruction of forests lead to any change.

"The records of the United States Signal Service of the mean monthly precipitation in this country for many years had been searched by the lecturer for statistical information on this subject, and he had based upon these records a series of computations which showed where the greatest irregularities in the monthly rainfall occurred.

"These differences were presented in tabular form, and showed a favourable uniform monthly precipitation of rain in the middle Eastern States. Here it is known that the approximate limit of safety of forest-cutting has been reached, as torrential action began to show itself in sections where much timber had been cut away.

"The topography of the country was shown to have a most important bearing upon the quantity effect of forests upon the rainfall ; the mountain ranges, when forest-covered and extending across the path of the south winds, acting as powerful condensers of moisture. The way in which limbs of trees entangle and kill the wind, to which a house or block of houses forms hardly any obstacle, was explained in an interesting manner, and was shown to be dependent on the angle of incidence.

"The true relationship of atmospheric electricity to rainfall was traced through the reactions of the correlated force, so often incorrectly termed "latent heat." The limbs, boughs and leaves of the forest were (when considered mechanically) natural machinery most wonderfully adapted to the purpose of grasping upon the atmosphere, and thus causing those dynamic changes which induce precipitation of moisture.

"The forests were, in fact, most singularly complicated condensers, and performed their peculiar office in the atmosphere far better than the most skilfully contrived alembic of the chemist.

"Forests were shown to be essential to a uniform rainfall when existing in the proper localities, as determined by the great local meteorological laws.

"A knowledge of the path of storms in any locality, and of the topography—the elevations and depressions, the rivers, marshes and lakes—was shown to be essential to any exact estimate of the limit of safety of the cutting of forests. The only way in which the wide-spread knowledge necessary could be obtained would be by a general system of observation by farmers and others throughout the whole country, of the great facts of the local rainfall, direction of winds, etc., which could be easily done with little trouble.

"With these observations, and an accurate system of topographical and forest maps (which every State should have made), it would be possible to make close estimates as to where forests must be preserved, where replanted and where they might be safely cut. The lecturer told of his personal experiences on the mountain peaks of the Adirondacks and the Rocky Mountains, traced the origin of rain from its evaporation by the sun's rays from the sea to its condensation to cloud—and showed how Buy Ballot's law readily enabled meteorologists knowing the path of storms, from a mere knowledge of the present direction of the wind and the area of the last high or low pressure, to determine the probable maximum or minimum liable to follow, and probable change in the direction of the winds ; but that the location of forests greatly modified the exact application of

this law, and rendered imperative that we should study the path of storms on exact topographical maps giving the location of forests, and that then only should we be able to make exact predictions."

THE FORESTS AND THEIR MANAGEMENT IN OTHER COUNTRIES.

To obtain knowledge on this head, no better source of instruction is available than the extensive report made on the subject by Captain Walker, a gentleman who passed nine months on the continent, by direction of the European Government, for that purpose. I cannot copy his voluminous report, but will give a short review of what refers to each country visited, and anything likely to be useful for our purposes here in Canada. The Captain first visits Hanover, describing the system in which territory to some extent describes all, for he tells us that the system there may be considered as typical. He gives then, the administration there, and a brief statistical record of the others, except in those points where they decidedly differ. Now, as to Hanover.

Hanover.

Its forests under State management amount to 900,000 acres. Some are Government, some Church, some belong to municipalities or communes. Government manages the forests by officers appointed, while the community pay four cents per acre towards the pay of the officers. The method appears to be that of giving the owners as much wood, pasture, or litter for manure, as their original right to the forest entitled them to; but to give it at the hands of government officials. If the forest is of sufficient extent to employ a special officer, the commune, instead of the four cents, are charged his pay and allowances, as well as other working charges.

The government forests are about 600,000 acres of the above, and the cost of working and all expenses is about $650,000 annually, the receipts being $1,500,000, and the profit therefore $850,000, or, taking the actual figures, about $1.50 per acre per annum. This, of course, takes no account of the value of the land, or what it might rent or sell for if cleared.

Hanover is a province of Prussia. The head office is therefore in Berlin. The Forest establishment of Hanover consist of one forest director and over-forest master, who is also a councillor; twenty forest masters in charge of circles or divisions, forming also a board of management in all forest matters; one hundred and twelve over-foresters in charge of forest districts *(revier)* averaging seven or eight thousand acres each; four hundred and three foresters who assist the over-foresters, and have charge of portions of a district; three hundred and forty-three overseers, under-foresters, etc., employed in watching and protecting the forest, and supervising the work which is executed by hired weekly or daily labour, or on contract under supervision of the fixed establishments. A cash-keeper is attached to each over-forester, who receives and disburses all moneys out of the forest cash chest, with which the over-forester has nothing to do, although his accounts should, of course, tally with those of the cash-keeper. For payment of labourers, etc., he gives orders on the cash-keeper, whose books are examined by the forest-master

in charge of the division, and accounts rendered to the head office in Hanover, and thence to Berlin.

All the forests have been surveyed, valued, and divided into blocks in this manner :—

Besides those already enumerated, there is, for the sole purpose of measuring, valuing, and framing working plans for the forest, a superintendent, draughtsmen, and clerks, generally practical foresters, and a staff of surveyors and forest valuators, who are generally candidates for the position of over-forester.

When a forest was about to be taken in hand and worked systematically, a surveyor and valuator were despatched to the spot, the former working under the directions of the latter, who placed himself in communication with the local forest officer and the inhabitants interested, and obtained from them all the information in his power. The surveyor first surveyed the whole district, then the different divisions, as pointed out by the valuator, who defined them according to the description of the timber standing, and any conditions affecting the nature of the trees to be grown in future. While the surveyor did this, the valuator valued the trees, formed a register of rights with a view to commutation, considered the best plan of working the forest, the roads, in fact, all which enabled him to form a plan for the head office, and a subordinate plan to be handed over to the executive officer as his " standing orders."

The valuator and surveyor return to head-quarters, and prepare the maps and plans, which are submitted to the board of forest-masters, the forest-director and other councillors of the Finance Department, who are thus prepared to listen to any objections made by communities or individuals, which are very rarely made now, as the people have learned that the action of the officers is not adverse to their interests, and are willing to allow them to settle matters.

The executive officer has thus in his hands maps showing each division of the forest tract in his charge, and instructions—the quantity to be felled yearly, the extent to be planted, the state in which the forest should be ten, twenty or a hundred years after the plans were made, all calculated—so that the over-forester has only to carry out the instructions given him, allowance being made for unavoidable difficulties—failure of seed, occurrence of storms, and the like.

The forest-masters have no executive work, but control four to six over-foresters, of whose labours they make frequent reports to the Director (both in forest and office work). The over-foresters give annual reports of operations. They spend most of their time in the forest, supervising the felling, planting, sowing, thinning, carting and selling of timber. The laying down of roads is done by a forest officer, but the actual work is carried out by the local officer, who has also much office work, giving grazing licenses, etc., and preparations of returns, but his work is out of doors compared to that of the forest-master, who has more office work : comparing operations and rates in the districts, collecting statistics, settling disputes, and as a member of the forest committee, revising working plans.

The main object aimed at in any scientific forestry is, to convert the natural forest, consisting of trees, young and old, good and bad, too thick and too thin, into blocks of trees of the better description, of the same age, and capable of being worked—that is, thinned out, felled, and reproduced, or replanted, in succession, a block being taken in

hand each year. In carrying out such a system, considerations must be attended to, such as the relation of the block to the whole forest system ; the needs of the people in timber, firewood, leaves for manure and pasturage ; the soil, the situation as regards winds (which must be attended to in felling to lessen damage), and precautions against insects, fire, trespass or theft.

The plans need revising every twenty years, though it is marvellous to notice to what an extent the original scheme has generally answered.

After a forest has (to give some idea of management) by thinning, planting, and so forth, been gradually got into perfect order as described, the system of natural reproduction forms great part of the German method. It is as follows :—

The rotation and periods are fixed in the working plan. For beech "hochwald" it is in Hanover one hundred and twenty years, divided into six periods of twenty years each, that is to say, when the forest has been brought into order there should be nearly equal areas under crop of trees in each of the six periods, that is, from one year to twenty ; from twenty years to forty, and so on. When a block arrives in the last period, felling is commenced by what is called a preparatory clearing, followed by a "clearing for light" in the first year after seed has fallen (the beech seeds every fourth or fifth year) with the object of—1st, preparing the ground for the seed ; 2nd, allowing it to germinate ; 3rd, affording light to the young seedlings. If there is a good seed-year and sufficient rain, the ground should be covered with seedlings in two or three years after the first clearing ; but it is better generally to wait for a second seed year, and aid nature by hand-sowing, transplanting from patches of many to the barer spots, and turning up the turf to give the seeds a better chance of germinating.

When the ground is well covered the old trees are felled and carefully removed, so as to do as little damage as possible to the new crop, and the block recommences life, so to speak, nothing further being done till the first thinning. The time allowed between the first and final clearings is from eight to fifteen years. But in many provinces they do away with this system, and remove the old trees so gradually that there can hardly be said to be any clearing at all, the new crop of trees being well advanced before the last of the old trees is removed.

In these forests can be seen all the periods of growth—nurseries and schools for seedlings, which are transferred thither, at the age of two to four years, from the seed-beds, and are pruned and transplanted as often as seems required till finally planted out, sometimes not till twelve or fourteen years old. There are many methods of planting adopted here. The steepest and most rocky sides of the hills are covered with forests, which have been created by the labours of the Forest Department. In many such places, where even the few handfuls of soil placed round the young tree had to be carried some distance, it is not contended that the first plantations will yield a pecuniary profit, but the improvement in climate by the retention of the moisture, and reclamation of large tracts formerly barren and unproductive, is taken into account ; besides which the dropping of leaves and needles from the trees will ere long create a soil and vegetation, and insure the success of plantations in future years, and consequent surplus.

Prussia.

Prussia has twenty millions of acres of forests, ten millions of which are private, and the remainder, with which we have more to do, state, commercial, and ecclesiastical.

Of these the income is $14,000,000, and the expenses $7,500,000, leaving $6,500,000 clear. This will not show much, in fact not more than 65c. per acre, but there are other returns of more than mere yearly revenue importance. When it is considered that this result is arrived at without trenching on the capital or stock of timber in the forests, which, on the contrary, is being increased and improved in every province of the kingdom; and that the indirect value to the people of many forest privileges, which they exercise free of charge, must be very great, not to mention the benefit to all in the shape of public recreation grounds and an improved climate, some idea may be arrived at of the enormous value and benefit such a system of state forests must confer on Prussia.

The forests, as already stated concerning Hanover, form part of the finance department, and are presided over by an overland-forest-master, and ministerial director, aided by a revenue councillor and joint ministerial director, and a numerous council or board.

There are two forest academies, one near Berlin and one in Hanover. The overland-forest-master is curator of the academies, and at the head of each is an over-forest-master, who is aided by a numerous staff of professors and assistant-professors.

There are twelve provinces in Prussia, divided into thirty circles, and to each an over-forest-master, who is appointed to represent the forest department in the council of local administration, and is aided by councillors and by the forest masters as a board, to represent forest interests in the government. Next in order come the forest-masters, numbering one hundred and eight, in charge of divisions with an average area of sixty thousand acres, and then the executive officers, seven hundred and six over-foresters, to each of whom is 7,000 acres, and to each of whom is attached a cash-keeper, and three thousand six hundred and forty-six foresters, or overseers, with ranges of a thousand to three thousand acres.

At the academy near Berlin are seven professors with assistants. There is an experimental garden attached, with an over-forester in charge of the technical portion, and professors for the meteorological, zoological, and chemical sections. The number of students averages sixty-five. The varied apparatus includes a building where the seed is dried and separated from the cones, large seed-beds of spruce, fir, and willow, full opportunities of transplanting seedlings, and examples of every kind of trees for botanical study.

There is here a museum, rich in specimens of all sorts of birds, animals, and insects found in the forests. In cases where the animal or insect does damage to trees, specimens of the branch, bark, leaf, or cone, in a healthy state, and after being attacked, are exhibited close to each, so that the students can see at a glance the nature of the damage, and connect it with the animal which causes it. Thus we have squirrels, rats, beavers, mice, set up gnawing the barks, grubbing at the roots, etc. Insects are shown in the several stages of their existence—larvæ, chrysalis, caterpillar, moth, with their ramifications in the stem or branches of the tree. These, with specimen blocks of almost all descriptions of timber, form a most instructive collection. There is a forest district

attached, remarkable for the growth of Scotch fir and spruce on a poor sandy soil, and in spite of repeated attacks by insects.

Nothing is more remarkable than the extent of study required from forest candidates, and the number of years they are content to spend in studying or waiting an appointment. The would-be over-forester, which is the lowest of the gazetted appointments, must pass certain terms at a Government school, a year in a district with an over-forester, an examination as forest-pupil, two years at a forest academy, an examination in scientific forestry and land surveying. He is then a forest-candidate. Then two years practical study, nine months of it doing duty as an actual forester; then another examination. He is now an over-forester candidate. The first examination tests his theory; the second his practice. Then he will be occasionally employed in the academies, or in charge of a district, only then getting allowances. After five years of this he may look for steady employment.

Thus five years without pay are given in study; five in probation with but meagre pay when employed, and the time is often longer, before regularly installed. Yet so great is the desire for Government—especially forest—service, that there are numerous candidates.

The qualifications for admission into the subordinate grades—forester, sub-forester, overseer—have a military tendency. Candidates, after two years in the forest, enter a jager battalion, and bind themselves for twelve years' service. After three years they obtain leave, and are employed in the forest as huntsmen or gamekeepers. After eight years they must have passed the forester's test, which consists in six months' charge of a district, and an examination. At the end of twelve years they are discharged with a certificate entitling them to employment in the forest establishments. The appointments are much sought after, and in 1867 there were two hundred and twenty-one applicants for one hundred and forty-five vacancies; but many are absorbed by communal and private forests.

In some provinces the Prussian Government has certain rights concerning the management of even private forests—in others none.

While on the subject of Prussia, it may be well here to insert some extracts from a letter received from Baron Von Steuben, a Prussian nobleman, now Royal Chief Forester of the German Empire, by the Forestry Congress, at Cincinnati, in April of last year. He remarks :—

"There can be no doubt that every country requires a certain quantity of well-stocked woods, not only to supply the demands for building material and fuel, but more especially to secure suitable meteorological conditions, to preserve the fertility of the soil, and out of sanitary considerations. The ratio of the minimum quantity and judicious local distribution of the indispensable forest to the aggregate area cannot be expressed by a universal rule, but the same can only be approximated by scientific investigation. Above all things, it is essential to prevent forest destruction where such would injuriously affect the fertility of the soil. It is important, then, to preserve and to cultivate judiciously those forests which stand at the head-waters and on the banks of the larger streams, because, through their indiscriminate destruction, fluctuations in the stage of water, sand-bars, and inundations of arable lands are occasioned. It appears also necessary to preserve and properly to cultivate woods in quicksands, or the summits and ridges, as well as on the steep sides of mountains, along the sea coasts, and other exposed localities.

"In Germany, and especially in my more narrow-bounded Fatherland, Prussia, it is regarded as of the greatest importance, not only to preserve the forests already there, but to extend them as much as possible.

"In the National Appropriation Bill large sums are set apart for the purchase of such lands as are unfit for cultivation, and for utilizing the same by planting trees.

"With reference to forests owned by private individuals, they are not restrained in the use of their forests, and may, according to their own judgment, clear the same and till the soil, in short, do what they like, and yet there may be certain restrictions placed on the free use of the same as soon as danger to the common welfare is feared; these restrictions are prescribed by the law of July 5, 1875, relative to forest protection.

"This law is applicable in cases:

"1. Where, by reason of the sandy nature of the soil, adjoining lands, or public grounds, natural or artificial courses, are in danger of being covered with sand.

"2. Where, through the washing away of the soil, or through the formation of cascades in open places on the ridges of hill and on hillsides, the arable lands, streets, or buildings living below are in danger of being covered with earth or stone, or of being flooded; or the lands or public grounds, or buildings lying above are in danger of sliding.

"3. Where, through the destruction of the forests along the banks of canals or natural streams, riparian lands are in danger of caving, or buildings hitherto protected by the woods are in danger of iceflows.

"4. Where, through the destruction of forests, rivers are in danger of a diminution of the stage of the water.

"5. Where, through the destruction of forests in open places and near the lakes, neighbouring fields are seriously exposed to the detrimental influences of winds.

"In the cases above mentioned, which have been copied verbatim from the statute book, the manner of use as well as the culture of forests may be legally ordered, in order to prevent those dangers where the dangers to be averted are considerably in excess of the damages which would result to the owner by reason of the restrictions."

Saxony.

The state forests are nearly 400,000 acres, worked at an expense of $500,000, receiving $1,750,000, leaving a clear rental of $3 per acre. The expenditure is planting, draining, roads, improvement of inferior woods, felling, transport, killing insects, etc. About 5,000 acres are planted yearly, at an average cost of $7.50 per acre.

The fixed establishment is one inspector, fifteen over-forest-masters, one hundred and twenty district foresters, sixteen cash-keepers, thirteen engineers, twenty-seven foresters, and eighty-three sub-foresters.

There is a forest academy at Tharandt, with a separate staff of professors.

The system of planting now principally experimented on is much the same as that previously described, the young trees being several feet high before the old trees are all removed. One operation is noticeable. It was decided to convert a mixed hardwood forest, patchy and irregular, with impoverished soil, in 1820, into a coniferous forest, and maps were drawn showing what it would be in eighty years. Private intersecting lands have been bought up, and by 1900 the ideal chart will be actual. Already, in place of a straggling wood, irregularly covered with timber trees of inferior growth, we have now a compact close forest, regularly wooded in sections of different ages, principally spruce and Scotch fir, but containing also fine oak, ash and beech, with straight and clean stems. In many cases the young oaks have been left where pines were planted, and the introduction of the latter has had a wonderfully good effect on the oaks.

All private rights were abolished and compensated in these forests by a Bill passed in 1832.

Bavaria.

The state forests are 3,000,000 acres. They return, after paying all expenses, about $1.50 per acre per annum. About 30,000 acres are planted or sown annually, taking 35,000,000 plants and 1,000,000 lbs. seed. Persons found guilty of breach of forest rules have been punished by enforced labour in the woods. Private forest rights are being bought up by the Government.

The system of management is much the same as that previously described. There is a forest academy at Aschaffenburg, with one hundred and sixty-five students.

It will be interesting to notice the injury and process of repair in the fine forests of the Spessart in Bevaria The deterioration was caused by felling the forest trees as soon as, or before, they were mature, the impoverishment of the soil by the removal of leaves and litter, and the allowing dense underwood to grow unchecked. Inferior trees got the upper hand and prevented the growth of good, while they drained the already impoverished soil and gave nothing in return. Early in the present century the matter attracted attention, and every means have since been adopted to grow oaks, beech, and coniferæ. The result is, though not yet equal to the uniformity of other forests, nowhere can one find finer clumps and individual trees. Inferior trees will soon be rare in the whole forest. In remote portions where the humus had not been destroyed, the growth of beech and oak is truly magnificent, tracts of 120-year old beech and 300-year old oaks being common, the latter with clear trunks running up to a hundred feet high. When we compare these with other portions where the crippled and stunted appearance of the trees shows the effect of unregulated grazing and loss of litter, burning of the decayed wood, and forest theft and mischief, or the soil and vegetation, the result is marked. The circumstances, says the Indian Commissioner, are analogous with what has gone on in India for centuries, and is still more or less permitted. The vast extent of forests, which once clothed the hill sides and extended far out on the plains, and the luxuriant growth of the tropics, have hitherto, or until the last two years, prevented the gradual deterioration of our forests being marked or felt, but the subject has now attracted attention, and none too soon. If any have doubts in the matter, let them visit the Spessart, study the history of its forests and judge for themselves.

The forests are sharply protected by law, the average number of prosecutions annually being thirty per thousand acres. The crimes are mischief to wood, pasture, grass, straw, and miscellaneous.

Austria.

Scientific forestry is not so far advanced as in Germany, but officials are busily introducing a reorganization, by means of which, there is no doubt, it will soon be on a par with other states.

The state forests have been largely sold to meet state necessities, but there still remain nearly 2,000,000 productive acres, which yield, however, after expenses are paid, little over twenty-five cents per acre.

The existing establishments of forestry are not uniform, but there are about twelve hundred employées, of whom twenty-two are forest-masters. Some of these have almost

sinecures, while others have six times too much to do, and it is the same with those in the subordinate ranks. The forest academy is at Mariabrunn, near Vienna. There are about thirty-five students.

The collections are fine, possessing specimens of all instruments and appliances made use of in felling, squaring, sawing, carting, and preparing timber, models of sawmills and machinery of all descriptions, plans of river beds improved and embanked for floating, sluices of all sorts, dams and piers for directing rafts in their course and catching firewood, models of rafts, and specimens of home and foreign timber of all kinds. The damage done by animals and insects is also exhibited here comprehensively. There is also a forest garden attached to the academy for the instruction of the students.

The staff of the academy consists of the director, thirteen professors and assistant professors, with subordinates in the account office, laboratory, etc. There is also a forest school at Bruhl, for training young men (of whom eight were there) as practical foresters.

The greater number of those trained here are intended for private and not for Government service, their expenses for board and lodging being paid by noblemen and large proprietors, from whose estates they come, and to whom they return as forest officers and workmen. The state maintains the schools, and pays the professors' salaries, and there are no extra fees. This cannot fail to assist the intelligent management of the private forests of the empire, which are very extensive. The absence of numerous candidates for the government forest service, and preference for private employment is noteworthy, when compared with the opposite state of things in Prussia. The irregular promotion, lack of system, and low salaries in the Austrian forest service are the explanation.

The Austrian crown forests have been neglected; they are patchy with a low and decreasing yield per acre. There has been till now no attempt at rotation of blocks. working in periods. As is found in India, a glance at the outskirts of the forests would lead one to suppose it fairly stocked with timber, but a more careful inspection proves that this is not the case, and that only in the valleys and more remote portions, where the soil is particularly good and the axe has not been so frequent in its inroads, is there a fair and regular crop.

Herr Schuppitch, the present director, is trying hard to change matters, and is changing the hardwood crop, which has exhausted the soil for that class, with pine growths, which besides grow quicker and pay better. He is also dividing into blocks and periods, and planting up many bare or ill-covered tracts, where natural reproduction is impossible owing to the absence of standard trees.

Grand Duchy of Baden.

We shall now notice a private forest, that of the Prince of Furstenburgh, in the Black Forest. The receipts and expenditure are not obtainable, as are the public ones, but we are informed that the forests are economically worked, and that the liberal sums expended on road-making, fitting rivers for floating, housing foresters, &c., were well repaid by the facilities secured, and contentment and zeal of the employées. In the case of this, as of other private forests, it is evident that a private individual is not burdened with considerations of policy and public good as in a State. The forests are, therefore, worked with the best profit compatible with their retention as capital.

There are about 72,000 acres, in charge of eighteen foresters and over-foresters, who of course have many subordinates. The method employed is the slow felling and continual reproduction before mentioned, a block being after forty years in clearing before all the old are replaced by new trees. Attention and intelligence are necessary, for the seed will not grow nor the seedlings flourish without enough light, and the forest officer must watch that they get it; and again much greater care is needed in felling and hauling away when the trees are surrounded by lofty saplings and young trees than when the seedlings of the next crop are not more than a foot or two high. In this the axe-men of the Black Forest are adepts, and the damage very slight to what it would be in other hands.

It may be useful to describe their manner of bringing timber down the rivers. It cannot here be done when the stream is in flood; in fact, the less water in it the better so long as sufficient is stored up above to float the rafts. Reservoirs are made, and the water poured into the river bed when the raft is ready. The streams are often small, of only fifteen or twenty feet in width, and have to be prepared for floating, by being cleared of any large rocks or boulders, and "sleepered," if we may use the expression, by pieces of wood firmly fixed in the bed of the stream every few yards. These prevent the formation of holes in the bed, and serve for the raft to slide on if it touches the bottom. The first impression of the Indian commissioner, when he saw the float, composed of stems from twenty to sixty feet in length tied together with withes at the ends, and lying zigzag in the bed of a mountain stream, up and down which they extended sixteen hundred feet, was that it was simply impossible they ever could be floated down the stream, with all its windings, and over the locks and rocks which occurred pretty frequently. It contained 880 stems, eight or ten of which abreast formed as it were a link in the raft. There were thirty links, not fastened laterally, but only at both ends to the next link. The breadth is greatest at about two-thirds from the prow, which is narrow, and consist of only three stems abreast, with in front of all a piece formed of old wood and raised out of water like the bow of a whale-boat, so as to lead the raft, and the largest and heaviest stems placed in the broadest part and towards the stern or hinder part, which does not taper at all. There are two or three breaks, by which the speed is slacked or the raft stopped if needed. When all is ready, the water from above is let loose, and the raft, perhaps not now lying in more than a foot of water, begins to float a little, but is not let go till two-thirds of the water is passed, as it is a curious fact that when let go, if there is much descent, it travels faster than the water, and has to be stopped to let the water get ahead again. The raft has eight or ten men and boys, one or two of whom stand by the master at the chief break, on which the safety of all depends.

When let go it is exceedingly curious to see the forward part dart off at the rate of five miles an hour, and the several links which have been lying zigzag and perhaps high and dry uncoil themselves and follow in its wake till the whole dashes along at great speed and apparently uncontrolled. Accidents are rare, as they are well trained (lads of six or eight can be seen going down in miniature floats); but for one not accustomed to it, it is nearly impossible to stay on the raft at all, as it literally springs out of water on touching a rock, dashes round a rapid turn, or jumps a weir with a fall of several feet. Forty or fifty miles can be got over in a day if stoppages to let the water ahead are not too frequent or the stream is not swollen by rains.

Remarks on Germany.

The Indian commissioner proceeds to remark on the German system of forestry. Perhaps it will be here admissible that I make one myself. Let me say that, when we consider the immense extent and rapid growth of forests in India, the vast amount in Government hands, and yet find that they are so rapidly deteriorating as to necessitate the despatch of commissioners to Europe to learn the methods of preserving the forest, it is likely that Canada has just as much reason to bestir herself in the matter. Let us notice also, by some of the valuable tables Capt. Walker has furnished, that in Germany and Prussia alone there are nearly two hundred and fifty millions of acres of forests. We will well have already understood, by the foregoing pages, how different the great mass of these forests, with their great reserves of growing and well cared for trees, planned and prepared for many years, so that the forest can be depended on to give its regular and annual yield of valuable timber in perpetuity, are from our Canadian reserves, which are cut without regard to the future, and are fast disappearing before the combined assault of the settler and the lumberman.

On asking, where are we to look for a model or precedent on which to work, he replies "To Germany, where the management of forests by the State has been carried on for hundreds of years. Not the mere planting of a few hundred acres here, or reserving a few thousand acres there, but a general system of forest management, commencing by a careful survey, stock-taking, definition and commutation of all rights and servitudes, careful experiments in the rate of growth, the best soil for each description of tree; in fact, in every branch of the subject, and resulting in what we find to-day, hundreds of thousands of acres mapped, divided into periods and blocks, and worked to the best advantage both with regard to present and future, and the annual yield of which now, and for many years to come, is known and fixed to within a few hundred cubic feet."

"The great difference," says the commissioner, "in climate and local conditions between India and Germany would, doubtless, necessitate important modifications, but I can see no reason why the broad principles of organization and forest management should not be applied with success to our Indian forests, that is, gradually feeling our way as regards the best mode for the forest, and the wishes and interests of the people and the State."

I would here remark that this is still more applicable to Canada, as our climate presents no difference of moment.

"I do not think," he continues, "that we have much to learn from the Germans with regard to the planting and rearing of young trees; but it is with regard to the best method of managing groups or plantations that I consider we may, with advantage, take a leaf out of their book. For instance, I would certainly introduce, in an experimental manner, and on a very small scale, their system of rotation, clearing, and periods, and endeavour to bring forward a second crop before the first is off the ground, encourage the growth of the better descriptions, and keep down the least valuable, so as gradually to arrive at groups of trees of the same age, description, and class, and eventually at blocks worked in rotation, and containing always a sufficient stock of crop coming on to meet the requirements of future years. To arrive at all this the most careful observations and experiments will have to be made as to the rate of growth and yield per acre of each description of forest, the conditions under which trees grow best and form the most timber, some requiring close and some open planting, some nurses and some not; some, like the oak, requiring a great deal of light, while some, like the beech, do best for many years in the shade. All these points, and many more, demand attention, and till they are

settled we shall be merely groping in the dark. In fact, I think it may be taken for granted that all we will do in the way of forestry in the Madras Presidency, during the present century at least, will, after all, be but experimentalizing, which fact, however, need in no way delay the demarkation, survey, and settlement of the forests."

It may be said here that, if it be necessary to commence at once, in India, it is probably more necessary in Canada, where the process of growth is so much less rapid.

Concerning the capabilities of German foresters, the Captain says:—"An over-forester, and even many of the foresters and overseers, can tell the name, local and botanical, of any tree, shrub, and plant, classify it, and state its uses; name and classify every beetle and insect in the forest, and know whether they are harmless or destructive to trees, in what shape they do damage, and what are the best known preventive measures; inform you of the nature of the soil, and to what period the formation belongs; what trees will grow best, and why. All this is known thoroughly, theoretically and practically.

"Then as to the district, the exact yield, rate of growth, and annual increase in value of each block is thoroughly known and can be put down in figures at each moment by the over-forester, who can tell at the commencement of each year how much timber he is going to cut and sell, and from what parts of the forest it is to come, how many acres have to be partially cleared for natural reproduction, how many to be planted, sown, thinned, or planted up. The mere details of all this are left, as a rule, entirely to the subordinates, who thoroughly understand them.

"The forest-masters in charge of divisions possess not only the theoretical and scientific knowledge acquired in the forest academy, and the practical experience gained while they were over-foresters in charge of a district, but the more extended knowledge and wider views from their larger field for observation and comparison of causes and results. They are then qualified to decide most points, revise working plans, and supervise operations generally, whilst settling complaints and complications in connection with the forest administration, advising the local head of the department, and compiling valuable reports and statistical information."

The British Isles.

There are many forests, both Crown and private, in the British Islands, concerning which, as they appear to be managed on different systems, I shall merely state such points as seem to have some bearing on possible operations in Canada, or may show the progress made in late years in planting and foresting operations.

In the New Forest, Hampshire, containing 91,000 acres, much has been planted with Scotch fir and larch in 1853, and with oak in 1857. What is noticeable is that the first, planted as nurses, are planted here so much before the others (both are elsewhere frequently planted at once). It is done to establish the nurses, and give shelter from the cutting winds prevalent here. They transplant here from the first nursery to another—the last one near the ultimate destination of the trees.

The Dean Forest, in Gloucestershire, has 22,000 acres, in all. The commissioner visited twelve plantations here, ranging from 1844 to the present year. Nurses and hardwood are put out together.

In Scotland, the nurseries of Lawson & Sons, near Edinburgh, are noticed. They contain 270 acres. There were thirty millions of coniferæ seedlings in the beds. The *pinus pinaster* is largely used for planting on light sandy soils near the sea.

Before sowing or forming the nursery bed the land is trenched to fourteen inches, and a crop of potatoes taken off to clean it. In the following spring the seed beds are

laid out, and the upper soil carefully prepared to suit the nature of the trees which are to be sown. Most of the coniferæ prefer a light dry soil with a considerable proportion of sand, and this has the advantage that the seedlings are easily shaken out and freed from each other for transplanting. In the case of Scotch fir and larch, the seed is sown in May or June, and left in the seed bed for two seasons. The seedlings are then planted out in lines fourteen inches apart, and three inches between each plant, are left thus for sometimes two years, and then planted out for good. It is thought better, if the frost can be prevented from killing the seedlings, to sow in April, and transplant one year after, or even the same autumn, as soon as the leaf bud is hard. The spruce requires two years in the seed beds, as its growth is slower than that of larch. The *pinus pinaster*, *austriaca*, and *laricio* are sown in May or June, and transplanted the same autumn into rows six inches apart, the plants close together. Hence they are transplanted the following autumn, into rows fourteen inches apart, where they are left one or two years before being planted out. It is considered an object to shorten tap-roots and encourage laterals. (This last idea, it will be noticed, may assist the tree; but not that main object of forest preservation, the connection between the upper and lower strata.)

The Earl of Seafield's woods, in Strathspey, give an instance of the rapidity with which planting is going on in Scotland. There are 60,000 acres, of which half are in timber, yet so young, that the commissioner saw little large wood ready to cut, but plenty of thinnings. The overseer intends gradually to plant the whole, so that, in course of time, a thousand acres could be cut annually and a thousand planted out, which could not, it is said, fail to bring in a large revenue, without trenching on the capital of timber. Three lines of Scotch fir the commissioner saw lifted and tied in bundles for planting out. This was done expeditiously by the five-pronged fork, two men digging out the young trees, which are then lifted by women, the earth shaken off, and tied in bundles for planting. This list will give some idea of the progress on only one estate:— Duthil Hill, 700 acres, planted six years; Deshar, 1,100 acres, within seven years; Sluemore, 600 acres, five years; Revock, 700 acres, four years; Bengalupin, 1,200 acres, six years; Advie, 300 acres, one year.

A point here presents itself which, though it seems vague, and not according with Canadian experience, it might be well to examine and find the meaning of. The Strathspey overseer considers that "in Strathspey, at least, the land should be left barren and untouched, after it is cleared of trees, until the natural herbage, whether heather, grass or moss, which existed before the trees grew, recovers; and that if planted before this takes place, failure will result."

It may be remarked that oak is now little planted here, its use for ship-building being much less than formerly; while, even for backing for ironclads it is abandoned in favour of teak, which has not the injurious effect on the iron produced by the contact of oak. Scotch fir and larch are much planted, and are rapid in natural reproduction. Whenever the natural vegetation has sprung up in places formerly covered with coniferous trees, the seeds germinate. This is then protected by wire fences with great success. In a large tract of self-sown forest in the Grantown district, enclosed six years ago, the Scotch firs average six feet high, while individual trees run up to ten feet.

Wire fence, tarred, three feet eight inches high, can be constructed for seventeen

cents per yard, posts and all, and is much used. After ten years, or when the trees have grown out of harm's way, pasture is sometimes let. Enclosed plantations for this purpose command 2*s.* 6*d.* per acre, while ordinary hill side pasture gets but 6*d.*

The Earl of Mansfield's woods, in Perthshire. These are about 10,000 acres. Planting is going on constantly. There are nine district foresters, and a large staff of woodmen. A large plantation of Douglas pine is mentioned as doing remarkably well. They were planted in pits fifteen feet apart, fifteen inches square, and ten inches deep, with larch and Scotch fir nurses at four feet apart. The pines average twenty-five feet in height. The nurses are being removed. The overseer disagrees with the Strathspey statement as to leaving the land bare, and considers that it is only the insects (the beetle) which hinder the growth of seedlings on land cleared of conifers. He succeeds well by excluding cattle for one year, letting the grass, etc., grow, then burning it when dry, and planting out.

The Duke of Athol's woods, in Perthshire comprise 10,000 acres, and were commenced in 1728, principally with larch, which has done well in places, but is now undergoing the substitution of Scotch fir, which pays better. Oak coppice cut at intervals of twenty years yield $60 per acre.

Forests of Luss and the Harz.

Another gentleman, M. Gustav Mann, Conservator of Forests in Bengal, has proceeded to Germany for the same purpose as Capt. Walker, and gives some further important information relative to the German forests.

In the plain of North Germany the Scotch fir is the principal forest tree, and better suited for deep, loose, sandy, than for heavy loaming soil.

The great "Luneberg Heath" is mentioned, as having been covered with wood, but the indifference of the inhabitants to the existence of forests, originating in the common belief that they will continue to exist, no matter how recklessly treated, the desire of the villagers to get grazing ground for their cattle by burning the forests, the indiscriminate usage of the wood and method of felling in vogue, have destroyed hundreds of miles of forest, and have left the greater part of the Luneberg Heath barren, covered almost exclusively with heather, and of little use to any one. Now the evils are seen, and with a view of restoring these forests large sums of money, and much skill and labour, are being expended.

I will quote here a short description of the method used in planting the Scotch fir in such localities. The land is first ploughed, after which a man proceeds along the bed, making holes at distances three feet by five, with a wedge spade (one quite straight, made all of wood except the edge, which is shod some inches high with iron, and is two inches thick at the top of the blade). This he forces into the ground, withdraws it, and passes on, while two women follow him, who plant by holding the seedling against one side of the hole, while with their foot they press the opposite earth against the plant. The material for planting consists of one-year old seedlings of Scotch fir, and occasionally a two-year old seedling of spruce, which are raised in the ordinary way by sowing in furrows. The Scotch fir requires more light and air than any other, and does not thrive at

all in the shade of other forest trees. For the same reason natural reproduction (in forests) is very difficult, and not attempted here. As a tree affording some shade to other trees which require it, the Scotch fir is well suited. If sown or planted very close, early attention to thinning out also is necessary, as plants early stunted never fully recover their strength. The soil not being rich, the trees are not allowed to grow older than sixty to eighty years, this being the age at which the comparative yield of wood is best. Spruce is planted in small numbers with the Scotch fir, and even where the soil is not good enough for it to grow up into large trees with the fir, it becomes beneficial by the cover of its dense foliage, which facilitates decomposition of the soil, and keeps it moister and cooler than the fir alone could do.

It will, perhaps, be as well here to give Mr. Mann's very lucid description of beech culture :—

Seed beds for beech are prepared in the ordinary way, and the seed is sown in autumn as well as in spring. If the former time is preferred, care has to be taken that the seed does not germinate too early, so as to be exposed to spring frosts. This is prevented by covering over the beds after the surface gets slightly frozen, and by removing the covering in spring so late that the young seedlings have nothing more to fear from the frost. If sown in spring, the seed has to be carefully stored during the winter. Steaming, as well as excessive drying, must be guarded against. The first is avoided by turning over the seed or even keeping it spread out; the second by slightly watering it and turning it over afterwards, so as to distribute the moisture equally. A cool, moist room on the ground floor is preferable to a warm and dry one.

From the seed beds the plants are either removed at once into the forest, or into other nurseries for transplanting and keeping until they reach a height of three or four feet. If they are to be planted in open ground, without the protection of old trees, they are sometimes kept in the nursery until they reach a height of ten or twelve feet, which however is a very expensive measure. In this care is taken that the young shoots are not removed from the stem, as the bark of the beech is very easily burnt by the sun, and otherwise apt to be damaged by the weather. Unnecessary exposure of the roots of the young beech is carefully avoided, as they are very sensitive, and demand special care during the removal of the plants. Where it can be done some of the soil is left on the roots for the same reason.

Ordinarily the beech forest trees get re-established by natural production, *i. e.*, the shedding of seed from old trees. When the beech gets mixed with other kinds, as in the coppice with standard, its regeneration is furthered or checked according to circumstances, but planting is seldom resorted to.

In the pure, high forests of beech the natural reproduction is brought about by gradual and well-considered fellings, which tend to effect this as completely as possible. In hilly or mountainous localities fellings are commenced at the top of the hill. These fellings take place when the trees have reached maturity, and are three to four in number, and distinguished according to the immediate effect they are intended to have on the forest.

The first felling, called in Germany the preparatory cutting, is intended to facilitate the decomposition of the dry leaves and branches which cover the surface, and thus pre-

pare it for the reception of the seed, which latter, without this precaution, frequently germinates without being able to penetrate with its roots the comparatively hard and leathery leaves lying on the surface, and often dies in consequence, while weeds and scrub easily get up in it, and cover the surface soon, thus adding to the difficulties to be overcome by the young plants. It is commenced several years before the intended regeneration, and carried out gradually; but where the air and light thus admitted are not sufficient to render the surface fit for the reception of the seed, a timely permission to villagers to remove some of the dead leaves is resorted to. Besides the preparing of the soil, this opening out of the forest induces the tree to flower and bear seed more frequently than when standing very close.

The second felling—the so-called seed-cutting—is carried out as soon as the bearing of seed becomes probable, which can be judged of beforehand by the appearance and shape of the buds during the preceding winter. An abundant seed-bearing season generally occurs with the seed after longer or shorter intervals, but sufficient seed for the regeneration of the forest may be reckoned on every second or third year. Precaution is used not to remove too many trees at once, as in case of the flowers being destroyed by spring frosts or other causes, the restocking of the ground with young plants does not succeed. Too much light would dry up the surface of the soil, and induce the weeds to overrun the ground, both circumstances seriously interfering with the germination of the seed at a future season. Where at this time the suitability of the soil remains doubtful, a timely loosening and preparing of it in stripes and patches is resorted to to insure success.

When the expected seeding of the trees turns out a failure, further clearing is carefully avoided, to prevent the deterioration of the soil or overgrowing with weeds. If, however, the season is a favourable one, and produces sufficient seed, and the young plants germinate, this felling is soon extended to a greater number of trees to admit more light and dew to strengthen the young plants.

For the purpose of getting the seed worked into the ground, herds of swine, cattle, etc., are often driven through the forest with good effect.

Seed beds are sometimes established in the neighbourhood of a forest at the same time, to furnish young plants for the filling up of vacancies, which, however, are also obtained nearly as good out of the forest itself from places where the plants stand thick enough. Altogether the aiding of the natural reproduction by artificial means, either sowing or planting, is at the present time generally resorted to at once, as such measures always lead to a more satisfactory accomplishment of the desired regeneration, and save time.

The third felling is called cutting for light, as its chief purpose is to admit light and air in greater abundance as the young plants require it. This is generally commenced when the seedlings are two years old. It is also regulated very much by circumstances, and while in the one case the forest trees may be required longer on account of the spring frosts, so very injurious to the young beech, in others their early removal is necessary, even if an increase in size be sacrificed, for the establishment of the young trees. Neither do partial failures prevent the removal of the old trees, but are resorted to at once by

sowing or planting as the safest and quickest mode of securing the establishment of the young forest.

After the third or light felling follows the gradual removal of the old trees, or final clearing, which is regulated in the first instance also by the requirements of the young trees, and after this by the fixed yearly out-turn, as laid down in the working plan. As a general rule, all these fellings are carried out gradually, without causing sudden changes in the forest. The aiding of natural reproduction is either accomplished by sowing, if failures are perceptible early, such as non-germination of the seed or death of the seedlings; or by planting, if the seedlings get destroyed later by spring frosts, or are choked by weeds. The sowing is carried out in the forest in strips two feet wide, in furrows, or in patches two to three feet square, prepared by hoeing for the purpose, and by loosening and levelling of the soil; while planting is done by seedlings two to three feet in height taken from adjoining nursery beds, or from spots in the forest where there are more than are necessary.

"It is evident," says Mr. Mann, "that if, with all this care and attention to aid natural reproduction, still occasional failures occur, how unreasonable it is to expect forests in India to keep in an equally rich and thriving condition if left to themselves, or worked only with a view of extracting the timber from them." I would also apply the remark to Canada, and observe also that Captain Clarke respecting India, and Hon. M. Joly concerning Canada, make precisely the same statement, to the effect that the forests in both countries, cut over and carelessly managed, are often, so far as any available supply of good timber is concerned, only forests in appearance.

It may be noticed that the beech, of all other trees, is said to improve the land, forming a rich vegetable mould, to gain the benefit of which other trees—oak, ash, maple, larch, Scotch fir—are planted among the beeches, and do well. I may notice here that in Canada, while clearing the forest, this did not appear to me. I generally found the maple on the richest land, and where beech were intermixed a lighter loam.

One description of forest much used in Germany is called "Middle Forest." It contains a number of high trees cut at long intervals for timber, and below them a coppice (smaller trees growing from roots of previously existing trees, and which will themselves, when cut, be succeeded by similar ones) cut at much shorter periods for firewood. In cutting the coppice, young trees are left to replace the tall ones when cut.

A method of planting used here should be noticed. A small spade of solid iron, about twenty pounds in weight, fourteen inches long, seven inches broad at top, five at bottom, with a handle four inches long, is driven into the ground, and bent to all sides, then drawn out. The plant, three to four years old, of beech, spruce, or oak, etc., is dipped into a thin mixture of loam and water, which adheres easily. In this state it is pushed with its roots into the hole as far as possible, and with continual shaking, by which the roots get straight down into the hole, drawn up to the level at which the plant should stand. Here it is held by one man, while another drives in the spade a second time, about three inches from the first hole and parallel with it, and first presses with its point towards the first hole, and then with the broader part, by which means the plant gets very firmly pressed into the soil. If necessary the spade is driven in a third time, to close up the second hole slightly. The soil is then beaten firm with a mallet all round

the plant, but not striking closer than three inches. This mode is very successful ; it is carried on without preparing the soil, and answers in stony ground, on account of the strength of the spade.

On the Harz Mountains (the scene of many a supernatural legend) are vast forests of spruce, kept with much care. One remarkable point in the management is the Government seed-drying kiln at Westerhof, for getting the spruce seed out of the cones and cleaning it of wings, which is carried on here extensively, the spruce being plentiful, of excellent growth, and producing exceptionally good seed. The cones are collected by contract work, and varies according to the seasons, if plentiful or otherwise, and generally enables the workman to earn 50 cents to 75 cents per day. After all the Government stores are filled, private persons are allowed to collect, for which the person has to pay a small sum per season. In the cones the seed remains good from seven to eight years. The Government kiln turns out about 180 cwts. per season, while private parties in good seasons have turned out as much as 1,600 cwts. besides. The cones, when first brought in, are stored in large rooms, with perforated walls, so as to admit a free current of air through them.

The kiln itself consists of three rooms, the centre one of which is heated by means of a large oven, from which large iron pipes, six inches in diameter, pass twice through the room before they enter the chimney. This room is separated by walls, in which there are holes of nine inches, from the two outer rooms, in which the cones are being dried. By means of these holes, which can be closed at pleasure, the temperature in the drying room is regulated, and kept between 122 and 128 Fahrenheit. The drying is done in large wire drums, out of which the seed falls on the floor of the room. There are twelve in each room, and are turned from the outside of the room, where it is cooler. They are filled in the evening, the temperature got up, and so left for the night. The next morning the fire is lit again, and the drums being turned every half hour, by night the cones are empty. Half the cones are used to heat the kiln ; the rest sold for fuel. It costs Government about six cents per pound. What is not needed is sold at nine.

It is noticeable that the spruce wood, among other uses, is ground into pulp for paper manufacture, several mills in the Harz Mountains being employed in this manner. It might be worth consideration whether, under an improved system of forestry, the waste wood left in such quantities in hewing and score-hacking could be, in our great Canadian spruce forests, so employed.

It will be well to give an account of the method of reproducing and caring for spruce forests, both because our own forests will soon need replanting, and to give some idea of the care taken in maintaining woodland property in foreign lands.

Natural reproduction of the spruce is seldom attempted, as too slow and uncertain ; but if there are thriving naturally some clumps of any extent, they are kept up. Almost all spruce forests are regulated high forests, with complete clearings, either re-sown, which is still preferred by some, or planted, which is by far the most general mode of establishing or re-establishing spruce forests. If sown, lines about two feet in width are prepared by clearing the weeds, etc., off the ground, and placing this at the edge of the lines to prevent the wind blowing among the seed, or rain washing them off. The soil on these strips is sometimes loosened and left as it is if the seed is to be sown broadcast. If

the seed is sown in rows, small furrows are made. Between the strips, ground twice as wide is left. For plantations, the seed is sown in seed-beds, which are good, even, and sheltered pieces of land, about half an acre in size, and well dug up, afterwards levelled and occasionally slightly manured by the ashes of the weeds, remains of wood, etc., collected on the surface, brought together and burned, and afterwards mixed with the soil. These seed-beds are usually in the immediate neighbourhood of the ground to be planted, and have to be fenced in. If the seedlings, after they are three or four years old, have to be removed from here at once to the spot where they are to remain, the seed-beds have to be larger, especially if the young plants are to be planted out in numbers, *i. e.*, three or four in one hole. In the latter case the seed is sown generally in furrows, one foot apart, as being more convenient, and requiring here in the hills about seventy-five pounds of seed for half an acre, which is sufficient to plant fifty acres of forest. The better plan, however, is to have the plants from seed-beds, after they are two years old, transplanted singly into a nursery at about seven inches distance, where they remain until they are four or five years old; this, however, requires as much space again for the nursery as for the seed camp. Not unfrequently four to six year old seedlings are taken from the adjoining forest, where they are generally so close as to permit of the removal of many of them; and this is the most inexpensive way of procuring seedlings in limited numbers. Where there is a demand for thinnings, the planting of three or four plants in one hole recommends itself. If it is likely that the ground get run over rapidly with weeds, or the soil dried up by the sun, the replanting is done as soon after the removal of the old forest as possible, whilst where the danger from insects, especially the small beetle, is great, the ground is let lie two or three years first. Planting is done in autumn as well as in spring, but the latter is preferred. Spruce is planted four or five feet apart.

To protect the spruce forest against damage from insects the forester has to be constantly on the alert, as they are many, and if not checked in time, great damage is done by them. The most destructive noticed was the ordinary spruce bark beetle, which attacks the bark of living trees, and had, in some of the localities visited by the commissioner, destroyed so many trees that, when the diseased were removed, the forest had become so open that the wind would soon have removed the rest had they not been felled. Experienced men are told off to guard against this danger, by going through the forest to search for the trees attacked by the beetle, and fell and bark them to prevent the spreading of the insects. In most cases, they are quite able to hold the insects in check. These generally attack trees loosened in the roots by wind, known after the beetle gets in by their foliage turning yellow. In spring, when they are worst, healthy living trees are felled at the southern margin of the forest in sunny spots, for the purpose of attracting the beetle. Such trees are often full of them three or four days after being felled. The trees attacked are barked, which destroys the larvæ if not too far advanced; if so, the bark is burned. To prevent any escaping while barking, a cloth is spread under the stem. The timber beetle, which attacks new felled trees, going deep into the wood, is also common there, and is watched for closely. For the young plantation of spruce the first mentioned is the most dangerous, as it eats off the bark above the roots, and kills the tree. Fresh pieces of bark a foot square, inner side down, are laid around before or after planting. The beetles go under, and are caught and killed. The bark is examined every morning.

Silver Fir and Spruce in the Black Forest.

The Black Forest mountains are the home of the silver fir. The winters are severe—five to eight feet of snow on the hills from November till April; three feet in the valleys from December till March. They are partly regulated forest, in which, however, a gradual felling for their reproduction is carried on over one-third or one-fourth of the whole area at once, from which every year during thirty or forty years the largest trees are removed, while the rest are allowed to grow larger during the remaining years. This is done, as the price these large trees fetch is much higher in proportion than that of the smaller ones, and all are felled and removed in one piece if possible. Natural reproduction is chiefly resorted to in these forests, which, in consequence of the young plant growing well in the shade of the old trees, is very easily accomplished, even though it is extended over such a long period as thirty or forty years. To be able to keep as many trees as possible growing on the lands on which the regeneration of the forest is going on, the branches up to one or two-thirds of the height of the tree are sawn off to admit air and light to the young plants below, which does no harm to the silver fir, but, on the contrary, is said to aid the more rapid increase of the trunk, while the branches are used for litter. This sawing off of the branches is commenced from above by men who earn about forty-five cents a day. Regular seed-bearing seasons occur at longer or shorter intervals, but nearly every year there is sufficient seed to increase the number of young plants where it is wanted. Moss cover is very favourable for the germination of the seed, whilst in such places as get covered with grass or weeds, or where for other reasons the seed does not germinate freely, the soil is at once prepared, by clearing and slightly loosening it in strips and patches, for the reception of the seed, the germination of which is thus facilitated. If the open space in the forest is so large that the seed from the old trees does not reach the whole of it, sowing by hand is resorted to early, so as to let the young plants be as nearly as possible of the same age. If, by the time the old trees are nearly all removed, there are still some parts not covered with young trees, planting is resorted to. For the better growth of such planted trees the existing groups are somewhat rounded off, to avoid the young trees planted having to struggle with the others, perhaps already twenty to thirty years old; and where, on incompletely stocked spaces, which have to be filled up by planting, there are single trees of some twenty or thirty years, they are cut down altogether; or, if they are standing in numbers, and are not quite so large, some of the lower branches are lopped off the outer ones, so as not to interfere with those planted. These plants are either taken from nurseries or out of the forest, if the latter have not grown in too deep shade, which would render them liable to suffer on being removed to open places.

The seed is collected with some risk from the trees in October, before the cones open and it falls out. As the seeds are very oily, they are best kept in the cones or sown at once. The sowing is done in prepared beds in rows four inches apart, and after germination the ground is covered with moss to keep in the moisture. The seedlings one year old are transplanted into rows six or seven inches apart, and three inches between the plants in the rows, after which the soil between them is also covered with moss. Here they have to remain for two or three years before they are fit for transplanting. Shade

from the side is very beneficial for the seed beds as well as for the nursery. Plants for the nursery are preferable to those out of the forest; and the latter, when used, are as a rule removed with some of the soil adhering to the roots. Planting is better done in spring than in autumn, and in the usual way, the roots of the young plants being cut as may be necessary. They have to be sheltered as far as possible against sun, dryness, or spring frosts, and the plants as a rule thrive better on the cool northerly and easterly slopes of the mountains than anywhere else. The silver fir grows very slowly at first, and does not get much higher than six inches in the first four or five years. At the age of twenty-five years it begins to grow very fast, and increases most between the ages of eighty and a hundred and twenty years. It likes best a deep, cool, moist and loamy soil with a covering of moss, and sends its roots deeper than the spruce, in consequence of which it suffers less from wind and storm than the latter. There are many spruce intermixed, used when natural reproduction of the silver fir fails. Thinnings are necessary in the thirtieth year, and have then to be repeated every tenth year, till the gradual felling of the largest trees commences. These fellings are regulated by the needs of the young seedlings, and are carried out only sufficiently to admit light to the young plants, leaving as many of the old trees to stand as can be permitted.

Moorpan.—In Hanover and elsewhere, where the Government are bringing up thousands of acres of heath for the purpose of planting forests, great difficulty is found in penetrating and converting into good soil a hard layer called "moorpan." This is broken by plough and pickaxe, and Scotch firs planted, whose deep tap-root passes down into the layer of better soil below. The Government pay about $11 an acre for the land.

France.

The administration of forests in France is entrusted to the Ministry of Finance, and the head of the Department is the Director-General, assisted by two administrators, one charged with the management of the forests and the sale of the products, the other with the police of the forests and the forest laws. In the departments there are thirty-two conservators, each in charge of one or more departments, according to the extent of forests in each. The immediate supervision is entrusted to inspectors, who are assisted by sub-inspectors and *gardes-generaux*, who live near, and personally superintend all operations and work of the forest guards. The brigadiers and forest guards live in houses in the forest and serve as a police over a certain range. They are required to be present at all operations, and to go round their ranges at least once a day to report any violations of forest law that may take place.

The saw-mills in the forests are usually owned by the Government and hired at a certain rate to the wood merchants, who buy the cuttings. The timber is allowed to be sawn up before it is inspected and marked by the forest guard under the superintendence of an inspector.

The forests under the management of the bureau are (State and Commune) about 7,500,000 acres. There were nearly a million more, which went with Alsace and Lorraine to Germany. Also, there are in France 15,000,000 acres of private forests.

Of schools of forestry, the French have, at Nancy, one of the best in the world,

where pupils are instructed both experimentally and theoretically in all forest learning, the collegiate home studies being constantly varied by excursions of parties of pupils, under charge of professors, to those forests where, at the time, most can be learned. Proficiency in these schools forms, of course, a strong recommendation to future advancement in the Government or private forest service. For admission to the school candidates must bring a letter of authorization from the Director-General of Forests, which can only be obtained by those from nineteen to twenty-two, without infirmities, and having a diploma of Bachelor of Letters, or attainments in classical studies to warrant such diploma. They must also have an income of $300 per annum, or a pledge from friends to provide it, and $120 afterwards till employed as garde-general on active duty.

In the difficulties which have hindered the efforts being made, especially in America, to preserve a due amount of forest, one of the most formidable has been the disinclination to interfere with private rights. It will be of service in Canada in this matter to notice how summarily, in France, this matter has been managed. I will therefore quote the principles of law upon which the forest code of France is founded, as stated with great precision by Professor Macarel (a writer deservedly of the highest estimation) in his "*Cours de Droit Administratif.*" As they embrace views applicable in other countries under like necessities—being, in fact, an extension of the right of eminent domain, or that maxim of Roman law, *salus populi suprema est*—they will be especially germane to our purpose. He says:—

"*Restrictions Implied in the Free Enjoyment of the Soil.*

"As to the woods and forests:

"The preservation of forests is one of the first interests of society, and consequently one of the first duties of Government. It is not alone from the wealth which they offer that we may judge. Their existence is of itself of incalculable benefit, as well in the protection and feeding of the springs and rivers as in their prevention of the washing away of the soil from mountains, and in the beneficial influence which they exert upon the atmosphere.

"Large forests deaden and break the force of heavy winds that beat out the seeds and injure the growth of plants; they form reservoirs of moisture; they shelter the growth of the fields; and upon hill-sides, where the rainwaters, checked in their descent by the thousand obstacles they present by their roots and by the trunks of trees, have time to filter into the soil and only find their way by slow degrees to the rivers. They regulate, in a certain degree, the flow of the waters and the hygrometrical condition of the atmosphere, and their destruction accordingly increases the duration of droughts and give rise to the injuries of inundations, which denude the face of the mountains.

"Penetrated with these truths, legislators have in all ages made the preservation of forests an object of special solicitude.

"Unfortunately, private interests—that is to say, the action of those who do not directly feel the power of the Government—are often opposed to this great national interest, and the laws framed for protection are often powerless.

"In France, the ordinances prior to the revolution carried too far the restrictions imposed on private owners. The new regulations fell into the opposite extreme, and allowed the proprietors free and absolute liberty to dispose of their woods.

"A large destruction followed this imprudent translation from excess of restraint to excess of liberty. The proprietors abused this unwonted freedom, and clearings multiplied indefinitely, without distinction as to the places where they were made, so that in many localities the rushing down of the denuded soil and the deforesting of mountains caused the soil needed for vegetation to disappear and left the rocks naked. The rise in the price of wood and the easy and certain resource offered to proprietors in the clearing of a

planted tract, when compared with the remote and eventual advantages offered in their preservation; the hope of compensation, and, beyond this, the advantages, in one way and another, of cultivation, may be recognized as among the causes which sufficiently explain the inducements offered to many of these proprietors, which led them to undertake these clearings."

I would here notice that this is precisely what we have been doing in Canada, and that the ill effects which followed in France will surely in no long time be felt in Ontario. They are already felt; we have not the climate we had, nor the favouring moisture when most needed. Yet we could get along as we are. But that is just what is impossible. We must, while there is time, use some means of averting the evil, or we shall certainly become much worse off than we are. M. Macarel goes on :—

"At length, this progressive deforesting of the soil of France, joined with the incessant need of firewood, and the demand for wood by manufactories and ships, have, during forty years, made sad havoc with our forest wealth.

"A renewal of the ancient prohibitions by the law of 9 Floreal, year XI., was deemed necessary to oppose this excessive clearing of woods by private owners. It was accordingly decreed that, during the twenty-five years dating from the date of the promulgation, no wood should be cut or carried off unless six months' notice had been given by the proprietor to the forest conservator of the arrondissement of the district in which the wood was located. Within this time the forest administration might object to the clearing off of the wood, and was charged to refer the question before the end of this time to the Minister of Finance, upon whose report the Government might definitely decide within the same time. It therefore resulted in this, that to make a clearing an authorization precedent by the administration was necessary, and that if the administration thought proper not to grant this, the proprietor was restrained against cutting.

"Thus, according to this branch of agricultural industry, the general law of France is, that owners are free to vary, within certain limits, the cultivation and working of their lands; but, as to woods and forests, the public interests demand that individuals shall not be free to clear them from the soil whenever they please. From hence it follows, that the administration has a right to pronounce its prohibition against clearing whenever it is deemed that the public interests require that this be done."

The penalties for clearing when forbidden are, I may state, a fine of about $200 per acre, and compulsory replanting within three years. This law was, I conceive, in full force in 1874, as this quotation forms part of a report to the U. S. Congress of that year. It probably is in force still, and justly so. The voice of the people, not of solitary citizens, should decide in so important a matter as deforesting a country.

The French Government have, at great expense, replanted vast and almost barren districts; they have also established great forests along the sea-shore where formerly the sand threatened to destroy whole departments, and have averted the evil. But the chief means is the prohibition of clearing; for it is the interest of an owner who does not clear to plant and improve his forest, so as to receive an increased income from the trees arriving at maturity in increased numbers yearly.

Switzerland.

In no country in Europe has the waste of forests been more rapid or destructive than in Switzerland, and in none, perhaps, has this improvidence been followed by more disastrous results. The woods, being considered common property, were uprooted; and the soil on the mountains being exposed to the wash of the rains, was rapidly carried

away, leaving broad areas of naked rock, from which the water would at once sweep down the valleys in sudden and destructive inundations. The autumn of 1868 is memorable on account of these floods.

Public attention has, however, been thoroughly awakened, and active measures are in progress to remedy, as far as may be, these evils. The cantons which have charge of these operations have for some time, at great expense, been constructing works to control the streams, and planting trees wherever practicable.

I would here remark that this is a very difficult matter compared with what it might have been. It is easy to preserve a forest on a hill-side, but the soil once washed to the rock, it is another matter. I could point out places in Ontario where splendid forests stood, and yet might have stood, now for many miles

"White rock and grey rock,
Barren and bare."

The matter is now in Switzerland taken into the hands of the national Government, and the following article gives the idea :—

"Art. XXII.—The Federal Union of Switzerland has the right of supervising structures for the protection of water courses, and of the forest police in mountain regions. It will assist in protective structures for water courses, and in the planting of forests at their sources. It will enact the requisite regulations for maintaining these works and the forests now existing."

Italy.

Soon after the present Kingdom of Italy was established, a central forest school was organized near Florence, under the direction of A. di Berenger, formerly in the Austrian forest service of Venezia, and author of an excellent work on the history of forest management in Italy. The school is located in the splendid silver fir forest of Vallombrosa. We all remember

"Thick as autumnal leaves that strew the brooks,
In Vallombrosa."

This is below the crest of the Appenines, on their western slope, about twenty miles east of Florence. In winter it is transferred to a lower station at Paterno, in the region of the olive. Italian forest literature of direct practical application is comparatively modern, but of late the publications of the Ministry of Agriculture, to which sylviculture is entrusted, contain much that is valuable. The two most important of these give the statistics of forests and the forest law of Italy. There are over five million acres of communal forests, over six million of private forests, and only half a million acres of State forests. One-fifth of the land is in forest. This is scant enough, apparently, or the nominal forests have been culled to depreciation, for we are told that:—

"Projects of a general forest law for the whole of Italy have been repeatedly submitted to the Italian Parliament. The evil effects of denudation have been severely felt in many parts of the country, and the aim of these proposed legislative enactments has hitherto been to guard against further mischief by determining beforehand which lands shall, in the public interest, be clothed with forest or kept under forest, and then to place the whole of these lands under the supervision or control of the public forest officers without distinction, whether they belonged to state, village, commune, or private persons. From a report with which the Minister of Agriculture submitted the project of a general

forest law in 1870, it appears that the financial exigencies of the country had rendered imperative the alienation of the greater part of the forests at the disposal of the State, and that it was only intended to retain a limited area of State forests, mainly with the view of supplying the timber required by the navy, and the forests required for this purpose the bill proposed to declare inalienable.

"Thus, with regard to forest matters," says Captain Walker, "it seems probable that Italy will pursue a policy different from that which has of late years been initiated in most provinces of India. In those provinces we acknowledge the necessity of maintaining certain areas under forest, or of clothing them with forest when they are bare; but we do not expect any satisfactory success in those attempts, unless the forests to be thus maintained or created are under the entire control of the State, and we entertain no serious hopes of effecting any real good by the supervision of private forests, or by any general kind of control over communal forests, unless the administration or management of such communal forests can be vested entirely in the hands of the public forest officers.

"In those provinces, therefore, of the Indian Empire, to which I now refer, our principal aim is, in the first place, to consolidate the State forests wherever the State has suitable forest lands at its disposal; and we hope that eventually, when the majority of public forest officers shall have acquired that professional knowledge, skill, and experience which is necessary for a satisfactory management of forest land, that they may be found competent not only to manage the State forests entrusted to their charge, but also to induce large landed proprietors to follow their example in the management of their own estates, and, if such should ever be found necessary and expedient, to exercise an efficient supervision over private and communal forest lands; but we think that any attempt to exercise supervision and control over private and communal forest lands through the agency of forest officers who have not actually charge of public forests entirely under their own control, and who cannot point to the management of their own forests as an example to be followed in the management of the private or communal forests, would lead to unsatisfactory results. The further development of the general forest policy in Italy will doubtless be followed with great interest by Indian foresters, and on this account it appeared to me right to add the present remarks."

It may be valuable here to notice that in this, as in other points, the practical ideas of the Indian commissioner might well be applied in Canada. There is good reason to fear over-denudation here; there is also reason to believe that we shall have an interval in which to take measures for avoiding the evil. In that interval the course stated by the commissioner as likely to be followed in India might, it appears to me, profitably be pursued here, namely, the taking in hand by Government of any amount of forest fit for the purpose, and which could be spared from the operation of the system at present pursued, and preserving them on the European plan. This will further on be more fully treated.

Russia.

In this vast empire, where, as in the United States, we have been accustomed to believe the forest is interminable, and where, in fact, the amount of woodland in the northern two-thirds is more than twice as great in proportion to its area as in the United States, the Government has turned its attention energetically to the subject of forestry, and has undertaken to establish by regulation conservative measures. As yet, private persons and establishments owning forests enjoy the absolute right to cut and clear at will. But these do not own nearly so much as the Government, which has about three hundred and thirty million acres of woods; the others holding about one hundred and fifty. About forty per cent. of the country (Russia in Europe) is timbered. I must remark that this amount, after so long an occupation, shows that the timber has been taken

some care of already. For the immense Government woods, they have been placed under the care of the Minister of Public Domains, who has a director of the Forest Department, and the organization of the service is very complete. For the purpose of fitting young men for the duties of forest agents and agriculturists, either for the Government service or upon private estates, two special schools of agriculture and forestry have been established—one at St. Petersburg, and one near Moscow. The course of instruction extends through three or four years, and the schools are placed near forests, where every detail is illustrated. There is also another forest school at Lissino, of the second grade, where the course is very practical.

Sweden.

In 1859 a bureau of Forest Administration was created. Forest regulations, however, extend back to 1647, and even before that, private owners were required to plant and protect from cattle two trees for each one cut.

In 1868 a commission was appointed, under the direction of Mr. E. V. Alinquist, to enquire into the need of further legislation, and in December, 1870, he submitted a report with a bill, making 392 pages, besides numerous tables.

One clause in the reported bill is a compulsory feature, which, though less stringent, is in the spirit of the enactments now in force in most of the countries of continental Europe, namely, forbidding trees to be cut for sale smaller than eleven inches at the butt, or eight inches sixteen Swedish feet therefrom.

India.

The necessity of preserving tropical forests has fortunately attracted the attention of Government in British India, where the importance of maintaining an equilibrium of temperature and humidity is of much immediate consequence to the social welfare; and the growing demands of railroad use, and the various applications of the arts, render it a subject of direct practical utility.

The matter has been agitated since 1850, and in 1864, Government laid the foundation of an improved general system of forest administration, for the whole Indian empire, having for its object the conservation of state forests, and the development of this source of national wealth. The experience acquired in the forest schools of France and Germany has been brought to apply in this great national undertaking. Among the more important general principles laid down for the execution of this measure is that all superior Government forests are reserved and made inalienable, and their boundaries marked out to distinguish them from waste lands available for the public. The Act of 1864, defining the nature of forest rules and penalties, has been adopted by most of the local governments, and the executive arrangements are left to the local administrations. Various surveys have been made to obtain accurate data concerning the geographical and botanical characteristics of the reserved tracts, and the kind of timber best adapted for various localities has been carefully ascertained.

In 1866, the Government resolved upon sending out five young men, duly qualified by education in the forest schools of France and Germany, for the forest department of India. An arrangement was made the same year by which forest officers in the India

service, who might choose to come to Europe on furlough, would be able to increase their professional knowledge by studying forest management and other subjects connected with forests in Great Britain and on the continent. A number of officers have availed themselves of these arrangements, and some of their reports have been published.

Of these, that by Captain Walker, and that of M. Gustav Mann, I have largely used elsewhere, as the reader will have observed.

"At the moment of our writings," says the author of a report from which I have obtained much, presented to the U. S. congress in 1874, "the public journals are giving most painful accounts of the distress in India from famine. From a careful study of this subject we cannot doubt that this calamity is due to the fact that the forests have, of late years, been swept off by demand for railroad and other uses much more rapidly than formerly, and that the exposure to winds and sun, thus occasioned, may have largely contributed to these painful results. The remedies are to be sought in the restoration of that due proportion of forest-shade upon which agriculture depends for success. If the officers to whom the opportunities for European observation fall, improve them as well as some reported by Captain Walker, we may reasonably hope for a radical though not an immediate restoration of abundant harvests throughout the vast countries of India."

Now, since this was written, we have Sir Richard Temple's valuable book, "India in 1880," which I have noticed before. This gives us some idea of what has been commenced by the gentlemen who have been writing the reports we have used. He says:—

"The Government of India has enacted a law regulating all matters connected with forest conservancy, and the provisions of this law are being carried into effect by the several local governments. The forests are divided into two categories; first, those which are 'reserved,' being preserved and worked through state agency, in a most complete manner; secondly, those which are 'protected,' being preserved less thoroughly. The best timber markets are mainly supplied from the 'reserved' forests. Care has been taken to determine what tracts shall be 'reserved' and 'protected,' and to mark off their boundaries. The area thus defined in the several provinces already, or likely to be defined ere long, will prove to be hardly less than eighty thousand square miles for the whole empire. The primary object of the administration is to preserve the forests for the sake of the country. Due attention is also given to the financial out-turn; much income is already secured. The expenditure is over five hundred thousand pounds annually, but the receipts amount to nearly seven hundred thousand, and in time the forest department will have a prosperous revenue.

"The superior officers of the department are for the most part British, trained in the forest schools of France and Germany. The Inspector General of Forests with the Government of India is Dr. D. Brandis, whose services to the empire have been conspicuous in organizing a system of forestry which is sound and scientific, and is yet adapted to the circumstances of the country. Instructions in forestry is afforded to natives also; forest schools are established for them, and in time they will take a large share of the administrative work.

"As might be expected, the system of forest conservancy, though generally accepted by the natives who dwell near the 'reserved' and the 'protected' tracts, is sometimes opposed by them. There must always be some danger lest the foresters should, in their zeal for conservancy, infringe upon the prescriptive rights of the inhabitants. The local civil authorities are vigilant and prompt in asserting and vindicating the rights of the people in this respect; for the recognition of which rights, indeed, ample provision is made by the law. They should, however, be careful to support the forest officers in the execution of duties which are of the utmost consequence to the welfare of the country. Many of the hill tribes habitually burn patches of valuable forest, in order that the ashes may so fertilize the virgin soil as to render it capable of producing a crop without tillage. Having reaped one harvest, they leave the spot marked by charred stumps of timber trees, and move on to repeat the same ravage elsewhere. This barbarous and wastefully des-

tructive practice is gradually and cautiously checked, by reclaiming these people from agricultural savagery, and inducing them to plough lands, and raise yearly crops by ordinary husbandry.

"According to the latest returns there appear to be 29,600 square miles of demarcated reserve forests, 3,500 square miles of protected areas, and 35,000 square miles of unreserved forests, or 68,000 square miles in all. This appears a comparatively small area for so large an empire, especially when it is remembered that of this not more than one half is effectually preserved. Some extensive forest tracts exist, however, in the Madras Presidency, of which a return remains to be rendered. There are, further, 31,000 acres of plantations in various districts."

These plantations, I may remark, are those commenced by the foresters under Dr. Brandis, and are being every year added to at the rate of some thousands of acres. It may be noticed that the forest officers trained in Europe for India, and at work there now, number forty-six out of a staff of ninety-three, who have, of course, an immense number of subordinates.

Concerning other countries, it may be generally remarked, that all the nations of continental Europe are moving in forestry matters, and that there are many schools besides those I have mentioned.

South Australia.

The colonies of Australia and New Zealand are working earnestly in the matter of tree culture. In South Australia there is, we are told, far too little woodland. The consequences are that so arid is the country in parts that the reports state they can never expect to grow wheat unless the rainfall can be, by the assistance of plantations or otherwise, increased.

South Australia has moved vigorously in the matter. They have appointed a Conservator of Forests, Mr. J. E. Brown, F.L.S., who has written a valuable work on tree culture there. Reserves have been mapped out, of which one is about fifty thousand acres, another nine thousand, another twenty thousand, with smaller ones of six or seven hundred—the larger evidently intended to be improved into forests on the European plan —the smaller as nurseries and seed-bed for young plants. Houses have been built for nurserymen, and all suitable buildings erected, and forest rangers and police appointed. The Forest Board had been in existence three years in 1879, and from the report of operations sent in by Mr. Brown in that year, giving full and admirably worded details concerning the soil, trees, and method of procedure adopted and to be adopted on all the reserves, there is little doubt that South Australia will, considering how rapid growth, when encouraged, is there, (twice as rapid as in Britain) soon possess large and valuable forests, fit to yield yearly a regular and large quantity of timber, without either clearing or injuring the woodland reserves.

New Zealand.

To show the destruction of timber even where unnecessary for clearing, it may be observed that it is evident New Zealand possessed, when first colonized to any extent, in 1830, much land in a prairie or unwooded state, as her area was sixty-six million acres, and her wooded area twenty million acres. However, by 1868 she had destroyed five

million acres of woods; and by 1873, she had lost eight, leaving her but twelve million acres. The destruction was principally caused, not by clearing, but by carelessness in allowing bush fires; and it was evident the land would, at that rate, soon be deforested altogether. The well-known writer, Hochstetter, says:—"Individuals should not be suffered to turn the country into a desert to the detriment of whole generations to come. The woods are ransacked and ravaged, in New Zealand, with fire and sword. During my stay in Auckland, I was able to observe from my windows, during an entire fortnight, dense clouds of smoke whirling up, which proceeded from an enormously destructive conflagration near the town. When the fire had subsided, where had been a large beautiful tract of forest was now nothing but ashes." An official of the New Zealand Company had also pointed out the destructive propensities of the settlers in cutting down valuable wood. He says :—"A melancholy scene of waste and destruction presented itself to me when I went up to see the forest. Several square miles of it were burning, having been fired in order to make room for the conveyance of logs down the creek. Noble trees, which had required ages for their perfection, were thus ruthlessly destroyed in great numbers."

In consequence of this state of affairs, public opinion in New Zealand was loudly expressed, and numerous reports were presented to the Legislature causing animated debates, and large and valuable compilations of these were published. By this time, there is every reason to believe, if these reports and plans have been properly attended to and carried out, New Zealand has made good progress in the matter, though we have not, as in South Australia, an actual Forest Literature, such as the conservator there has published.

United States.

The United States have for some years past established a bureau of forestry under the able superintendence of Dr. Hough, who has issued several valuable yearly reports, and whom I have to thank for copies of these as well as for other valuable publications connected with the subject. Largely in consequence of Dr. Hough's labours, tree-planting is receiving a rapid impetus throughout the United States, especially in the prairie sections; while in many of those States which have been principally cleared of their forest, great interest is being created in the subject, and important works being carried out.

EXPERIMENTS IN PLANTING IN THE STATES AND CANADA, AND DIRECTIONS FOUNDED THEREON.

Tree Seeds.—Methods of Planting.

In a report of a committee upon forestry, made to the Iowa State Horticultural Society in 1875, by Prof. Henry H. McAfee, the following practical statements are made upon this subject:—

"Seeds may be classified for purposes of treatment into three sorts, viz: nuts, hard seeds, and soft seeds. The nuts should always be planted where they are to remain permanently, as the nut-trees do not usually transplant without considerable injury, and the nuts must be kept damp from the time when they are ripe till planted; at least the kernel must not be allowed to become dry, or they will surely fail to grow. Thin, soft-

shelled nuts, like the chestnut, will, if exposed to sun and air, dry in a few hours enough to prevent growth. So nuts must be kept in earth or on the earth under mulch, or in something that will prevent drying till used. Peat, moss, old straw, dust, etc., will do. A very good way is to spread them in a thin layer upon the ground, or in a trench so located that water cannot stand among them, and cover them thoroughly with mulch, planting them at corn-planting time, and about as deep as corn is planted.

"The hard seeds are generally somewhat slow to germinate, and need to be in soak for a long time, to be frozen wet, or to be scalded before planting, or to be treated with some substance to hasten germination. This class embraces honey-locust, which is kept dry and planted in spring, will seldom ever grow the first year, and sometimes will not sprout till the third season; also the stones of cherries and plums and even the seeds of apples and pears. If mixed with sand (two parts of sand to one seed by bulk) and dampened fully, and subjected to moderate freezing through the winter, all this class except honey-locust, coffee-nut, the hawthorns, and red cedar are likely to grow the season planted. For these exceptionally hard cases water, heated to boiling, is poured over them, and, standing upon them for an hour or two, some may swell, and can then be picked out and planted, and the more incorrigible treated to another scald, and thus till they all swell, or they are planted in fall and left to grow when they will; or, in case of haws, they may be mixed into bran-mash and fed to sheep or cattle, and the droppings planted, when the seeds, softened by the digestion, are likely to grow.

"The soft seeds, comprising all not named in the two other classes, may be still further divided into spring, fall, and winter seeds, each of which require or permits different treatment. The spring seeds are those which ripen in spring or early summer, as silver or red maples and red and white elm, all ripening from May 15th to June 5th, and the rock-elm a little later than the others. These seeds will not keep well and should be gathered from the trees before they fall, except where they are so situated that they may fall into still water, when, being light and floating, they may sometimes be scooped up in large quantities. As soon as possible after gathering they should be planted, not covered deeply, say one-half inch, in good mellow soil; and if a fine mulch, like damp chaff, can be obtained, it should be lightly spread over the ground, which sometimes takes place in June.

"The winter soft seeds are ash-leaved maple, green and black ash, sycamore, basswood, etc., or those seeds which have a tendency to hang all winter in sheltered localities. These seeds may be gathered sometimes as late as planting time and immediately planted; but if gathered earlier, had better be spread thinly upon the ground, and covered till planting time. All others of the soft and winged seeds, not classed as spring or winter, are the soft fall seeds, and they should all be stored as directed for the nuts. Hackberry and cherry, though properly classed with the hard seed, should be freed from their pulp in fall and stored in earth to freeze, and planted in spring without scalding. All seeds, but nuts, which are large enough to pick up readily, and such as may be gathered floating on still water, as noted above, are best gathered from the trees and stored so as not to dry too much. They must not be kept in too large masses, as, so dealt with, they may heat and spoil.

"If ground is not very weedy, it may be economy to plant all seeds in permanent plantation; but in old or weedy ground it is generally best to grow them in seed-bed or nursery rows. If put in the permanent plantation, allowance should be made for poor seeds, and more planted than you want of trees. The question of check-row or drill planting is to be decided by the planter, and the same reasons which determine the manner of planting corn have weight in forestry, though, generally speaking, forestry is more satisfactory in drills than is an annual crop like corn. If check-rows are used, several seeds per hill are desirable; and if drills, generally twice or three times as many seeds as you need trees should go in. It is not worth while to put tree seeds into any but mellow, moist soil, and to secure good results with them, thorough culture the first year is necessary. A rule of depth sometimes given is to cover with soil as deep as the seed is thick, and that is of course very thin for small seeds. But seeds of trees often get covered too deep, and any seeds but the nuts ought to grow with half an inch of fine earth lightly packed above the seed. Nuts may be planted a little deeper, but not much.

"Seed-beds and nursery rows are, all in all, to be advised, and they are generally used for seedling trees. Seed-beds are usually four feet wide and of any convenient length, and four inches above the surrounding level. For evergreen and larch seeds, which, by the way, ought not to be attempted by any one not trained in the nursery business, shades are used in the form of lath hurdles, with openings of less width than the strips, and generally, in addition to the hurdles, windscreens around the beds, while some nurserymen build arbors over their seed-beds, and such seed is generally put in broadcast, covering by sifting on sandy earth. But for any of our native tree-seeds, shading will hardly be necessary.

"Drills across the beds one foot apart may be planted, or drills, twenty to twenty-eight inches apart, may be made of any length, and on the general level, and the seeds planted at the rate of twenty to forty to the foot. Culture, while plants are young, should be by hand, running a hand wheel-hoe, and hand-weeding in the drill, if necessary; but when the trees have attained some growth, a steady horse may be used, and if the nursery is made of long rows, of course horse labour is better employed than if it is in short rows. Most of the native trees will be fit at one year old to remove to permanent plantation, and if to be so used, should be dug in the fall, and stored by burying, or in cellar, ready for early planting the next spring."

Evergreen Planting in Nebraska.

As to the proper season for planting evergreens, the author of an article in the Fourth Report of the Nebraska State Board of Agriculture, remarks :—

"The exact time when evergreens should be moved has excited much discussion, and there is a wide difference of opinion as to the proper season. My experience after repeated trials, is that just when the buds first begin to swell in the spring is the time; while those removed after they have grown an inch were mostly failures. While a deciduous tree, when planted, is without leaves, an evergreen has an abundance of foliage to give off evaporation. Just at the time mentioned, the spongioles have commenced vigorous action; the resinous sap is thinned, and what is needed to secure a new growth is careful handling; see that the earth, which should be in close contact with the roots, is finely pulverized, and avoid by all means giving too much water. To insure the growth of any tree a certain amount of warmth in the soil is necessary. This cannot be found when the planting is done early in the spring, and in consequence the fibres lose their vitality and are unable to draw the required nourishment. Advantage should be taken of cloudy days, when both roots and tops are not exposed to the hot sun or drying winds, and, if the ground is moist, sufficient water only is needed to settle the earth about the roots, and then mulching to some distance round the tree will retain the moisture and keep down the weeds."

Rules of E. Ferrand on Evergreen Culture (Nebraska).

Suggested by Ten Years' Experience as an Evergreen-tree Raiser, and Ten Years as an Evergreen-forest Planter.

"1st. Never plant your evergreens in the fall of the year, but do it in the spring as early as you can obtain the trees.

"2nd. Do not set your trees in the ground deeper by an inch than they stood in the nursery. Use no manure of any kind in planting evergreens or larch, but let the soil be mellow and friable, without lumps in contact with the roots.

"3rd. Do not plant trees under two years' old even for stocking a nursery, and for the garden and lawn give the preference to trees one to three feet high.

"4th. Never dig deep among the roots of your trees, but keep the soil mellow and moist at the surface by a high mulching of bruised straw or hay, that will prevent the weeds from growing.

"5th. Last, but not least, get your trees direct from a nursery, carefully avoiding

trees that are hauled in by peddlers in the fall, because such are always killed at the root, notwithstanding their green appearance; and here allow me a little digression. Give your preference to home nurseries. You have men here engaged in the business, who have spent their life-time judging what varieties of trees you could better plant, for your profit and success."

Method of Cultivation by a Winner of a Prize.

A statement made by Hiram O. Minick, of Nemaha County, Nebraska, to whom a premium was awarded for the cultiuation of a grove of not less than 1,000 trees, gives the following account of his method of cultivation:—

"The ground was ploughed in the spring, the same as for a crop of corn, and crossed out at distances of five feet by seven. The cottonwood yearling trees were procured on a sand-bar in the Missouri River, in the fall previous, and hauled in during winter. By selecting a spot on the sand-bar where the surface of the sand is but little above the water in the river, the yearling trees can be pulled out with great rapidity, probably at the rate of a thousand in twenty minutes, the operation being similar to pulling flax, and the trees can thus be taken up preserving their rootlets entire, thus securing them in the best possible condition for transplanting; and taken at this age they receive but little check in their growth by the operation. Part of my grove was planted with the spade, the operation being the same as for a hedge. Another part of the grove was planted by drawing a deep furrow with the plough, and dropping the trees at the crossings of the furrows, the roots in the furrow and the tops projecting out, and then cover by throwing another furrow-slice upon the roots and base of the stock with a plough. This left the trees leaning at an angle, say of forty-five degrees, and fearing this position would be injurious to the trees, I took the pains to place some of them carefully erect; but upon an examination of the trees, after one year's growth, no difference was perceptible in those left leaning and those straightened up, as they invariably start their growth from a bud near the base of the stock and grow erect. The portion of my grove, composed of cottonwood, contains about 3,000 trees, and was the work of two men, a boy and team, one day planting. This required one hand and horse, two days each year, to five acres of ground, The maple portion of my grove was planted by preparing the ground the same as above and dropping the seed (which had been procured from trees on the Nemaha River), in the furrow, and covering with the harrow, and cultivating as above. The seed ripens about the middle of May, and is generally very abundant. The following may be considered as a fair estimate of the cost of the grove:—Hand and team one day procuring trees, $3; two men, boy and team employed in planting, $5; ploughing ground, $5; two years' cultivation of trees, $9. Total, $22."

TIMBER GROWING IN NEBRASKA.

(From an Article by J. W. Davidson).

"The best method of stocking our prairies with timber, is to prepare the soil precisely as you would if you were going to raise a large crop of corn. The quickest way to raise a grove is with cuttings of cottonwood or willow. I plough, drag and mark the same as for corn, four feet each way, which will contain 2,722 hills to the acre. I should plant one-half to trees, four feet one way and eight the other, making 1,631 trees, and the other in corn for two years, to pay for cultivation, and that is all the cultivation needed. I should adopt the same plan in planting acorns, hickory-nuts, white and black walnuts, soft maple, elm and ash, where the sprouts are one year old. White pine, arbor-vitæ, red cedar, European and American larch, when large enough to transplant, require more

cultivation. I estimate the cost of preparing an acre, and getting the cuttings of soft maple or ash (they can be had by the thousand along our streams) at $3 per acre. A man can plant two and a-half acres per day. That is all the cost for ten years, except interest and taxes on land. I have 1,361 trees per acre; seven years from planting, I will cut one-fourth, or 340 trees, equal to fifteen cords of wood; the eighth year fifteen cords more; the ninth the same; the tenth year you see my profits. I should cut what is left, 456 trees. Allow four trees to the cord, so as not to overestimate it. I have several trees only ten years old, which are fourteen inches in diameter and fifty feet high; four, I think, would make a cord. Allowing six trees to the cord, we have seventy-six cords, and with forty-five cords cut before, 121 cords. At $3 per cord, allowing $1 for cutting, I have $242. I contend that five acres planted to cottonwood, after a growth of seven years, will furnish one family with fuel for one stove a life-time, and sell enough to pay for the use of the land besides. I claim, after fifteen years' experience in tree-planting on this plan, which I adopted last spring, on Arbor Day, on my new farm in Otoe County, Nebraska, that the white willow is equal to soft maple for wind-breaks and fuel, and superior to all trees for rapidity of growth, as well as good for timber. Chestnut, too, is super-excellent. The climatic influence of timber is discernible in the regular attraction of rain and tempering the chilly winds of winter."

PLANTING IN NEBRASKA.

(From an Article by James Morris.)

"What shall we plant in Nebraska that will most quickly and fully meet our requirements?" Shelter and shade are our immediate and imperative necessity. To provide these we unhesitatingly recommend, first of all, our native trees, in the following order; soft maple, willow, cottonwood, buckeye, ash. The maple is raised from the seed as easily as corn; makes a good shelter when strictly planted in rows, and a grateful shade where room is given to its lateral branches. It furnishes a fuel, which, though it does not consume as slowly as oak and hickory, makes a good hot fire. The willow, objected to by many as a harbour for insects, yet offers a complete break to the keen winds, grows rapidly to a good size, and some varieties, as the white and the weeping willow, furnish good timber for fuel and manufacturing purposes. The common osier, planted upon wet spots, will pay as well as any other crop on the farm. Cuttings of all varieties are easily and cheaply secured.

"As a source of profit the raising of trees in Nebraska ranks next to the raising of stock. A quarter section planted with chestnut, spruce, larch, maple, mammoth aspen, or even inferior trees, would, in ten years, yield a satisfactory return for the investment."

Close Planting of Cottonwood.

"Judge Whiting, of Monona County, Iowa, remarked in 1869, that he had at first planted cottonwood eight feet apart each way, giving each tree sixty-four square feet of ground. They grew well, but too many branches in proportion to the amount of body of wood. He had adopted the rule of planting three feet each way, giving nine square feet to a tree, and in this order they grew tall and straight, soon shaded the ground, and in three years needed no further cultivation than thinning as became necessary, by removing alternate rows and drawing out the poles with one horse and a chain."

SUGGESTIONS ON PLANTING—(Iowa Experience.)

Mr. Suel Foster, of Muscatine, Iowa, in a prize essay on forest-tree planting, offers the following suggestions as applicable in his State :—

"The larch is of tolerably rapid growth ; growing half-an inch or more in diameter each year for the first ten years, and the next ten years fully equal to one inch. This is in size equal to our black walnut, and it grows much better and straighter. The little trees should be bought of nurserymen, for it is a nice and particular thing to raise the larch or evergreens from seed. I would recommend to the farmers of Iowa to buy European larch at two years old at $10 to $15 per thousand. They should be set in nursery rows, four and a-half feet apart, and one foot in the row, so that when one row is taken out it will make a waggon-road through the grove. Larch must be moved very early in the spring, for they are among the very earliest trees to start to grow. The ground should be ploughed very deep in the fall, then ploughed in the spring, as soon as possible ; harrowed and pulverized very finely by turning the harrow bottom up the last time. Then stretch a line and set with a spade. Have a mud-hole to dabble the roots all in. While the man uses the spade, a boy can handle plants. About 2,000 will be a day's work, and will cover about a quarter of an acre. They must be carefully ploughed and hoed for two years, and if the weeds start too quick in May and June, the third and fourth years they should be ploughed.

"Cost—8,000 plants for an acre, $80 ; setting out, $8 ; ploughing and hoeing the first year, $8 ; ploughing and harrowing the land before setting, $4 ; second year, $4 ; two years after, $4 ; interest on the land at $50 ; eight years, at 8 per cent.=$32. Total cost of an acre of European larch, at eight years, $140.

Planting of the Ash.

"Mr. J. L. Budd, now of Ames, Iowa, in a paper published in the Transactions of the Northern Illinois Horticultural Society (1867-'68), advises keeping the seeds of the ash through the winter in kegs or boxes, mixed with clean moist sand, taking care that they become neither too wet or too dry. Freezing will do no harm. The ground should be marked and prepared as for corn, and planted at the intersections, placing four to six seeds in a hill. They should be carefully cultivated, and the next spring thinned to one plant in each hill, the vacancies being supplied. By planting thus thickly, the young trees get a straight growth. At the end of six years, every alternate row north and south should be thinned out, and at the end of ten years every alternate three in each row. When twelve years old, on good soil and with proper culture the first four years, the grove would have 12,000 trees on 10 acres, averaging eight inches in diameter. By cutting the stump close to the ground, and covering with a light furrow on each side, a second growth is obtained in eight or ten years more valuable than the first."

Professor C. S. Sargent, in speaking of this timber, says :—

"To develop its best qualities the white ash should be planted in a cool, deep, moist, but well-drained soil, where it will make a rapid growth. That the plantation may be as early profitable as possible, the young trees should be inserted in rows three feet apart, the plants being two feet apart in the rows. This would give 7,260 plants to the acre, which should be gradually thinned until 108 trees are left standing, twenty feet apart each way. The first thinning, which might be made at the end of ten years, would give 4,000 hoop poles, which at present price would be worth $400.

"The remaining thinnings, made at different periods up to twenty-five or thirty years, would produce some three thousand trees more, worth at least three times as much as the first thinnings. Such cuttings would pay all the expenses of planting, the care of plantation, and the interest on the capital invested, and would leave the land covered with trees capable of being turned into money at a moment's notice, or whose value would increase for a hundred years making no mean inheritance for the descendants of a

Massachusetts farmer. The planting of the white ash as a shade and road-side tree is especially recommended, and for that purpose it ranks, among our native trees, next to the sugar-maple."

CALCULATIONS OF COST OF GROWING PINE TIMBER.

"Mr. Sönson, a highly intelligent Norwegian gentleman, who has made a large fortune in the timber trade, informed me some time ago that, according to a calculation which he had made, pine and spruce timber actually costs and is worth much more than the price at which it is sold. His theory is, that an acre of grown timber is worth the sum that the lowest or nominal price of wild land—say $1 an acre—would amount to as an invested capital, drawing interest at the expiration of the period required for timber to develop. In the report on Swedish forest culture, it was shown that in the northerly parts of Sweden, two hundred years,—and on poorer soils three hundred years, are required for the pine to grow to good timber. In the south part of the country one hundred years are sufficient. It may be assumed that one hundred and eighty years are required for the growth of pine timber in the north-west part of the United States. Now, $1 invested at 5 per cent. interest per annum, will double say, in twenty years. In forty years it will be $4; in sixty years, $8; in eighty years, $16; in one hundred years, $32; in one hundred and twenty years, $64; in one hundred and forty years, $128 and in one hundred and sixty years, $256. If a thing is worth what, under favourable circumstances, it costs to produce it, then this last mentioned sum of $256 represents the value of an acre of land originally bought at $1, at the time pine timber will have come to maturity upon it, and this without including the charges of taxes on the land. These figures would seem to show that the pine forests of the United States are being or have been sold and consumed at a price very much below their actual value.

"In years past vast quantities of pine timber in the north-west part of the United States have been stolen from the Government, and at the very time the latter was employing agents to guard it. In very many instances, after the timber has been stolen, innocent parties, supposing from the official maps that the land was timbered land, have purchased it from the United States at private entry, at $1.25 per acre. Interest on the purchase money, and taxes have in the course of twenty years, made such lands cost the owners from $3 to $4 per acre, and yet the land would not bring fifty cents per acre. Many a man has been kept poor paying taxes on such lands. Again timber-lands have been sold off in such large quantities and so rapidly as to glut the timber market.

"But a more important fact still is that no means have been taken to promote regrowth. Where hardwood timber is cut there is always a chance for regrowth by sprouts from the stumps and roots, but with pine and spruce it is otherwise; and where closely growing forests of pine and spruce are cleared without leaving seed-trees, the land may remain for ever a waste, growing every year more barren.

"In the report above referred to, it was shown that the practice in Sweden when cutting pine timber is to leave six or seven seed-trees to about each quarter of an acre. After five or six years the seed trees may be cut."

Profitable Method of Cutting.

A suggestion of management in some degree comparable with European methods, was made by Peter Guillet, in a work on timber-measurement published in 1823. He says:—

"Individuals wishing to make the most of their woodlands will find it very profitable to cut their timber by sections, sparing to every acre ten or twelve of the most promising size white oaks or pines, whichsoever the soil will produce best; range the order of their land so as to cut a section every year. For example, say a man has 200 acres of woodland divided into sections of ten acres each, then, by cutting one section every year, he would have young timber twenty years old which makes excellent firewood, and I

should say that in common lands, wood of twenty years' growth would yield fifteen or twenty cords of firewood per acre, besides fencing timber sufficient to always keep in repair an inclosure of two hundred acres. Then the ten or twelve trees growing in reserve, will, at the end of eighty or one hundred years, furnish timber fit for shipping or staves. Where land has become useless from long cultivation, a little trouble only is necessary to make it productive and profitable to the owner. By enclosing it for a few years and encouraging the growth of the most promising young trees, which will generally spring up spontaneously, all the advantages above described will be derived from it, which is certainly the best way that worn out or sterile land can be disposed of. Such a course recommended to and adopted by individuals would not only be to their own private gain, but also of great public utility."

A New-Hampshire Experience.

"The Hon. Levi Bartlett, of New Hampshire, has given in the result of his experience, an interesting illustration of the profits that might be realized from tree-planting in this State, covering a period of above fifty years. A tract had been cleared and thoroughly burned over in a very dry season, about the year 1800. It immediately seeded itself with white and Norway pines, and about twenty-five years after came into his possession. He at once thinned out the growth on about two acres, taking over half the number of the smallest trees, the fuel much more than paying the expense of clearing off. From that time, nothing was done with the lot for the next twenty-five years—having sold it, however, during that time. Upon examining it, he found that, by a careful estimate, the lot which had been thinned was worth at least a third more per acre than the rest which had been left. It was worth at that time at least $100 per acre. He thought that had the land been judiciously thinned yearly enough would have been obtained to have paid the taxes and interest on the purchase, above the cost of cutting and drawing out, besides bringing the whole tract up the value of the two acres which had been thinned out.

"At the time when this part was thinned (twenty-five years from the seed), he took a few of the tallest, about eight inches on the stump, and forty to fifty feet high, and hewed on one side for rafters for a shed. At the next twenty-five years (fifty from the seed), he and the owner estimated that the trees left on the two acres would average six or eight feet apart. They were mostly Norway pine, ten to twenty inches in diameter, and eighty to a hundred feet high. He was greatly surprised seven or eight years after, to see the increase of growth, especially the two acres thinned thirty years before. The owner had done nothing except occasionally cutting a few dead trees. It was now the opinion of both, that the portion thinned out was worth twice as much as the other; not, however, that there was twice the amount of wood on the thinned portion, but from the extra size and length of the trees, and their enhanced value for boards, logs and timber. There were hundreds of Norway and white pines that could be hewn or sawed into square timber, from forty to fifty feet in length, suitable for the frames of large houses, barns, and other buildings. There were some dead trees on the two acres thinned at an early day, but they were only small trees shaded out by the large ones. On the part left to nature's thinning, there was a vastly greater number of dead trees—many of them fallen and nearly worthless. Of the dead trees standing, cords might be cut, well dried, and excellent for fuel. Estimates were made that this woodland would yield 350 cords of wood, or 150,000 feet of lumber per acre. Allowing that these were too large, the real amount must have brought a very large profit on the investment."

The following from Mr. Emerson, of Massachusetts, is valuable especially in its suggestions of what might be done to improve our present forests:

"On nearly every farm in Massachusetts, more land is under cultivation than can be profitably managed. Many acres now in tillage might, with great advantage be turned into forest, and the labour and manure which have been spread upon them, be used in the better cultivation of the remaining acres. All that portion of every farm which is

hilly or very stony, and all that does not readily bear good crops of corn and grass, may be, at comparatively little expense, sown with the seeds, or set with the young plants of the most valuable forest trees. The sowing or the planting should be very liberal, the young trees, when close together, protecting each other, and the poorer ones, when the plants become too close, affording excellent fuel, and serving, as they grow large, many important purposes. In this way a valuable permanent wood-lot might be added to farms, the owners of which are now obliged, at large cost, to get their fuel from other sources.

"Much is to be done for the improvement of woodlands now existing. In some cases they are managed with great care; the best means of thinning, pruning and felling, are studied and practised. But in many cases—indeed, in most instances—they are left in utter neglect. The consequences are often very visible. In the cedar swamps just spoken of, the natural seed-sowing has been so profuse, that the plants spring up thick enough to almost cover the ground. Ten or twelve may sometimes be seen on a square foot. These grow up well together for a year or two. Afterwards they seem to be struggling for existence. The growth of all is retarded—almost stopped. In a few years the strongest overtop the others, which gradually die. Still the number left living is far too great for the ground, and few of them become fine and vigorous trees. All the side branches die for want of light and air, and the topmost shoot, never sufficient to form a shapely tree, is left alone. The same thing takes place in beech groves. Ten or twenty times as many plants spring up as can be sustained. They go on together vegetating, but hardly growing. I know instances of beech woods, which have made little perceptible growth for twenty years. . . The remedy is obvious. Every year, from the first, they need to be thinned. For the first few years the plants removed are of no value except for transplantation for fuel. Afterward they are of use in innumerable ways; the young cedars, larches, and chestnuts, for stakes and poles; hickories for walking-sticks; oaks and ashes for basket work; lever-wood and hoop-ash for whip-stocks and levers; all of the five latter for hoops. The products of the thinning will thus obviously far more than repay the labour, even if this were not necessary for the welfare of the remaining trees."

Mr. Fay, of Massachusetts, says:—

"When I bought my place, except a few stinted red cedars at Parker's Point, and some white cedars in the swamps, there was not an evergreen tree within three miles of my house, and hardly any tree of any kind in sight of it. The woods (oak, beech and hickory) were in the dells and valleys behind the hills fronting the sea, and it was maintained that trees would not grow and could not be made to do so, in the face of the salt-laden winds from the south and south-west. The exposure was certainly great and the soil poor, and trees planted singly or sparsely, perhaps, could not have resisted it, but close planting made a shelter, and those not specially from an inland habitat (like the white maple) have done well, and seem to the manner born.

"In twenty-three years after commencing to plant, Mr. Fay has a plantion of 125 acres, of which he had sown a hundred broad-cast and planted twenty-five. The plantation consists largely of pine, spruce and larch; they have succeeded well and are generally about thirty-five or forty feet high, and a foot through at the ground. Mr. Fay says that he planted these trees as a matter of taste and experiment, but that if he had sought a market, there would have been a profit already in the sales of wood. He has endeavoured, he says, to raise a forest about him at the least possible cost of labour, and not looking much to the hurrying of the result or to count up an early profit. The land was denuded, and exhausted, and moss grown, and he took this method to cover it with verdure and restore it, believing that the wood would compensate him or his heirs sooner or later. . . . . In closing his discursive remarks, he says that, considering the position of his place, exposed on the north-west to the violent winds of winter sweeping across Buzzard's Bay, and in summer to the strong breezes from the south-west, bringing salt spray from Vineyard Sound, the vigorous growth and promising appearance of his forest plantation is very encouraging to those more favourably placed. Not only may the destruction of our forests be partially remedied at a cheap cost, but the waste and sterility of our land by long cultivating and pasturing, be removed and replaced with fertility by

the simple process of nature. It is much also, to restore shade in summer and shelter in winter, by the renewal of our forests."

Mr. Morrill Allen, of Pembroke, Mass., says: "A man in Bristol County, about fifty years ago, planted a field somewhat exhausted, with acorns; when the young trees were two or three inches high he ploughed and hoed as in a field of Indian corn; the trees grew, to the astonishment of the whole neighbourhood, and in less than forty years were ripe for the axe. About a century since there was an experiment in this town in planting the white oak for ship-timber, the success of which ought to have encouraged frequent repetition. The grove was in cutting for timber thirty years since, and a man between seventy and eighty years old told me that in his boyhood he assisted in planting those trees. It is not to the existing generation so helpless an undertaking as some would represent it, to plant forest-trees, even those of slow growth. I recollect measureing the circumference of an oak tree in West Newbury, the acorn of which was planted by Benjamin Poore, who is yet comparatively a young man, and I think it measured twenty-seven inches. It is a well-proportioned, handsome tree. Had he planted at the same time fifteen acres of similar soil it would have become before now an inexhaustible wood-lot for the use of one family.

"Another gentleman, also of the name of Fay, of Essex County, commenced, in 1846, planting on his estate near Lynn, in Essex County, and in that and the two succeeding years planted 200,000 imported trees, to which were afterwards added nearly as many more, raised directly from the seed, nearly 200 acres being covered in all. The sites of these plantations were stony hill-sides, fully exposed to the wind, destitute of loam, their only covering a few straggling barberry bushes and junipers, with an abundant undergrowth of woodwax, always a certain indication, in Essex County, of sterile soil. He employed in his plantations oaks, ashes, maples, Norway spruce, Scotch and Austrian pines; but the principal tree planted was the European larch. No labour was expended on the land previous to planting, the trees, about one foot high, being simply inserted with a spade; and no protection has at any time been given them, save against fire and browsing animals. I recently visited these plantations, twenty-nine years after their formation, and took occasion to measure several of the trees, but more especially the larches. Some of these are now over fifty feet in height, and fifteen inches in diameter three feet from the ground, and the average of many trees examined is over forty feet in height and twelve inches in diameter. The broad leaved trees have also made a most satisfactory growth, and many of them on the margins of the plantations are fully forty feet high. During the past ten years about 700 cords of firewood have been cut from these plantations, besides all the fencing required for a large estate. Firewood, fence-posts, and railroad sleepers, to the value of thousands of dollars, could be cut to-day, to the great advantage of the remaining trees. The profit of such an operation is apparent, especially when we consider that the land used for these plantations did not cost more than $10 an acre, and probably not half that amount."

Mr. Henry Ives, of Batavia, Genesee County, New York, in a communication to the New York Farmers' Club in the spring of 1876, states the result of experience in tree-planting as follows:—

"Five or six years ago I planted two acres with four-year-old seedlings of white elm and soft maple into forest rows, sixteen feet apart and three feet apart in the row. Now the best of them are twenty feet high and twelve inches in circumference, and for thinning out the rows I sell trees for more money than wheat would have brought, grown for these years, and I can continue to sell so until they are so large that I can take them for fire-wood, and I am growing a good crop of orchard grass between the rows. So that these acres in forest timber are paying as well, and are likely to pay for years to come, as any other acres on the farm. I am cutting now the second crop of wood, where the first or original timber was taken off about twenty-five years ago, and last winter 1,000 rails were taken by a neighbour from one-third of an acre of growth, besides a quantity of wood from the top, and timber not making rails. Another neighbour used nice black

walnut lumber in building a fine farm house, sawed from the trees he had helped to plant when a boy."

The late Horace Greeley, in speaking of the available opportunity for timber culture in West Chester County, remarked :—

"I am confident that ten thousand acres might to-morrow be given back to forest, with profit to the owners and advantage to all its inhabitants. It is a fruit-growing, milk-producing, truck-farming country, closely adjoining the greatest city of the New World; hence one wherein land can be cultivated as profitably as almost anywhere else. Yet I am satisfied that half its value may be more advantageously devoted to timber than to grass or tillage. Nay, I doubt that one acre in a hundred of rocky land—that is, land ribbed or dotted with rocks that the bar or the rock-hook cannot lift from their beds, and which will not, as yet, pay to blast—is now tilled to profit, or ever will be until it shall be found advisable to clear them utterly of stone breaking through or rising within two feet of its surface. The time will doubtless arrive in which many fields would pay for clearing of stone, that would not to-day. These, I urge, should be given up to wood now, and kept wooded until the hour shall have struck for ridding them of every impediment to the steady progress of both the surface and the subsoil plough.

"Were all the rocky crests and rugged acclivities of our country bounteously wooded once more, and kept so for a generation, our floods would be less injurious, our springs unfailing, and our streams more constant and equable; our blasts would be less bitter, and our gales less destructive to fruit; we should have vastly more birds to delight us with their melody, and aid us in our not very successful war with devouring insects; we should grow peaches, cherries, and other delicate fruits, which the violent caprices of our seasons, and the remorseless devastations of our visible and insect enemies, have all but annihilated; and we shall keep more cows and make more milk on two-thirds of the land now devoted to grass than we actually do from the whole of it. And what is true of West Chester is measurably true of every rural county in the Union."

The advantages of wind-breaks are set forth by Judge C. E. Whiting, of Iowa, from his own experience as follows :—

"I have, in belts around my fields, varying from single to twenty rows of trees, mostly planted 4,356 to the acre, about forty acres of timber. The trees in these belts vary as to the time of planting; some are eighteen years old and some only one year planted; the greater portion are, however, from five to twelve years of age. The needed thinning of these belts furnishes all the wood that is wanted on the farm, including stakes and rails to keep the fences in repair, posts for all repairs needed, and many for new fences I annually build in extending my farm. When my walnuts get a little larger I will have all I need and many for sale. There is not a stick of needed timber on the farm, from a pea-brush, a grape-vine stake, or a binding-pole, up to a fair-sized saw-log, that cannot be had from my groves, without cutting a single tree that does not need thinning out from the groves.

"About five miles of my timber-belts are so planted that I have commenced using the standing trees for fence-posts. Where a light fence is not needed, with the use of the barbed wire, and a little change in the staple, the use of these live posts is a perfect success. Strongly and urgently as I have heretofore advocated the planting of thick belts of timber round our fields, each year but confirms me in the opinions then expressed. The land that remains will, year after year, produce larger and more certain crops than the whole field would produce without such protection. I also repeat that, in spite of all the learned discussions and scientific theorizing in regard to the cause of our timberless prairies, our cultivated forest trees, year after year, grow right along with immense rapidity, in blissful ignorance of all the reasons *why they should not grow.*"

Hon. J. Sterling Morton, of eastern Nebraska, lays down his rules, and mentions his results, as follows :—

"First, the original sod should be broken and turned over in thin, evenly-laid strips. When completed, a good breaking will appear, like a vast floor of well-laid two-inch plank, painted with lamp-black. Then plant and cultivate, not to see *how much* you can manage, but *how well*. Then come trees; walnuts, cottonwoods, willows, mulberries, and elm will make the home seem civilized. Tree-planting is an avocation that barbarians never follow. Indians never adorn their wigwams with orchards, nor indulge in floriculture. There is no record of an aboriginal horticulturist in any book I have read or heard of anywhere. It may seem a long time to raise a saw-log from the walnut which lies in the palm of your hand, but the rain and frost of winter and the sunshine of summer, together with the fertile and forcing soil of Nebraska, crowd a walnut into the dimensions of a respectable saw-log in less than twenty-five years. Upon a farm where I have lived, in Otoe County, for more than twenty years, one may see black walnut trees which will make good railroad ties, and some which will do to saw up, which I planted with my own hands. . . . And again there may be found cottonwood sawlogs growing there which are more than six feet in girth, and when I first saw them they were only wandering germs, floating in the air, like down from a bird's breast. But they are adult sawlogs in 1876. These remarks, somewhat egotistical though they may be, are made for the purpose merely of impressing you, and through you the farming people, with the tree-possibilities of this State, and I only preach in this regard what I have faithfully put in practice, and the witnesses of the truth of my theories stand majestically verifying me all over the farm whence this is written to you, in the form of beautiful, thrifty, and valuable fruit and forest trees. Come down and see them, and in the hot summer days, while you rest in their shade, even their foliage will tell you in whispering with the wind how pleasant and profitable a thing it is to plant the prairie with trees."

The following shows in how short a time firewood may be procured from the planting of trees :—

"Twenty years ago cordwood sold in Nebraska city for seven or eight and sometimes ten dollars a cord, and that, too, when her population was not one-fifth what it is now; and notwithstanding the demand for fuel is at least ten times greater now than in 1857, it is a fact that good merchantable wood can be bought in our streets for from $3.50 to four dollars per cord. The reason of this is simply from the fact that the natural groves have been protected from fire, and the artificial groves are turning out an abundance of good wood, such as the necessities of the country demand for fuel. It will agreeably surprise any one not acquainted with the fact to know the amount of timber one acre of land will produce in the course of ten years. Mr. Richard Justice, who came here (Otoe County) in 1857, and planted about ten acres of cottonwood in 1859, has one or two outhouses built from hewed logs taken from that grove, and the family have all the fuel they need. Hundreds of such cases might be mentioned throughout the eastern portion of the State, did space permit."

Mr. George Stanton, of Simcoe, Ont., writing to the Hon. H. G. Joly, says :—

"You know that this Long Point country was a great black walnut district, and on the Lake Shore there are still quite a few trees left. I have measured to-day, some five trees, and got their ages as near as I can, relying on what the owners have told me. The first tree that I saw, measured five feet eight inches, four feet from the ground, and is twenty-four years old; it is growing on very rich black sandy loam.

"The second measures five feet four inches, three feet from the ground, is thirty years old, on very light sand. The third and fourth measure twenty-three and one-half and twenty-four and one-half inches respectively, three feet from the ground, and both are eleven years old, on good clay ground, but were transplanted when young. The age of these trees the gentleman told me he was sure of.

"Number five measures seven feet eight inches, five feet above the ground, is fifty-five years old; this tree is on very light sandy soil. I mean in all the measurements, the *circumference* of the trees.

"You see from this that the soil has everything to do with the growth of a tree; the richer the soil the more rapid the advance, and, therefore, I hope that by putting my trees on rich virgin clay soil, I shall have a *return in about twenty-five years.*"

Mr. James T. Allan, of Omaha, Nebraska, writing to the last American Forestry Congress, says that there is a very rapid increase of forests in this comparatively new State, and that to-day there are forty-three millions of forest trees growing where, but a very few years ago not a tree could be seen on her wide prairies. There are thousands of stock farms in Nebraska, the owners of which are practical tree-planters. The value of groves and belts of the fast-growing poplars and white willow is well understood, and this protection for animals against driving storms, in a country where lumber is not cheap or plenty, seems to have been ordained to meet the want. But this want of lumber for all the needs of the farm will not long exist. Hundreds of groves of the earliest planted can now furnish work for the portable saw-mill, and these too, are the once despised soft woods, those of the most rapid growth which are now prepared to equal pine in durability.

The commencement of tree-planting by the Union Pacific Railway, which has yet been confined to deciduous trees of some ten varieties, and mountain evergreens about their stations, so far is successful, and will soon make these grounds objects of pleasant attraction to the thousands who are daily moving across the continent. The intention of the railway is to plant tracts of considerable extent at different points for a future tree supply, and by example induce others to plant the seeds for a crop of railway sleepers, which must be early harvested.

Mr. W. M. Pennel, of Russel, Kansas, says:—

"At least one-half of my 6,000 black walnut trees are bearing fruit this season. 3,500 box alder (ash-leaved maple) transplanted this spring, are all living; and notwithstanding the severe drought which is now parching our section of the country, my trees are making a fine growth."

Mr. John Dougall, Editor of the New York "Witness," contributed to the American Forestry Congress, such a concise and complete *resumè* of the whole subject that I insert it here:—

"The greater part of the North American continent was covered with forests when first invaded by Europeans. These forests had stood for many ages undisturbed, except by the slow decay of one generation of trees, if we may so speak, and the slow growth of another. These operations had been going on simultaneously since the creation, or since the last great convulsion of nature, and the annual falling of leaves and the gradual decay of branches and trunks had covered the earth with a vegetable mould of considerable depth.

"*A Universal Mine of Wealth.*—This mould, possessing all the elements of fertility, was an immense treasure, everywhere abounding, and tempting the settler to clear away the trees, and reap the benefit of the virgin soil. When trees were cut down, a crop, which had probably required several hundred years to grow, was reaped in a few weeks or years, thereby leaving the earth bare, and the vegetable mould was used up in a few years by continued cropping in wheat, corn and potatoes. The writer knew an excellent bush lot which produced great crops at first to be reduced in ten years to mere rocks and stones. And this process of exhausting the vegetable soil went on everywhere as fast as settlements advanced. Of course where the subsoil was good, and was turned up in part to mix with the vegetable mould, fertility continued much longer, but, in course of time,

all except prairie lands were reduced so much in fertility as to require the application of fertilizers at great expense. Had the soil at first required these fertilizers the progress of settlement would have been exceedingly slow or more probably there would have been no progress at all.

"*War against Trees and its Effects.*—The labour of cutting down great trees, cutting them into short logs, and piling them into log heaps to burn, was, however, so great that a feeling of dislike to trees as the settlers' natural enemy became general and the vengeance against them was so great that in extensive regions the land was completely bared, and thus rendered not only unsightly but unsheltered. Bleak winds had full play and droughts parched the earth. What was even worse, the clearing away of trees on the hills and mountains by the settlers, the lumbermen and forest fires, left the snow of winter exposed to the spring sun; and the sudden melting and running off of this accumulation of frozen water made dangerous floods in the streams in early summer and left those streams nearly dry in the hot season.

"*Calling a Halt.*—At length the evil results of the indiscriminate cutting down of trees began to be perceived. The improvidence of previous generations was lamented, and efforts to conserve what forests were left and to plant trees gradually became popular. The first class of efforts was directed to preserving a few acres of the original forest in each farm where that still could be done, and merely thinning the trees for firewood, fencing, etc., thus leaving the smaller trees room to grow more rapidly. The grove thus preserved became one of the most necessary and valuable portions of the farm, and that without any labour of ploughing, sowing, or cultivating. It also afforded a delightful shade in hot weather for man and beast.

"*Forests in the Territories.*—The preservation of the vast forests in the territories belonging to the nation attracted attention also, and laws were enacted to protect them from wanton waste. Secretary of the Interior Schurz distinguished himself for endeavouring to enforce these laws, which are very difficult of execution on account of the opportunities lumbermen have in an almost uninhabited region of cutting trees on Government land, and the frequency of forest fires kindled by careless Indians, hunters, trappers, lumbermen and settlers. These fires often do more damage to a forest in a few days than lumbermen could do in as many years, and how to prevent them is as yet an unsolved problem.

"*Forestry Laws.*—The only remedy, and that only a partial one that can be suggested, for the wanton destruction of forests, is a national system of forestry laws, somewhat similar to those of France, Germany, Austria, Norway, and other European countries, which prohibit under severe penalties the injury or destruction of trees by unauthorized persons, and also the kindling of fires, or even smoking in the woods. A forest police was created to see to the execution of these laws, and at the same time providing for the utilizing of forests by gradual thinning out and selling the larger trees, so as to leave more room for the smaller ones. In this way the public forests are an annual source of revenue, and after centuries of such management they are in as good condition as they were at first."

I will here insert, also from the Forestry Congress, the statement of a gentleman of great practical knowledge, concerning the first steps to be taken by any who may wish to make plantations from seed for themselves. Mr. D. W. Beadle, of St. Catharines, said :—

"It has occurred to me that there may be farmers who are obliged to go to nurserymen for young trees when they want to plant them either for useful purposes or for ornamentation, and if they want to plant largely they may find it impossible to get them in sufficient quantity from nurserymen, who generally confine the planting to fruit trees, and they have not grown, to any large extent, forest trees for the sake of timber. But these parties can form a nursery of these trees themselves by procuring a small piece of ground, and have it especially prepared and well manured, so that there will be strength in the soil for a few years, and then they can raise whatever kind of tree they want. The seeds of elms, maples, ashes, and of the walnut and butternut can be found in almost

any part of the Province. The important point in planting by seeds is that they should be planted as soon as perfectly ripe. Some of our trees ripen their seeds quite early. The soft maples, the dasycarpum and rubrum, and the elms, ripen their seeds in June. These maples ripen their seeds in June, and it should be gathered and sown at once so that you can get a tree of considerable growth before the winter season. The seed of the elms should also be sown at once; it should be sown in drills not deeply, but very lightly. These small seeds require to be covered with only sufficient earth to keep them moist, and they will produce plants in a very short time, and gain sufficient strength to tide over the cold season. If, however, you are not in a position to sow the seed at once, and wish to keep them till the next spring, they should be mixed with sandy soil and kept damp, yet not so damp as to cause them to germinate, and not be allowed to get dry. In this way you may preserve them with safety. If kept dry in papers some of them will have vitality in the spring, but very many of them will not germinate the next season, and the proper way to preserve them is to mix them with moist earth. But it is not true of all the maples that they ripen their seeds so early in the season. The sugar maple ripens its seeds late in the autumn, as well as the ash-leaved maple, and unless you wish to sow them in the autumn, you have to preserve them and sow them in the spring. Now come to the butternuts, chestnuts and walnuts; these all ripen in the late autumn, and, in suitable soils, may be planted as soon as gathered, and allowed to freeze and thaw with impunity, as they will not suffer therefrom, but will generate freely in the spring. But in soils which lie under the effect of alternate freezing and thawing, it will be better to mix the seed with soil in sufficient quantity to keep the seeds moist, and prevent them from moulding, and keep them until spring before planting, or they may be spread out very thin upon the ground, and covered with a sod, in which manner they will keep fresh. It is not necessary that the nuts will be subjected to frost, that is a matter of perfect indifference; the important thing is not to permit them to become dry. These trees can be grown in nursery fashion, until they attain sufficient size to be planted where they are to remain, especially the elms, maples, and ashes. The nut-bearing trees will make better growth if they be planted in the nut where they are to remain. The bass-wood ripens its seeds about September or October, generally late in the fall; those of the cedar also ripen in the fall. White cedar is propagated from seed, and when the seeds are to be preserved, they should be mixed with nearly dry earth, moist, but not wet."

Senator Allan gives some statistics, for the accuracy of which he vouches, concerning certain trees:—

"Elm trees taken from the woods as young trees of about six inches round the stem, and between eight and nine feet high, have attained in forty-five years a height and girth round the stem at three feet from the bottom, in several instances, as follows:—One sixty feet high, eight feet in circumference, at three feet from the ground; one sixty-five feet high, eight feet two inches in circumference at three feet from the ground; one sixty feet high, seven feet nine inches in circumference at three feet from the ground. Another elm planted about fifty years ago, a small tree from the nursery gardens, has now grown to a height of seventy feet, with a girth at three feet from the ground of eight feet six inches.

"A red oak, planted as a sapling about forty-eight years ago, is now nearly fifty feet high, and measures five feet eight inches round the stem at four feet from the ground.

"A maple of the same age is six feet five inches round the stem, and nearly sixty feet high, and two others planted within the same period, are six feet in girth at four feet from the ground, and between fifty and fifty-five feet high.

"All three of these were, when planted in their present position, young trees about six or seven feet high—just the size at which they can be most safely transplanted when taken from the woods.

"Of beech I have no record that I can entirely depend upon, but I believe one that I measured, which gave nearly four feet as the girth at about the same height from the ground, and was about thirty-eight feet high, has been planted over forty years.

"A butternut between forty-seven and forty-eight years old measured six feet round the stem, four feet from the ground, and has attained a height of seventy-five feet.

"Of two ash trees planted fifty years ago, one is sixty feet high, with a girth of six feet five inches; the other about fifty-five feet high, girth a little over six feet (three feet from the ground).

"It will be seen from this memorandum that the elm has made the most rapid growth of all these trees, and the maples come next, although the ash is close upon them.

"Of evergreens (native), I can only give with certainty the white pine. Two of these—both planted fifty years ago—have reached, one a height of near seventy feet, the other a little over sixty feet. One measures six feet six inches; the other a little over five feet, at four feet from the ground."

"Mr. Beall, of Lindsay, has experimented with the black walnut. These trees, in fourteen years *from the seed*, have attained a growth of some eighteen to twenty-one inches in circumference, are twenty feet high, and have borne nuts for five years."

Mr. Caldwell, M.P.P., says:—

"Lombardy poplars twenty-two years old, measured by me, are from six feet to eight feet four inches in circumference."

Mr. Beadle says:—

"Some little blocks of forest have been planted with maple trees, with a view to their sugar-producing qualities, and some of these have attained a diameter of six or eight inches, and a height of thirty or forty feet. They have been planted some years. I do not think they received any cultivation after planting."

Mr. Roy, at Owen Sound, says:—

"Ten years ago I planted black walnut seeds, and at the present time two or three of the trees bear nuts. They are not only ornamental, but coming to be very useful trees. The diameter of two or three of them now will be as much as six inches."

Mr. Galusha says:—

"A white willow which has grown from a small cutting put in thirteen years last spring, now measures six feet two inches near the ground, forming a head on top thirty feet across."

Mr. Bucke, of Ottawa, says:—

"There has been a good deal of talk before the Commission about growing trees from the seed, but if I were going to plant trees, and particularly maples, I would go into the woods and pull up seedlings a few inches high, as I am convinced they will succeed better than by any planting of seeds. I planted a number in that way, and they are the best lot of young trees I know of. I planted them in nursery rows, about six inches apart in the row, and I have succeeded in raising a large number without losing any. I trimmed the roots before planting."

REPORT OF THE HON. H. J. JOLY.

I promised my readers at the commencement of this work, that we should return to the valuable report on the forests of Canada, issued by the Hon. H. J. Joly. We will now notice what his opinion is concerning the rate of exhaustion of Canadian forests,

and we must remember that he speaks of the whole of Canada, Upper as well as Lower. He says:

"*Our forests* :—Our public forests are worked by the lumbermen under a license system, entailing ground rent and stumpage dues.

"They contain a great variety of timber, but I will principally call your attention to the pine and spruce, as they form nearly all our exports to Europe, and are really the produce of our forests; while the hardwood we export, especially the fine oak, nearly all comes, at present, from the Lake regions of the United States, as we have very little of our own left.

"For some time past, the idea has been gaining ground among men who take an interest in the future of the country, that our great pine and spruce forests are getting rapidly exhausted, and that, before long, a trade which enables us to export annually over twenty millions of dollars' worth of timber (nearly twenty-seven millions in 1874, twenty-five millions in 1875, and twenty millions three hundred thousand in 1876), will shrink down to wofully reduced proportions.

"Thinking men have begun to sound the note of alarm; we owe it to them, but especially to ourselves, as a nation, to try and find out how far their previsions are likely to prove true.

"Apart from our timber lands, a large portion of our territory consists of fertile prairies, with rare clumps of fine trees; of swamps without valuable timber, and of barren regions of rocky soil, with only a dwarf stunted vegetation. In those parts of Canada where the soil and other circumstances are known to be generally favourable to the growth of pine and spruce, and where a pretty accurate idea can be formed of the quality of timber already taken off by the lumberman, who can say, without continually renewed investigations, how much is getting swept away every year by our great enemy, the fire fiend?

"Let us now try and make an inventory of the timber resources of the Dominion, beginning in the west. On the Pacific shores of the Dominion, in British Columbia, the bountiful gifts of Providence are still stored up for us, and the forests have scarcely been attacked by the lumberman. How long those treasures will last us, and what advantages we shall derive from them, depends, in a great measure, upon ourselves.

"Let us now turn eastward, and see if we can learn there, any lesson that will help us to manage our forests of the west.

"From the Rocky Mountains to the Province of Ontario there are scattered here and there, certain tracts of well-timbered land, but they are the exception. That timber will be required for the local wants of the people who are now only beginning to settle our fertile prairies, and it will never, I think, contribute to swell the bulk of our timber exports.

"The great forest of Canada, *par excellence*, is spread over that vast territory watered by the Ottawa, the St. Maurice, the Saguenay, and their tributaries, over one hundred thousand square miles in extent. Before drawing your attention more particularly to it, I will mention our remaining timber limits, that cannot compare with it either for size or resources. They are found in the Georgian Bay country; the Muskoka and Nipissing regions; the eastern townships of Quebec and south shore of the St. Lawrence to the Gulf; the region on the north shore of the St. Lawrence, from the Saguenay down to the Bersimis, and, perhaps, still lower down, as far as Mingan; and the country watered by the St. John, the Miramichi, the Restigouche, and their tributaries. Those limits, in many places, are scattered and isolated; they have, with few exceptions (such as the Bersimis at the east, and some newly discovered pine tracts at the west, on Lake Superior), been worked for a long time, and cannot be expected to supply, much longer, any considerable quantity of first quality pine, but they still contain an immense quantity of spruce, principally in the east, sufficient for a great many years' supply, if carefully worked and protected. The spruce, unlike the pine, reproduces itself with wonderful ease, and a good spruce country, carefully worked, where you leave untouched all the trees under a certain size, say twelve or thirteen inches at the foot, can be worked and worked again after a few years' rest, I might say almost for ever.

"As a match to the timber wealth of British Columbia in the west, there have been lately discovered at the extreme east of British North America, in the recent explorations through the hitherto unknown interior of Newfoundland, magnificent forests. Let us hope that, before long, they will take their place among our Canadian forests.

"I will now return to the *Great Canadian Forest*, our great pine country, with its wonderful network of streams, and its three great arteries, the Ottawa, the St. Maurice, and the Saguenay.

"Does it begin to show signs of exhaustion? Is it possible that, in such a short time, man has been able to make an impression upon those millions and millions of acres of forest?

"If there is no sign of exhaustion, what is the meaning of the complaints that come over the seas to us, every year louder and louder, about the falling off, in quality and size, of our pine, hitherto considered the finest in the world? Are they no more than the ordinary complaints of the purchaser? I leave it to our lumbermen to answer.

"But, before they answer, I will ask them why are they compelled to go now to such enormous distances for the really superior quality of pine they used to get so much nearer home a few years ago?

"Look at the map of that great region, and you will see how little of it is now left untouched. On the Ontario side, all the most accessible tributaries of the Ottawa, the Madawaska, the Bonnechère, Mississippi, Petewawa, and others, have been worked for years; the lumbermen are now round the eastern end of Lake Nipissing, with the Mattawan for an outlet to the Ottawa, that can only be reached by a land road; they are still much farther north on the shores of the Montreal River.

"On the Quebec side, they have nearly reached the head waters of all the great tributaries of the Ottawa, the Rivière Rouge, the Rivière du Lièvre, the Gatineau, with the Jean de Terre and Lake Kakebouga, and the Lac des Rapides; they are now working three hundred miles higher up than Ottawa, as the river runs on Lake Temiscamingue and the Keepawa.

"On the St. Maurice, they are as far up as Lake Manooran, on the western side of the river; its great tributaries on the eastern side, the Bostonnais and the Rivière Croche, have been deprived of the greatest part of their fine pine; it is now sought at the head waters of those rivers.

"As for the Saguenay region, it still contains a good deal of spruce, but there is only a limited extent of pine still untouched, or nearly so, south of Lake St. John, between the Meetabetchonan and the head waters of the Rivière Croche, near Comissisoners Lake and Bouchette's Lake. There is a little pine left north of Lake St. John, and a certain quantity on the River Shipsha, and in the lower Saguenay on the Ste. Marguerite and Petit St. Jean, etc. As for the large rivers that flow into Lake St. John, the Chamouchona, Mistassine and Peribouca, the pine that was on the lower part of those rivers has been nearly all cut, and the remainder of their course, from their distant northern sources, is through an immense burnt up wilderness, where the vegetable soil has been consumed by fire.

"That huge tract of lumber country, between the Ottawa and the St. Maurice, that separated (or, rather, appeared to separate), the lumbermen working on those two rivers, by what seemed an inexhaustible and endless forest,—that huge tract is tapped through and through, and the Ottawa lumberman has met the St. Maurice lumberman on the shores of Lake Manooran. A glance at the map will show what that means.

"Those who think that there will never be an end to our timber may say, 'We can still go north.'

"Not very far north. From Lake Temiscamingue and the Montreal River, on the shores of which the lumberman is plying his axe at this very moment, they cannot go very far north before they strike the height of lands dividing the St. Lawrence watershed from the Hudson's Bay, and the country is generally poor and barren. There is still some fine pine there, in what quantity is not known, along the head waters of the Ottawa, but it cannot be brought down to market, at least as square timber, until very extensive and costly works have been executed for the improvement of the great Rapide des Quinze.

"Once over the heights that divide the St. Lawrence and Hudson's Bay watersheds one from another, the streams, without which timber cannot be brought to market, all run north to St. James' Bay and Hudson's Bay. Those regions are generally represented as a huge barren wilderness, with little timber and that mostly of a stunted growth. There is, doubtless, some good timber, but the idea of driving it down the Notway, the Rupert, the Harricanaw, and all those long rivers to the shores of St. James' Bay, and taking it home down Hudson's Bay, eight hundred miles long, and through the dangerous Hudson's Strait, does not appear very practicable. Whatever timber is there may as well be considered as out of our reach for the present; in the course of time the scarcity of timber fit for export may become so great as to encourage the lumbermen to turn their efforts in that direction, but that region may safely be left out of our reckoning of the present available timber supply.

"In a very short time, since the beginning of this century, we have overrun our forests, picking out the finest pine, and we have impoverished them to a serious extent, and what makes it worse, impoverished the country too, for, owing to the force of circumstances which we shall consider later, our timber export trade has not given Canada such a return as she had a right to expect. There still remains to us a great deal of spruce and second-rate pine, which for generations to come will be in excess of our local wants, if we are careful; but the *really fine pine*, required to keep up our great timber export trade to its present standard, is getting very scarce and inaccessible, and I fear that we must prepare for a sudden and considerable falling off.

"While every one admits the great value of the timber trade to Canada, no one would complain in a new and scarcely peopled country like ours, if the finest pine forests were to disappear and make room for fine farms. But, unfortunately, we cannot comfort ourselves with such hope; the soil of the pine region is not generally favourable to agriculture, and when the pine disappears, the farmer does not often take its place.

"Men are the same all over the world; they never set much value upon the free gifts of Providence, and disregard them in proportion to their abundance—timber, fish and game have been destroyed everywhere in the same way. When what appeared to be inexhaustible becomes exhausted, it then begins to be valuable; we must pay for our experience.

"Our neighbours, in the United States, have applied to the destruction of their forests their superhuman activity and energy, and they are now worse off than we are for timber. But their eyes are being opened; the President, in his last message, has earnestly drawn the attention of Congress to the subject, and the following quotation from the last Annual Report of the Secretary of the Interior, shows how thoroughly they appreciate the gravity of the situation:—

"'The rapidity with which this country is stripped of its forests must alarm every thinking man. It has been estimated by good authority, that if we go on at the present rate, the supply of timber in the United States will, in less than twenty years, fall considerably short of our home necessities.

"'It is the highest time that we should turn our earnest attention to this subject, which so seriously concerns our national prosperity.'"

Concerning the ravages of fire in our forests, Mr. Joly says:—

"It is estimated by those who are most competent to form an opinion on the subject, that *more pine timber has been destroyed by fire than has been cut down and taken out by the lumberman;* not only is the large ripe timber destroyed by fire, but all the young trees too, upon whose growth we must depend for the restocking of our forests. It is not practicable, in our Canadian woods, to plant trees to take the place of those that are cut down.

"The difficulty of guarding against fire in such immense and distant forests as ours is enormous, and as for extinguishing it when once fairly started, *the power of man cannot do that.* It will sweep onward as long as it can find food, leaping at one bound like a giant over such rivers as the great Ottawa and Miramichi, and will only stop when brought to bay by large lakes, or when it reaches rocky or barren ground with nothing to

burn ; it will riot for weeks, until starved for want of food, or drowned under torrents of long expected rain.

"In France and Germany, where the science of forestry is brought to high state of perfection, where the forests are much smaller than ours, divided and isolated one from another, kept as much as possible free from rubbish and dead timber and all the light stuff that carries on the flames so rapidly, protected by stringent laws, strictly enforced for generations ; watched over by large staffs of foresters ; even there disastrous fires are of frequent occurrence, and they call for such an effort to suppress them, as is totally beyond our power, as the following example will show :—

" 'Considerable pine forests have been created within the last two or three generations in the south-west of France, and now cover large regions that were once barren heaps of sand rolled up far inland by the action of the sea. Those forests, created by man, now yielding a large and ever-increasing revenue, are highly valued and must be protected, one would think, as well as any forest can ever hope to be protected. Nevertheless, fires are frequent among them.'"

Speaking of the safety-strips used as a means of prevention in other countries, Mr. Joly says :—

" Even there, wherever the wind is very strong, it has been found to carry fire, such as pine cones, one or two miles, and start fresh fires."

I may remark, in reply to this, that there should be foresters in advance to watch and extinguish these. I have myself been employed at such work, almost night and day for months at a time. Mr. Joly goes on to say further that,

"Though not always sufficient, those safety-strips are, nevertheless, of great service, but their opening is scarcely practicable with us. It would entail incredible cost and expenditure on account of the great length we would have to prolong them, and the distance, and because, furthermore, the brush and timber felled down to make them would have to be removed, otherwise it would soon dry up and increase the danger instead of decreasing it. Then, to maintain their efficiency, they would have to be kept clear of a new growth. We cannot think of undertaking such a gigantic work, at least in our large and remote forests. Neither can we undertake, as they do in Europe, to clear the underbrush and to remove the deadwood and rubbish ; but if we cannot profit by these good examples, we can, nevertheless, do a great deal to prevent our forests being set on fire."

Concerning this, I may say that, in another part of this work, I have pointed out how these safety-strips might be profitably made and kept clean here. I may here remark that parties making them must not be allowed to fell timber, right and left, into the woods as if they were making a road, nor to carry brush, nor leave rail chips in there.

Concerning fires by settlers, Mr. Joly says :—

" A frequent cause of disastrous fires in the woods is the mode of clearing land now generally followed by settlers. Of course, they must have recourse to fires in order to clear wood lands, *but fire ought to be our servant, kept under continued control, not our master.*

" Wood land can be cleared with comparatively little danger from fire, and be made ready to sow earlier than by the mode now generally in use (as I know from practical experience), if the settlers will only burn the shrubs, branches, leaves and tops at once, as they cut them down. Light a good bright fire to start with, after having made a *safe place* for it, and then begin cutting away, and as you cut throw upon the fire at once ; children will help immensely with the light stuff, and willingly too. The fire once well

started, everything will burn up, the green wood with the sap running out, and the green leaves too, not only those of fir-trees, but of every hard-wood tree. As you throw in the branches the whole of the green leaves upon them catch fire simultaneously with a sudden flash, and burn up with a crackling sound as if they had been steeped in grease.

"I have often done it, frequently in wet weather. We get rid immediately of all light, inflammable material, from which the greatest danger of bush fires is to be apprehended; the larger branches and trunks of trees, if you must burn them (which you ought not) present little danger of fire in dealing with them. When you get inconveniently distant from your first fire, you light a second one and let your first one burn out; it is remarkable that those fires generally burn down to the ground more thoroughly than the carefully constructed piles that have been drying up for a whole year.

"Increased safety from fires is not the only advantage that would accrue to the settlers from the adoption of this mode of clearing wood lands. Take them as a whole, for the sake of comparing them, and this mode does not give more work than that now in use. True, you have got to convey the stuff you intend burning a little further, because one single fire, continued and replenished for some hours, will dispose of as much stuff as would have made one or two dozen average piles, but then, think of the advantage of having got all that rubbish out of the way at once, instead of having it to cumber the ground until next year, when perhaps the season will be too rainy for burning, or so dry that you will run the risk of setting fire to your own farm and the whole surrounding country. As the work is now done, even in a small clearing, no settler can keep all his fires under absolute control; he is obliged to wait for dry weather, and then he has got twenty, thirty and more fires going on at once. A sudden gust of wind, which is often produced by the intensity of the fire itself in the stillest weather, and off the fire goes, reaches the fire close by, and meets there with such encouragement as to get very soon beyond human control.

"As a further precaution against the danger to the forest arising from the clearing of lands by fire, I would recommend that the Government should confine the settlements, as much as possible, to the hardwood lands, of which there are large tracts still available. 'As a general rule (to quote the words of Mr. Allan Gilmour in answer to questions of a Committee of the House of Assembly of Quebec) it is well known that they are of much better quality for farming purposes, than those covered to any great extent with pine, while they are at the same time much more easily cleared, and will give, as a first crop, a good return, in the shape of pot or pearl ashes from the burnt timber, should the parties clearing the land choose to make them—a benefit which cannot be had from pine burnt in the process of clearing.'

Mr. Joly recommends also, "Such a study of our unsettled lands as would enable them to be classified under two distinct heads—lands fit for agriculture, to which the settlers ought to be sent, and lands unfit for agriculture, from which the settlers ought to be kept away, for their own sake as well as for the public good."

I should rather underbrush in the way Mr. Joly proposes than in any other, as I am certain that it would injure the humus of the soil far less than the ordinary way. In my clearing days, I frequently thought of trying the plan for this reason, but never actually made the experiment. It may be remarked that the reason why the settler likes to leave his brush piles lying everywhere till his chopping is done is, that he may then, after it dries in the spring, set fire to all together, which often burns up many of the logs and saves him much logging. Mr. Joly's plan, however, offers many advantages, and I do not know whether, so great is the danger of fire under the old system, it would not be well to render his plan of clearing compulsory.

Speaking of the danger of fire from lumbermen and others, Mr. Joly says:—

"Lumbermen cannot set fire to the forests in winter, while carrying on all the operations necessary for the cutting, squaring, and hauling of the timber; the danger only

exists when they drive it down streams, in the spring and often in summer. They light little fires wherever they stop on the banks of the rivers, to dry their wet clothes and warm themselves, to enliven their few minutes of rest, or, when the season gets more advanced, to smoke away the flies. Before the fire is fairly blazing, a shout is heard, and as the canoe, or the crib, or the loose logs dart past, our friends take a flying leap upon them, and down they go with the swift current, leaving the fire to itself.

"It ought to be impressed upon the foremen, as one of their most important duties, that they must look after their men carefully in the matter of fires. As the lumbermen themselves have recommended in their conventions, careful men ought to be selected in each drive to see that the fires are lighted and put out with every precaution.

"*Fishermen* are more dangerous than hunters. It is not their fault, and I do not mean to cast any aspersion on their character; for when we see them exercise, in the pursuit of their avocation, so much patience and coolness, we are bound to credit them with the sister qualities of caution and prudence; it is the season during which fishing is allowed (and during which only it can be allowed), the driest part of the summer, that makes it so dangerous.

"In granting leases for the right of fishing rivers, it would be advisable for the Government to increase the stringency of their regulations, so as to cause the lessees to be very careful how they themselves, their friends, and those under them, light and put out their fires.

"The precautions indicated in the Quebec Act, already alluded to, 34 Vict., cap. 19, especially those in section 4, for lighting and putting out of fires in the woods, are very practical and effective, and ought to be adopted and enforced everywhere. They order a careful selection of the locality where there is the smallest quantity of vegetable matter, dead wood, branches, brushwood, dry leaves, or resinous trees; the clearing away of those inflammable materials, within a radius of four feet from the fire to be made, and the total extinguishing of the fire before quitting the place. Any honest, conscientious man, with a head on his shoulders, ought to take those precautions, and be as careful of the property of others as he would be of his own. There are times in the long droughts of summer, when a man is just as guilty who throws down a lighted match in the woods, *as if he threw it in a barn full of hay.*

"The enforcement of regulations made for diminishing the danger of fire during the fishing season would not entail such expenditure as might be expected. The wood rangers and fishery inspectors would not have to watch over every square acre of forest, an army could not do that. An officer, well up to his work, would soon become acquainted with every good fishing pool where fishermen are likely to go, and would keep an eye on those spots; in his rounds he might watch, warn, and arrest careless people, if necessary."

Concerning the over-rapid cutting, in the face of the absence of reproduction, in our pine territories, Mr. Joly says:—

"The lumbermen have indicated the remedy for over-production, but have not been able to apply it. They can only apply it successfully with the help of the Provincial Governments. I respectfully maintain that it is the right and the duty of those Governments to interfere; the right, because the timber belongs to the Province—the duty, because they are answerable for every stick of that timber.

"Each lumberman is ready to admit that he (or rather his neighbour) is cutting too much timber, and that he would make more profit with a lesser quantity. It is bad enough that so much money should be wasted away in cutting down timber for no good; but if there was an inexhaustible supply of timber on the Crown lands, the Government, receiving a larger amount of timber dues than it might otherwise, would not be likely to interfere to protect the lumberman against himself.

"But our forests are getting rapidly exhausted, and their produce sacrificed; it is a loss for Canada and for the lumbermen. It is full time for the Governments to interfere. Will they do it, and can they do it, in justice?

"Of course, the first result of a decrease in the production of timber, in so far as the Government was concerned, would be a corresponding decrease in the Crown lands re-

ceipts. I won't call it the revenue, because there is something deceptive in the use of that word; we are apt to fancy that it always means (as Worcester has it) 'the income or annual profit received from lands or other property.' It is nothing of the kind in this case. We have not been spending the income or annual profit of our forests, but the forests themselves—not the interest, but the capital.

"It will be said that, without the large sums of money derived from the cutting of timber on our Crown lands, the building of railways could not have been encouraged as it has been. Nothing can contribute to the prosperity of a new country more than a railway carefully located so as to satisfy some great public necessity, without calling for sacrifices beyond the forces of the country; but while looking forward to the benefit to be derived from it, the cost must not be forgotten. We have been sacrificing our forests for the sake of our railways.

"So far as mere power is concerned, it seldom happens that a Government can control any trade as completely as our Provincial Governments can control the timber trade without laying itself open to the charge of undue interference with business. In this case, the Governments themselves are parties to the trade, since they are the owners and the sellers of standing timber.

"But if we wish to save our forests, the necessity for the prompt application of some effectual remedy is the same in every Province; the quantity of timber cut every year must be considerably reduced, if we wish to balance the yearly cutting of our forests with their annual growth. The revenue of our Crown lands must shrink, of course, but it will become a *bona fide* revenue upon which we can permanently rely.

"To sum up, the Provincial Governments can do a great deal towards checking the over-production of timber, improving thereby the tone of the timber market and preserving our forests.

"Opinions will be divided as to the best and fairest mode of action, and as to the right of the Governments to interfere. If they can alter the amount of timber dues, they can interfere most effectively, and without exceeding the limits of their power, and compel, if need be, the lumbermen to submit to such just restrictions as will preserve our forests from destruction.

"I would recommend limiting the lumberman to a maximum cut of so many thousand feet per square mile of his limits. Let it be understood, I do not mean that he should have to cut so much on each and every individual square mile, but that out of his whole limit he should not take more than at the rate of so many feet per square mile. Of course, any plan that may be adopted will require very careful consideration and adjustment."

I would myself suggest, considering what the European plan is, and its evident success in preserving the forests in perpetuity, that there the Government or the forest owner are, in fact, the lumbermen—that is, they point out the sticks that are to be cut and dictate the manner of cutting them. And being the lumbermen, and being also the owners, the forest is preserved that it may yield in future as it does to-day. I would therefore ask whether it would not be well to do one of two things, either sell the lumber tract to the lumberman altogether, with the condition that he is limited to so many thousand feet per annum, and such further conditions as shall make it his interest to preserve the tract in a reproductive and lumber-yielding state, in which case he will soon find out the best methods of forestry himself; or else let Government take entire charge, sell what sticks they choose, and see for themselves that their forests remain in a condition to replace them.

Mr. Joly speaks of the waste in making square timber, and says:—

"In making square pine, the waste of timber is generally estimated at one-fourth of the whole, and the best part of the tree, too, that part which in saw logs gives the splendid broad deals, for which Canada is famous. As it is not every tree that is sound

enough for square timber, many a pine is cut down and left to rot. There may be something wrong about the heart or in the length; that would not have prevented it from being turned into saw logs, but won't do for square timber, and so it is condemned.

"Chips made in squaring trees considerably increase the danger of fire. In summer they get very dry and inflammable, and the way in which they are disposed in straight lines, thirty, forty, and fifty feet long, like trains of gunpowder, appears well calculated for spreading the flames through the dead pine leaves, dry branches, and moss.

"But, perhaps, they cannot do without those huge beams of timber in England? In most cases, the first thing they do, when they get them there, is to cut them up."

Mr. Joly proposes that we should cut them up ourselves, and says:—

"I think it would come cheaper to the consumer in England. Square timber is not invariably sound all through; when cut up, unexpected flaws and rots are often discovered that were invisible from the outside. Those flaws would have been discovered if the timber had been sawn up here, and the defective parts would not have been sent across."

Mr. Joly states that the heavy loss incurred in throwing away so much of the best clear timber at the butt of the tree, in order to square it, is altogether unnecessary. It is done, he says, merely to please a few people in England who have large sawmills, and have their wealth in the very simple craft of cutting the beams up on their arrival there. To check this, Mr. Joly proposes the simple expedient of charging sufficiently high export duty on large square timber, in which case, he thinks, and apparently with good reason, we ourselves would cut up the whole log to the sizes required, send it all to England, and get as much per foot for the whole as we now do for the three-fourths. This would be better evidently for the lumberman, for the Government, for the country, and for the English consumer.

Mr. Joly notices that this regulation exists in Quebec:—"It shall be no longer permitted to cut on Crown lands pine trees measuring less than twelve inches in diameter at the stump;" and in Quebec only; and states that the same regulation should be enforced everywhere.

Concerning the planting of forest trees, he says:—

"It is not only in old countries, like England, France, and Germany, that new forests are planted; it is in countries younger than Canada, in New Zealand and the Australian Colonies, for instance, where wood is not such an object of first necessity as with us, and where it is not so scarce as on our western prairies and, I am sorry to say, in some of our old eastern settlements.

"New Zealand, the Australian Colonies, and India have taken active steps for planting new forests; and, at our doors, the United States Government are giving encouragement, by grants of land and otherwise, to those who are willing to plant trees, while a number of societies are working in the same direction. We have only, if I am not mistaken, one society in the Dominion whose only purpose is to encourage the plantation of forest trees (I do not speak of orchards). It is in the Province of Quebec, where the want of it is seriously felt; each member binds himself to plant a certain number of trees every year. Government will have to give some encouragement, and go to the expense of making experiments on a larger scale, before any important results can be anticipated."

Mr. Joly says, with regard to the selection of trees for planting:—

"I have made experiments for several years past, and the conclusions arrived at by me are so much at variance with the general opinion of the experienced men to whom I have communicated them, that I feel a considerable degree of hesitation in making them known. However, they are founded on facts and not mere theory, and no harm can re-

sult from awakening public attention to such questions except, perhaps, exposing my ignorance and want of judgment.

"The general opinion is, that soft wood, say pine and spruce, grows much faster than hard wood, oak and black walnut, for instance. I have met with the greatest incredulity everywhere when stating that it was exactly the reverse.

"If you take the *Douglas pine (abies Douglasii)*, which is described as one of the most rapid growers of the coniferous family, making about one inch in diameter in four years, there is not much difference to what there is in favour of our oak and black walnut; but if you take our white pine you will find that it grows about one inch in six years. I have often seen Canadian oak (*Quercus alba*) and black walnut (*Juglans nigra*) that had grown one inch in three years and a-half. As for white spruce, it is nowhere as compared with either oak or walnut or pine; men who have handled it all their lives have never thought of ascertaining what its rate of growth was; if they would only count the annual rings from the heart to the circumference, or even one or two inches long of them, they would be surprised to see what a slow grower white spruce is.

"If our black walnut and oak do really grow faster than the pine and spruce (as I think they do, and it is very easy for one who chooses to find out for himself), it is one point in their favour. A second point is that they are easier to grow from seed (nut and acorn) than pine, and that they bear transplanting better; the drying off of the top is not so fatal to hardwood trees as it is to conifers. Having sown a good many of each kind, I have often noticed that the oak and black walnut acquire strength and vigour sufficient to protect them against ordinary accidents much sooner than the young pine, which is much more brittle.

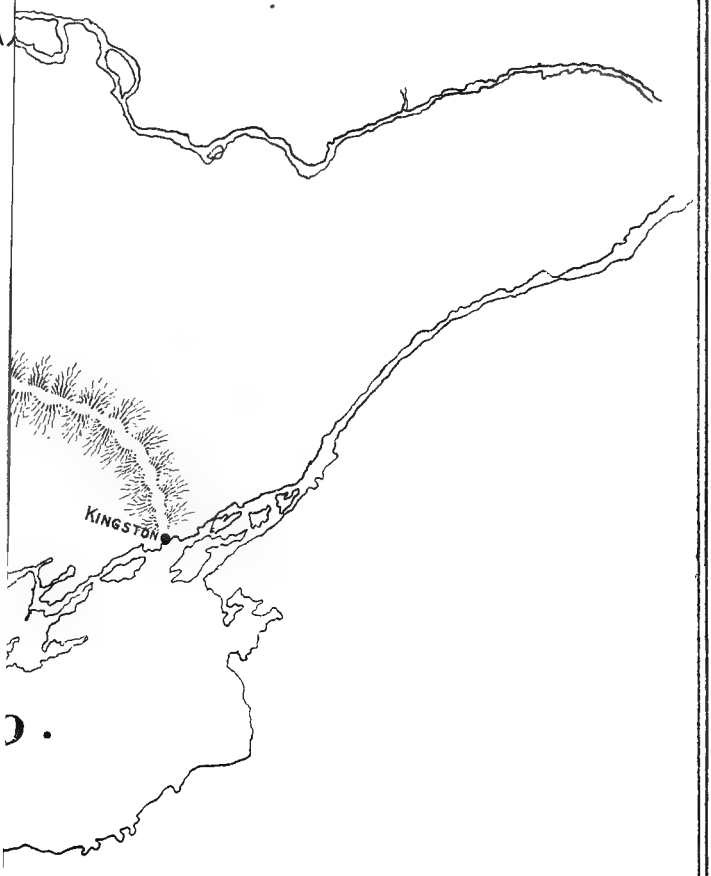
"Then, again, a forest of oak and walnut is not exposed to the same danger from fire as a pine forest is; I would refer to the chapter of fires by settlers, in the first part of this report, for proofs of the correctness of this assertion.

"As the timber of the black walnut and oak is much more valuable than the pine and spruce, as their growth is more rapid and more secure, and as they are less exposed to the danger of fire, they appear to be entitled to preference over pine and spruce for planting wherever the soil is favourable to them, as it is in the western prairies, whose fertility is well known, and where, as Professor Macoun says, all our forest trees will be easily grown.

"In dry, sandy soil, of course, the conifers must have the preference."

THE HEIGHTS OF LAND OF ONTARIO.

We will now proceed to consider, in the light afforded us by the preceding, what should be done to preserve the due proportion of forest and consequently regular summer rainfall in Ontario. My readers will have noticed of what vital importance it is to preserve the higher lands in forest. There are four elevated ridges or plateaux in Ontario. The first and nearest of these is that, well known as the Oak Ridges, north of Toronto about thirty miles, which passes round to the west, coming at Hamilton close to the Lake, going round the head of the Lake, and dying away in the Niagara peninsula. Going eastward from the same point, thirty miles north of Toronto, it gets much nearer to the Lake at Cobourg; passes on, strikes the Lake at the Trent and dies away there. This ridge being near the front, and entirely in the older settled portion of the Province, has probably long ago altogether passed out of Government hands. Much of it is by no means the best of soil, and could it have been retained in timber, and the height of the trees increased by replanting, the benefit to the Province would have been incalculable; for this long belt of forest would have met, and precipitated into rain, the moisture of the



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south-west winds coming across Ontario and Erie, which rain would then have frequently and regularly fallen through the summer on the great cultivable area of land to the north, instead of passing, as it now does, largely on to the Nipissing forests. In any scheme of planting forests for the benefit of the Ontario climate, the reforesting of portions of these ridges would exercise an influence extremely valuable. I should therefore recommend that the possibilities of working in this direction should be carefully considered.

The Watershed between Kingston and Nipissing.

This is a true watershed, the rivers running both ways from its summit. The height of land extends, with a slight curve to the north, from Kingston to Lake Nipissing. To the east of this all streams flow into the Ottawa; to the west of it they flow into Lake Ontario. Much of the land on this ridge is still in the hands of Government, and, both for purposes of increasing rainfall, and preserving moisture at the source of numerous and important streams, it would be well that large masses of forest were preserved along the whole line. Along this line, if possible, hundreds of thousands, or even millions of acres might well be left in forests; for this ridge should be the preserver of fertility and source of moisture to the whole of eastern Ontario, from Toronto to the Ottawa. If this line should be allowed to become deforested, very injurious results may be expected throughout all Ontario, east of Toronto. On the other hand, if forest be maintained there, clearing can then be proceeded with along the whole north-east of the preserved forest, and this cleared region will then receive the spring and summer rain precipitated by the preserved line of forest along this watershed.

The Watershed of Western Ontario.

This is a height of land in about the centre of western Ontario, and is best known as the locality of the great Garafraxa Swamp, which contains many thousand acres. Such of this as is not in Government hands, might, no doubt, easily be obtained, and probably, much land in the neighbourhood cheaply added thereto, and the timber on the whole reservation carefully preserved and increased by planting. This central point is a thousand feet above Lake Ontario, and from its four sides the rivers run to the Georgian Bay, to Lake Huron, to Lake Erie, and to Lake Ontario.

The Blue Mountains.

This is a ridge of mountains at the extreme north of our peninsula, extending from near Collingwood, past Owen Sound, and to the northern point of the promontory extending between Lake Huron and the Georgian Bay. Much of this is yet in the hands of the Government, and much of it should, if possible, be preserved in timber.

For the purpose of attracting rain in summer and spring, which would otherwise probably pass to the north on its way to the pole in the great equatorial air current, there is little reason to doubt that large masses or belts of forest, left standing on these ridges, would be more efficacious than a much larger amount left scattered through the country. Moreover, these elevations are the natural storehouses and reservoirs of moisture. The woods on their slopes were intended to hold the water of rain and snow from flooding the land when it was not needed, and to deal it out in creek, river and underground channel, as

it should be needed throughout the year. Any one who has read the valuable records, examples, and statements, collated and compiled in the preceding part of this volume, will need no further evidence, and will well understand, on being shown the heights of land and watersheds, what should be done with them. It is extremely desirable that they be, where possible, maintained in a forest state, the manner of doing which has been previously explained; and that, where disforested, they be, in preference to any other land, the scene of foresting operations.

It should also be pointed out that it has been found in every country where forestry is practised, expedient to set in operation several nurseries for the purpose of raising the seedling trees adapted for planting, of such varieties as are most suitable. These should be selected, not necessarily in any of the localities described as heights of land, but as a small portion of land would be sufficient, in any part of the country, where the soil and situation were considered most favourable for the young plants, considered with regard to their future destination. This can be well learned by consultation with those who have made such experiments, of which some are reported in these pages. It may be remarked that, although it is recommended by some experimenters to rely on the forest for seedlings, yet in other countries, where equal or greater facilities exist in that respect, nurseries are always found necessary, and would, for various reasons, probably be so here.

It would appear that, in planting or preserving these heights of land, the trees chosen should be largely of the pine variety. In the first place, their height is of great additional service. 2nd. They are evergreen, and preserve deep forest shade and shelter in summer and winter, spring and fall. 3rd. The soil of these localities is likely to resemble that found suitable to these trees in other lands. 4th. They may be relied upon for a paying return, year after year, if preserved with care, as this is the most valuable tree for commercial purposes. 5th. They will, many authorities say, grow to size fit to cut much sooner than the hardwoods of equal value. 6th. They can be, it appears, very successfully interspersed with the hardwoods, especially the beech, which would add to the plantation all the advantages of a deciduous forest.

THE GREAT FOREST TO THE NORTH-EAST.

As mentioned in the first part of this book, there is a great and largely untouched forest to the north-east of the Province of Ontario. The reason why this mass of forest has not been ere this more deeply penetrated by the settler is, that the land is not nearly so good for agricultural purposes as that in the older settled districts of the Province.

In one word, it is the Laurentian formation, an outcrop of the backbone of the world, and that backbone, unlike other bones, contains no lime; it is a granite formation, and, though there are in parts of it opportunities for obtaining lime from the gneiss rock, yet, do what you will with it, this district will never equal in an agricultural capacity *(cæteris paribus)* that based on a limestone formation. The detritus of granite is not, and in the nature of things cannot be, for agricultural purposes, in any respect the equal of the detritus of limestone. This great region is reached from Toronto at a point near Gravenhurst, and its border would be marked by a curved line from Gravenhurst to a

point about five miles east of Kingston. To the north-east of all this line is a vast mass of forest, pierced in many points by colonization roads, and interspersed with clearings along its southern edge. To this district we may add the Muskoka and the Parry Sound regions, which are, in many respects, similar. In these three are situated great pine districts, many of which have been cut over by the lumberman, while much is yet untouched and in the hands of Government. It is, it appears to me, a matter of great importance to preserve many of the pine forests in these vicinities, and that for these reasons :—

1. They are the true pine reserves of the older districts of Ontario.

2. The land whereon they stand can never yield, for purposes of agriculture, anything like the return it is capable of producing if maintained in continual pine-bearing forest.

3. If proper care be taken these great districts can, by the adoption of European methods, be placed in a state of continual reproduction, which will allow, every year, a very large amount of valuable pine to be cut without clearing the land or in any way injuring the forest capacity for production.

4. It would be far better to commence the preservation of forest areas along the present existing line of clearing than to commence similar operations much farther back. If, as is stated, the land is much better farther to the north, it would be better to renew the clearing there, so as to leave a broad belt of forest to the south of the new settlements; for a forest district to the south (without prejudice to the height of lands considerations) will attract summer showers to the cleared land north of it, while from a north forest comes little rain at the season when most needed.

Protection from Fire.

The great difficulty in maintaining forests in this country lies in protecting them from the ravages of fire, to which they are peculiarly subject. Our hot summers dry the edge of the forest, the cuttings left by the lumberman greatly increase the danger, the cattle of the settler dry and impoverish the forest edge for many miles, a dry season comes, fire is ignited by the clearing fires of the settler, by those of the lumberman or the hunter, or it may be at some point where the railway has touched the forest line, by a spark from a locomotive. There are two seasons when fires are likely to run—the first is during the hot months of summer, the second late in a dry fall, when the fire runs on the thick carpet of dry leaves. This last I think the more rapid of the two. I have seen it come miles abreast through the forest with the speed of a fast walker, firing every inflammable substance in its way. The terrible devastation caused by these fires when under full headway is ruinous beyond imagination. Hundreds and thousands of square miles of beautiful forest have been reduced to ashes in periods of a fortnight or even of a week. It has been well remarked by persons fully competent to express an opinion on the matter, that the fire destroys more timber in Canada than the axe. If, then, some means could be devised to check this devastation, the result would, no doubt, be extremely beneficial to the country.

The recommendation I have to make, with respect to these forests, is one based partly on the character of the soil, partly on the practice existing in India and in Europe,

and pursued there with the same intention. It is impossible to preserve the extensive Canadian forests from fire without appointing certain rangers, few or many, as may be judged expedient, whose business it shall be to carry out, in this country, as far as their numbers will allow them, the policy pursued in European countries of guarding against fire, giving warning where it occurs, and prosecuting all individuals who infringe the fire laws established by Government. To my own knowledge, the laws enacted by the Ontario Government with reference to the management of fires, their lighting and extinguishing, are carelessly observed; or even altogether ignored in the back districts through which I have travelled. I should, therefore, recommend that a certain number of men be appointed to watch breaches of these laws and institute the necessary prosecutions.

The East Indian practice to which I refer is this. In the vast Indian forests, under the careful supervision which has been established there by the Indian Government, every effort has been made to suppress or hold in check what with them is a still more dangerous enemy than with us, the ignition of the forests. The principal means recommended and used by them is, the cutting of what are called fire lines through the forests for long distances. These lines, it is recommended should be made two hundred feet wide, and be kept quite clear of brushwood, or any other inflammable matter.

In travelling through different parts of this north-eastern district of Ontario, and having in successive years passed over several hundred miles of it in different directions, I became decidedly of opinion, that the whole country was far better suited for extensive grazing grounds, interspersed with manufacturing villages, than to be given out in one or two hundred acre lots to the ordinary settler. Considering the character of the land, I am of opinion that many ordinary settlers will not be able to give it that care which alone can maintain its fertility; I fear they will, in many instances, be obliged to overcrop it, to impoverish it, and to abandon it. The granite formation, I fear, will never show the staying qualities of the limestone-founded portions of Ontario. On the other hand, I think if much of this land were given out to men of capital, who would be willing to establish large grazing farms thereon, they would be able to cover the soil with a heavy clover sod, which, with careful management might be maintained for ever.

I will, then, suggest what would be my plan if some millions of acres of this vast forest were mine, and I were desirous of preserving it from the ravages of fire. I would cut the fire protecting lines, as used in India, through and through it at different points, clearing them thoroughly from brushwood, but I should make them wider, say, a hundred yards broad, and I should suggest that paths a hundred yards broad cut through these forests, and fenced at each side, would make excellent grazing runs for cattle, if got under grass, and would operate as most effectual firebreaks. I should think that an arrangement might be made whereby graziers would gladly lease these lines, undertake to seed them with grass and use them for the fattening of their cattle, which would readily find water at the numerous streams these firebreaks would necessarily cross. A portion of the consideration paid for the use of these grazing-lines, might well be the undertaking on the part of the grazier to send a certain number of men to extinguish any fire which might arise in his vicinity. In this manner, I conceive that, by the assistance and supervision

of a small force of Government rangers, very large forests might be preserved from the ravages of fire.

In connection with the manufacturing capacities of this region of country, I would remark, that it possesses many and valuable water-courses, which would dry up were the country cleared, but which the retention of the forests will retain in full value. I would also state, that the quality of the water flowing over the granite bed, it being free from lime, is remarkably well adapted to various textile manufacture, and would suggest that large manufacturing villages and towns might find occasion for profitable existance in the heart of the large forests which, I conceive, Government should retain in this part of the country.

I would also suggest that such towns and villages will by no means lack communication with other parts of the country, as the Canada Pacific, and its connecting railways, will pass through the present wilderness near the vicinity where it is desirable these forests should be maintained.

I would here suggest that large portions of forest might be preserved, let us say, after the merchantable lumber has been carried off by the lumberman, by allotting them in free grants to persons who would undertake to maintain the land in its wooded condition.

The opinion of Mr. Ward, of Montreal, is, "To have our country remain well wooded for many years, it is but necessary to give the trees indigenous to our country leave to grow, and there will be no necessity to plant. I have no doubt but that much of the land that has been denuded of its timber would in a few years be covered with a spontaneous growth of wood, and so prevent our country from becoming an arid waste, utilizing only that portion of it that can be profitably worked." Mr. Cleveland, of Chicago remarks "A vast area of woodland is running to waste, yielding no revenue and promising nothing better in the future than firewood, of which a very large proportion is yet susceptible of redemption and conversion into timber of great value, at far less cost of time and labour than would be required for the planting and rearing of new forests." If then we give free grants of land where clearing and cultivation is desirable on condition that the land be cleared and cultivated, I should think it would be well to give free grants of forest where forest is desirable, on condition that the forest be kept in good order, that it be fenced against cattle and thinned as directed by regulations which should be laid down by a Government official of knowledge in such matters. This would give people who wish to acquire land, without being compelled to reside thereon, the opportunity of doing so, as they could hire the necessary labour and care, of persons in the neighbourhood, and they would naturally see that their employées preformed their duty properly, since that would constitute their only right to the land, and their only protection against fire overrunning it.

THE NORTH-WEST TERRITORY OF ONTARIO.

A word may well be said here on this subject. Full control of this territory is withheld from its proper possessors by the delay in ratifying the Boundary Award. It contains a large quantity of very valuable timber, comprising one of the chief timber reserves in all the North-West, so far as present information is obtainable. This

timber, in a position where it will always command ready sale, and comparatively untouched by the lumberman or settler, offers as yet a most excellent opportunity not only for procuring timber, but also for maintaining the supply. If this reserve were at once taken in hand and managed on the European or East Indian plan, those trees only cut which are of age and size, and cut so as not to injure others; and the whole forest then mapped into sections, each in charge of a competent forester, the forest could be maintained in perpetuity as good as, or better, than it now is, and a large supply of the best lumber yearly drawn therefrom.

Further hindrance of the right of control belonging to Ontario will be most prejudicial. For in the meantime the demand for lumber in the North-West will grow apace; private individuals will commence to cut; lumbering operations will be carried on by rival parties; and as soon as these operations are proceeded with on a larger scale, and with the reckless haste which probably will characterize them, fire is certain to occur, probably at many points, and, in that region of rocky timbered slopes and ridges, fully open, too, to the sweeping prairie winds, it may well be expected from what has happened in far less exposed localities, that before the boundary is found, this great forest, of priceless value if properly used now, will be utterly lost.

THE POSITION IN WHICH FORESTS WOULD BEST AFFECT THE ONTARIO CLIMATE.

To produce their best effect on climate, three points are to be observed. 1st. To occupy the heights, firstly that they are generally of poor land well spared for that purpose; secondly, that wooded elevations preserve rain, feed springs, and continue water-courses in regular action. 2nd. They should be of considerable depth as well as length, as a thin line of forest will not by any means preserve the moist and humid atmosphere within their bounds on which their beneficial action depends. For such purposes, they should not, if it could be avoided, be less than a mile in depth from front to rear, and they had better be ten or twenty. To act as reservoirs of humidity they must be of fair extent, otherwise they will neither be able to feed the water-courses, nor to send upwards to the clouds those moist currents which, it appears by all experiment, meeting with a differently constituted atmosphere of the air, produce rain at those seasons when it is most needed. 3rd. If possible, such forests should stretch across Ontario in lines from north-west to south-east. They would then be in position profitably to intercept the south-west wind, which is the great bearer of moisture hither from the Gulf of Mexico and the tropical seas. For instance, as has been observed, the great forest north-east of Ontario does not bring much rain relatively to Ontario. Most of the rain a forest obtains will fall north-east of that forest. The exceptions are when an east or north-east wind, meeting the south-west current, produces rain, and is sufficiently strong to carry before it the rain-bringing current; but this is not to be depended on, the intention in endeavouring to preserve the forest in the line mentioned, being that the ascending currents shall meet and produce rain from the moisture-bearing winds, which are mostly south-west in reality, though often deflected and turned away by local or other influences. Of course it is not expected that Ontario can be mapped out in field and forest at this late

day. But we can know in what direction to strive here, and where forest overspreads the whole country, as in part of our territory elsewhere, very much indeed can be done.

It must always, however, be remembered that east, and even north-east winds, can and do bring rain of their own force from the Atlantic direction. But the south-west wind is the chief rain bringer. The others may be called, with reference to Ontario, local. The south-west wind brings moisture to the whole northern hemisphere.

TREES BY THE ROADSIDE.

Premiums have been very properly offered here, in a Bill just passed through Parliament, to those farmers who shall plant and maintain in growth certain descriptions of trees. The Bill refers principally to lines of trees set along the highway and the dividing lines of farms. These, or small plantations of any sort, are valuable, but by no meant fulfil the functions of deep belts of forest. Their great value is, if planted over sufficient sections of country, that they preserve the land from drying winds, and in that way, if they do not, as the forest does, bring rain, they preserve the effects of rain for a much longer period. Secondly, and a very important benefit indeed, they prevent the wind from drifting the snow off the fields they enclose, and the roads bordering them. Left evenly on the ground, the snow is a vast benefit to the soil and the coming or existing plant; driven into great heaps by the wind, it not only injures both, but also renders transport over the roads difficult or impossible.

A WORD ON THE PRESENT AMOUNT OF FOREST IN ONTARIO.

It will be seen by the accompanying list that the state of Ontario, as regards possession of forest land, is as follows:—On the north-east she has a large forest, and in Muskoka and the Georgian Bay District, forests of some size. These are all the Province possesses to feed the streams, we may say, east and north-east of Toronto, and they largely at present perform that function. But the whole great peninsula to the west is destitute of most of the original forests on the elevated lands which gave her rivers water, and has little in the way of woods save the small reserves farmers have kept for themselves on their farms. As I pointed out previously, these are being rapidly used; one after another they fade away from the land and are not replaced. The accompanying lists will show exactly exactly the acreage under wood still left in each county, and when we remember that but a century ago all was forest, we shall be amazed at the rapidity of destruction; and, noticing how fast the small reserve is disappearing, we shall be quite convinced that in a very few years, unless remedial measures are successfully applied, the great peninsula of Ontario—our chief territory in a farming sense—will be to all intents and purposes, as far as climatic influences and connections are concerned, a disforested land. And I may here observe the fallacy of the statement sometimes ventured, "Oh, we cannot be in want of forests, there are so many million acres in Ontario, and of them only so many are cleared!" May I ask what this has to do with the question? Neither the woods of Keewatin nor of Muskoka can in any degree assist the farmers of the great Ontario peninsula, from Windsor on the west to Toronto and Collingwood on the east. Nor will the small patches left on each farm assist them. They are too small

and too isolated, and far too certain to vanish, to maintain the proportion of shaded land necessary for climatic purposes. But these districts, it is said, give fair crops now. They do not yield so easily as once, nor is the sky so propitious now, as the careful investigations of Dr. Bryce and Prof. Dewey, some pages back, show. But the great point is this,—they soon will, in all human calculations, suffer severely. Now, if the matter be commenced in time, we have yet space, before it be too late, to carry out what all civilized countries have acknowledged the necessity of and are to-day engaged in,—the work of making provision for a continuous forest area, and constant supply of merchantable timber.

Something can be done, and no doubt should be done, in certain parts of Ontario towards replanting our destroyed forests—destroyed in localities where forest, to improve climate and subserve agriculture, should especially have been allowed to remain. But the great opportunity which yet remains is that of preservation. This is found to be the case in India. The Government of that great country, expending yearly its hundreds of thousands of pounds sterling for preservation and replanting, has not yet planted a hundred thousand acres, while it has improved, is improving, and has to a very great extent already changed for the better, the character of many millions of acres of forest land. If we pass through much of the forest which Ontario still retains in governmental hands, we shall find, here and there, many a large expanse desolated by fire and growing up again, a brushwood choking itself to uselessness, covering a burnt and impoverished soil. We shall find great areas of forest the lumbermen have culled of pine and spruce, of ash and oak. Every here and there are the relics of their operations—the close hewn stump, and, a goodly distance therefrom, the great pile of decaying branches where the head of the tree had fallen; while the whole distance between, if round timber had been got out, shows nothing but a few scattered side limbs, but if square it is paved with immense pine fragments—short thick slabs whose deep clean cut show the force of the score-hacker's arm, and long lengths of those peculiar chips, slightly connected, thin and broad, smooth on one side, the depth and straightness of which show how deftly the handler of the broad-axe has plied his unwieldy tool,; and if you come near the stump, and it has been heavy timber squared for the English market, you will find in great masses, hewn off, thrown away and rotting, as much clear timber as, sold at Toronto prices, would go far towards the whole sum the lumberman will ever get for the log. The piles of *débris* are everywhere, and form a most inflammable portion of the touchwood of a forest. Then before the strong oxen could drag the great log to the river down which it had to be floated an avenue of smaller trees had sometimes to be cleared from the way, and these likewise piled in desicating heaps, their skeleton branches protruding among the green undergrowth, like the ghastly relics of mortality on a forgotten battle-field, cumber the forest floor.

You will find many places where trees are choking one another for want of air and light, until in lapse of years some stronger one shall tower above his fellows. You will find places where hurricanes have cut their way through the forest, and the trees lie for miles, as the ranks mown down by the mitrailleuse. You will pass the solitary bush road, the trees which once grew therein chopped right and left into the forest by the makers of the track, where they lie in dry heaps for miles on miles, forming as pretty a fire-track as one could wish to see. And everywhere you will find millions of young

trees giving full promise, if spared axe and fire, of becoming trees as sturdy as any the lumberman has carried away, but nevertheless, the impression produced on you by the whole pilgrimage will be that, if no preventive measures be used, the fire which has taken so much already will sooner or later take the rest. When one compares the state of our forests with that of those in some parts of Europe, and thinks of the long avenues of fire-breaks, the forest-rangers on the watch, the careful management, the incessant thinning and replanting, the long succession of goodly trees yearly ready for the axe, and the certainty, with equal care, of such a succession for all time to come, one is apt to think it full time that some such system were introduced here.

The Possible Profits.

It is to be remembered that (whether in the case of planting, or that of forest preservation), what is proposed will not be an unremunerative work. Putting altogether to one side the vast benefits to be expected in climate and in crop, there are direct returns of no small amount. For instance, most of the European reports give, after all expenses are paid, a large aggregate annual income, as does the East Indian also. Taking the opinions of scientific men, Mr. Galusha's estimate is that ten acres planted in ash and walnut will within twenty-five years produce sixteen thousand dollars in profit over expenses. Other estimates, by men who have practically experimented, give even more, especially in the case of pines. Let us take the figures of the gentleman named. He allows $20 per acre for cultivation. Let us increase it, and say cultivation costs $50, and that five thousand instead of ten acres are tried. The amount spent would be $50,000 a year for five years. The return at the end of twenty-five years would be eight millions of dollars. And, all this while, the plantation would be a valuable asset upon which money could, if expedient, be borrowed. And it is to be noticed that more profit may well be expected than has been gained, for the valuable descriptions of wood will grow scarcer and dearer while, during the experiments stated (such of them as were practically carried out), these woods were purchasable at low rates. In fine, it is a work in which great climatic and agricultural advantages are sure to be gained, while, as for the money advantages arising from the sale of timber, the only reason why Canada will not immediately profit as other nations do is that she has yet much timber for use and sale without having to grow it. But the time to commence what will be a work of time, is while there is yet no actual scarcity of the article to be produced; our existing forests will give us time to grow others; and above all, there is the necessity for action to preserve from fire and waste those which now stand. The means and system used to procure fresh forests will largely tend to preserve the old in efficiency.

I will give here a few additional statements of profits from the Congress Reports :—

Mr. David Nicol, Cataraqui, Ont., says of the European Larch :—

"Experienced planters have long ago decided that the larch should be planted entirely by itself, because of its quick growth, it soon outgrows all other trees, and when scattered thinly throughout the forest, the tender top shoots are apt to be damaged by high winds; they do best when planted thickly, because they shelter one another; they are often planted as near as three feet, and sometimes as near as two feet, but I would prefer the former distance; planted at this distance, they rapidly shoot up straight, clean,

and healthy. At three feet apart, an acre contains about 4,900 ; in this state, they should be allowed to remain six or seven years, when they will have attained the height of twenty feet, if they have been well cultivated the first three or four years ; they should then be thinned for the first time by taking out every alternate row ; the thinnings make the best quality of hop-poles, worth at present about five cents apiece—2,450 poles, at five cents, brings $122.50. Then being allowed to remain in this state about three years longer, they should have the second thinning. By taking out every alternate tree in the row, this would leave them six feet apart each way ; the thinnings are now five to six inches through, and are worth ten cents apiece for boat masts and yards, supports in mines, etc.—1,225 spars, at ten cents, brings $122.50. After growing five years at this distance, they should be finally thinned out to twelve feet apart ; the trees will now be seven to ten inches through and over thirty feet high, can be sawed into rafters, fencing, flooring, etc. ; and are worth at least twenty-five cents apiece—612 spars, at twenty-five cents, brings $153. Now, if we suppose that the sale of poles and spars would be sufficient to defray the expense of making and upholding the plantation, and that each tree still remaining on an acre, say fifteen years after planting, is worth only twenty-five cents, the value of 612 trees is $153, there would be a handsome profit after allowing $2 a year for rent, which, for fifteen years, would be $30, and a great deal of land suitable for growing larch would not rent for more than half that amount. Now, the expenses cease, because the forest can be pastured with sheep without danger of injury to the trees ; the increase of value is now much more rapid, the annual increase of the circumference of the trees will average one and one-half inches until they nearly reach maturity, which is in about fifty years after planting. The trees will then average thirty to forty inches in diameter, three feet from the butt. Each tree will produce about 450 feet of lumber, at $25 per thousand, $11.25, less expenses for drawing and sawing $2.25. It would surely not be considered extravagant to value each tree at $9—612 trees at $9, $5,508, less thirty-five years' rent, at $2 per acre ; $70 from $5,508 leaves a net profit of $5,438. Be it observed that plantations of larch do not impoverish the land but rather improve it. The annual deposit of leaves gives more nutriment to the soil than is taken from it by the trees."

Mr. Hicks, of Roslyn, L. I., says of the yellow locust :—

"Hough's Report on Forestry mentions its lasting fifteen to twenty years as railroad ties, while oak lasts only five to ten years, and chestnut six to eight years. The timber is used very extensively by carriage builders, and in some instances in preference to hickory. Brewster & Co., of Broom St, New York City, using it and paying higher prices for it than for hickory.

"On Long Island, near New York City, this tree is the most valuable grown. After thirty years' growth the tree will make posts eight, ten, and twelve feet long, three to five inches in diameter, at the small end. In New York City the posts are worth, for eight feet in length, four inches in diameter, forty-eight cents ; ten feet, four and a-half inches in diameter, seventy-seven cents ; twelve feet, four and three-quarters inches in diameter, ninety-five cents ; six and a-half feet fencing posts, four inches diameter, twenty--eight cents. The trees will often cut one piece or stick twelve feet, one ten feet, one eight feet, one six and a-half feet, making $2.48 per tree ; these are the wholesale prices. In the most famed localities, and with five or ten years' more growth, the tree will make, say one stick sixteen feet, thirty-six inches girth ; one twelve feet, thirty inches girth, and one ten feet, twenty-five inches girth, this making the tree worth many times as much, as it sells for from sixty cents to $1.25 per cubic foot. As to value in other localities, Dr. Warder states that he is cutting trees, having a growth of twenty-four years, averaging twelve inches diameter, and sixty feet high, trees making eight to ten good fence posts, seven feet in length, six to eight inches face at the top end, trees standing 400 to the acre.

"Ezra Sherman, of Preston, Ohio, states that locust seed was sown in 1830 ; three years afterwards, the trees were planted in a grove of fifteen acres, also an avenue of 20) rods. In 1870, two-thirds of these last were cut, 180 trees making 1,500 posts, worth thirty-five cents each, or $525 ; and Mr. Sherman says, that the fifteen acres will furnish

fence for the farm of 1,500 acres for all time, and that the pasture, together with stakes and poles for fencing, furnished from time to time, will pay as good interest as the open land would."

Mr. A. Furniss, of Indiana, speaks of the catalpa and locust :—

"Much of the cost of timber grown by cultivation depends on the price of land on which it is produced. Assuming the average price of land away from the neighbourhood of cities and villages to be fifty dollars per acre, which would be a high estimate for us in Indiana, and the cost of catalpa plants set four feet apart each way, making 2,722 per acre, at a cost of five dollars per thousand—(I grow my plants and they did not actually cost half that figure)—we have thirteen dollars and sixty-one cents for plants. But the ground must be prepared for the plants, and the transplanting is rather tedious work, hence we will allow $11.39 for preparation of land and transplanting, making investment in plants and labour, twenty-five dollars per acre. Total investment, seventy-five dollars per acre. In Indiana lawful interest is six per cent. Now, let us compound this amount for ten years, and we have principal and interest in round numbers, $134.30. To this we will add five dollars annually for four years for cultivation. With us the renter never pays taxes, but we will add that which would be about five dollars. To this add five dollars annually for keeping up fences, and contingencies, and we are debtor :

To cost of land and plants compounded for ten years.....	$134 30
" cultivation four years.....	20 00
" fence, and contingencies, tax, etc.....	50 00
Total.....	$204 30

"At the expiration of ten years we propose to remove one-fourth of the trees, which, if all are standing, will be 680, for which we may claim credit. Many of these by this time will make from one to two good fence posts, and at the lowest wholesale price in car loads would be worth twenty cents each. At an average of twenty cents per tree, we have $136, to say nothing of the tops for fence stakes and fuel, all of which will be consumed on the farm. This reduces our debt to $68.30. This we will compound for two years more and we are debtor to $76.73. At this time, twelve years from setting, we propose to remove one-half of the whole original number, which gives us 1,360 trees. These at the very lowest estimate are worth twenty-five cents per tree, or $340 for the lot; from this amount deduct our indebtedness, and we have a credit of $263.27. We will now compound this for four years more, and our credit is $332.35. Now we propose to close the account and sell the one-fourth yet remaining—680 trees. These are worth a dollar a tree; from this, however, I must deduct the interest on the land for the last four years, which is $13.12. That leaves a net profit of $1,049.23. But, suppose, I am told that my last lot of trees are not worth a dollar apiece. To this I reply that I know of quite a number of *catalpa speciosa* about that age, and for all such trees well grown and within twenty miles of my farm I will give a dollar each and go after them. The catalpa in University Square, Indianapolis, have been set about sixteen years, and average one foot from the ground about one inch in diameter for every year of growth, and notwithstanding they have not been crowded so as to give them the most desirable shape, yet, if the city authorities wish to dispose of them, I will take them at the above figure and be glad of the chance. Of course twenty-five dollars would not move one of them, but as this is not their commercial value, it cannot be used as a basis of calculation.

"Forty years of experience as a tree-planter has taught me that trees do not always grow where they are set precisely as desired or indicated; but, as the catalpa transplants with a remarkable degree of certainty—even growing without roots—I believe on good ground it is within the scope of practical demonstration to realize three-fourths of the result above indicated; but should one half be attained, we have $524.61 as the return from one acre of land for sixteen years, and all this with very little labour or expense after the setting and three or four years' cultivation at the beginning, after which they require no further care."

Mr. Budd, of Iowa, who has grown trees largely, says :—

"A grove of ten acres of white ash, thinned to six feet apart, containing twelve thousand trees, at twelve years were eight inches in diameter and thirty-five feet high, the previous thinning paying all expenses of planting and cultivation. Ten feet of the bodies of these trees were worth, for making bent stuff, etc., forty cents each, and the remaining top ten cents, making a total of six thousand dollars as the profits on ten acres in twelve years, or a yearly profit of fifty dollars per acre. Mr. Everett is said to have sold twenty-three acres of black walnut, of twenty-three years growth, for twenty-seven thousand dollars, of fifty dollars per acre for each year's growth. By the way, it is well to remember that ash will grow where many trees will not.

"But the great point noticeable is that the money is secured, or rather secures itself, without labour after the first ten years. Any plantation, men of experience say, in which the trees are six feet high, and the ground so shaded that weeds and grasses cannot grow, needs no more care till the time comes to thin it for posts. As Mr. Dumbiedikes observed, the trees grow while we sleep. It may be of interest to remark how diligently Scott practised his maxim. For planting, we are told 'he had always, no doubt, entertained a strong partiality. Even in childhood,' he says, 'his sympathies were stirred by reading the account of Shenstones 'Leasowes,' and in after life there was nothing which seemed to afford him so much pride and pleasure as in watching the naked hill-sides gradually sprouting with the saplings he had planted.

"You can have no idea," said Scott to Captain Basil Hall, "of the exquisite delight of a planter; he is like a painter laying on his colonrs; at every moment he sees his effects coming out. There is no art or occupation comparable to this. It is full of past, present and future enjoyment. I look back to the time when there was not a tree here, only bare heath; I look around and see thousands of trees growing up, all of which, I may say almost each of which, have received my personal attention. I remember five years ago, looking forward with the most delighted expectation, to this very hour, and, as each year has passed, the expectation has gone on increasing. I do the same now; I anticipate what this plantation and that one will presently be, if only taken care of, and there is not a spot of which I do not watch the progress. Unlike building, or even painting, or indeed any other pursuit, this has no end, and is never interrupted, but goes on from day to day, and from year to year, with a perpetually augmenting interest."

RAVAGES OF FIRE.

To show what loss is being incurred by the fires which run through our forests, let us take up the report of the Commissioner of Crown Lands for 1882. There are nine reports of surveys. Let us see what they say in succession :—

"*Timber Berths North of French River.*—The greater part of my line passed through a burnt country, the fire having gone over some parts a second time. Over this burnt country all the timber has been killed."

"*Township of Dunnet.*—Over one-half of this township has been burnt."

"*Township of Hugel.*—The greater portion of this township has been overrun by fire and the timber destroyed."

"*Township of Ratter.*—About one-sixth of the township has been burnt over, all the timber being utterly destroyed."

"*Township of Kirkpatrick.*—Nearly the whole of the township has been burnt over."

"*Township of Hagar.*—Bush fires have destroyed nearly all the timber."

"*Township of Field.*—No mention of fire."

"*Township of Dryden.*—The greater portion of the timber has been destroyed by fire."

"*Township of Wilkes.*—Not injured by fire."

In last year's report, out of fifteen surveyor's statements eleven speak of the ravages of fire.

THE PINE LUMBER REMAINING.

The latest opinions of value procurable on this head are perhaps those given by Messrs. Drummond, Little, and others who have studied this subject, at the last year's Forestry Convention. Maine and Michigan were mentioned. At Bangor, long famed for vast lumber mills, only fourteen million feet were procurable in 1877, against over a hundred million in 1856. The whole Saginaw valley, Michigan, the very home of the lumber trade, is nearly culled. What this means may be imagined when we learn that it has been cutting with mills of six hundred million feet capacity. Their lumber journals declare that in all Michigan, Wisconsin and Minnesota—the western pine States, there is not ten years' supply with the present demand. We may, I think, consider that the demand is likely to increase, perhaps to double. With this, and especially if they have a recurrence of their terrible fires, there may not be five years' supply. Concerning Ontario, we are told that Mr. Little has consulted the best authorities, and is persuaded that in Canada (5,000, Quebec; 3,500 Ontario; N.B. and N.S. 1,500) we have but ten thousand million feet of pine, while we are at present cutting a thousand million feet yearly, leaving ten years' supply. Consider this in the same light, and look at some Canadian fire statistics further on, and we may well doubt whether we have five years' supply. In Newfoundland there is little good pine left. It must be noted that a well-known lumberman, Mr. J. K. Wood, puts the amount manufactured yearly in Canada at nearly two thousand million feet, adding to pine spruce and other woods. If we count the pine timber remaining in the States, we shall find that, after Michigan, Minnesota, and Wisconsin are exhausted, say in seven years, there will probably be twice as much, say fourteen years supply, in the other States, such as the large and slowly decreasing forests still standing in Arkansas, Louisiana, and California.

In view of these facts, let us observe what will, in a very few years, be our position in Ontario, or even in Canada. We have but between five and ten years' supply. The Americans have their Southern and Pacific States as a reserve, where, though at great cost of carriage, they may obtain pine. But Ontario has no such reserve. In a few years we shall have but some districts of woodland to our north and north-east, culled of their best pine, and alternated with great sections over which the fire has swept, while the rest but wait for it to arrive, that the destruction may be complete. At one of the late forestry conventions Mr. Thistle, a lumberman and surveyor, gave it as his decided opinion that ten times as much lumber was destroyed by fire as by the axe. Let us carry this to its conclusion. We have been exporting perhaps twenty million of dollars worth yearly. What if we have been losing two hundred millions? Is it not time—would it not have paid fifty-fold—would it not still pay—to give the care to preserve our forests that Europeans give theirs? It was thought that this was a wooden country, and that there was no such danger. I would ask my readers to study the descriptions of European forestry in other of these pages. They will not be able to avoid the conclusion that, in a few years, Germany, Prussia, and other European countries will be better

wooded than Canada. We will glance a moment at what is told us of the forest when the lumbermen have culled it. Here is one description by Mr. Ward, a Canadian lumberman:—"To the uninitiated traveller through the woods, after the shantymen have taken all they think worth taking, he would hardly notice that the chopper had been there, except for seeing an occasional stump, a few chips, or the top of a tree." Now we will take another, Mr. Smith, in the "Flora of Michigan":—"The valuable trees were felled years ago, and the lumberman moved on to fresh spoils, leaving behind an inextricably confused mass of treetops, broken logs, and uprooted trunks. Blackberry canes sprang up everywhere, forming a tangled thicket, and a few scattering poplar, birch, and cherry trees serve for arboreal life, above which tower the dead pines, bleached in the weather and blackened by fire, destitute of limbs, and looking at a distance not unlike the masts of some great harbour. Thousands of such acres, repellant alike to botanist and to settler, can be found in any of our northern counties." What we had better conclude, I fancy, concerning the difference between the two, is that the second had undergone a second and yet sharper and more reckless culling, after it had passed the stage described by Mr. Ward. It is evident that the time has passed when it was a matter of choice to attend to forest preservation in Ontario. If we are to retain any, it is now an affair of immediate necessity.

In fine, if we wait longer, our forests will be gone, and can then not be renewed, except at the vast expense of time and money required in planting.

If we move energetically now, we can preserve great forests, the maintenance of which is most necessary to our prosperity, and shall also have time to plant, where no other means exist.

FOREST EXISTING IN ONTARIO COUNTIES.

(From Agricultural Commission.)

Prescott and Russell:—About forty-seven and a-half per cent. of the entire area is under timber, consisting of hemlock, cedar, tamarack, beech, birch, elm, basswood, ash, balsam, pine, spruce, walnut, butternut, whitewood, dogwood, soft maple, and red and black cherry; used principally for lumber, fencing, firewood, railway ties and saw logs.

Glengarry, Stormont and Dundas:—Probably about thirty per cent. of the entire area of these counties is still timbered with hard and soft maple, beech, birch, ash, tamarack, elm, basswood, hemlock, spruce, balsam, and some pine; used for fuel, lumber, railway ties, telegraph posts and shingles.

Carleton:—About 287,000 acres of land in this county are still uncleared.

Leeds and Grenville:—In all the townships, except South Burgess and North Crosby, which have suffered from the ravages of bush fires, there is a large amount of standing timber, consisting mainly of hard and soft woods; used for firewood, fencing, lumber, buckets and pails.

Lanark:—About twenty-four per cent. of the uncleared land is covered with timber or bush. The timber is chiefly pine, beech, maple, basswood, ash, birch, cedar and tamarack. A considerable export trade in hardwood is carried on, and there is a large local consumption for railway ties, fencing, fuel, etc. A great destruction of pine took place from the great fire in 1870.

Renfrew:—About forty-six per cent. of the entire area is still timbered. Red and white pine exist in large quantities. There is also an abundant supply of ash, elm, maple, basswood, spruce, cedar, tamarack, balsam, poplar, beech and hemlock. Lumbering

is extensively carried on for exportation to European and American markets. The hard woods are chiefly used for fuel and cedar for fencing.

Frontenac:—As nearly as can be computed, about fifty per cent. of the land in Frontenac is still timbered with pine, basswood, ash, hemlock, beech, balsam, tamarack, cedar and maple; principally used for lumber, fencing and fuel.

Lennox and Addington:—Owing to the returns being in several instances obviously inaccurate, the extent of land in the counties under timber cannot be estimated. Four-fifths of Denbigh and associated townships are, however, reported to be under pine, maple, beech and cedar, and lumbering is extensively carried on. There is also a considerable quantity of timber land in North and South Fredericksburg, in Camden and in Sheffield.

Prince Edward County:—About sixteen per cent. of the entire area is still covered with timber, consisting of beech, maple, elm, cedar, oak, black ash and some pine; used for lumber, fuel, coopers' staves, fencing and building.

Hastings:—A large proportion of the acreage is still covered with timber—in some townships to the extent of seventy-five per cent.

Haliburton:—About eighty per cent. of the entire area is still under timber, consisting principally of maple, beech, birch, hemlock, basswood, elm, ash, pine, tamarack and cedar; used for lumber, fencing, railway ties, telegraph poles, shingles, bolts, saw-logs, etc.

Peterborough:—A large proportion—not far short of one half of the area—is under timber, consisting of pine, cedar, beech, maple, hemlock, basswood, tamarack, birch and ash; used for timber, fencing, firewood, shingles, bolts, railway ties and telegraph poles. Bush fires have destroyed large tracts, particularly in the township of Harvey.

Northumberland and Durham:—About eighteen per cent. of the total acreage is still timbered with hardwood, cedar, pine, hemlock, and tamarack. The former is used principally for fuel, the latter for building, fencing, and barrel staves.

Victoria:—Probably about fifty per cent. of the uncleared land is under timber, consisting of cedar, pine, hemlock, maple, birch, beech, basswood, black ash, mountain ash, balsam, tamarack, oak, and elm; used for lumber, fuel, building, and fencing.

Ontario:—About seventeen per cent. of the area of Ontario is still under timber (excepting the township of Reach, which returns no percentage). The timber consists of pine, maple, beech, basswood, tamarack, balsam, cedar, black ash, hemlock, and elm; used mainly for lumber, fuel, fences, staves, and domestic uses.

York:—About twenty-two and a-half per cent. of the area of York is still under timber, consisting of beech, maple, elm, basswood, pine, hemlock, cedar, tamarack, and birch; used for building purposes, fencing, and firewood.

Simcoe:—It is impossible to glean from the returns the total acreage under timber, but probably over one-half of the entire county area is under maple, beech, elm, basswood, tamarack, pine, hemlock, cedar, balsam, birch, ash, and oak. Lumbering operations are very extensively carried on in several of the townships, and there is a large amount of business done in hemlock bark (which is largely used within the county, and also exported for tanning purposes), and in railway ties, telegraph poles, and shingles. The hardwoods are principally used for fuel, and the soft woods for building and fencing.

Peel:—About eleven per cent. of the entire acreage is still under timber, consisting of beech, maple, hemlock, cedar, white and red oak, ash, elm, hickory, and basswood. A few pines are scattered in Chinguacousy and Toronto townships. The timber is generally used for fuel, fencing, and domestic purposes.

Halton:—About seventeen per cent. of the entire area is still timbered, chiefly with hardwood and a limited amount of pine. The timber is principally used for lumber, fencing, and fuel.

Wentworth:—Fourteen and a-half per cent. probably under timber, consisting of pine, beech, maple, elm, black ash, cedar, tamarack, oak, hickory, walnut, and chestnut; used for lumber, firewood, fencing, building, and general purposes.

Lincoln:—Exclusive of the township of Caistor, which does not report the area of land still timbered, Lincoln has over 24,400 acres still covered with beech, black ash, maple, elm, oak, hickory, and some pine; used for firewood, fencing, building, and manufacturing purposes, also for ship timber and railroad ties.

Welland:—About eighteen per cent. of the area is still under timber, consisting of beech, maple, oak, ash, basswood, elm, hemlock, poplar, birch, chestnut, walnut, and butternut; used for shipbuilding, housebuilding, fencing, and fuel.

Haldimand:—About twenty-four per cent. of the acreage is still timbered, consisting chiefly of hard woods; used for fencing, fuel, and building purposes.

Norfolk:—About twenty-four per cent. of the entire area is still timbered, and the standing timber consists chiefly of pine, oak, maple, chestnut, black and white ash, elm, and cedar; used for railway ties, lumber, fencing, firewood, and general purposes.

Brant:—About twenty-five per cent. is yet in timber of maple, beech, elm, oak, pine, cedar, basswood, tamarack, hickory, and ironwood.

Waterloo:—About twenty-two and a-half per cent of the area is still timbered with pine, oak, beech, maple, cedar, ash, and hemlock.

Grey:—About thirty-four per cent. of the land is still timbered chiefly with hardwood. Very little pine exists and only sufficient cedar for fencing purposes.

Bruce:—About twenty-five per cent of the land is timbered. Maple, basswood, elm, hemlock, cedar, ash, beech and birch predominate; there is also some pine.

Huron:—About twenty-nine per cent. is covered with timber; hard and soft woods.

Perth:—About twenty-one per cent. is covered with timber, consisting of beech, elm, maple, basswood, black and white ash, pine, hemlock, cedar, birch and tamarack.

Oxford:—Seventeen per cent. under pine, cedar, beech, maple, elm, ash, basswood and oak.

Elgin:—Thirty per cent. is timbered with most of the indigenous woods excepting cedar.

Middlesex:—Thirty-five per cent. under hardwood and some pine.

Lambton:—Forty-eight per cent. covered with oak, ash, elm, beech, maple, basswood, hickory and some pine.

Kent:—Thirty-seven per cent. in oak, black and red ash, hickory, hard and soft maple, cherry, and sycamore, some black walnut, and some tulip.

Essex:—Two-thirds still under bush, consisting chiefly of whitewood, oak, ash, elm, hickory, bass, sycamore, and other woods.

Wellington:—About fifteen per cent. is still timbered with beech, maple, elm, cedar, hemlock, basswood, ash and balsam.