The Horticultural Society of New York

INCORPORATED 1902

MEMOIRS, VOLUME II

Proceedings of the

International Conference on Plant Hardiness and Acclimatization

1907

Held in the rooms of the American Institute of the City of New York, and in the Museum Building of the New York Botanical Garden

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Papers Presented at the Conference

First Session, Tuesday, October 1

Second Session, Thursday October 3

Papers Read by Title

INTERNATIONAL CONFERENCE ON PLANT HARDINESS AND ACCLIMATIZATION.

First Session—Morning.

Held in the Rooms of the American Institute, 19 West 44th Street, New York City, October 1st, 1907, at 10 A. M., the President, James Wood, presiding.

The President—We meet in these rooms as the guests of the American Institute of the City of New York, and we have the President of the Institute here with us this morning, Mr. Rutter, and I am sure we will be pleased if Mr. Rutter would give us a word of welcome here.

Mr. Rutter—Mr. President and Gentlemen and Ladies: I am glad to see you, the members of the Horticultural Society of New York.

On behalf of the American Institute, it affords me very great pleasure to welcome you, not only to the City of New York, but to the use of the rooms of the American Institute.

In former years it held very large expositions, and every individual who had anything useful or anything novel that he wanted to introduce to the world, was only too ready to take space and exhibit it in the interests of the world, in these institutes, shows and exhibitions. Since that time, of course, the City of New York has changed to that extent that exhibitions of that kind at the present day would in no circumstances, in my judgment, prove a success, for every manufactory, every department store, every florist's establishment, has exhibitions of its own, that the public can see day by day, and in this way no interests would be served by such an undertaking by the American Institute at the present time, in the form of an exhibition, or an exposition.

I am pleased to say that the American Institute always takes an interest, and is always ready to afford its accommodations to kindred organizations, to all the societies that have at heart the welfare of the agriculturists.

I believe it has become an undisputed fact that not only the wealth of individuals, but the wealth of nations is derived from the soil, and the man or the woman who possesses the ability to make two blades of grass grow where only one grew years ago, has certainly proved a benefit to the world at large, and that is what you are doing, bringing to bear at the present time all the scientific knowledge, and all the scientific appliances to produce greater results from the soil than have ever been produced heretofore.

I am sure if you keep on, with the progress that has already been made, and advance still farther, which doubtless you will do, that we who are confined day by day and year by year within the bounds of a narrow office or manufactory, will only be too glad to take advantage of the benefits you have conferred upon us, to get into the open and enjoy the sun and the light of heaven.

I welcome you, gentlemen, in the house of the American Institute, trusting your deliberations will be pleasant and beneficial, and that you will leave us with a good impression of the City of New York.

The President—As to the particular subject of our meeting, we are here to do what we are because of the work of two great laws. One is the force of heredity and the other is the force of environment.

Under those two laws we are what we are, and those laws are of such wide and universal application that the subject to be considered comes under their operation.

Plants are influenced by heredity, and this force is potent, very potent. It is, however, subject to some changes and modifications, such as Professor DeVries has recently called our attention to.

Plants are influenced by their environment. Their environment and the environment of their progenitors have determined their character, and it is the change that comes upon their character by the influence of environment that we are to consider.

There are few more interesting things than the consideration of the application of the great universal laws, and I am quite sure that our meeting here and the papers which we will hear read, and which will be discussed, I hope, and I believe, will influence and enlarge our knowledge upon these interesting and important matters. The programme calls first for a paper from Dr. MacDougal, now of Tucson, Arizona, on "Factors Affecting the Seasonal Activities of Plants."

Before Dr. MacDougal begins the reading of his paper, I want to say that the new work he is introducing in Arizona is one for which he is eminently qualified. Of course, we know of his admirable work here in our own New York Botanical Garden, and that he is working there under most exceptional conditions, having a range of elevation of over a mile as his experiment station. He has the climate, he has it practically in his hand, and he has opportunities for observation that are equalled by few in the world.

Dr. MacDougal—Mr. President and Members: I think you have handicapped me by these preliminary remarks, because I shall not probably be able to show results equal to what you will expect.

The following paper was read by D. T. MacDougal:

Factors Affecting the Seasonal Activities of Plants.

By Dr. D. T. MacDougal,
The Desert Laboratory, Tucson, Arizona.

DISTRIBUTION AND ACCLIMATIZATION.

Every species inhabits the areas which it has been able to reach and occupy from the starting point of its place of origin. Neither its birthplace nor any of the places within its range may offer the most suitable conditions for the best growth and highest development. Beyond seas, over mountain ranges, across the equator or past other equally effective barriers may lie plains, valleys, plateaus or even continents, where if once introduced, it might overbear all competition from the plants already there, extending its distribution a thousand-fold and the number of its individuals a million-fold. Let the barriers be but once passed and it enters into a new kingdom, as the various invasions of weeds amply testify.

The soil, the various factors of climate, the course of the seasons, and the actual composition of the plant-covering already present in the region, may be such that the intruder becomes an integral part of the flora, and it may indeed perish in its original habitat and in the places successively occupied by it, leaving us no clew as to its place of origin.

The value of a cultivated plant is fairly co-ordinate with the extent of its possible distribution and culture. Not only does its greater cultivation bring a greater total product, but the greater the crop the better developed may become the facilities by which it and all of its constituents are used to the fullest, and to the greatest economy by the human race.

Our conscious efforts to widen the range of distribution and extent of cultivation of species of interest and economic value facilitates and aids one of the most basal processes in the life of the plant, and it has before it the possibilities of limitless success, to compensate for the numerous failures which the worker must necessarily encounter.

Two main considerations confront us in the problems of acclimatization. First, a careful examination reveals the fact that nearly every species in the wider usage of the term includes several races or elementary species, which bear different hereditary qualities as to hardiness, capability for accommodation, rapidity of growth and productiveness. Careful culture enables a comparison to be made among a group of such forms and to select those which bear the desired qualities to make an introduction or acclimatization operation successful. Perhaps the necessary qualities may be discerned in separate races of elementary species, and by hybridizations these qualities are brought together into races or species capable of meeting the conditions to be encountered. To recount, or even adequately illustrate the triumphs and accomplishments of the horticulturist by methods for the most part very crude, during the last century, would be impossible.

Now, however, by the light of present knowledge, profiting by the splendid results of Nilsson with cereals, all such operations may be carried out with much greater exactitude and much more rapidly than by the old-time method of trial and error, most wasteful of skilled energy and time-consuming in human life. To-day we may expect as much from the breeder in ten years as he might have been able to accomplish in the previous half century. The realization has been tardily reached that if we are to make alterations in the hereditary qualities of the plants useful to us, we must make an accurate analysis to disclose the constituents of the species with which we are dealing, and having this information we may proceed with the exactitude of the chemist making compounds and extractions in his laboratory.

With so much to our credit in the way of advance made in knowledge of the nature of the plant and its behavior, the other important task which confronts us is that of making a similarly exact study of climate and of all of the factors which constitute the complex set of conditions which we term environment.

A simple analysis of the relations of a plant to external conditions will be useful for a better understanding of the character of the problems involved. The principal factors affecting vegetation are undoubtedly light, temperature, moisture, food-material and chemical composition and physical consistency of the soil. It is obvious to the veriest novice in gardening that certain intensities or concentrations of these agencies are necessary for the welfare of the plant, and that the combinations suitable for one are not for another.

It will be impossible to give even a brief consideration of the special relations of each of these factors to the plant, but we may gain an insight into their general character by a consideration of the more important details with respect to temperature, which is one of the most widely interlocking elements of climate. The conclusions derived from its consideration may be held to apply to the other agencies as well.

Living matter is an extremely complex substance and we must be prepared therefore to find that its relation to its environment is not simple; this is especially marked with regard to temperature.

CARDINAL POINTS IN TEMPERATURE.

All of us know by every-day experience that there is a certain general degree of heat at which any given species grows best, and a discrimination as to the application and regulation of temperature constitutes one of the most important features of the practice of greenhouse gardening. This temperature, which is customarily termed the *optimum,* may be ascertained to within a degree or two very easily. If the heat is increased in a greenhouse in which a plant is happily growing at the *optimum,* it will soon be found that such increase lessens the rate and amount of growth, and a continued increase will soon bring the thermometer to a point where a *supra-optimum* will be reached at which growth ceases. This may simply bring the plant to rest as might the cold of autumn, and with but slight damage. But if the heat be increased still further a third point will be found at which the plant is killed and by such a test we will have ascertained the point of *fatal heat.*

Starting again with a plant at the *optimum* it will be found that as the temperature decreases, growth slows down until an *infra-optimum* is reached at which growth ceases as it did at a certain point above; this is the temperature of *fatal cold* at which living matter is totally disorganized.

Our efforts at acclimatization and our work in securing the feature of hardiness in plants, with respect to temperature, consist in operations by which the position of the cardinal points of the plant with which we may be working may be altered on the scale of the thermometer. These cardinal points undergo wide changes in a state of nature, and it is by taking the inherited capacity for adaptation of any plant with regard to this particular into account that we may hope to make our greatest progress. First of all it is obvious that these five critical points in the life of any plant change with the development of the individual, and that the *optimum* slides up or down the scale, or all open out more widely. Take any plant, such as the radish, wheat, squash or sunflower, and it has been found that seed or grains air-dry, and in resting condition, may endure the lowest cold that can be produced, that of liquid hydrogen at about 454° F. below the freezing point of water, which proves that the fatal cold in such cases is extremely low, and to have only a theoretical existence. The same seeds in a resting and dried condition may be subjected to the heat of boiling water at 212° F., so that the points of fatal heat and cold lie far apart in this stage of the existence of the plant. Now give them a supply of moisture and start germination, and a radical change in the position and relation of the critical points ensues. A cold fatal to the active seedling will be found near the freezing point of water, and but slightly below the *infra-optimum,* the *optimum* will be found to lie between 80° and 98° F., the *supra-optimum* and cessation of growth will be found between 100° and 120° F. for most plants, although many species, especially those native to the desert, range higher, while a fatal heat comes within a few degrees above the *supra-optimum.*

As the plant nears maturity, the tissues harden, the protoplasm becomes more highly granulose and denser, and has an altered chemical composition, by which it again becomes less susceptible to alterations, and again the cardinal points take positions more widely separated from each other, and in the seed are again able to endure any cold which they may encounter.

THERMAL REQUIREMENTS OF A PLANT.

This brings us at once to the consideration of the practicability of some estimation of the thermal constant of any form, or the amount of heat necessary for its seasonal or cyclical development. The first effort toward fixing any such standard appears to have been made by Reaumur, the inventor of the thermometric scale which bears his name. He adopted the sum of the mean daily temperatures, as recorded by his thermometer in the shade, as an index of the amount of heat required to bring a plant to any given stage of development, using averages of the daily maximum and minimum to obtain his mean daily temperatures. According to Abbe, Reaumur calculated the sum of the averages constituting the heat exposure of a plant at his locality in France during the 91 days of April, May and June, 1734, to be equivalent to 1160° C., but in the following year it amounted to only 1015° C.

Adanson disregarded all temperatures below freezing, taking only the sum of the positive temperatures on the centigrade scale, and began the summation of heat exposures thus derived with the first day of the calendar year for any given season.

Boussingault attempted to derive the thermal constant of a vegetative period, or any part of it, by multiplying the mean temperature of the air by the duration in days.

Gasparin calculated thermal constants from temperatures obtained from insolation thermometers exposed to direct sunlight while lying on the sod, which would record 20° to 30° C. higher than shade temperatures, and showing a difference equivalent to three to six degrees latitude. By this method, the thermal constant required for the germination and maturity of the seed of wheat amounted to 2450° C.

Variations in the method of calculation of the thermal constant have been made by various investigators, in which this standard has been obtained by multiplying the mean temperature by the square of the number of days involved, others multiplying of days by the square of the mean daily temperatures.

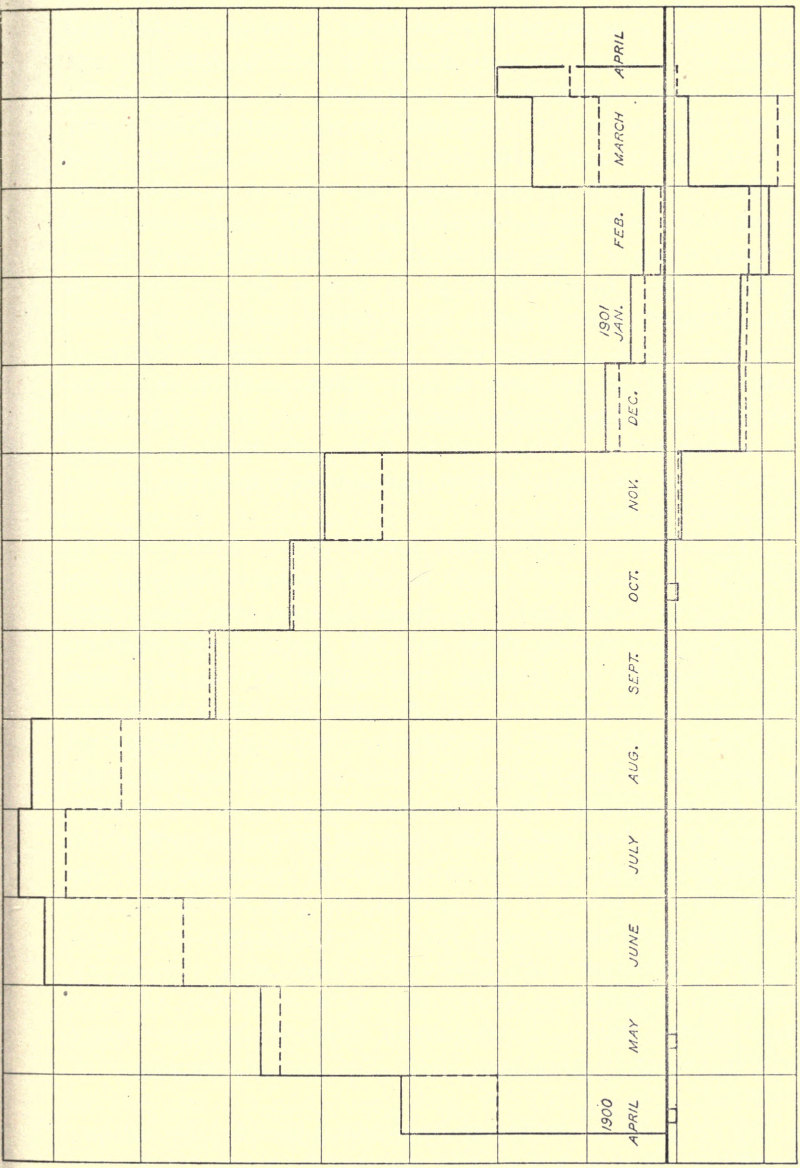
Some begin this calculation of the heat exposure with the appearance of the earliest species to show sign of awakening activity.

As an application of the principle of the thermal constant many bio-geographers have attempted to explain distribution by the mean annual temperature to the regions concerned. Among the most notable of such works is to be mentioned that of Hoffman, of Giessen, South Germany, who used the sum of the insolation temperatures from the 1st of January in calculating the thermal constants, and it is his data which are quoted so freely in all general treatises on plant geography and the thermal relations of vegetation. Drude uses the mean annual temperatures in his treatment of the subject, in which he is followed by Pound and Clement in their Phytogeography of Nebraska.

It need scarce be said that the mass of data accumulated by the various methods described during the last century and a half is confusing on account of the highly empirical character of the principles upon which each separate investigation has been based, the different standards of thermometry, and the utter lack of uniformity of technique. The last defect alone is sufficient to invalidate most of the results, which are nearly all valueless so far as any application is concerned, in this connection. Concerning the futility of research upon this subject it is most significant that Warming and Schimper refuse to recognize the thermal constant as a definable factor in the relations of plants to climate.

In the effort to outline some method for the calibration of heat exposure of plants growing in the open, the work of Herve Mangon seems to offer the most valuable suggestions. Mangon computes all shade temperatures from the time of germination of seeds until maturity of the plant was reached, disregarding all measurements in which the mean daily temperatures is less than 6° C. (42° F.). By this method he found the sum of mean daily temperatures necessary for the ripening of wheat in Normandy in 1870-1879 to vary between 2219 and 2517, and with the data of several seasons at hand it was possible to predict the date of ripening of wheat within three or four days.

The great variation shown by a plant with regard to the heat exposure calculated by Mangon's method is in all probabil-



Total heat exposure in New York Botanical Garden, April, 1900, to April, 1901. The areas above the heavy base line enclosed by the solid lines represent the total heat exposures in hour-degrees-centigrade, of the herbaceous grounds. The areas above the base line limited by the dotted lines, denote the exposure in the hemlock grove. Exposures below the freezing point in both localities are similarly represented below the base line.

ity due to the faulty method of calculating such exposures. The performances of an engine are not to be calculated by the total averages of the steam pressure during its working days, but may be quite exactly determined by multiplying the pressure by the number of hours during which pressure was kept up and used.

A similar relation holds with regard to the use and effect of radiant energy in the plant, and although any method of estimation must be more or less arbitrary, yet it seems possible to select one which will be capable of wide application and corresponding value. In the evolution of such a method for plants in the temperate zone it seems less artificial to begin the calculation of the heat exposure with the winter solstice instead of January 1st, and as has been done by several writers, or if economic plants are under consideration, take the date of planting as a starting point. It also seems most convenient to use the temperature of the freezing point of water as a base line for the thermometry of the plant.

The application of the method then simply entails the calculation of the number of hours to which a plant has been exposed to temperatures above the freezing point from the winter solstice or other starting point until the stage of development, such as flowering or fruiting, under consideration has been reached. The time factor is then properly applied to the height of the thermometer above the freezing point during the period mentioned. In actual practice this may be easily done by computing the area enclosed by a thermographic tracing of the temperature and the base line of the sheet for the period over which the development of a plant is to be studied by means of a planimeter. It was found by this method that the flowers of *Acer saccharinum* were mature and ready for fertilization on March 26, 1901, in the New York Botanical Garden, after 1100 hours' exposure to temperature above zero with a totality of 3109 hour-centigrade units: *Draba verna* attained the same stage something earlier in 974 hours, with 1644 hour-centigrade-units' exposure.

Now, it is by no means to be assumed that the above data represent the fixed and invariable constant heat exposure of the plants in question, for as has been described previously, the cardinal points, including the *optimum* for growth and development, may be altered by other conditions which affect the plant. The variation of which a plant is capable represents its possible geographical range which may be mapped with fair accuracy. Thus the individuals of a species which live nearest the pole have made such accommodations that they are able to accomplish development with a minimum number of heat units, in a minimum number of hours. As the range of a species is traversed toward the equator or to lower elevations, a place is reached where the heat exposures are at an *optimum* for the plant, and beyond this, development is retarded until the southern limit of the species is reached. The actual limits are of course determined by the entire complex of conditions, of which insolation is also an important factor, but for the sake of clearness, attention is focussed upon temperature alone.

The gradual accommodation and acclimatization of grains to regions to the northward has nowhere been more systematically studied than in the Scandinavian peninsula, and Schubeler's consideration of available results led to the conclusion that corn from lower latitudes or elevations ripened earlier when taken northward and upward, although the light and average temperature was less. This precocity in development persisted for some time, when seeds were taken back to the southern localities. In some cases the seeds and sometimes the leaves reached a greater size if the conditions permitted full development in the northern extensions, but this accommodation was not carried to the first generation in plants in the south from northern grown seeds. It was also noted that the colors of various organs as well as the aroma was increased in plants taken northward if the introduction did not go beyond the limit of conditions allowing full development. (Schubeler, F. C. Viridarum Norvegicum. Norges Växtrage. Et Bidrag til Nord-Europas Natur-Og Kulturhistorie. 1. Christiania, 1885. Rev. in Bot. centralb. 28: 203. 1886.)

The relation of the plant to negative exposures is one of endurance and not of performance, and the interpretation of the influence of cold upon distribution may not be made by the formula given above. The total amount of negative or cold exposure is undoubtedly the predominating one, but the minimum, the range in variation, and the occurrence of minima below the freezing point during the vegetative season, are also of importance in distribution and await the acquisition of additional data before their interpretation may be attempted successfully. Some of these factors are extremely localized, and the poleward limit of distribution in the northern hemisphere of many species is known to run in extremely irregular lines.

Some illustration of this is gained from the results of the comparative study of the climate in the hemlock grove of the New York Botanical Garden and the meadow of the herbaceous grounds, not more than 500 yards distant, made in 1900 and 1901. The data obtained show that the meadow carpet received 78836 hour-degrees of heat during the year ending April 1, 1901, extending over 7282 hours of exposure to temperatures above the freezing point, while the hemlocks received but 68596 similar units with an exposure to temperatures above the freezing point for 7024 hours. The meadow was exposed to 5569 units of temperature below the freezing point and the hemlocks 5791 units. The herbaceous grounds were below the freezing point for 1478 hours, and the hemlocks for 1736 hours.

Here, then, in two localities within rifle shot are to be found two habitats for plants in which the difference in the length of the season as indicated by the number of hours above the freezing point amounts to nearly eleven days, the total number of heat units in the meadow being 13% in excess of that of the forest. The maximum and average maximum of the meadow are higher, and the minima and average minima are lower, the mean average of the hemlocks being lower, however, than that of the meadow. The value of such observations is greatly enhanced by the fact that they represent a comparatively narrow range of variation. Thus, in the several years in which observations were made as to the matter, the length of the period between the last frost of spring and the first of autumn lay between 167 and 171 days in the New York Botanical Garden.

The data upon which these conclusions rest are shown in the accompanying tables. The amounts given under "total exposure" represent the product of the number of degrees above freezing point multiplied by the number of hours. The value of the centigrade-hour-unit represented in such amounts is 9/1600, and of Fahrenheit-hour-units 81/8000. The number of hour units is therefore to be found by simple division. + indicates temperature exposures above freezing; — below freezing.

THERMOGRAPHIC OBSERVATIONS IN N. Y. BOT. GARDEN, 1900-01.

Date	HERBACEOUS GROUNDS. Total Exposure	Number of Hours	HEMLOCK GROVE. Total Exposure	Number of Hours
April 9 to 16, 1900	+4.25	149	+3.50	152
	— .14	19	— .08	16
April 16 to 23	+9.50	168	+8.47	168
April 23 to 30	+8.45	168	+7.56	168
April 30 to May 7	+7.75	168	+8.50	168
May 7 to 14	+9.45	164	+10.25	168
	— .02	4		
May 14 to 21	11.56	168	10.91	168
May 21 to 28	12.37	168	11.76	168
May 28 to June 4	12.50	168	11.66	168
June 4 to 11	12.85	168	11.77	168
June 11 to 18	13.00	168	12.10	168
June 18 to 25	15.21	169	12.93	169
June 25 to July 2	16.32	167	14.17	167
July 2 to 9	16.85	168	15.16	168
July 9 to 16	15.80	168	15.42	168
July 16 to 23	17.73	168	15.19	168
July 23 to 30	15.35	168	14.42	168
July 30 to Aug. 6	14.46	168	13.00	168
Aug. 6 to 13	18.86	168	15.94	168
Aug. 13 to 20	15.66	168	14.10	168
Aug. 20 to 27	15.27	168	14.29	168
Aug. 27 to Sept. 3	16.36	168	15.17	168
Sept. 3 to 10	15.84	168	14.93	168
Sept. 10 to 17	13.25	168	13.24	168
Sept. 17 to 24	10.21	168	9.81	168
Sept. 24 to Oct. 1	12.35	168	10.12	168
Oct. 1 to 8	13.30	168	11.80	168
Oct. 8 to 15	9.30	168	8.56	168
Oct. 15 to 22	+6.25	159	+5.95	168
	—0.15	9	....	
Oct. 22 to 29	+10.25	168	+9.90	168
Oct. 29 to Nov. 5	7.16	168	7.70	168
Nov. 5 to 12	+4.30	156	+4.50	168
	— .24	12	....	
Nov. 12 to 19	+4.40	138	+2.90	135
	— .41	30	— .50	33
Nov. 19 to 26	+7.50	168	+6.05	168
Nov. 26 to Dec. 3	+2.86	146	+2.80	155
	— .65	22	— .30	13
Dec. 3 to 10	+3.15	133	+1.95	138
	— .71	35	— .50	30
Dec. 10 to 17	+ .60	32	+ .35	22
	—3.60	136	—5.90	146

Date	HERBACEOUS GROUNDS. Total Exposure	Number of Hours	HEMLOCK GROVE. Total Exposure	Number of Hours
Dec. 17 to 24, 1900	+1.50	74	+1.27	48
	—2.25	94	+1.28	120
Dec. 24 to 31	+1.50	90	+ .90	65
	— .85	78	— .90	103
Dec. 31 to Jan. 7, 1901	+ .80	68	+ .50	40
	—2.10	100	+2.84	128
Jan. 7 to 14	+ .80	140	+ .60	126
	— .60	28	— .40	42
Jan. 14 to 21	+1.10	68	+ .65	46
	—2.60	100	—2.70	122
Jan. 21 to 28	+ .80	102	+ .50	42
	— .60	66	—1.00	126
Jan. 28 to Feb. 4	+2.25	20	+ ...	...
	—4.00	148	—3.55	168
Feb. 4 to 11	+ ...	...	...	...
	—4.30	—168	—4.80	168
Feb. 11 to 18	+ .50	— 56	+ .20	32
	—2.20	—112	—2.10	136
Feb. 18 to 25	+ .50	36	+ .20	14
	—1.50	—132	—3.00	—154
Feb. 25 to Mch. 4	+1.50	88	+1.20	76
	—1.20	— 80	—1.50	— 92
Mch. 4 to 11	+1.80	102	+1.20	108
	—1.70	— 56	—1.65	— 60
Mch. 11 to 18	+2.40	149	+1.40	145
	— .30	— 19	— .20	— 23
Mch. 18 to 25	+3.60	154	+2.70	149
	— .10	14	— .20	19
Mch. 25 to April 1	+7.56	162	+2.65	141
	— .10	— 6	— .25	— 27
April 1 to 8	4.70	168	3.41	168

STIMULATION AND ACCOMMODATION.

There yet remains to be considered the stimulative reactions and accommodations of the plant under changes in the environmental forces which act upon it. Generally speaking, it may be said that sudden changes in the intensity with which a force acts upon a plant results in stimulation, and that gradual alterations are followed by accommodations, and that such adjustments or adaptations may be produced by the long-continued uniform action of any external factor.

A striking example of stimulation followed by accommodation is offered by the sensitive plant, and the well-known response of this plant to a touch or blow consists in folding movements of its leaves and leaflets. In repeating the test of it, perhaps this blow may be given by a drop of falling water, or by a slender pencil. Now place a healthy plant under a fine shower nozzle from which water not too cold will fall in thousands of repetitions upon the same leaves. The first of the mimic shower causes the leaves to undergo the characteristic movements. The steady, gentle tapping of the falling drops continues, however, and the leaves become so accustomed or accommodated to their shock that they no longer constitute a stimulus, with the result that in a few hours the leaves are fully expanded in the falling drops, the first touch of which caused a full and rapid closure of all of the leaves and leaflets. The accommodation is to falling drops only, since if the leaves are struck with a rod, or exposed to the action of heat from a shielded burning match, closure follows. The test may be repeated by arranging a clockwork to cause a small rod to strike the leaves or stems at frequent intervals, when accommodation will follow in the same manner. This is one phase of accommodation. A second is one in which a force is slowly increased. Thus, suppose that instead of suddenly exposing the plant to a shower of drops, we had placed it in a damp chamber and began spraying it from an atomizer in which the size of the particles of water was slowly increased until they became large raindrops. Treatment of this kind would be followed by no reaction movement, the protoplasm having ample opportunity to make the necessary adjustment to the size of the drops and the increased force of the blows.

An even much more familiar illustration of stimulation is that offered by the practice of storing dormant bulbs and tubers at a low temperature, then bringing them into a warmer room for sprouting. The change in the temperature is the shock which awakens the resting plant in such operations, and the difference between the storage pit and the growing chamber may be so great that it should be made in two steps to avoid damage. On the other hand the beneficial effects of such stimulation may be readily appreciated when plants are stored at temperatures too high to secure this shock by the change, and it also accounts in part for the slow, feeble action of some species when kept at an equable temperature during the entire year. But this stimulus is not to be thought of as always a change from a low to a high temperature, for the reverse may have a like effect. *Encelia* *farinosa* is a desert shrub which has been introduced into the xero-montane plantation of the Desert Laboratory at 6,000 feet, being taken from a habitat at 2,500 feet and correspondingly warmer. It is a winter perennial, however, and its season of activity lies within the cool season of February to April, at which time it goes into a resting condition. Now, if the roots are taken up at this time and carried up to the 6,000-foot level, the stimulus of change to the cooler temperature again causes it to awaken and put out a new set of shoots. Exact observations upon this stimulative reaction of any plant are possible, and many of the practices of the gardener are the results of long practical experience upon the matter. An interesting set of data have recently been obtained by Dr. B. E. Livingston with respect to the change from the *infra-optimum* to the *optimum* with regard to moisture from which it is seen that seeds of *Cereus, Fouquieria, Phaseolus* and *Triticum,* germinated when transferred from an air-dry condition to soil containing 15% of water, *Impatiens* in soil containing 20 to 25%, *Raphanus* demanded 20%, and *Trifolium* 25%.

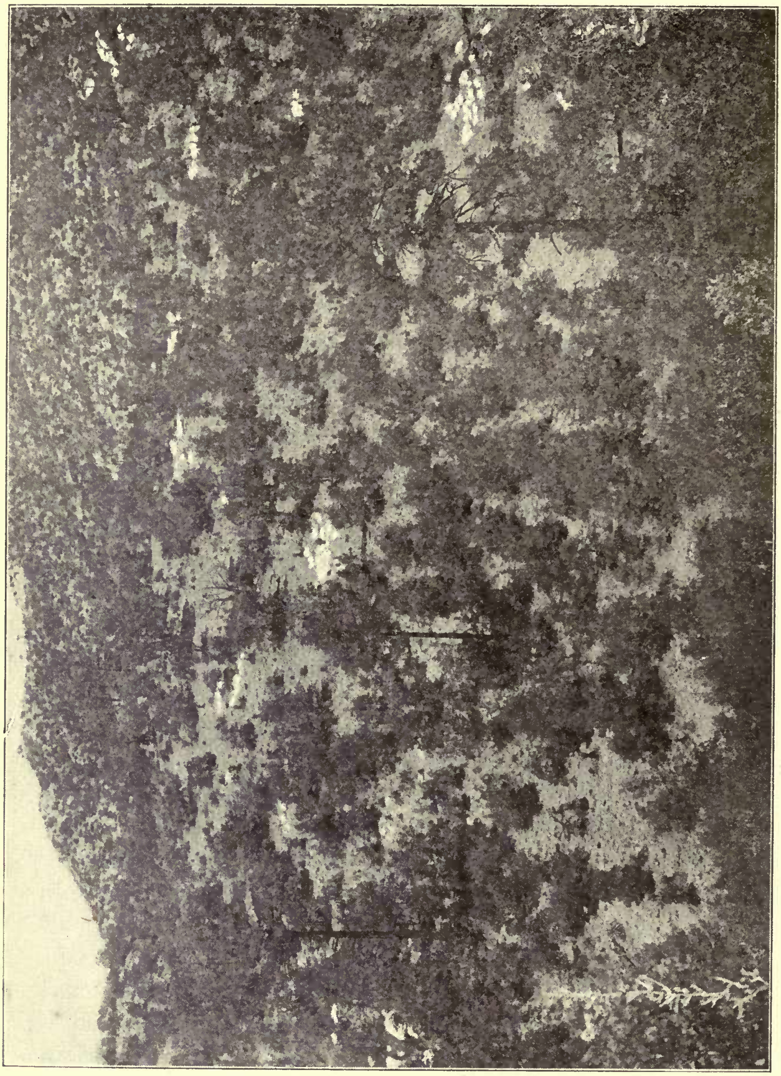
Gradual changes in the temperature, or in any of the other agencies affecting plants, may allow the protoplasm to make such adjustments of the living matter that the cardinal points are much changed and a species may accommodate itself to conditions ordinarily unendurable. Experimentation in this phase of the subject has been carried on most with bacteria and the simpler fungi, and it has been found that these organisms are capable of making such slow changes as to be able to undergo temperatures, comparatively very low and very high. The facility with which these organisms may be handled has also led to the result that they have been found to accommodate themselves to very great changes in the composition of the nutrient medium, and to endure the presence of poisonous substances, the concentration of which was increased very gradually.

In all such cases the power of endurance of the plant to an excessive or defective action of any one force is very much modified by the presence of or action of others. Thus, in the matter of the seeds, the endurance to extremes of temperatures is seen to depend directly upon the amount of moisture present.

Again the time element or the rapidity with which the intensity of external conditions is changed is a basal factor in all accommodation processes. As a plant accommodates itself to live at unwonted temperatures, or in unaccustomed soils, but little doubt exists that it undergoes changes in intricate structure, which, however, are not always to be demonstrated. So long as the species remains under the new and strange conditions the acquired structure will be retained from generation to generation, whether propagated by cuttings or seeds. If the species is returned to its original habitat or to the normal conditions in which it originally grew, the acquired structures may persist for a time, but in accordance with the power of accommodation which originally brought them into existence, they will disappear when the inducing factors are removed.

The classical cultures of Bonnier made in the Alps and Pyrenees, twenty years ago, furnish us with the bulk of the systematic information available as to the influence of elevation on plants. From these it was seen that plants taken from lower to higher altitudes, up to about 7,000 feet, and not exceeding the *optimum* of the species, developed shorter internodes, the subterranean parts of the plant were relatively much larger, the leaves were smaller, more deeply colored, and the flowers were also more vividly tinted.

No better illustration of the changes in structure shown by plants, when accommodating themselves to habitats presenting strange external conditions, can be found than those found in the American water-cress (*Roripa Americana*), with which some extensive experimentation has been carried on. Originally taken from the muddy bottom of Lake Champlain, where it grows in water at a depth of 1 to 3 feet, it had been gradually accommodated to the propagating bed, the cold frame, and the hothouse in the New York Botanical Garden, from whence it has been successfully transferred to the Laboratory at Cinchona, Jamaica, and to the montane plantation of the Desert Laboratory in the Santa Catalina Mountains in Arizona. During this dissemination it has substituted radish-like structures for the bunch of fibrous roots characteristic of it, and developed new forms of leaves and stems, while throughout it shows tissues and arrangements of tissues wholly unfamiliar to it; all of which has been brought



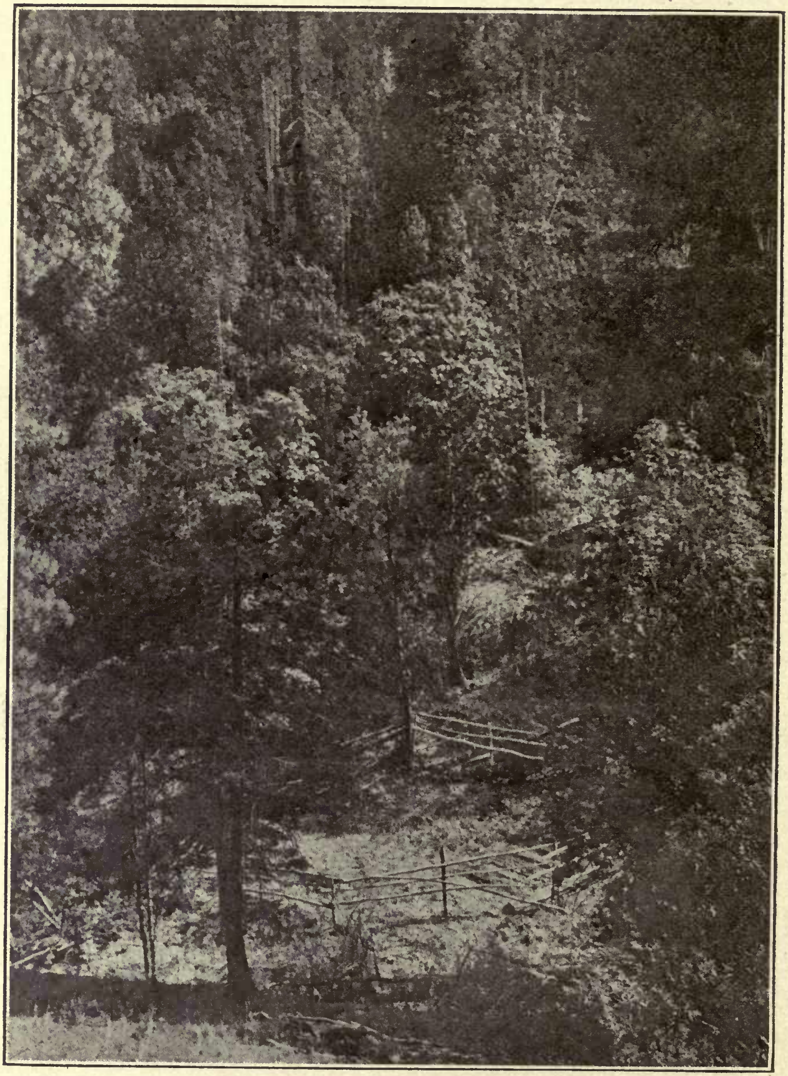
Location of xero-montane plantation of Desert Laboratory among piñons and junipers, at 6,100 feet, on southern slope of Santa Catalina Mountains, Arizona.

about with comparative rapidity in five years. On the other hand, *Lysimachia terrestris* has been transferred from a terrestrial habitat to an aquatic, with similar sweeping changes by way of accommodation in even a briefer period.

So important are the possible results in this phase of experimentation held to be that the Department of Botanical Research of the Carnegie Institution of Washington has established plantations, under permits from the management of the National Forest, at 8,000 feet, in a moist alpine climate, and at 6,000 feet in an arid situation in the Santa Catalina Mountains, in connection with a small experimental farm, at 2,200 feet in the alluvial irrigated soil of the Santa Cruz Valley near Tucson. Without going into detail at this time it may be stated in general that the experimental work carried on at these plantations involves an interchange of plants among the three stations, and also introductions from various locations in different parts of the world. In the two seasons that have elapsed since organized, ample reward has been obtained for the effort expended.

The methods and the results discussed above refer wholly to adaptive or responsive changes made by the bodies of plants subjected to any given environment, and forming accommodations to it. These alterations are of the greatest importance in the extension of the range of any plant, and by a study of them the accommodation response may excite the plant to increase the very feature of its structure of economic importance, and suppress those useless or harmful in its application to our needs.

Still a last possibility is to be taken into account in the great changes to which plants are subjected in acclimatization work. I have recently demonstrated that external agencies may be made to act upon the germ cells of plants in such manner that changes take place which are expressed in the progeny, and are heritable from generation to generation, constituting in fact the origin of new forms having the standing of species. The experimental methods used are fairly simulated by natural forces Likewise Dr. Tower has been able to induce similar changes in the germ cells of beetles by the application of such stimuli as variations in temperature and moisture. It is to be said, therefore, that in taking plants from their native habitats to the



Montane plantation of Desert Laboratory among spruces and poplars, at 8,000 feet, on a northern slope, Santa Catalina Mountains, Arizona.

uttermost extent of their possible ranges, we possibly subject them to forces which may be a most potent factor in the origination of new qualities and new lines of heredity.

GENERAL CONSIDERATIONS.

A more direct application of the ideas elaborated in the foregoing may be possible by a brief restatement of the more important generalizations.

The forces or factors affecting vegetation are simple physical properties capable of ready apprehension and easy measurement. Much is known as to the mode of response, reaction, accommodation and adaptation to such single factors or to a complex of them, and further experimentation upon the problems involved may be readily organized.

The thermal requirements of two plants, as indicated by the records of a season, have been tested, and with reasonable allowance for variation may be taken as characteristic of the forms in question. The method used consists in the measurement of the number of hour-degrees exposure, beginning with the winter solstice or with the germination of seeds.

The difference between localities only a few hundred feet apart at the same altitude may be sufficiently large to make existence in one impossible to a form which may find its *optimum* in the other.

The stimulative reactions of plants to sudden changes in environmental conditions form the basis of many important gardening practices. On the other hand the capacity of the plant for accommodation to conditions widely different from the average, following gradual changes, is very great and is perhaps the most important phase of the subject with respect to acclimatization. The more extensive studies in this problem have been concerned with the northward extension of the cultivation of fruits and cereals, and comparative cultures at low and high altitudes.

It is to be recalled in closing that but few plants occupy more than a fraction of all of the possible habitats by non-conscious distributional movements, and that the intelligent consideration of the factors of climate and a development of cultural methods may most readily secure the economic dissemination of plants from the localities in which they do grow to the full range of habitats where they may grow. Not only may species be carried and established in numberless new localities offering conditions equivalent to their natural habitats, but a study of the adjustments and accommodations of which the plant is capable enables or allows it to be introduced into unfamiliar conditions, under which the structural response may take on qualities more valuable than those usually shown by it.

The President—Dr. MacDougal has given us in that portion of his paper which he has read, very valuable points, and the paper and the subject is now before the meeting for discussion; I am sure that Dr. MacDougal would be glad to answer any questions that may be asked him upon any point that has been presented.

Does anyone desire to make any remark upon this subject just presented by Dr. MacDougal?

A. L. Willis—What is the range, Dr. MacDougal?

Dr. MacDougal—It covers the common prickly pear of this region—and then we have the Indian turnip and the columbine and several others that are taken from Northern Lake Champlain and the climate in the Botanical Garden—which has now had its range extended until this plant is growing in the desert laboratory, at 6,100 feet, and also in the soil at 8,000 feet.

I will take the liberty of saying that this produced the widest adaptation which has yet been recorded concerning any plant.

Mr. Southwick—I would like to ask the widest range of temperature, the widest variation?

Dr. MacDougal—We have the walnut trees on the top and on the bottom, looking very different. I don't know whether they really range up and down the whole mountain or not. Some one has submitted specimens of these walnut trees to Dr. Britton, and he thinks they are inseparable. Now, here is a vertical range of a mile. I do not believe the juniper would cover much over a vertical mile. I know some other plants which will cover this. I think there is one which has a range greater than this. This is a plant that grows at sea level in Mexico, on the west coast, in latitude about 27, and then it goes northward seven or eight hundred miles and climbs up to four thousand feet. I believe that is the widest range of anything I know of.

On the wideness of range, I don't believe any study has yet been made of the botanical features or capacity on which this wideness of range rests. I don't know what there is about the juniper that makes it do this, or the walnut tree, either.

Mr. Southwick—How about the birches?

Dr. MacDougal—The birches are too much mixed up, sir, for me to follow them. I don't want to venture anything on the birches.

Mr. Southwick—I would like to ask you another question. Do you believe there are some ripening processes? May it not be the case, Dr. MacDougal, that there may be a ripening process in the seed which is to be fulfilled before the seed will germinate? You know that we find that the Solanum tuberosum has to have a ripening process before it will germinate? In other words, it will not germinate until spring. Is it not possible that the seed will have some ripening processes, changing sugar into starch and starch into sugar before it will germinate?

Dr. MacDougal—This is a very elusive subject. In my paper, I say that these seeds were made to germinate seven or eight months ahead of the time when they normally would germinate. That is to say, Professor Southwick, the seeds are made to germinate when they would not ordinarily until next February, so if there is a ripening process there, it is finished very quickly. That matter of the ripening period is something I have never been able to get any information on that is at all satisfactory.

Mr. Southwick—Is it true about Solanum tuberosum?

Dr. MacDougal—It is true that some will germinate in September and some will not until later. That whole matter is a very elusive one, and I have never been able to make a very satisfactory statement of it, to myself, or anybody else.

Dr. Evans — In some experiments with the nightshades, I have been able to germinate the seed at once in the fall, and raise them during the winter in the greenhouse. The peculiar thing about it was that the plants were set all winter and would not do anything in the way of growth until about the normal time in the spring. A most remarkable case this was. I was never able to force them. They simply stood dormant after the seed had made a few leaves, and with the gooseberry and currant (the wild species) I found several cases where they would not force during the winter. If the buds were just about open, they would stay until about the normal time in the spring. Last fall up in Lapland where I went for the Department of Agriculture, I noticed a most remarkable situation in the experiments going on at Lulea. That is up in the extreme northern part of Sweden, the Gulf of Bothnia. They have an experiment station there for the purpose of hardening plants, making them more resistant to cold. Two ice houses were constructed, one a cooling house and one a freezing house. They had them constructed so they could hold the temperature to a fraction of a degree, if necessary. They had some barley and some cereals in boxes in the earth, and at different times they were submitted first to a cooling process and then to a freezing process, imitating untimely freezing in the spring and fall. The trouble in that province is that barley especially being the main cereal up there, was apt to freeze out about once in 11 years. I found them laboriously selecting the plant that had grown under those extraordinary conditions, to be frozen in the midst of a full vegetative growth, and I suppose the idea was to force the germination.

I am just wondering whether the reverse could not be done: To put the plant into an extremely hot climate for a time to see if they could not force the plant to adapt itself to a hotter place.

Mr. Macoun—We have growing at the experiment farm now, quite a number of Solanum tuberosum. It is ripening in 62 or 63 degrees in Canada. It seems to me a very interesting fact, because it shows the wide range of the potato. We usually consider the potato, so far as the ripening of the seed is concerned, as having a very wide range, but this, as you know, is a very good many miles north of your latitude, 62, and I think my father was up there in '72 and he noticed the great abundance of potatoes the next spring, after wintering over in the ground, and I feel certain that the seed must have remained over, instead of the tubers, because the seed germinated with a very high percentage of vitality, and I think the point might be very interesting in this discussion.

Dr. Hansen—I was much surprised last fall to see the potato cultivated a good way north of the Arctic Circle in Europe. The potato has come from Archangel on the Arctic Ocean, down to the experiment station in Northern Norway, and up nearly to the Circle, and they were raising it in that locality. They were rather small, but they matured in that latitude. That shows there has been a change in its early maturity.

Mr. Evans—In connection with our experiment up in Alaska, I want to say just a word. We have a regular experiment station, of which you will probably hear later on. But speaking of the potato; there is a station up there which is about 60 miles north of the Arctic Circle, and the man there sent me last summer two potatoes that weighed nearly ¾ of a lb. each, well matured, and as a curiosity he saved a number of seed balls with fully developed seeds, and they were sent early in the season, in August, but they were not yet ripe. Up in Alaska, the potato has been grown for the last three years to my knowledge successfully as a garden vegetable.

The President—It has been a surprise to me to see the extreme northerly latitude in which the potato grows. I am quite sure I have seen it a hundred miles north of the Arctic Circle. I don't know about the maturing of the seeds but the tubers matured sufficiently to grow from the eyes without any apparent difficulty. Indeed, they were not able to tell me when the varieties they were growing were introduced into that region, showing for a long period they had continued to grow from the tuber. I was not able to get any information in regard to the seed. I would state also, though it has no specific value, that the potatoes grown there are of very excellent quality.

We will now hear a paper on "Air Drainage as Affecting the Acclimatization of Plants," by Ernst A. Bessey, Subtropical Laboratory, Miami, Florida.

The following paper was read by Ernst A. Bessey:

Air Drainage as Affecting the Acclimatization of Plants.

By Ernst A. Bessey,
Pathologist in Charge of the Subtropical Laboratory and Garden, Miami, Florida.

To those living in Florida is offered a most excellent opportunity to see extensive experiments in acclimatization and to note some of the factors influencing their success or failure. Besides the numerous importations in recent years by the United States Department of Agriculture, there have been ever since the settlement of the State, innumerable attempts to establish plants from all parts of the world, from both temperate and tropical regions. It was to be expected that only a small percentage of these attempts would result in success on account of the many factors coming into play. For instance, the question of soil has probably accounted for more failures than any other factor except minimum temperature. In almost the entire State of Florida the soil is to a very large extent composed of sand, in many places very deep and with no subsoil. In these sandy soils the large annual rainfall (50 to 60 inches) is counterbalanced by the porosity of the soil, which often causes the death of a plant from lack of water, while in the heavier soils of California the same plant may thrive with a far smaller annual precipitation. The lack of plant food in this sand must also be taken into consideration, as it is of great importance, it being impossible to replace it satisfactorily in all cases by the use of fertilizers.

Another very important factor is the fact that in Florida the chief period of rainfall is in the warmer months. This is distinctly advantageous in most cases, being in direct contrast to the conditions in California, where the rainy season is in winter.

The most important factor of all, however, is the question of temperature, especially that of the minimum winter temperature. Two classes of plants can be distinguished here, viz., those that are killed by a more or less long-continued period of cool nights which do not reach the freezing temperature, and those which endure such periods without injury but which are killed or seriously injured by a comparatively slight and short drop in temperature below the freezing point. It is of certain factors affecting the acclimatization of this latter group that I wish to speak.

It has been long recognized that the slope of the land has a great bearing upon the liability to injury of fruit trees from late spring frosts. So, for example, where danger of frost injury to peaches is to be feared, the orchards are planted on hill slopes or near steep inclines which will drain away the cold air. During the winter this air drainage is of no avail since the whole mass of air is cold. In the spring and fall, however, when the general mass of air is warm the air next to the ground is cooled by radiation, forming a cold layer of limited depth.

In southern Florida, e. g., in the vicinity of Miami, the temperature of the mass of air never falls low enough to cause death of plants by freezing. By radiation, however, the layers of air next to the ground sometimes become colder than freezing temperature. It is under such conditions that air drainage becomes a factor in acclimatization. If the general air mass should occasionally become cooled below freezing temperature, those plants mentioned above which are subject to injury by such temperature would be killed out, regardless of location, but since, at Miami, the cold air is only of limited depth the location determines whether the plant is killed or not.

The principles stated above were clearly demonstrated at Miami last winter (1906). During the daytime of December 23d, 24th and 25th, there was a heavy, cool northwest wind, but the sun shone brightly and the temperature remained about 50° F. At sunset each of these days the wind ceased almost absolutely, and the temperature began to fall at once. On the morning of the 24th, at the Subtropical Laboratory building about seven feet from the ground, the temperature was 32° F.; on the 25th, 28°, and on the 26th, 26°. Immediately after sunrise the temperature rose at once to above freezing. This lowering of temperature was not due to the down-flow of cold air from above but solely to radiation from the soil and other objects. This was demonstrated by the fact that a lath roof which could not have prevented the inflow of cold air from above, for the spaces between the laths were the width of the laths themselves, prevented radiation to such a degree that pineapples under this roof suffered no injury, while where the roof was lacking, owing to previous destruction by wind, the plants were badly injured, although no lateral barrier was between the plants.

A few days after the freeze I drove all around the country about Miami making observations upon the effects of the cold. It was at once apparent that the layer of air causing the damage was not deep. In few places did any injury appear more than four feet above the ground, while in many spots the injury was confined to within a foot or two. At the Subtropical Garden a number of two-year-old mango and avocado trees were killed. For several days, in one case for several weeks, the tops remained green, then suddenly died. I found that for a distance of six inches to a foot from the ground the bark and young wood had been killed. The same observation was made on a number of tamarind, india rubber and other trees set out along the avenue for ornamental purposes.

In several places the injury to the foliage of tender plants was noticeable from the ground up to a certain level, the line of demarcation between killed and uninjured foliage being very distinct and perfectly level. In one place, especially, where a grove of avocado trees stood in a kind of basin about one hundred yards across, the injury was not apparent to the trees at the margin but reached higher and higher the further one advanced into the center of the basin, while at the other side the injury again became less and less. Sighting across it was clear that a lake of cold air, level at the top, had occupied this basin.

In marked contrast to such places as this was the absolute lack of injury where the slope of the surface was such as to permit the cold air to flow off. Thus at Cocoanut Grove, about four miles south of Miami, the land near the bay is sloping while half a mile or so inland it becomes level. On this level portion the injury from cold was very severe, but on the sloping portion it was entirely wanting except where obstacles intervened to hold back the cold air. So, for example, one rather steep slope showed no signs of injury whatever, except near the base, where a close stone wall about five feet high held back the cold air, acting as a dam and forming, as it were, a little pond. The plants standing in this pond of cold air were seriously injured. That the general lack of injury was not due to the proximity of the bay is shown by the fact that at the Subtropical Laboratory and Garden, right by the water, but level and with the outflow of cold air hindered by a fence and trees, the injury was exceedingly severe.

To summarize: air drainage is an important factor in the acclimatization of plants in those regions where the general mass of air is not cold but the cold occurs in a rather shallow layer of air. Under such conditions with proper drainage the cold air flows off, preventing injury.

The President—Miami is an extremely interesting place for a study of this kind, and I think there is real value in the paper that has been presented. Does any one wish to make any remarks upon it?

Dr. MacDougal—This is an interesting paper. Dr. Bessey brings to mind some very accurate experiments made in the same place some fourteen or fifteen years ago by Dr. Roberts at the time of the great destruction of citrus fruits. These experiments were published in 1893. This is a subject that I have been interested in and have published a little on, the last being in 1899, in which I find this inversion of temperature a very important factor in the distribution of wild plants. I find it reaches its greatest accentuation in regions of low humidity and not in arid regions. I have published some observations in a valley where it drains from a mountain range 13,000 feet high. Now, a thermograph at this place, and the observations and the result show the minimum record at times often varies as much as fifteen or twenty degrees, so it may be twenty degrees below freezing and up on the hill a few hundred feet above, it may be twenty degrees warmer. Now, these inversions of temperature have the effect of carrying the distribution of wild plants southward, that is to say, downward, down the mountain slopes, in these ravines where the air is cold at night and the plant runs down where it makes existence possible there. This air drainage is accountable for a great many so-called anomalies. That is, you may have a plant which belongs on the top of a mountain, and find it down some ravine where the cold air flows.

Mr. Macoun—I would like to give some observations as to the death of plants in cold weather.

In the Province of Behring in Canada, and also in the United States, I believe one of the chief causes of death in fruit trees is the killing of the trunks in winter, which we believe is due to the constant flow of cold air during the winter months. We had a very good example of it in Ottawa, which as you know is not in Behring Province, last year, when we had a kind of winter killing which we have never had before in twenty years' experience. I believe this coincides in a very large extent, with the winter in Behring Province. We had a very serious kind of winter, with greater cold than usual. There had been a steady flow of air all through the winter; that is much more than the average. The result was a large number of apple trees which were killed in the trunk for about two feet entirely around the trunk. Now, as a rule, the form of winter killing in the winter that is known as sun killing usually occurs on the south and southwest side of the tree, and is due largely, we believe, to the sudden changes of temperature, thawing and freezing, but in these cases, I suppose, there were one hundred or one hundred and fifty trees destroyed in that way, killing right around the trunk. The bark and the trunk were destroyed. The trees leaved out as usual. Some are living yet, but they gradually die and those that did not die last year will die next year. I just wanted to give this example and give one in Behring Province, where the fruit trees are killed by too much air drainage.

Mr. Southwick—I think it is a well-known fact that the lowering of the temperature of the soil has the same effect upon plants in appearance at least as frost. You take the eucalyptus plant. If you have a very wet cold soil the plants die. That is the result of my experiment in Central Park now. They were planted near the house in the shade and the moisture and the lowering of the temperature has caused them all to die and I think it is a well-known fact and a very important fact, every act of the lowering of the temperature and the excessive moisture deprives the plant's leaves of the nourishment they require, and they die. I think Dr. MacDougal can say a few words about that.

Dr. MacDougal—It is true in regard to the eucalyptus plant that the fatal cold in some places is between 36 and 38 degrees Fahrenheit. That is to say, they freeze to death before the freezing point is reached. They are not killed by cold, so that this thing you speak of is probably a combination.

Mr. Macoun—I would just like to say, as I mentioned before, that we believe—although I haven't any data to prove it—that the driest part of a tree is the trunk. Perhaps Dr. Hansen has some information on that point. We know that near the tip there is more moisture than any other part, but I believe the driest part of a tree is the trunk and this constant flow of air in the winter dries out the trunk so that there is not sufficient moisture to stand the strain, and the result is that the tree dies from lack of moisture, and the bark is killed by the lack of moisture.

T. V. Munson—I think the name of air drainage, in some places is not quite the right name. We have in connection with drainage a down flow in my region, located on the south side of Red River, located some one hundred and seventy to two hundred feet above the bed of the river. I have known several times that we have succeeded splendidly with certain varieties of fruit, peaches, for example, while those on the opposite side of the river; the north side of the river, Red River running in that region from west to east, that we had full crops while on the other side they had none. There seemed on those occasions, a very slow movement of the atmosphere from north to south, what we would term a "freezing norther." It seems that in that case the valley of the river is quite broad and heavily forested, so that the heat that had accumulated in the valley during the day gradually flowed upward over the bluff on the south side of the river and kept the trees at such a temperature that they were saved, while on the north side they were lost, but in other cases where we have had still freezes, that is, where the air became apparently a dead freeze, great destruction was the result. I have seen that illustrated in my own old place, north of Denison. The elevation of the hill was about fifty feet above that of the little creek where I reside, and frequently plants were killed in the bottom, the same varieties that were not hurt at the top of the hill, and I observed that the difference in temperature was between 8 and 10 degrees. Now, in that case, and in some other cases, the drainage seems to be a wedge of cold air settling gradually down into the hollow, and displacing the warm air there, and it flows up over the hill. That is the character of the drainage, it seems to me. I remember very distinctly, four or five years ago quite a severe wet freeze came when the grapes had pushed from 6 to 8 inch shoots, nearly at the blooming period, and my present place lay pretty well on the little plateau between Red River and the Creek south, and on the upper portion of that grapes were not damaged at all. We made a good crop. I noticed at the lower portion of our place, probably fifty foot below the upper portion, frost began and from there on for fifty miles, all vineyards in the valley were killed. There were no grapes at all, except on the scattered secondary buds pushed forward, and in this case it would seem that there was a lake of cold air below the freezing temperature—to be considered a lake, although it may have had a slow motion down the valley and creek. The creek is quite crooked and pretty well forested, so there would be very little motion, but in that regard, it was like a lake, like the lake mentioned —and below the line there was no damage.

The President—I would like to mention one or two illustrations, of the economic influences and values resulting from this question of this fact of air drainage.

In the north of this latitude, the peach crop is somewhat uncertain, as a rule, taking it over the country generally. It is a fact in this whole country of northern New York, that when a peach orchard is planted on a slope of a hill where there is active air drainage, the crop is much more reliable. Then there is another thing in connection with this that if, in this cold north country of ours, the peach orchard is planted on the northern slope of a hill, it is vastly more reliable than when planted on the southern slope of a hill, if it has active air drainage. Of course, there is another problem involved in this, and all these problems are very complex, gentlemen. We must not draw our conclusions from insufficient data, because Nature's problems are so complex. The northern slope is preferable to the southern, because there is greater uniformity of temperature during the late winter and early spring, and with the southern exposure, the direct rays of the sun to the square foot are very great, and you have the soil thawing out when the temperature rises, whereas on the same hill, an eighth of a mile away on the northern slope, there is no change perceptible whatever. There is no slope and the sun's rays impinging on the square foot are not more than one-quarter, and indeed, hardly as much. Of course, if the hill is steep enough, there is no impinging of the rays at all, and the only heat you get is the diffused heat of the atmosphere. Now, in regard to this air drainage, there are great results from it. The greatest fruit country in the United States, and probably in North America, with the exception of the citrus counties in Florida, is Ulster County, just north of us. Peaches were not grown there thirty or forty years ago because they were utterly unreliable. They were planted in sheltered valleys where the northerly winds would not strike them. They supposed that the home of the peach was in Persia in a warm climate, and so they thought the peach trees should be planted in a warm valley. The fruit culturists in Ulster County were advised to plant their peach orchards on the northern slopes. The result was that the finest peaches in the city market to-day are the peaches grown in that county. If you go down to the great Washington Market of this city where the fruit is received, and you see any specially fine fruit to-day, and ask where it comes from, the chances are it is Ulster County, but it may be Northern New York, but it is grown on the hillside where there is the most complete air drainage, and on the northern slope, because the fluctuations of temperature are much less there than on the southern slope.

You know the native hemlock is a northern tree. I have often said that it is the most beautiful evergreen on this earth. I have never seen anything to qualify me in that statement, that the hemlock is the most beautiful evergreen to be found. It is a northern tree. It is said that the most southern hemlock grove is the one which is growing in Bronx Park, but you know the hemlock is found far south on the Carolinas—perhaps in Georgia as well. I don't know as to that. It may be in Georgia around on the mountain ranges. I happened to be interested in an extensive tract of land in Virginia, including a considerable portion, some forty or fifty thousand acres, on the Shenandoah Mountain.

We are lumbering to-day the northern hemlock on the slopes of the Shenandoah Mountain, where they exist, because of the air drainage, in my opinion, from the mountain range, coming down the slopes, as it is easy to see by the configuration of the mountain that the air comes down. Hemlocks are found away down the valley, where but for this air drainage, I believe there would not be a hemlock within a hundred miles, and here they are, magnificent great specimens, with trunks six feet in diameter, and making marketable timber 80 or 100 feet up the trunk. They are there, and the only way you can account for their being there is the air drainage from the mountain coming down into the warmer valleys bringing with it the possibilities of a vegetation of another latitude altogether.

Mr. Southwick—I think the factor omitted in what you just said is this:

I was brought up in Greene County, New York, and raised peaches there and farmed it until I was twenty years old. I found by planting our peach orchards on the north side of the hill, they were retarded in their growth in spring, and to add to that, we tamped the snow around the trees and kept them back a while longer, and we were free from having the buds frozen, and from them we had some beautiful peaches. We kept the ground there cold and in this way the trees were kept back. I think that is a very important factor.

Dr. Hansen—I would like to quote an experiment. I do not think that the last speaker did keep back the buds of a tree. I would not like to have that point passed without stating that the result of experiment has shown that such a process will not keep back the blossoms of any tree.

Mr. Macoun—We have tried many careful experiments of tamping the snow about the trees, and it does not keep back the buds at all.

The President—I will supplement my remarks by saying I have a peach orchard about 35 miles north of the city on a slope of a hill perhaps nine hundred feet above the level of the sea, and that orchard has not failed in giving a most satisfactory crop in fifteen years. That illustrates two things: first, it illustrates the vigor of the tree, that the peach orchard should continue for fifteen years in a good condition. Secondly, it also illustrates the principle I have been speaking of, that it is usually uniform; whereas, in the whole region around in the valley, they have not had in this fifteen years this peach orchard has been fruiting, without any exception—they have not had a peach crop in more than a third of the time. I would say one thing further in regard to this particular locality, an elevation of 900 feet, a northern slope where the sun does not strike in winter, and where there is perfect air drainage. In my boyhood I used to go up to this point, and there was the greatest peach tree I had ever seen. Its trunk was 22 inches in diameter and I found by consulting the old people, that the age of that tree was over seventy years. A peach tree in this latitude seventy years old, with a trunk 22 inches in diameter! The property was not then in possession of my family, but the old owner of the land used to say that he would go up there and he would think that perhaps there would be a bushel of peaches on that tree and he would pick them and find ten bushels on one peach tree. I do not think it was the soil. I think it was simply the situation that caused the whole result.

Mr. Munson—Just one word in order that the example I propose may not be misconstrued. The slope of the Gulf from the north side extends through several miles very gradually up and down over small hills and valleys, and on the southern side likewise, so that the killing occurred entirely over the territory north for several miles, while for several miles each side of the river, we had abundant peach orchards. This could not be explained by the southern exposure of hillsides, and must be accounted for by some other theory, and the only theory that they could possibly think of was the slope to the southern side, and the heat in the valley that gradually drifted southward in that case. Now, as to drainage, the idea has been advanced that the drainage about a mountain comes from the top down the side of a mountain. I am inclined to take issue with that view. The flow is not steadily downward next to the earth from a mountain. It is upward. There is a high swift current of air passing over the top of a mountain. If you will observe over any ridge over which the wind flows in snow-time, the wind blows over the top, and you will find a counter-current coming up and you will find a hollow place. The current comes over it and hits the ground beyond and banks the snow up and there will be a hollow behind it. So it is with the circulation about a mountain; the air passes over it, the warm air from below comes up the opposite side of the mountain, and that cold air takes its place beyond, and you will find that the freezing is heaviest and begins first in the centre of the valley on a still night. This wedge of cold air from above settles down, and the warm air follows the hillside and flows upward. You build a fire somewhere near a large tree, and you will find that the flames, instead of going up, will seek the side of a tree and will go up the tree, and so the hill has the same power of furnishing a sort of back for the air to creep up while the cold currents drop beyond.

Mr. Macoun—I think that Mr. Munson is confusing two things, the movement of winds and the gravity falling of cold air. When we speak of air drainage, and the inversion of temperature, we consider the air resting on a plane as absolutely still. Therefore, what he says about air currents across the top of mountains has nothing to do with it. When air gets cooler it drops, and if you cool it on the top of a mountain, it of course, flows down the slopes. In my work on the Rocky Mountains, I had always found that if there are any mosquitos, it is advantageous to camp in one of these cold-air spots, as it drives the mosquitos away, and so our camp is always at the mouth of a cañon, leading up to a mountain, knowing it will not be salubrious for the mosquitos. This matter of inversion of temperature is a matter that has been studied by thermometers and instruments of all kinds, and I am quite astonished to have this conclusion of Mr. Munson's quite contrary to our observations, and I think his statement is due to the fact that he is confusing wind action with the actual settling of cold air.

The President—I think that the difference in the two opinions comes from these facts: Mr. Munson comes from Texas. The cold weather they have there comes from the north. They do not have any fall, so far as I have found out, in Texas, although I have not been there the year around. Our temperature here falls the most when there is no wind, and that is where you have the air drainage. Buds of our fruit trees are killed on still nights, not on windy nights. They are killed when it is a perfectly still night, when there is no movement of atmosphere. I think here you have the explanation of the difference. I have had experience in the Gulf and in Mexico, myself.

Mr. Munson—Just a question to Dr. MacDougal: In driving across the plains in Nebraska and the West, hundreds of times I have experienced this, that we would come to a ravine that would be several miles in length, having a very little down flow, and beyond as we began driving down into that ravine, we felt a body of cold air, and felt quite chilly, while it was quite comfortable on top. On very still evenings when we drive through it, we feel those conditions. How do you explain that?

Dr. MacDougal—I think it is a splendid explanation of my theory, and I am glad to get it. Just imagine you had a fine mist of rain which is heavier than air, poured on the ground. It naturally seeks the lowest places, doesn't it?

Mr. Munson—I would like to know where cold air comes from?

Dr. MacDougal—It is cooled all over the surface of the ground and flows to the lowest places.

The President—We do not think of cold air coming from high elevations and coming down somewhere. The effect of cold air comes from radiation all over, and it runs like water, and as that water that falls upon the ground runs down into the ground, so this little stream of cold air runs down the valley.

Dr. MacDougal—It is more accentuated, of course.

Mr. Munson—Our thermometer all along the surface of the ground and up on the hill does not show that temperature which you should get on the bottom.

Dr. MacDougal—There is not enough of it there. Just as soon as it is cooled, it begins to move. The moment you have a particle of air that is colder than any particle next to it, it begins to move, so you have on this hill slope particles of cool air that begin to move down into the hollow. You do not have a lake on the side of a hill; you have a lake falling and running down in a thin sheet.

The President—If your thermometer was on a slope a foot above the ground, it would not be in the stream of cold air at all. If your thermometer was exactly on the flowing line, it would give it, but really there is not enough of it. There would be radiation enough from the ground so perhaps you would not get any.

Mr. Munson—Has any downflowing current been discovered near the ground?

Dr. MacDougal—I don't know how we are going to escape it. It has been a matter of observation with me. I am using the mountain in my illustration, because here we have a thing that is most accentuated. Take this cañon situation. The wind there becomes so strong as to become actually unpleasant, and in the autumn or in the spring, much of the time we find the temperature is too uncertain for comfort. I find the Indian, and next to the Indian, the prospector, and the man who is out of doors, avoids these cañons and keeps on the cooler ridges where he is not bothered at all. This movement is reversed during the day. You have the upflow during the day and the downflow during the night.

Dr. Gager—May I say a word in response to a request for a specific instance of the observation of such an occurrence? The matter has been very thoroughly worked out on Cayuga Lake, by the observations of Cornell University, and the result has been published as to this downflow of cold air.

A recess was here taken until two in the afternoon.

First Session—Afternoon.

The President—The time for our Afternoon Session has arrived. We will have a paper on "The Real Factors in Acclimatization," by Frederic E. Clements, University of Nebraska. In the absence of Mr. Clements, Dr. MacDougal will read the paper.

The following paper, by Frederic E. Clements, was read by D. T. MacDougal:

The Real Factors in Acclimatization.

By Frederic E. Clements,
Department of Botany, University of Michigan.

The exact study of plant environments by means of instruments, which has been carried on in the Colorado mountains for the past ten years, has thrown light upon a number of current ideas as to acclimatization and hardiness. It is hoped that a brief statement of some of the results obtained in nature may prove of interest and value to the scientific horticulturist actually engaged in acclimatizing plants.

The advantages of a mountain region for studies of acclimatization are decisive. On Pike's Peak, for example, as many climates are found in ten miles as occur between the fortieth and seventy-fifth parallels, a distance of 3,000 miles. The climatic zones of the mountains are further broken up into a great number of local climates, owing to the extremely irregular surface and the varying maturity of the different land areas. The result is a diversity of climates not to be found elsewhere, and an accessibility to different climates that is unique.

In experimenting to determine the causes of the well-known dwarfing of alpine plants, it was found that the influence of light is negligible, and that water, in the form of soil water, is more important than temperature. Since dwarfing is merely the characteristic sign of alpine adjustment, i. e., acclimatization, it seems evident that for all dry regions at least, water, and not temperature, must be regarded as the controlling factor in acclimatization, and hence in hardiness and winter-killing. This conclusion has been repeatedly tested with the alpine shrubs and trees at timber line. On many of the Colorado peaks, as elsewhere, the timber line is fringed with a zone of thickets, chiefly willows and birches. These regularly reach their highest altitudes in moist depressions, especially where the exposure to bitter cold and strong winds is extreme. In such cases, the drying-out at low temperatures, and not the actual cold, seems to be the cause of winter-killing. Additional evidence of this is furnished by the alpine spruces and pines. These extend 500 to 600 feet higher where they occur in shallow ravines and depressions with a higher water content, particularly on the exposed north and northwest slopes. This same phenomenon is even more marked on the Continental Divide, where the alpine thickets carry the spruces to outposts far above timber line proper by increasing the water content of the soil, decreasing the depth of frost, and protecting the young trees from the drying effects of the constant winds of winter. The upper timber line on mountains is accordingly a line of winter-killing. Its direct cause is not the extreme cold of winter, but the excessive water loss at a time when the water supply is chiefly in the form of ice, and hence non-available.

The feeling that the climatic habits of plants are fixed is widespread though it appears to rest upon no definite foundation. It has led not infrequently to the statement that woody plants, and trees in particular, cannot be acclimatized. The evidence from the mountain forests of Colorado is distinctly in favor of the conclusion that trees and other woody plants can be acclimatized. Indeed, it only requires reciprocal planting at various altitudes to constitute final proof. The spruces (*Picea engelmannii* and *P. parryana*), the firs (*Abies concolor* and *A. lasiocarpa*), the yellow pine (*Pinus scopulorum*), lodgepole pine (*P. murrayana*) and limber pine (*P. flexilis*), and even the Douglas spruce (*Pseudotsuga mucronata*), have repeatedly been found growing vigorously in such divergent local climates, measured in terms of water content, humidity, temperature and soil, that the conclusion is unavoidable that they adjust themselves readily to new climatic conditions. For a time the apparent distribution of the aspen well within the forest zone of the mountains was a puzzling exception, though an extra-regional outpost was known at 4,000 feet in western Nebraska. This difficulty was finally cleared up by finding that the aspen occasionally reaches the lower limit of *Pinus scopulorum* at the base of the foothills. It was also found this summer growing at an altitude of 12,000 feet on Long's Peak, in the form of a dwarf shrub scarcely a foot high. That trees show great differences in their adjustability is too well-known for comment, but it has not been so clearly recognized that the restricted range of a native species may be due as much to a lack of migration as to the difficulty of adjustment to physical factors. The plumed pine (*Pinus aristata*) is in general restricted to the region of the upper timber line, and the piñon (*P. edulis*) to the lower. This distribution is primarily a matter of migration, shown by the fact that the plumed pine is represented by many outposts due to migration taking place more readily down the mountainside than upward.

The whole question of acclimatization hinges upon the meaning given to the term climate. In ordinary usage, climate means weather, and it is applied to conditions and areas of the vaguest limits both physically and geographically. General meteorological results which are chiefly restricted to temperature and rainfall are taken as the usual criteria, and factors of greater importance, water content, humidity and evaporation, largely ignored. The first step toward the exact study of acclimatization must rest upon a thorough investigation of the many factors that compose a climate. This can only be done by an extensive and intensive study by means of instruments.

By climate we usually understand the atmospheric factors of a region merely, and, as indicated above, soil factors are equally important, and often more important. For these reasons, the ecologist prefers to substitute the term habitat, as the sum of all factors that affect the plant, for climate, and to replace acclimatization by the word ecesis, the process of becoming established in a new home. These terms at least serve the purpose of emphasizing the fact that all of a plant's environment must be taken into account in studying its behavior and structure. Climate is too general as well as too restricted a concept for scientific purposes, at least for the biologist. Botanist and horticulturist alike speak of the climate of Colorado, of Nebraska, etc., when as a matter of fact the differences between sets of physical factors, or habitats, within each are often much greater than differences between neighboring States.

Colorado has a half-dozen or more distinct climates, while Nebraska, though more uniform, shows markedly different climates in prairie, sandhill and foothill region.

The use of instruments for measuring all the physical factors of the plant's environment is imperative if we are to know exactly what conditions the plant has to meet, and how it meets them. Furthermore, it is only in this way that we can discover real differences between habitats, or climates, determine the best source for promising forms, decide upon the most practicable method of treatment, and forecast the probable outcome. The exact measurement of the water of the soil, and the humidity of the air, of light, temperature, evaporation, wind, soil salts, exposure, slope, etc., will work a revolution in the methods and results of plant introduction and plant evolution. It will force attention to the fact that regions and areas which possess essentially the same climate, or weather, really show physical differences of the greatest importance to the experimenter. Finally, it seems probable that exact ecological methods of this kind will demonstrate that all variation is first or last only a question of environment; that the minute variations of plants, as Darwin understood them, can be traced to minute physical differences of the habitat, and that, as the final crown of the work, measured sets of physical factors and measured habitats can be made to produce definite desired adaptations in both cultivated and native plants.

The President—Cannot you supplement it with remarks, Dr. MacDougal?

Dr. MacDougal—I find much in this paper which is in accord with my own views. I rather object to anyone picking out any one physical factor and saying it is the keynote of the business, because it is not. He might as well say the left hind wheel of a wagon is most important, but it is not; on the other hand, the four wheels are equally important, and they get out of line unless all four are together. When Professor Clements says the soil moisture is the most important factor in a given situation, he is considering something to be a fact which is not a fact. In the main, however, I think I can say that I agree with him in the principal things.

Mr. H. A. Siebrecht—There is one thing I notice in this connection, and that is that the plant or tree suffers more from dryness or drought in cold weather. That I have experimented with myself, I find it is a fact, and I have often spoken of it in this way, to use a common every-day phrase. I said a man with a full stomach can stand a good blast of wind in cold weather, whereas a person with an empty stomach cannot stand so much. I have found that out with plants. For instance, we take evergreens, planting them in vases in the fall of the year, taking up all the roots, and putting them into those tubs or vases, or places where they have not been growing, just for decorative purposes—I find that as long as the moisture is available, they stand all right. But as soon as it freezes up, and dry-cold wind comes, then the plant suffers and it sort of curls and folds up and it generally gets its death-blow during such a period, when we have the very extreme cold, and no water is available. I find that where they are exposed and where they can get the moisture, they can stand so much more cold, than where they are more dry, and I think that is very correct.

The President—I was struck, in listening to this paper, with the sweeping statement concerning moisture. I expected to see some proof of this statement, but he does not offer any. It is simply an assertion. What we want is the proof. Now, in regard to this question of moisture, if you look at the condition of various plants in their natural habitat, you will notice in the district north of this city where we have very rocky hills and our forests are very rocky, that you find trees growing in situations where they are as nearly destitute of water as they would be in any desert in Arizona, except the moisture of the air. There seems to be no soil moisture. I have given special attention to this matter of the growth of forest trees where the situation would seem to indicate, if not absolutely prove, an absence of soil moisture that would be accounted fatal to almost anything. Perhaps we may say that these roots penetrate to the crevices of the rocks to great depth. Indeed, they do undoubtedly, but owing to the situation, the supply of soil moisture is extremely limited, but still they will stand the droughts of summer and the freezing of winter and come through with marvelous hardiness. Of course, they have the same degree of air moisture as other trees. In fact, whoever is familiar with the forest region of our country notices that this rather conflicts with his assertion.

Dr. Hansen—Just an observation which ought to go on the record, possibly, in this connection: We find it a common practice in the northwest where we have 40 degrees below Fahrenheit, sometimes without any snow, that it is a great advantage not to permit apple trees or other fruit trees or plants to go into winter quarters without an abundance of moisture in the soil, to give the plants or trees a thorough watering just before they freeze up, otherwise they are very much more injured.

The President—There is a common expression all through the United States, to the effect that it is very disastrous when the winter sets in before the swamps are full of water. When the swamps are full of water, then let winter come, but before the swamps are full, it is disastrous, and occasionally, we will have a season that is so dry that the swamps are not full of water, and then we see in the plantings of our lawns or in our forests, a great destruction of trees, greater than we ever find at any other time. That is in line with the Professor's assertion.

The President—Our next paper is "Evaporation as a Climatic Factor Influencing Vegetation," by Dr. B. E. Livingston, Tucson, Arizona. In Dr. Livingston's absence, we will have the paper read.

The following paper, by B. E. Livingston, was read:

Evaporation as a Climatic Factor Influencing Vegetation.

By Burton Edward Livingston,
Desert Botanical Laboratory, Tucson, Arizona.

All plants, excepting aquatics, are influenced in their growth and behavior to a marked degree by fluctuations in the external water supply. This is almost wholly due to the continual loss of water occurring from all aerial surfaces of the plant body, especially from those surfaces which, by the presentation of wet membranes to the air, are possible channels for the entrance of the food material, carbon dioxide, and for the exit of the waste product, oxygen. By far the greater portion of the water that the plant appears to use is not used at all in the true sense, but makes up for the loss by transpiration, and is itself soon lost by transpiration. This water must, of course, be drawn from the soil by the roots and transmitted to the transpiring organs by the conducting system.

The rate of water loss by any plant, while it does not strictly follow the rate of evaporation in its hourly fluctuations, is determined for the entire day or for longer periods by the evaporation rate, i. e., by the evaporating power of the air around it. This is of course true only so long as the water supply of the soil is adequate to keep the tissues at their normal condition of saturation.

Every plant has a certain maximum rate of water intake through its roots, this maximum being highest for any stage of growth with the *optimum* amount of water in the soil. This rate increases as the root system becomes more extensive, and decreases when for any reason the root system is injured or partially destroyed. Of course this maximum also decreases with a lowering of the moisture content of the soil.

There must likewise be a maximum rate at which water can be transmitted through the conducting system to the leaves, etc., and this rate will probably decrease as the plant develops, since the path traversed becomes longer. We know practically nothing of the fluctuations of this latter rate, but it is probably safe to assume that it does not vary rapidly and is practically constant as long as it is not altered by growth.

Evidently, a resultant of the conditions just described is this, that the plant is able to maintain in its tissues a water content adequate to life and growth only so long as the transpiration rate does not exceed the maximum rate of water supply from the soil. It is thus possible for a plant to grow normally in a soil with a low water content, if only the evaporating power of the air about its leaves and branches (and hence its transpiration rate) is not excessive. The same plant may be observed to wilt and die at a later stage, for either, or both, of two very different causes: the water content of the soil may be decreased till the rate of supply to the transpiring tissues becomes less than that of loss, or the evaporating power of the air may be increased till the rate of loss becomes greater than that of supply. It will be seen that both causes bring about the same condition within the plant, namely, a shortage of water in the transpiring tissues.

From my own observations it appears to be true also, that a quiescent existence can be maintained with the rate of transpiration approaching or equalling the maximum rate of supply, but that growth cannot occur unless there is still a considerable margin of possible supply over and above the transpiration loss which is being experienced.

It is realized by every worker with plants that the water supply is the most important and fundamental of the conditions which are effective in determining growth. But it is not nearly so clearly appreciated that this is not alone dependent upon the amount of water in the soil but is to a great extent determined by the evaporating power of the air. At first thought it might appear that with high evaporation rate the soil would rapidly dry out and that at the same time the rainfall would be scanty, so that the air condition would be directly transmitted to the soil. But such is not the case, at least in many instances; for with rapid evaporation the surface layers of the soil often dry out so rapidly that the moisture of the lower layers does not have time to diffuse upward to the surface before a functional dust mulch is formed, which almost completely checks evaporation. We are thus confronted with the seemingly paradoxical fact that a high evaporation rate acts to really conserve water in the deeper soil layers. Neither does the amount and distribution of the rainfall furnish evidence by which evaporation conditions may be surely predicted, for a time of heavy thunder-showers may show a great precipitation for a particular week when the evaporation rate was uniformly high throughout the period, excepting for a few hours before and after each shower.

Doubtless one reason for the neglect of evaporation as a climatic factor is that the evaporimeters which have been devised are unsatisfactory in one way or another, so that the weather services of the world have been able to do but little with this subject. In weather prediction relative humidity has come to be regarded as giving the same information as would rate of evaporation, but it leaves out of account the factor of wind, which is extremely important in determining the evaporation conditions. Numerous as have been the efforts of various workers to establish a formula by which the evaporation rate may be derived from the data of the ordinarily observed climatological elements, the suggested formulas are all as unsatisfactory, if not more so, than the different forms of evaporimeters which have been devised. These formulas differ markedly from one another, and the best, could one but select it, must be regarded as only approximate.

With a suitable instrument, evaporation is far better suited to the needs of the botanist and agriculturist than is relative humidity. In the first place, humidity variations affect the plant only through their effect on the evaporation rate, so that the evaporimeter gives direct information regarding the physical conditions to which the plant is subjected. In the second place, the evaporimeter is a self-integrating instrument, like the rain gauge, but unlike the thermometer or hygrometer; for any given period a single reading gives the sum of all the evaporation increments which have occurred within that period. Thus an average rate is easily and quickly determined.

In attempting to determine some of the factors limiting the vegetation of the arid regions of southwestern America the writer has been led to a study of evaporation and its effects on plant life. The remark is often made in these regions that "with water, anything whatever could be made to grow here"; a statement which is far too broad. With water properly applied, it is certain that a large number of plants will succeed in the desert which could not otherwise live in such a climate; but all plants thus succeeding, unless it be in seasons of frequent rains when evaporation is retarded, must be adapted to withstand the high evaporating power of the air. A large number of the ordinary mesophilous plants of gardens are possessed of this adaptation, but others are not. The native desert plants usually have it to a great degree, but many of them are not so fortunate in regard to the opposite power, to withstand a wet soil and low evaporation rate at the same time.

A number of plants were tested in this regard during the summer just past, at the Desert Laboratory, Tucson, Arizona. Narrow beds were prepared in the open ground, being only five or six inches across and separated by irrigation trenches of the same width and of an equal depth. The soil was kept moist by lateral seepage from these trenches, which were filled once or twice a day. The water stood in the trenches only a few hours at a time and the soil did not at any time become water-logged. It was constantly very near its *optimum* water content. The soil was a heavy adobe clay, similar to that of the Chinese truck gardens near Tucson.

The evaporimeter used in recording the evaporating power of the air for this experiment was the porous cup form devised by the author and described in Publication No. 50 of the Carnegie Institution. The evaporating surface is provided by a cup of porous clay about five inches in length and three-quarters of an inch in diameter, closed at one end and reinforced by a thickened rim at the open end. The material of this cup is similar to that of the ordinary Chamberland filter tubes. The opening is closed by a perforated rubber stopper carrying a glass tube about fifteen inches in length, the latter passing through a cork stopper into a Mason jar, the container for the supply of water. Cup and tube are filled with distilled water and the tube is carefully inserted into the jar, which has been previously filled, in such manner that no air is allowed to enter the tube. Evaporation takes place from the surface of the cup and water to make up for the loss thus occasioned is drawn from the jar below. The jar bears a file mark on its side to indicate the standard level, and is filled to this mark at each reading, the amount of distilled water required for this being measured and furnishing the reading of the instrument. The apparatus was placed with the jar beneath the soil surface, the cup projecting about six inches above. Readings were taken once a week, which was found to be often enough for the work in hand. Considerable trouble was experienced this season with a consignment of impure water, which so clogged the pores of the cups that the latter became useless. Fortunately for the work, an instrument had been installed at the University of Arizona, by Dr. W. B. MacCallum, and his records have been used in place of those from the instruments which were injured. The University campus is so situated that the evaporation conditions there are very similar to those of the plantation where this work was carried out.

Among the plants tested were: the garden nasturtium (*Tropaeolum*), morning-glory, marigold, sunflower (*Helianthus annuus*), mustard, castor bean, muskmelon, teasel (*Dipsacus sylvestris*), and jimson-weed (*Datura Stramonium*). The seeds were sown in May, in the midst of the spring dry season, and the behavior of the plants was watched till early September, when the experiment was brought to a close.

From the time of planting, the drought conditions continually increased in severity until July 6th, when the summer rainy season opened. From May 13th to July 1st the weekly average of the daily temperature maxima rose from 87 to 107° F., while the corresponding average of temperature minima rose from 45 to 75° F. For the same period the weekly average of maxima and minima of relative humidity decreased from 45% (maximum) and 32% (minimum) to 31% (maximum) and

17% (minimum). The average weekly evaporation rate for the period from May 13th to July 1st was, as given by Dr. MacCullum's data, 323.8 cc.

The seeds germinated somewhat tardily but otherwise in a perfectly normal manner. With the castor bean and musk-melon, after a few days in the cotyledon stage growth was rapid, more so in the former than in the latter; but growth became still more rapid in both cases after July 6th. The other forms of the series slowly developed a few leaves and then practically ceased to grow at all. Day after day they were examined without the detection of any difference from the condition of the preceding day. The plants did not wilt and appeared healthy, except for the lack of growth. There was *some* growth in all cases during this period but it was so small in amount that it was practically negligible.

After July 6th the weekly averages of the daily maxima and minima of temperature and relative humidity were very close to those exhibited for the week ending August 26th, which were: for temperature, 100° and 80° F., and for relative humidity, 95% and 59%. It is at once seen that the temperature conditions were not greatly different during the season of summer rains from those of the spring dry season, so that the response in growth of the plants, which I am about to describe, cannot be related to this factor. The humidity conditions for the two periods were about what was observed in the case of the evaporation rate, which showed an average of 185 cc. per week during the second period, i. e., a decrease to about 57% of its rate during the dry season, as given previously (383.8 cc.). After the beginning of the rains irrigation was unnecessary excepting a few times when the showers were too far separated and the soil began to show signs of drying out. It is, of course, theoretically possible that the plant responses here to be described were caused by the change from well-water to rain-water. This is not at all probable on account of the fact that the saline content of the well-water is mainly calcium and magnesium carbonates, and that these exist in the soil in rather large amounts, so that the rain-water must almost immediately become of practically the same concentration as well-water. The responses of the plants were immediate and no time elapsed for the leaching of soluble salts from the soil by the first rains; in fact, a change in the behavior of the plants was observed before any precipitation occurred, for the evaporating power of the air began to decrease several days before rain fell.

With the coming of the summer season the plants quite generally responded in a very marked degree. The castor bean and muskmelon increased their growth, which had been rapid before. Morning-glory, sunflower, marigold, mustard and jimson-weed, all came rapidly into flower and fruit in a perfectly normal manner, and this within a surprisingly short time. The small rosettes of teasel which had been developed showed almost no response. They are still alive at the time of writing, but are only about three-quarters of an inch across. Nasturtiums were also scarcely affected by the change in conditions; they finally succumbed during the rainy season. A single plant, which was situated so as to be in the shade of a creosote bush for a few hours of the day, lived several days longer than the others, suggesting that light intensity may possibly have had a part to play in the failure of this form to succeed. But it seems altogether more probable that the plants of this form had been so injured by the untoward conditions of the dry season that they were unable to recover. The latter idea is supported by an observation made several times previous to the present experiment, that nasturtiums failed to succeed at the Laboratory, when grown in pots which were kept well watered. I have never started the plants from the seed in the rainy season.

The meaning of this entire experiment may be expressed in this way: that castor bean and muskmelon were able to absorb and transmit water from the soil to their foliage considerably faster than it was lost by transpiration, and hence were able to carry on an active growth even during the intense drought. The garden nasturtium and teasel failed to provide the excess of water needed for good growth even in the rainy season (although the latter form did not fail as completely as did the former). The other forms of the experiment were unable to supply the needed excess of water in the dry season, but provided it in a normal way in the season of summer rains. The power to absorb and transmit water was sufficient in all the forms to support life (that is, to prevent wilting and desiccation) during the drought period, but was adequate for growth during this period only in castor bean and muskmelon.

That the responses just described were due to the change in the evaporating power of the air is hardly to be doubted. There was not a sufficiently great change in temperature to account for it, as has been shown in preceding paragraphs. It might be suggested that the decrease in light intensity incident to the oncoming of the summer season may have been the cause of the response noted; but in the absence of reliable data as to the effect of such variations in light intensity (we have as yet no practicable photometer for such studies that measures the energy of the light as a whole instead of measuring mainly the less refrangible portion) and in the face of the *a priori* consideration that it is fully as probable that such variations affect the plant through changes in the evaporating rate as that the light intensity is *per se* the active agent, the evaporation power of the air seems by far the most probable climatic element to which to attribute the plant responses here dealt with.

Some of the native desert perennials respond to the change in seasons in a marked way, as by losing their foliage in the dry season; but it is difficult in these cases to distinguish between the effects of dry soil and those of high evaporating power of the air. The deeper soil layers of the Desert Laboratory reservation contain throughout the year a considerable water supply, so that it is entirely possible that the more deeply rooting perennials do not suffer directly from desiccation of the soil. A case where the rate of evaporation appears to be the controlling factor in the seasonal response is furnished by the experiment of Lloyd with *Fouquieria splendens,* in which he was able to cause the local development of leaves during the dry season by simply wrapping a portion of the leafless stem with a cloth kept wet by means of a siphon. No water was allowed to reach the soil about the plant, so that the response must have been due either to the local check imposed upon transpiration or to water absorbed through the bark of the stem, bud scales, etc. From what is known of the low rates of water absorption by stems and leaves it seems very improbable that the latter supposition is true. If the other is correct, it would appear that the *Fouquieria* plant in question was absorbing water and transmitting it up the stem at a rate which was inadequate for the development of foliage, as long as the evaporation (and transpiration) remained excessive, but that this rate became adequate for leaf formation with the local decrease in evaporation rate.

Another apparent instance of a response to evaporation conditions is afforded by *Sphaeralcea pedata,* a small red-flowered mallow attaining a height of about two feet, and bearing flowers and leaves the year round. In the winter and early spring (the season under the influence of the winter rains) the leaves have an area of from twenty to thirty times as great as in the spring dry season. While the leaves of the earlier season are bright green and nearly smooth, those formed in the season of drought are densely covered with white tomentose hairs. Growth is less rapid in the dry season and the longer branches often die back to the ground at this time. The leaves of the more mesophilous type mostly succumb before the arrival of the summer rains, leaving a plant of an appearance entirely different from that of the early spring. In the summer rainy season this plant resumes its more rapid growth and the leaves then produced are of the mesophilous type in the shade and partake of this character to a large extent even in the sunshine. It was observed that in the dry season potted plants of *Sphaeralcea* growing in a soil kept at the *optimum* water content refused to develop the mesophilous type of leaf, and that the same specimens produced that type during the season of low evaporation rate. The main difference noted between the potted plants and those in the open ground lay in the fact that the former retained the mesophilous leaves produced in the early spring somewhat longer than did the latter.

This evidence is of course very inconclusive, but it seems indicated at least that even with the soil kept at its *optimum* water content, *Sphaeralcea* responds to high evaporating power of the air by the assumption of an entirely different form and structure of leaf from that exhibited under less strenuous conditions of evaporation.

A consideration of evaporation as a controlling factor in plant growth would be logically incomplete without mention of the abnormal behavior of many pronounced xerophytes when subjected to conditions of low evaporation rate. Among gardeners the succulents are generally regarded as very difficult to grow in the more humid regions, and especially in glass houses. Such plants often fail to develop normally and often meet their death through the action of fungus diseases of the damping-off form. It is possible for the gardener to provide conditions of soil moisture very nearly approximating those of arid regions, but in most conservatories it is practically impossible to attain anything like the atmospheric conditions to which desert succulents are normally subjected for a great part of the year. I have had occasion to study the fine collection of cacti grown under glass at the Missouri Botanical Garden, at which place I enjoyed the privileges of working in the conservatories during two months of last winter, and it appeared that while many species were thriving well under the artificial conditions, yet a number of forms were not at all healthy. It was further determined that these plants were not transpiring in the normal manner. I have also often observed at the Desert Laboratory that pot-grown cactus seedlings are very prone to die of a damping-off disease or root disease, especially when subjected to a low evaporation rate. It would thus seem that certain of these plants which are adapted to great evaporating power of the air, do not thrive when exposed to low evaporation. Perhaps the transpiration stream is necessary in such cases. It may be that the epidermal covering does not develop normally in the absence of rapid transpiration, and that this explains the frequent destruction of these succulents by fungi when grown in conservatories.

It is possible that evaporation plays an important part in causing the marked differences in the vegetation of neighboring sunny and shady areas. In an experiment carried on by the Desert Laboratory in cooperation with a large number of workers distributed over the United States, a number of tests of the evaporation conditions in sunny and shady situations have been made during the growing season just past. These tests uniformly show a much higher evaporation rate in the sun than in the shade. An instance of this difference may be taken from the readings of two instruments installed at the Missouri Botanical Garden, at St. Louis. For these data I am indebted to the Director of that Garden, for an active and appreciative interest, and to Mr. Henri Hus, for the care of the instruments and the preparation of the data. In this test one of the evaporimeters was exposed 15 cm. above the soil surface in a denuded area about three yards square lying within the Experiment Garden. From this area vegetation was excluded during the season. The second instrument stood at the same height above the ground in a coppice in the Arboretum, where the shade was rather dense. For the period from May 19th to June 17th, the average weekly rate of evaporation was 142 cc. in the sun, and 58 cc. in the shade. From July 22d to August 26th, the average rates were 187 cc. and 61 cc. Records for the period intervening between these two were lost on account of an injury to one of the instruments.

Attention was called to the importance of evaporation in the general distribution of forest centers by Transeau, in a paper in *The American Naturalist,* Vol. 39, pp. 875-889, 1905. The same material, in a condensed form, appeared in the Seventh Annual Report of the Michigan Academy of Science, pp. 73-75. These papers call attention to the fact that the distribution of forest centers in eastern America cannot be accounted for on the ground of heat and precipitation. The author presents a map showing the ratio of rainfall to evaporation, expressed in percentages, deriving his evaporation data from the paper of T. Russell in the *Monthly Weather Review* for September, 1888, and shows conclusively that this map exhibits "climatic centers which correspond in general with the centers of plant distribution. Further, the distribution of grassland, prairie, open forest, and dense forest regions is clearly indicated. . . . This is explained by the fact that such ratios [of rainfall to evaporation] involve four climatic factors which are of the greatest importance to plant life, viz., temperature, relative humidity, wind velocity, and rainfall."

Dr. Transeau and myself devised a plan for obtaining evaporation data more definite than that at hand by asking the assistance of numerous workers in the country to install and operate the instruments for a widely distributed series of observations. The outcome of this plan was the cooperative experiment mentioned in a previous paragraph. Data are at hand for some thirty stations, but have not yet been sufficiently worked over to warrant their being made public here; they will be published at a later date. I am able to give at this time, however, a good example of the differences in evaporation of stations at different altitudes in the vicinity of Tucson, Arizona. Instruments were installed on May 12th, 14th and 16th, in the Santa Catalina Mountains at altitudes of approximately 6,000, 7,500, and 8,000 feet. These instruments were read on May 31st and June 1st and gave the following average weekly rates: 6,000 ft., 238 cc.; 7,500 ft., 147 cc.; 8,000 ft., 133 cc.

These instruments were placed at a height of 15 cm. above the ground and were all in the open, but were surrounded at some distance by the vegetation of the locality, the lower one by scrub oaks, the middle one by open pine woods, and the upper one by a denser growth of pine, Douglas spruce, etc. Later in the season these instruments were injured by the action of impure water, so that I am unable to give an average for a longer period. These figures would suggest that the evaporating power of the air plays a great part in the distribution of vegetation at the different altitudes of a mountain range of this sort, a conclusion which would be expected from the work of Transeau above mentioned.

The President—I am, myself, very glad indeed that this subject of evaporation is receiving this attention, which is indicated by Dr. Livingston's paper. I think we have not given a tenth of the attention we ought to give to this subject of evaporation from plants. I have not the figures at my fingers' ends about the amount of water evaporated by a tree in a day. We have statements of the amount of water evaporated by a field of grain, maze, in full vigorous growth. The amount of water evaporated by an acre of any plant, say of clover, or anything of that kind, is given to us, and it is staggering in the figures, and it certainly is a very important factor in this whole subject of plant development and plant life. The nursery trade generally will tell you the fall is the time to plant anything deciduous. You go through the nurseries and they are going all around—pulling the leaves off every tree. What is that for? It is to make the purchaser think that tree has shed its leaves and has got its season's growth, and secondly, they know if that tree is put up with those leaves on, the evaporation is going to exhaust the tree immediately and it will lose its life and it is going to die. The evergreen is a tree that carries its leaves the year around. It is not like a tree that sheds its leaves. There is a point to it, to which sufficient attention is not given, and I think it is extremely important because, as Dr. Livingston and Dr. MacDougal stated, there is a point beyond which, if the moisture of the plant is exhausted below a certain point, you have reached the death-point beyond which life cannot endure. By this investigation that has been indicated in this paper, I think we are going to get a great deal of light on these important matters.

Dr. Hansen—It has been our experience in our nursery work in the northwest (that means the northern part of the Mississippi valley) that the fall planting of all trees means death to a tree. They are usually dry enough to burn by spring. A tree has no chance whatever to establish communication with moisture in the soil, especially evergreens. It is sometimes said that our dry winter winds will take the moisture from a fence post.

The President—There is no doubt about it.

Dr. Hansen—Another point I have noticed in the spring is that the fruit trees in the nursery have the young shoots shriveled very much, and in the early spring it is unsafe to dig too much because the shoots are so shriveled that they lack moisture. They have had more moisture evaporated in the winter than there was in the twig, but by leaving them for a few days in the spring after a rain, they plump up and the shoots absorb enough moisture from the air, it is presumed, so that they have assumed a plump appearance. I think this question of evaporation is an important factor.

Mr. Southwick—I have in my notes here, a lecture given in this hall, in which it was stated that an elm tree evaporated 100 tons of moisture a day, and that an acre of grain—it does not say what was on it—evaporated one hundred tons of water in a day. Is that so?

The President—That is a remarkable statement. That is the trouble. A great many of us get hold of a truth and try to kill it in every way we can by exaggeration.

Mr. Siebrecht—I do not believe in late fall planting of evergreens. If you can transplant them early enough so that they will get at least three weeks or six weeks of warm weather with moisture with it, and you get nearly all the roots—I think under such favorable conditions, you can make our evergreens live. They will make small fibres, and if you will only take them along, they are all ready to spring. That is to say they keep dormant until late in the season, and all at once the hot sun comes in the latter part (or the early part, I have seen it on the 20th of April). Then the trees begin to bud, I am speaking of evergreens now, and put out new roots. Now, as to shade trees, it is very true, that the people place an order in the spring or in the summer for trees and shrubs, and cannot wait. A gentleman called me up yesterday and said, "Why haven't you planted those shrubs? My trees are all in." Well, we had to take a lot of trees, lindens, and Norway maples, and we stripped off the leaves, in fact, we cut them off. I do not believe in stripping because you pull them out of the socket, as it were, so we cut off half the leaves and transplanted that tree with a nice bunch of roots and fibres, and after such a good rain as we have had lately, they stand up and are nice-looking. If they should make a growth and the growth should not get matured, then of course it would suffer during the winter; but the nurseryman has got so short a time in the spring that you cannot blame him.

Mr. Macoun—In Canada, the subject of evaporation is a very important one, especially in our poorer districts. We find, for instance, in the Behring Province, that the evaporation is too great for most kinds of trees, and most varieties of tree fruit, and what we wish to find out is just how much moisture each variety of fruit must have during the winter to enable it to stand the winter, because it is quite evident that a tree must have a certain average amount of moisture during the winter. On the contrary at Ottawa, trees which are hardy there, different varieties, only some of which are hardier elsewhere, we find the tenderer varieties of those kinds have the largest amount of moisture. The analyses of the chemists say that the tenderest varieties of apples, for instance, which were killed at other places farther north, had the highest amount of moisture at Ottawa, hence a different treatment would have to be given those trees farther north than trees which had not so much moisture. For instance, Dr. Hansen said in North Dakota they recommended cultivating very late in the autumn in order to get the trees as well charged with moisture as possible. I believe that is true in certain limits for certain varieties, but in the country where I live, if we were to cultivate these tenderer varieties in the late autumn, those trees would have too much moisture in them, and not be properly matured, and hence would be killed back at the terminal growth. I think that the point that should be worked out by those who are making a study of this question, is how much moisture certain varieties of trees should have on the average, to withstand the cold climate there. Now, we all have to grow a variety of apples, so as to cover the season, but it seems to me that we must give these varieties different treatment if we are to have equal success, and that is not a subject which has been given enough attention—the different methods for different varieties. We have been working on the subject at Ottawa, of growing these trees according to the degree of hardiness in proportion to results, and we find that the trees which mature earliest are the hardiest, but those that are the least hardy have the most moisture.

The President—I would like to ask whether the subject does not bear directly upon what we call winter freezing. That is, the freezing and cracking of the trunk of a tree, which occasionally takes place, and which to me has always been inexplicable. Isn't that a part of this problem exactly?

Mr. Macoun—Yes, the freezing does this. Thus, in the Province of Nova Scotia, and I believe in a few places in New York, they have been troubled with what they call crown rot of a tree. That is the breaking away of the bark right at the base of the tree. In investigating this, I have come to the conclusion that that is almost entirely due to the late growth of the tree, and is due to the sudden breaking away of the bark of the tree, owing to the fact that right at the base of the tree you will have the most amount of moisture in the trunk. The first fall of snow prevents the drying out of moisture from that part of the trunk. That snow may go away and then there may come a drop of temperature to 30 or 40 degrees below, and the cracking takes place. In those parts where they adopt the highest method of cultivation, they are troubled the most. The late growth is the trouble.

Dr. Hansen—That must be the same trouble which we call "bark bursting." That occurs in nursery stock out in the northwest. The trunk becomes perfectly saturated with moisture, and it seems to fracture the bark at the surface. I did not mean in my former remarks to advocate late cultivation. I meant if we had a late fall we should give the trees a thorough watering before winter sets in.

Mr. Macoun—I notice that Professor Watkins advocates cultivating right up to the time winter sets in for hoed crops. I wrote to him but did not get any reply from him.

Dr. Hansen—One of our orchardists in Minnesota recommends the cultivation of orchards right up to winter when the snow comes, but what he means is not what we mean by cultivation. He simply means the use of a disk harrow to scratch the surface and keep in the moisture.

Mr. Von Herf—I have also had some personal experience in regard to plums, apples and peaches, and also grape-vines in North Carolina. The trouble does not occur every year, but it occurs in some years, sometimes being very disastrous. Sometimes hundreds of thousands of trees will be killed. I know of only one year, however, when grape-vines were killed in that way. Some were killed in the ground and others sprouted out, but were killed dead. We found the stopping of cultivation at certain times in the fall is a good precaution against this trouble, because we do not think it necessary of late to cultivate after the tree has made its growth. We think it is for no purpose. We stop cultivating about August. In regard to transplanting the trees, I have also some experience and I can corroborate what Mr. Siebrecht says, that the transplanting of evergreens is most successful just at the period when they are sprouting out. We transplanted with certain success along these lines, magnolia and other things. I can also cite an example in Washington. They have a nursery for street planting only and I was told some years ago by the gentleman in charge that they could never successfully transplant an American poplar. This is not an evergreen, but it seems to make the same demand as evergreens. He says they have no trouble now, if they transplant at the time it is sprouting out.

Mr. Siebrecht—Talking about excessive moisture, there is an example. The tree wants to be handled like an evergreen. If you take it at just the time the bud is swelling, you can transplant any size of tree, but you take it too early or too late, and you lose every time. Speaking about the excessive moisture and cracking of the bark in trees, I want to say just a word. I have found in my nursery—I have got all kinds and conditions of soil, upland and sandy soil and flat land and heavy soil—the heavy soil I must not cultivate late in the fall. There is plenty of moisture there. There is too much. I planted trees last winter, and many of them cracked up and down. That was late in the season, and too much evaporation took place, more than the body could contain, and the bark split. With the Norway maples, it was the same way: of those upon the high ground and the hillside, not one suffered, although they are not so luxuriant and the growth is slower, but the foliage was heavy. There is no cracking, either with the Norway maples, linden trees and plane trees. I find we have to study the conditions of the atmosphere and the ground and the locations for the different kinds of trees, and where it is a dry climate, with the climatic conditions on the dry side, late cultivation might be very well to give the tree all the condensation and the moisture you can. On the other hand, where it is very moist and wet, leaving it alone, letting the tree mature and letting it have its own way is a good thing; and then it can stand the winter in a dormant or semi-dormant condition.

Mr. Munson—I think a portion of this question is a matter of evaporation and condensation. I have had an experience of that kind. For example, the transplanting of the magnolia, one of the most difficult trees to plant if the foliage is left upon it, but by clipping the foliage off, they can be transplanted almost as easily as beech trees. It is true that evaporation enters into that problem, but why does it not transplant as readily as arbor vitæ at that season?

Mr. Siebrecht—You have got too much moisture to take care of. My observation leads me to this conclusion; that the magnolia and most of the evergreens are very slow in starting to feed the roots. It takes a larger amount of temperature to start the new roots to feeding, and you have got the tree loose from the soil and it cannot make feeding roots quickly enough, so in the meantime the evaporation from the foliage exhausts the tree. We take that evaporation away so that it can stand long enough for the roots to form and then it can feed and it is all right. If you want to transplant a tree in full foliage so as to make a showing at once, you must provide shade for it so as to prevent evaporation. Now, it works differently whether the tree be dormant or active. I have observed frequently that while in the spring we cultivate and work up a plot of ground, say for a peach tree, we push them into bud and bloom more rapidly than if we had not disturbed that soil. The evergreens cultivated in the same way will push a little more rapidly and become filled with sap sooner and the sharp freezing following, we lose the first crop of buds and shoots. They are more sensitive to frost. That is the young growths when they are full of sap, are more sensitive to frost than when they are dormant. When they are dormant, it seems that they are more hardy.

The President—Reference has been made to transplanting Magnolia grandiflora. I would say I have been laboring for fifteen or twenty years to acclimate it to this latitude, because it is, as you all know, the grandest magnolia in the world. So far as I know, the most successful specimens in this part of the country are at Riverton, New Jersey, a few miles north of Philadelphia. If there are any north of that, I would like to know it. I think this region is the center of the world, and that this place should not be satisfied until we get Magnolia grandiflora here, so I tried with a great number of specimens, but never could get them through a longer period than five years, and never got them to bloom. I thought by growing a number of specimens and protecting them well the first winter, a little bit the next winter and a little bit less the next winter after that, I should, by the fifth winter succeed, but unfortunately, I was like the good German who said he got his horse down successfully to a point where he could live on one straw a day, and then the horse died, so when I got this along to the fifth year, it died. So this theory of adapting the tree to its environment by slow process has not been successful with Magnolia grandiflora. The average temperature is just as low at Riverton, N. J., as it is at my place, although I am a good way north and there are other conditions affecting the surroundings, so it is not temperature alone. I don't know what it is, nor do I know what is the matter with the magnolia. The chief factor, however, I do not think is temperature.

Mr. Von Herf—I found a great difference between individuals. We have to consider that practically all of the magnolias we see are raised from seed, and if you pay attention, you will find there is as great a difference as between seedling apples, or any kind you grow from seed. Some grow tall and some not so tall. Some have broad leaves and others have leaves which are narrow as a laurel, also they differ in their capacity to bloom, and they differ in the same way as to hardiness. I found a large number of such seedling magnolias in a section where they are frostbitten, and some so tender that they freeze to the ground. These are individual specimens. Now, the most northern I have seen were in Philadelphia, and right in the city. I was recently in the city and I saw the place where it had been cut down, and it must have been very large, because it was a large trunk.

The President—It was on the corner of Broad and Chestnut Streets, and there is a seventeen-story building there now, and the two were not compatible. That is why they did not get on together.

Mr. Von Herf—The way is to select seed from the most northern trees and push them on in that way. I think it can be so arranged in New York as to get them in sheltered locations. I observed some Magnolia grandiflora growing in Washington City. One would think that as good a locality in which they would grow well as any place, but they do not grow there as well as they do a little bit farther south. I have in mind some trees opposite the White House. I saw them twenty years ago, and they appear to me now scarcely any larger than they did then. Now, in a proper location, they would be much larger than they were then. We can hardly expect to raise magnolias as fine as they are in their home, but I think they could be grown by proper selection in the manner I indicated.

Mr. Siebrecht—I suppose it was nearly twenty years ago when a lady, a customer of mine, offered me a thousand dollars if I would make a magnolia grow in 54th Street in front of old St. Luke's Hospital, and I declined the offer. Since then I have been practicing, like our president here, and at last I have got some that high (indicating about 4 to 5 feet), and those are from seed brought from Mount Vernon. Mr. Stuart, the superintendent of the grounds at Mount Vernon, said, "If you do not make these grow north, then it cannot be done. These are the most hardy we have." I have got them up to now, and I believe what my friend says. I have tried in the same way with English holly and have been fairly successful with the variegated and the laurel leaved, and also the common one in England. I have also succeeded in acclimating aucuba. It is doing very well. I have also acclimated the laurel and the big leaved laurel. I have got them but they are not very big trees and they are in sheltered locations, of course. I have succeeded in wintering over the crepe myrtle, and although they killed down to the ground very often, they are in flower now. Therefore I think we can, by trying, acclimate those things.

The President—I think that if I could get seedlings from trees that were native in North Carolina four thousand feet above the level of the sea, where the thermometer sometimes gets 25 degrees below zero, Fahrenheit, we ought to have them here, and I have brought them from four thousand feet above sea level, North Carolina, with the expectation of doing so. I have also had them from New Jersey and they did so well that they not only thrived, but perfected their seed, so I get seedlings from them and it would seem as though 4,000 elevation in North Carolina ought to bring it to New York successfully.

Mr. Von Herf—What place is that?

The President—Near Cranberry, southwest of Asheville. I hope in time we will have some publications from Tucson on this matter of evaporation which will throw some considerable light on this subject. I cannot understand how it is that nature overloads the trees with moisture in the winter time. It reminds me, while this matter is being discussed, of a man up in a little town who went by the name of Uncle Jabez, his name being Jabez Jones. He was like these trees which the winter affects—occasionally he would get overloaded with moisture, alcoholic moisture—and one day he came out and he evidently had too heavy a load on, and someone says, "Uncle Jabez, you are overloaded to-day," and with a twinkle in his eye, he said, "Yes, I would better have made two trips!" (Laughter). Now, Mr. Munson, let us hear about "Resistance to Cold, Heat, Wet, Drought, Soils, etc., in Grapes."

The following paper was read by T. V. Munson:

Resistance to Cold, Heat, Wet, Drought, Soils, Insects, Fungi, in Grapes.

By T. V. Munson, *Denison, Texas.*

As a general, if not a universal, law of adaptation of plants to environment, we find that the natives in the environment are better adapted than the exotics.

The vine is no exception to this law. Let us test the assertion by comparison.

What species and varieties of grapes resist winter's cold best? Certainly the vines, and vineyard varieties derived therefrom, native in cold regions, known as *Vitis vulpina (riparia)*, northern section of *V. labrusca, V. cordifolia,* northern section, *V. bicolor, V. cinerea,* northern section, *V. rubra.*

Of these, *V. vulpina* of Wisconsin, Minnesota and Dakota readily endures without protection, —40° to —50° F. But *vulpina* of Virginia and northern Texas can endure only —15° to —20°. The Labruscas of Massachusetts can withstand —20° to —25°, while those of South Carolina perish in —10° to —15°. The *cordifolia* of central Illinois and Ohio (about the northern limit of this species) endures —15° to —25°, while the Florida *cordifolia* is sometimes killed to the ground in northern Texas with zero or a few degrees colder. *V. bicolor* of southern Wisconsin endures —30° readily, while Norton Virginia, of the nearly allied species of *aestivalis,* finds its northern limits about Louisville and Cincinnati. So we might continue with all the species and their varieties.

The limiting lines of hardiness to withstand cold do not follow the parallels of latitude, but the isothermal lines. Hence we have wild grapes in northwest Texas that readily endure the winters of Massachusetts, and the *Vitis Californica,* found along Rogue River in southern Orégon,—its extreme northern range—winter-kills to the ground, when grown at Denison, Texas.

The Post-Oak grape of northern Texas endures the winters perfectly in middle Ohio, where temperature sinks to —25° sometimes. But when we come to reverse the test, the Massachusetts and Ohio grapes cannot endure the Texas summers anything nearly so well as do the native Post-Oak and Mustang grape. The Concord, that remains vigorous for fifty years in Massachusetts, its native State, survives only eight to fifteen years in Texas with equally good treatment. This brings into consideration another element of hardiness, the power to withstand great or only small range of climatic change. In this, the general law still holds good. Those species with their varieties native in a region subject to great and sudden ranges of temperature, can endure well, while those brought into such regions from where the range is small, will suffer, as is the case with grapes of Florida or New England brought into northwest Texas. Both suffer, while the vines of northwest Texas thrive well, both in Florida and New England, so far as resistance to heat and cold are concerned. In other words, northwest Texas plants have a much wider range of climatic endurance than have either those of Florida or Massachusetts.

No other section of the United States has so great a range of climatic conditions as northern Texas and Oklahoma.

This will suffice as to cold, heat, wet and drought; but we must not fail to observe, that some individuals of a species have greater resistance power than others, all developed in the same climate, soil, etc. This fact is seized by the plant breeder with great avidity, to increase the hardiness of his varieties of same blood and nativity by selection, depending on the law of inheritance to sustain his selections.

As to soil, the law holds good so far as resisting an excessive or injurious chemical element. For example: some varieties of grapes, the Labrusca, Lincecumii and Rotundifolia varieties, especially, chlorose very badly (turn a pale, sickly yellow in foliage), if set in soils having above 40% of carbonate of lime, while the Vinifera, Cordifolia, Cinerea, Berlandieri, Champini, Candicans, Rupestris and Monticola thrive in such soils. We find those that chlorose badly are natives of very sandy soils, along the banks of streams and lakes—the Vulpina, or on sand-hills, as is the Post-Oak grape of Texas, while those that grow best in very limey soils, belong to species native in such soils.

We find, however, that in some cases varieties of species, native in very sterile soils, take on far more vigorous growth when put into soils richer in humus, and the chief elements of plant-food; and this causes excess of wood and leaf-growth, to the detriment of fruit bearing, when carried to the extreme.

Nearly all species of grapes are native in warm, loamy, well-drained soils, and such cannot long endure with roots permanently in water, or in cold, livery, compact clays; but a few species are known that cannot long survive in soils not sub-irrigated, or having growing moisture at all times. Such are Vulpina, Rupestris, Cordifolia, Cinerea, Rotundifolia and Simpsoni. The last-named is often found with the roots perpetually submerged in the borders of swamps, and making immense growth. In such situations, the Vinifera, native on the limey hills of southwest Aisa, and Post-Oak grapes of the Texas sand-hills, would survive only a short time.

In land that is seapy during rainy weather and some time after, but in the dry, hot summers, dries out and becomes hard, no grape thrives. Cordifolia, above all other species, perhaps, can endure such situations longest.

Concerning resistance to mildews, rots, etc., it is true that all species native in high arid regions are very quickly and destructively attacked by the cryptogamic parasites, when moved into humid situations, where such organisms exist. For resistance to these parasites, natives of the parasitic regions must be sought. Perfectly resisting varieties in such regions, when hybridized with nonresisting varieties, produce only partially, or weakly resisting varieties.

Take a vine from a parasitic region, loaded with the parasites of mildew and rot, and plant it in an arid region and it becomes free of these fungi, simply because the parasites must have much moisture in the air to propagate.

This law does not hold good as to root parasites, or bacterial blights that live within the cells. For example, the Anahein grape disease, of California, thrives in the moist regions of northern California as well as in the dry region of southern California, where it originated, just as pear-blight, when once introduced into California and Colorado, is as contagious and destructive as in Georgia or Texas.

The insects that infest grapes know no specific bounds. The rose chafer, the fidia, the leaf-folder, the leaf-hopper, are just as bad in one region as another in which they can endure the winters, and on one species as another with few exceptions. Certain varieties resist, or are distasteful to these insects, and thereby escape, while others are greatly liked and damaged by them.

The leaf-folder, however, never hurts a vine that has leaves that are glabrous, that is, entirely without pubescence, or down of any kind on the upper side of the leaves. The egg is laid on the upper side and the larva finding no pubescence to tie its webs to, and thus unable to draw the leaf together over it, soon perishes in the sun, or is eaten by birds; hence only grapes with leaves more or less downy on upper side of the leaves are damaged by the leaf-folder.

There are some varieties of grapes much less bothered by the leaf-hopper, than others. These generally are the varieties with very firm, dense tissue, such as the Post-Oak grapes of Texas. The fidia and rose chafers make little choice of kinds, and are voracious feeders on the foliage. The Rotundifolia is freest from attack of fungi and insects, in fact almost entirely exempt.

The Phylloxera comes well under the general rule. It can do little damage to those species of grapes native in the same regions where the Phylloxera is native, yet there is much difference in resistance there. For example, *V. rotundifolia* is entirely immune; *rupestris, vulpina, cinerea, Berlandieri, Champini, candicans, Doaniana, aestivalis* and *Lincecumii* are so high in resistance as to be practically uninjured, though they may be attacked; while *Labrusca* is low in resistance and is much weakened in clay soils, if infested, and *vinifera* is entirely non-resistant. It is a native of regions never infested by Phylloxera, until introduced among cultivated vines.

To have given full lists of resistant and non-resistant varieties under each heading of this paper would have been entirely beyond its province, as from what is said, any one acquainted with grape species and their native habitats can readily select the resistant kinds in each case.

The President—The subject is now before the Conference for any discussion you may have upon it.

Mr. Von Herf—With regard to heat and cold, I experimented for nearly ten years with about 350 varieties, and they stood the winter very well, with the exception of one variety, which was very tender, which was the plant we got from the White House in Washington and which seemed to be quite tropical in its nature. Now, as to the resistance of vinifera, we had no trouble, because it was sandy soil, and they were mostly grassed and some got their growth. I believe if we could suppress the black rot on vinifera, they would grow just as well. They require more careful treatment and better fertilizing, and more care, but they will grow. There is no trouble about that. It is only the black rot which makes it impossible to raise fruit. We got vines from nurseries for a year or two, but the trouble got worse every year until we found it practically impossible to continue although there is a little difference in the different varieties, but we cannot even raise Niagara after the vines have reached some age. That is, after they are some three or five years old. The Niagara, I am told, has the vinifera in it. I think we produced vinifera from seeds, the vinifera vine from seeds coming up from Niagara grape seeds, so I think it is shown it has vinifera in it.

The President—Dr. Hansen has a paper which he will read entitled, "Is Acclimatization an Impossibility?"

The following paper was read by N. E. Hansen:

Is Acclimatization an Impossibility?

By Professor N. E. Hansen,

South Dakota State College of Agriculture and Mechanic Arts, Brookings, South Dakota.

The title of this paper would seem to indicate views decidedly iconoclastic and heterodox for a Conference on Plant Acclimatization. The casual reader might inquire why we should hold a conference on how to accomplish an impossibility. This line of thought has accumulated slowly in the course of extensive horticultural experiments extending over a series of years, and I will expect some objections from people who have never faced the problem of originating fruits capable of enduring —40° F. with the ground bare of snow. I do not believe in giving winter protection to any plant, because that is *horticulture on crutches* and hence something to be avoided if possible.

The argument may be divided into the following sections:

A. Acclimatization of perennial plants; Botanical names are insufficient for horticulturists; DeCandolle's law. What is possible for nature is impossible for man.

B. Acclimatization of annual plants; Easily done by man, but is really a process of sifting out of unfit elementary species; or minor changes, such as shortening the period of growth.

Horticulturists who have had to deal with plants in the prairie northwest have learned by costly experience that the source of seed of any variety of tree, or any other perennial plant, determines in a large measure its hardiness in a given locality. Hence my contention is that botanical names do not tell the whole story. Box elders from Southern States winterkill at the North. The people of Manitoba have learned long ago that they should not plant box elder seed native of the South, although they appear to be similar in all observable botanical characters. Russian foresters called our box elder tender, the seed having been gathered near St. Louis, Missouri; but when they secured seed from pure native trees in Manitoba they found the trees to be perfectly hardy at the north. They named this variety "Boreale," indicating its northern origin; as yet we have not waked up enough here to make this distinction as far as I am aware, and the average planter is blissfully ignorant as to whether the box elder he plants dates back to Arkansas, Manitoba, Missouri or North Dakota.

It has been found by many northern nurserymen that the red cedar of the South is tender and short-lived at the North, while the local northern form of the species is hardy.

Robert Douglas learned many years ago in northern Illinois that the black walnut of the South was tender at the North, whereas the local northern form was hardy. He also determined that there was a decided difference in hardiness on exposed prairies of the conifers from the Rocky Mountains; the forms of various species from the Pacific slope side being much inferior in hardiness to those from the eastern slope.

In the course of three trips to Russia I learned that Russian foresters had found the Scotch pine from western Europe, and from France and Germany, inferior in hardiness to the Scotch pine of northern Russia and extending into Siberia. Similar differences have been noticed between the west European and the east European and west Siberian form of the Norway spruce.

Many more instances might be given of the fact that a species extending over a wide geographical range, varies widely in its capacity to resist cold. It shows then that nature must have done a work in acclimating plants so that it will endure a greater degree of cold.

DeCandolle, in his "Origin of Cultivated Plants," states: "The northern limits of wild species . . . have not changed within historic times, although the seeds are carried frequently and continually to north of each limit. Periods of more than four or five thousand years, or changements of form and duration, are needed, apparently, to produce a modification in a plant which will allow it to support a greater degree of cold." This proposition means that plants cannot be bred so that they will be more resistant to cold by ordinary selection, as it would take too long. For hundreds of years on this continent, for example, we attempted to originate hardy grapes, apples, raspberries, plums and sweet cherries from the species originally brought over from the mild climate of southern and western Europe, but no success was obtained. Thousands of orchards, vineyards, and small fruit plantations, wrecked by our test winters in the prairie northwest, show that man's efforts at acclimatization were in vain. He could not secure a hardy plant from a tender one. In other words, we were starting on a ten-thousand-year job. Nature demands a century of centuries for the completion of some experiments. She can do such work, we cannot.

When it comes to the acclimatization of annual plants the problem is in the main of a different nature. A large late southern variety of Indian corn when moved too far north will of course be cut off by early frosts. If moved not too far north there is sure to be some extra early strain within the variety which the observing farmer will select for his next year's seed, and in a few years he will have an extra early variety adapted to his locality. By always selecting for earliness the Indians were able to carry corn, a semi-tropical plant, from South America north to Manitoba. This selection was accomplished by the Indians before Columbus discovered America. The Indians cured their seed corn by hanging it up in the smoke of their teepees to dry: and the best modern methods of curing seed corn by artificial heat are in a sense no improvement on this aboriginal method. In parts of south central America corn attains a height of twenty feet with kernels several times larger than our northern seed kernels, and it requires seven months to mature. At the northern limit in Manitoba it is perhaps five feet in height and requires three months to ripen, but in all this time we have simply shortened the season. Corn has not changed its nature in its requirement of extreme heat for ripening seed. As yet we have no corn that will endure frost to any extent, nor has northern Europe been able to originate a variety from a variety from our Indian corn that will ripen. A new light has been thrown on this matter by the mutation theory of De Vries. We now know that a systematic species is made up of a great many elementary species which are perfectly distinct from each other and absolutely fixed in type. While on my third trip to Russia in the summer of 1906, I visited the experiment station at Svalöf, Sweden, where Dr. Nilsson has been conducting with such remarkable success a series of experiments in improving cereals by isolating each variety as an elementary species. The Swedish Select oats, for example, which is now so popular in the prairie northwest, was originated at this station. Dr. Nilsson considers that an ordinary variety of barley, for example, is made up in reality of many varieties differing slightly but each perfectly distinct from the others and constant from seed. These sub-varieties are really elementary species, i. e., they are mutations. When grown in certain sections for many years these hold their own in varying proportions from year to year; but when raised at the South, the extra early mutations will be crowded out to a considerable extent by the later mutations, which are usually more productive. If now this variety is transferred say four hundred miles further north, a readjustment of these varying proportions takes place very rapidly. The late mutations are crowded out because the seed does not mature, while the extra early ones, which were in a decided minority before, quickly gain the ascendency and very soon the variety is made up entirely of these extremely early sub-varieties. So that the acclimatization of annual plants is in reality not a changing in the plants themselves, but only the sifting out of the unfit elementary species. In fact, Dr. Nilsson believes that extra early mutations can be isolated at the South, as well as they can be at the extreme North, provided sufficient care is taken in the selection. The farther south a variety is raised, the greater the care needed to select only the very earliest mutations, if a variety for the far north is desired.

It is worthy of note that the many failures in farming in the cold, semi-arid regions of the prairie northwest are due to the fact that the plants cultivated were from the milder climate of western Europe. In other words, it is unwise to farm in a dry, cold climate with wet, warm climate plants. This is a very fundamental proposition. The farmers of America have spent hundreds of millions in the vain effort to acclimate certain plants. Let it now be placed on record that my study of horticultural problems in the prairie northwest has taught me to have no faith in the possibility of acclimating plants to a greater degree of cold than that to which they are accustomed in their original habitat. I believe that those who are attempting to acclimate the common alfalfa, brought over from northern Africa by the Spaniards to South America and thence to California, to the conditions of our prairie northwest, are starting on a ten-thousand-year job and hence impossible. This led me as the first agricultural explorer from the United States Department of Agriculture to attempt in 1897-1898 an overland trip of two thousand miles through northern Turkestan, western China and southern Siberia in the endeavor to find a hardy form of the common alfalfa. Blizzards interfered and the trip was a severe test of endurance. As a result of the trip Turkestan alfalfa was brought to America for the first time for the spring of 1898. This initial exportation of eighteen thousand pounds I understand from good authority, has now risen to nearly five million pounds exported annually, the larger part of which goes to South America and about a hundred and fifty tons to the United States, and the amount is fast increasing. Turkestan alfalfa has proven to be more resistant to cold and drought than the ordinary alfalfa. But I was not satisfied that I had secured the most northern form of the alfalfa, so in a six-months' trip in the summer and fall of last year, I made another attempt and found that there were other species, yellow flowered, extending north of the common alfalfa limits one to two thousand miles across Asiatic Siberia. I only hope it will help to solve the alfalfa question on the American continent and that it will carry the alfalfa belt north as far as we care to farm.

SUMMARY.

My belief concisely stated is that to breed plants so that they will endure a greater degree of cold is a work demanding such a great period of time that it is for nature rather than man to undertake. The only way in which it might possibly occur is by some great mutation but so far, out of many instances, as in the case of the apple, raspberry, grape, alfalfa and clover, no noteworthy progress has been made in making plants hardier by selection from tender stock. The occasional test winters, such as that of February, 1899, in which millions of dollars' worth of alfalfa were destroyed, indicate that it is not feasible to get hardy plants by selection from tender plants. In each and every case it is starting on a work that may take many thousands of years for completion, and the test winters may compel us to begin all over again. Nature takes a century of centuries for some experiments. Let us leave such work to her.

But, you may ask, how may we get hardiness into tender plants? I look upon hardiness as something easily transmitted in crossing and I am working extensively along this line in my work of raising seedlings of native northwestern fruits by the hundreds of thousands. Hardiness may turn out to be a unit character obeying Mendel's law of heredity. In plants, such as plums and apples, which are propagated by some mode of division of the original plant such as budding or grafting, we will not need to go further than to secure the original hybrid that has the characters we desire. But this line of thought is not within the scope of this Conference, as we are discussing acclimatization and not hybridization.

The President—The paper is now open for discussion.

Mr. Siebrecht—I wish to say that as a boy and a young man, very often I grew Indian corn in the University in Germany, from English corn. There were thirty varieties that were adapted. That was in northern Germany, in Hanover.

The President—I think that this challenge from Dr. Hansen about this law means that no annual is admissible as an illustration. Dr. Hansen himself has spoken about the Indian corn. Indian corn does not bear at all upon it. It must be something that can bear through the winter, so when he spoke of this law, I said to myself, there are a thousand illustrations, but as I thought of it, I realized that no annual counts, because an annual does not bear through the winter, and no hybrid counts. And so when you eliminate the hybrids, it is the kind of law which you cannot meet, because you are always uncertain of your ground. While he spoke I thought of Indian corn, and I thought of a score of things, but they are not admissible. Now, let us see what we can find. So far as our information goes, the cherry is a native of Persia, and here is an illustration which conflicts with the law. When I have eaten such magnificent cherries, as I have in Scandinavian countries and in England, the same latitude as our Labrador, and find a thing which we have no thought of hybdridizing, I think that the law is met there completely. So far as we know, the peach is a native of Persia, with the exception that we have found it is also apparently a native of Manchuria. Whether the Persian peach came from Manchuria, or the Manchurian came from Persia, in prehistoric times, we do not know, but I think we have a right to assume that the peach is a native of Persia, and the Manchurian peach in some way strayed from Persia. If that thing it true, there is no comflict of the law. So far as we know, the currant is a native of the southern countries of Europe. It gets its name from Greece, and the currant is a native of Corinth. This is one of the laws which eliminates evidence. It is like the criminal trial to-day, in that you cannot introduce any evidence;—this is eliminated and that is excluded, and you have got nothing and the fellow gets free; so it is with this law, when you come to think about it. I am going to stand by the cherry and the peach and the currant, unless you can prove their origin from somewhere except the historic origin.

Dr. Hansen—You will have to eliminate the currants, Mr. President. But the currant which we buy in the market, and is grown on the coast of Corinth, is not a currant at all, but a grape. But our currant is a native of that region. We call it a currant, and what we call a currant comes from Asia Minor.

Mr. Munson—I think the position of Dr. Hansen can be sustained, if he would only give us the definition of procedure. If he means that I should pick a half a bushel of wheat out of a pile grown upon a field of wheat, indiscriminately, and sow it, and from the pile grown on that field, take another half bushel and sow that, and so on, it might take four or five thousand years to get a hardy wheat, and I can hardly conceive you would get one very hardy then.

The President—But you have got to get your wheat and leave it out of doors during the winter. You have got to have that seed carried through the winter.

Dr. Hansen—Let us have the whole thing. Give us the whole thought, whatever you have.

Mr. Munson—Take indiscriminately a lot of apple seeds out of an orchard, and plant another seedling orchard, and then take the seed out of that indiscriminately, an equal quantity, and continue to plant in that same quantity right along. You may take the seedlings from the orchard a thousand generations ahead, into a hardier climate, and they would be no more inured than the first one you started from. Now, I am on the Doctor's side that far, but suppose that I take that half bushel of apple seeds and plant an orchard of it here or in Texas and out of the most vigorous of those trees, I take a like quantity of seeds and plant them in an orchard in Kansas, I would not have as many trees in that orchard for a few years as I would in Texas, if they were adapted to Texas in the first place, I suppose. I take half a bushel of them and plant them in Iowa or Nebraska and continue to travel northward, I will have less and less trees, but I will have some apple seeds that will end after several years in having apple seeds that will survive in Iowa and Nebraska, and this, if we accept it for your application, will kill all our experimental work. We stand upon the foundation of the survival of the fittest in all directions. Take the iron pea of the south, a selection out of all peas, the common pea, the Whipple pea, etc. Out of all varieties of them, one was found that resisted, and that was selected, and now we have them growing in fields full of nematode and not a pea touched. We are using it as fast as we can get the seed. It has not been known to be attacked by the nematode.

Mr. Siebrecht—Is this the same as the cow pea?

Mr. Munson—The same as the cow pea, known as the iron pea. Now, we know this, that there are certain varieties of vinifera grape in Texas where we go as low as 15 degrees below zero, some fifteen or twenty varieties that have stood that temperature, while there are others that will not go below zero. Now, I am sure if I should take that one that has endured the most cold and take pure seed—that is, its seed fertilized by itself—and plant, say in Arizona or Kansas, I might find a few that would stand the winter there; or find some hardier in that lot, and continue to plant a few generations farther and farther north, I would find a hardier crop, but I would not have a species. A transformation to another species is impossible. I am confident of that, but it is these little selections and the selecting as rapidly as the breeding of the plant will permit, that enables us to make any progress, and it is through that, that we do make all our progress with reference to this matter, I believe.

Dr. Hansen—I have taken the so-called hardy peaches of Iowa that have been raised for forty years by the seedling method, and have tried those in Dakota. The trouble is that I don't get a single individual to stand the winter. They all get killed. I don't get any to stand. I have to start over again. The western people tried our box elder and they winter-killed. They were about to give it up and they got the seed from Canada and it winter-killed. Then they got their seed from St. Louis. There is an example where they began too far away in the first place. What do you mean by a few generations? The generation of vinifera seedling would be how long? Five years?

Mr. Siebrecht—Four or five years in its natural course. You could make it bear in three years.

Dr. Hansen—Ten generations would be fifty years. The only trouble about that peach is, are we sure about Persia being the natural home?

The President—We do not know.

Dr. Hansen—They are a hardier form. I believe northern China. Is not that considered about the native home rather than Persia?

The President—We cannot tell. Of course, it is Persia or Manchuria.

Mr. Siebrecht—Something just came into my mind about English walnuts. I know an English walnut tree that is, I believe, fourteen or fifteen inches in diameter, the stem or trunk, and I believe a perfect tree, and which bears anywhere from four to seven bushels a year, and that stands right on the heights, not very far from Andrews' Monument, Tarrytown, part of the old place that formed part of the estate of Pocantico Hills, belonging to John D. Rockefeller. I guess it has been sheltered since it was a little tree put out there, by some spruce trees and pines planted to the northwest of it. No doubt they have sheltered it somewhat, but that is a perfect tree, and where trees have been brought from down south and from the other side that would not grow here, walnuts taken from that tree as grown here, have proved hardy. That sides in with what Professor Munson says, that you can make it hardier and hardier. That tree stands there and it is the finest in this country, I don't care where you go. There are some down in Freehold, New Jersey. I planted some there twenty or thirty years ago, and they are good, but not so good as this. There were some good ones around here, but a very cold winter such as we had a few years ago, killed them out; they start again however.

The President—We do not know where the original rose-bush grew, as it grew in the garden of Eden, but there are certain varieties, such as the China rose, and others—but the difficulty with the rose is that we have no pure rose to-day. They are all hybrids. There is the Bourbon rose. The Bourbon rose is the most distinct and probably the purest-blooded. It originated on the Island of Bourbon, and it is in conflict with this supposed law. That is a very good illustration. There is the pecan nut of America. The pecan nut is believed to be a native of Texas and has strayed up along the Mississippi valley until it is found in Missouri, and isn't Missouri the most northern limit of the pecan?

Dr. Evans—The Wabash Valley, Indiana.

The President—I have never seen any pecan north of Missouri. I was going to give that as an instance of it, but we do not know, of course, that it has come up there from Texas.

Mr. Munson—I have seen it growing in the valleys of Illinois.

The President—I have got pecans growing here. I was going to cite that as an instance, but if they have got them in Missouri, why then, we don't know. Then beside, so many of them are hybrids. Let me instance that, since Mr. Siebrecht spoke about the English walnut. The "English" walnut that we know is the walnut that we get from the Mediterranean. We do not get any from England. They are called Grenoble nuts. We get our best nuts from South Africa, and the northern shore of the Mediterranean. If it is hardy enough to live, it is not hardy enough to fruit. It does not fruit properly under ordinary conditions. Now, the black walnut belongs to the same family, one of the hardiest trees. A few years ago I conceived the idea, now, why not raise hybrids from the black walnut and the English walnut? There is no difficulty about the crossing, and now with a sufficient number of specimens, we can get enough with the hardiness and vigor and fruitfulness of the black walnut with the quality and thin shell of the English walnut. So I went to work to have hybrids made, and now have several hundred growing. I picked the pollen from the English walnut and fertilized the blossom of the black walnut, and took the pollen from a black walnut and fertilized the blossom from the English walnut, and I have these trees growing now. If I can get out of three or four hundred specimens, one tree that has the hardiness and vigor and prolificness of the black walnut, with the quality of the English walnut, I will have lots of fun, but you see I will get nothing as an illustration, because the moment you get to the field of hybridization, you are outside of this matter. I do not think you can go by the law. It is like a great many other laws, the spirit may be good, but the letter of the law you cannot hold to. Now, right in this line, we have Dr. Evans of the Department of Agriculture who has a paper on "Experiments in Plant Acclimatization in Alaska," to present later and it may throw some light on this subject.

Here is a paper on "Developing Hardy Fruits for the North Mississippi Valley," by Mr. Samuel B. Green. Mr. Barron, our Secretary, will read that paper.

Gentlemen, I regret that I must leave you now, but I would ask Mr. Siebrecht to take the chair.

Mr. Siebrecht takes the chair.

The following paper, by Samuel B. Green, was then read by the Secretary:

Developing Hardy Fruits for the North Mississippi Valley.

By Prof. Samuel B. Green,
University of Minnesota.

The varieties of fruits that were introduced into this country by the original settlers, while they often proved of value for a few years, have generally been superseded by better kinds that have originated in the section in which they are grown. That portion of the United States commonly known as the Central Northwest, including the States of Wisconsin, Minnesota, the Dakotas and northern Iowa and Illinois, have had more difficulty in getting varieties of fruits suitable to their conditions than perhaps any other portion of this country. This has been due to their cold winters and especially to an occasional extremely cold winter in which the ground is bare of snow. The climate of this section too is generally drier in summer and not as well adapted to the fruits of western Europe as the portions of the United States lying east or even those sections near the west coast.

One of the most important of these horticultural problems is presented in the apple, the old varieties of which are not successfully grown in this section. About forty years ago Peter Gideon undertook at Excelsior, Minnesota, to solve this problem by combining the Pyrus baccata and its hybrids with the Pyrus Malus, and thus getting hardiness and good quality. In the course of this work he discovered the Wealthy apple, which is to-day a leading variety over a large extent of country; but the dozen or more other varieties (which are undoubted crosses between the P. baccata and P. Malus) that he sent out as being especially adapted for the cold Northwest have proven unsatisfactory in many ways, largely on account of their susceptibility to fire blight. The work which Gideon undertook to do was done in such a thorough way that there is no necessity of repeating it. The only important variety of apple which he did originate has been of so much value to the State of Minnesota, and elsewhere, that it has repaid a hundred fold all the money the State of Minnesota ever put into the experiment.

Other devoted horticulturists have put their time and means into similar lines of work, and often with very little in the way of remuneration except the consciousness of having accomplished something for the general betterment of mankind which, for most of these men, was reward enough. Among those who have especially benefited the pomology of this section by originating apples is Chas. G. Patten, of Charles City, Iowa, whose most important contribution has been Patten's Greening, but who has also introduced most excellent varieties in his University and Iowa Beauty.

H. M. Lyman, of Excelsior, Minnesota, began about twenty-five years ago to raise seedlings of the Wealthy, and devoted quite a portion of his farm at Excelsior to an experimental apple orchard. He originated a number of very excellent seedlings in the course of this work. Perhaps the most important and valuable of them all is a winter apple known as the Evelyn.

The Minnesota State Horticultural Society has made a special point of encouraging the raising of seedling apples and to this end offers liberal premiums for desirable seedlings exhibited at its winter meetings. The State Agricultural Society also offers liberal premiums for the same object. The Horticultural Society, in addition to these annual premiums, also offers $1,000 for a variety of apple that shall be as hardy as the Hibernal, as good a keeper as the Malinda, and of as good quality as the Wealthy. There are no limitations on this premium, and the officers of the society would be extremely glad of the chance to award it to any variety fulfilling the requirements, no matter what its source. The State Horticultural Society in conjunction with the Experiment Station has distributed to interested parties apple and plum seeds and seedlings and many experimenters have been thus interested in this line of work.

As the result of the work of the Horticultural Society and the Horticultural Division of the Experiment Station in encouraging the raising of seedling apples, it is quite common for fifty or one hundred plates of good seedlings to be exhibited at the September meeting of the State Agricultural Society. Some of these are of much promise.

The early settlers of this section found that the plums with which they were familiar in Europe, or in the Eastern States, were not hardy here, but that the native plums produced an enormous amount of fruit each year which was gathered in large quantities by the settlers. This fruit in its native state is perhaps one of the highest developed of any native fruit, and it was natural for the settlers to select the better trees from the woods and transplant them to their gardens. As a result of this work, and also of encouragement in the raising of seedling plums, we have now quite a list of plums that are well adapted for this section, and some of them are of very excellent quality and desirable for marketing. A new class of plums is now coming to us as the result of the combining of the native wild plum (P. Americana) with the dwarf Sandcherry (P. Besseyi). From this has come the so-called Compass cherry and a number of other fruits of considerable interest, and of probable value. The work of combining our native plum with the Japanese plums, to which it is closely related, has hardly been touched upon, but it seems to offer one of the most promising lines for experiment, and the Experiment Station of the University is putting a considerable amount of time on to the work of securing combinations of this sort. We think that from this work we ought to get plums of large size and good quality that are perfectly hardy, which will add very much to the pomology of this section.

We find that strawberries in this section are much more liable to be injured in winter than in the States farther east where the winters are milder, although when the beds are thoroughly protected here with straw they will produce heavy crops, and the Experiment Station is trying to obtain a hardier variety of strawberries than we now have, by crossing our cultivated kinds and some of the hardier forms.

The cultivated kinds of raspberries must be covered here in winter or they are liable to be severely injured. It is important to secure hardier sorts, and it seems as if it was probable that this might be obtained by crossing our better cultivated kinds on some of the native sorts, which are quite hardy.

The grapes of pure Labrusca parentage are often successfully cultivated in favorable locations in this section, but in severe locations and in severe winters they are injured in winter, unless laid down on the ground and protected, and even then the roots may be injured. It is desirable to secure a hardier kind of grape that will stand our winters, and be good enough in quality for general use. We have made something of a start in this direction by securing crossings between some of our cultivated Labruscas and our native *V. riparia,* and as a result have secured varieties that are perfectly hardy and extremely productive, and while the quality of these grapes is not up to the standard Labrusca sorts, yet they are a great addition to the general list of cultivated fruits suitable for our farmers.

What I have outlined will give you, in a general way, some idea of the problems that present themselves to the horticulturists of this section. The forms of fruit we now have have originated more or less by chance and largely through the sacrificing efforts of individuals who have profited very little, personally, from their labors. Our horticulturists have had in mind for some time the enlargement of the work of fruit breeding, and taking it up in a systematic way, and on a broad scale under suitable supervision. The matter was presented to our legislature last winter, and an appropriation of $16,000 was secured for the purchase of a farm suitable for this purpose. One hundred acres has been obtained and will be suitably equipped with buildings. On this tract of land we propose to carry on, but on a larger scale and more systematically, the work which has been done heretofore by individuals. We feel that we have had sufficient experience now in this line of endeavor so that we know where and how to work, in order to obtain the best results. We shall aim to keep careful records of the work done and to determine general laws underlying this work, which needs so much to be systematized.

The Chairman—Gentlemen, you have heard the valuable paper by Mr. Green. Is there any discussion about it?

Dr. Hansen—Mr. Chairman, I might say that in the work of combining the size of fruit of the Japanese plum with a native plum, we have made great progress. We had one this year that is excellent in qualities. It is as good as any plum we have ever eaten. As to the strawberry, we have been working a combination of native and wild strawberries with the best cultivated varieties. We have had fully ten thousand seedlings in that work and we have a great many varieties saved out of that vast lot—possibly over two hundred varieties—that we are working with still further, so that we have been able to secure strawberries in large numbers, that endure forty degrees below zero in winter. That is the test as to the hardiness. We never cover the strawberries. With the raspberry, we find in every respect the seedlings of all eastern varieties utterly failed, but the hybrids are perfectly hardy without any winter protection. Seven thousand seedlings have borne fruit and we have some excellent varieties and others coming on. Out of these seven thousand we expect the raspberry to be settled. We hope so at least. We have been working very successfully in that line, and I am pleased to see that work will be pushed in other States as well. It is certainly true that the only way we can get hardiness into our tender fruit is by crossing with species that are already hardy.

The Chairman—Yes, it would seem to resolve itself upon that point; our motto is, as in the Society of American Florists, "The art itself is nature." We assist nature, and I believe it resolves itself entirely upon that; we have to assist nature. We have to take the things we find at our hand, and with those do something. That seems to be the whole experience of everybody. You find your hardiest strawberries, and you take the better quality of strawberry, and cross.

Mr. Macoun—Mr. Chairman, this was brought out in Mr. Green's paper, what they are working for in the northwest, Minnesota, Wisconsin and the Dakotas. That is, Minnesota and Wisconsin particularly, which is the country of winter apples, they are working for a winter apple which will be good in quality and hardiness and will be productive, and they have offered one thousand dollars to the person who will bring forward a winter apple which will fulfil certain rules they have laid down, namely, that it will be perfectly hardy and productive, etc., and they have not got anyone yet to take the reward. We have been studying the situation a good deal at Ottawa, and have found certain facts in connection with the hardiness of trees, which we consider principles, which we are working on. In the first place, we find it is absolutely necessary to have an early maturing tree in order to get hardiness, and then we find in nearly every case, an early maturing tree means early maturing fruit, that is, fruit which ripens in the summer or autumn, which, of course, we do not want for a winter apple, but we find there are varieties which begin to mellow about November or early September, but which will hold up until the winter, and which have a texture different from other apples which enables them to hold up during the winter, and we are working on those apples, recrossing those with other kinds. We find that practically all the winter apples which originated within fifty or sixty miles of our station, are of that character, that is, they are apples which mature early in the season, or which will keep all winter, under good cellar conditions, and that is the point I make where the weakness of planting and breeding has been in the past. We have been bringing them from hardy apples like the Dutchess in order to get winter apples, thinking that would give the winter breed from the Dutchess. Well, having winter breeds growing all around them, the chances are very slight. On the other hand, we have been breeding from the King, the Baldwin, and so forth, thinking we would strike a hardier apple from these hardy varieties, but the chances are very slight that we will, but what I think we ought to do is to take the seedling that we have, approaching winter apples as much as possible; they are natural crosses between the tender summer kind and the hardy winter kind. Then go on breeding from them; and that is what we are doing. I could name many others, the Milwaukee apple which originated with us, the Baxter, the Rufus, and several others which originated in Northern Ontario, which seem to fulfil all conditions, except in quality. On the other hand, there is no reason in my opinion, why we should not have the highest tender quality.

The Chairman—I think the time will come when we will get it.

Mr. Munson—I have a few facts which might as well be stated here as any other place. Data and the clear cut defined facts are the ones we wish more than any other, free from any theory. There is one thing that is well known. I have known in my own experience several times, in cutting plants of strawberries of several kinds, and taking them to Texas and transplanting them, that for the first season they are weak in resisting drought and heat; and the same variety (of course propagated from its runners) becomes hardier the longer it remains there. So we find this has been done; taking this from our plant that has been there several years, and getting plants from, say Northern Iowa and planting under the same conditions, we found our plant endured much better the first year or two.

The Chairman—You are getting acclimated.

Mr. Munson—The point I want to make is this, that there is a variation which has the power of resisting climatic influences. Variation takes place, and I wish to state the entire number of facts before I make the point. With reference to trees of various varieties, a species has always been tried, Texas grown, planted in the same orchard beside the seed of northern grown trees. I know of no exception. Invariably the northern grown trees come out several days before the southern grown trees of the same kind. Looking over the orchard, you will see that the others are dormant, and there is no difference that I can see, except that one is grown north and the other south, for several years.

It is this, that if there is a variation under climatic condition to any practical extent, add those little variations constantly for a long series of years, a number of generations, and may we not get a very substantial change, making a new adaptation for climatic influences?

The Chairman—I think that is what we will have to do. I think it is the solution of it. I cannot see anything else. I know it, and you know it too. You take our potatoes. We bring them from Maine to get them early. You take Early Rose and bring them from Connecticut. Your Maine potatoes will rot.

Secretary Barron—Speaking about potatoes, there is a problem in adaptation to climate, if you compare the American varieties with the European varieties. You take the American varieties of Solanum tuberosum across the ocean, and all through Europe they flourish amazingly; but you take the European type, the English varieties over here, and you are lucky if you harvest the weight of your seed. Dr. Hexamer made extensive experiments one year. He gathered in Europe every French, Irish and English variety he could get. He planted them and could get nothing at all. I have tried the same thing myself with European varieties and it utterly failed every time, yet I know for a fact the other side of the case is all right.

Mr. Macoun—We have some English sorts that have beaten our American ones. We have the Dalmeny Beauty. It is one of their early varieties there and it is doing splendidly. It is among the most productive potatoes we have. We have had it for twenty years. It is one of the best we have and resists blight. We have tried hundreds of varieties from Europe, and as a rule they are as you stated, but there are exceptions to the rule.

Mr. Munson—If you took the European varieties at almost the same latitude as those you have here, then you have made practically no change.

The Chairman—I was going to say that, but I think we all understand that very well.

The time has come for us to close, gentlemen. There are some announcements which the Secretary will make.

The Secretary then announced the titles of the additional papers on the program which would be taken up at the next session.

The Secretary also announced a complimentary excursion up the Hudson River, to take place the following day.

The Conference then adjourned to meet again at 10 A. M., October 3rd, at the New York Botanical Garden, Bronx Park.

Second Session.

Held in the Museum Building, New York Botanical Garden, October 3rd, 1907, at 10 A. M., the President, James Wood, presiding.

The President—Gentlemen, we are informed that there are quite a number of gentlemen on the grounds who will be in later, but time is going all the while and perhaps we had better consider some of the routine matters first.

The Secretary has quite a number of papers that have been contributed for the conference and he would like to ask your pleasure in regard to what shall be read.

Of course, the chief value of this conference is in the bringing out of these papers for publication. In no other way is it found possible to get such a mass of valuable material collected in one form and one publication, as in the proceedings of a conference like this.

If these are published in the bulletins of various institutions, they are detached and you cannot examine them collectively. You do not get the concensus of opinion on these subjects which you get individually, but in a publication of this kind, you can sum up and get the judgment of a great many able men all in one volume.

If the Secretary will please state what he has in hand, we will dispose of them now to save time. When others come in, we will consider other matters.

(The Secretary then read the titles of various papers he had received.)

Mr. Nash moved and Dr. Evans seconded, that these matters be referred to the editor for disposition. Motion carried.

The President—Now, Dr. Evans, will you be so good as to present your paper?

The following paper was then read by Walter H. Evans:

Experiments in Plant Acclimatization in Alaska.

By Walter H. Evans,

United States Department of Agriculture.

During the summer of 1897 the writer visited Alaska for the purpose of making an agricultural reconnaissance with a view to the establishment of one or more experiment stations in that Territory. At that time there was no agriculture and very little gardening in the country. As a result of that visit a central experiment station was established at Sitka, with branch stations at Kenai, Copper Center, and Rampart. The results of the endeavors to develop agriculture in Alaska have been published in the annual reports and other publications of the Office of Experiment Stations of the United States Department of Agriculture. The decision to recommend the establishment of the stations was based upon direct observations, a study of the native and introduced plants, and analogy between known conditions in Alaska and those in countries in Europe.

In searching for evidence that agriculture might flourish, the data found were very meager. During the Russian occupation some desultory attempts to develop agriculture were made at a few points, but the records left are conflicting and show such a lack of careful planning and attention to the experiments that but little could be learned from that source. The Russians did leave fairly complete data regarding temperatures and rainfall covering a period of fifty years or more, that proved of service in determining the available temperatures for plant growth. The settlers at the time of the visit were mostly engaged in trading, fishing, or mining, and little was to be learned from them. Recourse was had to a study of the native and introduced economic plants. Careful searches were made about a number of villages and lists were made of the introduced plants that had survived and become established. Prominent among these were red and white clover, blue grass, and timothy. In several instances wheat, barley, and oats were found self-sown from feed or manure. In some cases these had made good growth and in some instances had ripened their grain. The few gardens existing about the towns were studied and additional data were secured. Most of the common hardy vegetables were found growing, although the varieties were plainly not of the best, and their cultivation was often neglected. Enough evidence was secured to warrant the establishment of stations that would more fully study and develop the agriculture of the region.

Among the first experiments planned after the establishment of the stations were some to test the adaptability of garden and field crops. Through the cooperation of the Bureau of Plant Industry of the United States Department of Agriculture seeds of a large number of varieties were obtained from northern Europe and elsewhere. These have been under observation at the several stations for some years and it is now possible to recommend varieties for planting that may reasonably be expected to grow and give adequate returns in average seasons. This has been of great value, especially to those who have small gardens about their homes. Formerly the seed supplies came from San Francisco or Puget Sound ports, and in many instances the varieties were not adapted to the more northern climate. A few specific results of the investigations may be of interest. With potatoes a large number of varieties have been tested, and for the past three years the variety Freeman has proved the best. In 1906 at the Sitka Station this variety yielded at the rate of 379 bushels per acre, followed closely by Gold Coin and Early Ohio. On the part of some varieties of potatoes there appears to be a tendency to a deterioration in quality after a few years' cultivation in Alaska, and investigations are in progress to determine its causes. Investigations have been carried on with cabbages, and the type represented by the Early Jersey Wakefield has proved the best for planting. The Drumhead and Flat Dutch types have almost uniformly failed at the station. Of peas the varieties Alaska and First and Best have given satisfaction and are now quite generally planted.

In addition to seeking for the best varieties of vegetables that were already grown, the stations have sought to introduce others, with considerable success. Kale, Brussels sprouts, Broad Windsor beans, rhubarb, cress, and various flavoring herbs have been distributed throughout the Territory and are being cultivated with marked success. In the gardens of Alaska all of the important hardy vegetables may be grown, and in some favored localities some of the more tender ones, as string beans, cucumbers, and tomatoes, are produced.

Considerable attention is being given to the introduction of hardy fruits, and about 12,000 fruit trees and shrubs have been distributed from the station nursery at Sitka. These consist of early maturing varieties of apples, crab apples, plums, cherries, raspberries, currants, gooseberries, and strawberries. Some varieties of all of these except the apples have already fruited at Sitka, and this year some of the apples bloomed and set fruit, but no report has been received as to their ripening. In connection with the fruit investigations, plant breeding work with strawberries, raspberries, and currants has been begun. In Alaska there are probably two distinct indigenous species of strawberries, one a coast species, the other occurring in the interior. Experiments have been under way with the coast form for a number of years. Plants were brought from Yakutat, where wild strawberries abound, to Sitka and were grown in rich earth for several years without fruiting. Upon transplanting them to poor, sandy soil they fruited abundantly. This species grows best in gravelly soil, is extremely hardy, and the berries are of excellent flavor. It has one serious drawback; the peduncles have the habit of strongly curving downward after fertilization, thus forcing the berries into the sand. Crosses have been made between this form and some of the best cultivated varieties, using the wild species as the staminate parent, and several hundred seedlings resulting from this hybridization are now under observation. Similar experiments have been begun with the smaller form that was secured in the interior of the country. Seedlings resulting from crossing the cultivated raspberry, which is frequently winter-killed, and the native salmon berry (*Rubus spectabilis*) are being grown and some should fruit next season. Similar experiments are being made with currants and other small fruits.

The climate of the coast region of Alaska is insular in character and is distinguished by a heavy rainfall. In the interior the climate is continental, with less rainfall and higher summer temperatures. On this account investigations in grain growing are confined to the stations located in the valleys of the Yukon and Copper rivers. In the Copper River Valley early autumn frosts have destroyed much of the grain, but in no season has there been a complete failure to mature some portion of the crop. At the Rampart Station, which is situated in the Yukon Valley, some 350 miles from the mouth of that river and only about 60 miles from the Arctic Circle, cereals have ripened every year since the establishment of the station in 1900. For each of these stations the earliest varieties of cereals have been secured and from each of the more promising the earliest ripening heads have been gathered for seed. This procedure will be continued until local varieties are developed that are suited to the average season in Alaska. Last year three varieties of winter rye, one of winter wheat, three of spring-sown barley, and two of oats matured at Rampart, and a recent letter states that the grains this season are even better than last year, all varieties ripening except some common oats that were sown for hay. At each of the interior stations experiments with vegetables are being conducted along about the same lines as described for the work at Sitka.

In the work of acclimatization in Alaska the problems are twofold: to discover or develop varieties adapted to the moist coast region where the summer temperature is rather low, varying but little from day to day, and varieties for the interior where the growing seasons are shorter, the maximum temperatures higher, and the range of temperature much greater. In some portions of the interior the summer rainfall is deficient and that adds another factor to be considered. That some progress has been made is shown by the somewhat hasty review of the results of eight years' work. The greatest difficulty experienced in the Alaskan investigations is not due to climatic conditions, but rather to the ignorance or prejudice of certain individuals who, comparing conditions in Alaska with those of the great Mississippi Valley or the Pacific Coast region of Washington, Oregon, and California, see nothing possible for Alaskan agriculture. Should the comparison be made with Norway, Sweden and Finland, which lie between the same parallels of latitude as Alaska, and where dwell more than 10,000,000 inhabitants, the contrast would not be so great and the possibility of agriculture along similar lines would seem more probable.

The President—The paper is now open for discussion.

Dr. Britton—I am interested in Dr. Evans' discussion of the conditions in Alaska. I would like to ask him in regard to the strawberries, if they both belong to the same genus.

Dr. Evans—I have not seen the one from the interior, but the one we have has seven leaves instead of five leaves. In the ordinary form of strawberry, there are five leaves.

The President—This paper of Dr. Evans' is very interesting to me, particularly for my sympathy with Alaska. I think it is a disgrace for the United States Government, that Alaska has been so shamefully neglected, and I hear with delight the work that Dr. Evans there has been doing in the establishment of an Agricultural Experiment Station, because it will lead to something more, and Alaska may be given, in process of time, by our Congress, a regular territorial government. The neglect of Alaska has affected all these interests in a great many ways. When we are considering the subject that Dr. Evans has given to us, we run right into Mr. Hick's field, of the thermal lines affecting the field of moisture. When this country purchased Alaska from Russia, we knew, if possible, less about it then than we do to-day, and the matter of the Pacific currents was not understood at all, and it was all that far-off region that nobody knew anything about, but the fact is that the Pacific current affects the climate of Alaska as the Atlantic current affects the climate of Europe and every part of Norway on the other side of the Atlantic, and we cannot judge by the latitude in this matter. I think, right along the line of discussion of this conference, it is possible to produce a variety of grains and of vegetables that will be adapted to that climate, or that latitude and that climate rather, and Alaska with its vast forest interests is worth a hundred times more than we paid for the whole territory. The gold mines and other mining interests are of very great value, and they should have an agriculture suited to their climate, as will assist all these other industries, that they may have community of interests there, without which you cannot have real development and progress anywhere. You cannot hang people on one peg or stand them on one stick. They have got to have foundations reaching around to every side, and this matter that Dr. Evans has presented is a matter of vast importance to that territory.

Dr. Hansen—Last fall I had the privilege of visiting Lapland, which is the northern section of Norway and Sweden, on behalf of the Department of Agriculture. I was exceedingly interested in the successful cereal cultivation, principally the raising of barley, and it is being done as far north as the Arctic Circle successfully. I hope some of these varieties will be a success in similar sections of Alaska. They raise barley and oats very successfully at 69 degrees and some minutes in some places in Norway. I was interested also in tracing red clover to its northern limit in Lapland. As near as I can get at it, in a state of nature, it is indigenous north of the Arctic Circle, the same as corn; it seems to be an elementary species, and is being selected by the Government in Northern Norway. One clover which I found exceedingly well suited to Northern Dakota was a form picked out by a peasant many years ago in the mountains, a perfectly smooth leaf, a form of red clover. It has lighter colored blossoms and no white spots on the leaves. We trust a few of that sort will be of value, so far as there will be no dusty hay. The hairs, I understand, make dust in the case of common clover. Several forms have been picked up in Siberia, forms of red clover, or closely allied to it, that were perfectly smooth in the leaf and very vigorous in habit. There is no reason, I think, why we should not extend cereal cultivation on this continent much farther north than at the present time, if we take advantage of the working of nature in adapting plants through the ages. As I said the other day, I believe to acclimate plants as we ordinarily understand the word, it is not the work for man to undertake. It is a work of twenty thousand years, but we can aid it by searching the world to find species that are adapted, and take them and take advantage of the work of nature through the work of ages, and then by taking advantage of hybridization of the forms, we may find it is possible to do a great deal.

Dr. Britton—I would like to ask Dr. Evans if he has an idea that the Great Indian fruit Quinoa would be of any value in Alaska, in case it could be grown there? Of course Quinoa is the fruit of South American natives right down to the coast, and I understand it is the staple food of perhaps eight million people where the cereals are not grown.

The President—High up in the Andes?

Dr. Britton—Oh, yes. I would like to ask Dr. Evans if there would be any economic utility in attempting that plant?

Dr. Evans—What is the name of the plant?

Dr. Britton—Quinoa.

Dr. Evans—I don't know. It is a case of educating the people, and we are having a hard enough time to educate them to grow some of their own food supplies. When they are perfectly willing to trade in some places and pay twenty cents a pound for potatoes when they could grow them themselves, and when they are willing to pay fifteen cents a pound for turnips—and I have seen turnips grown which would weigh from ten to twelve pounds, and a single turnip would mean quite a little—when they are willing to pay those prices, it is hard to get them to do anything.

Now, in the interior of Alaska, there is probably—the Geological Survey has made an estimate and Professor Jordan has made an estimate—between fifteen and twenty thousand square miles up there that would be adapted for agriculture as is general in Northern Europe. But I was going to say that probably not one hundred acres all told are in cultivation, save perhaps in the vicinity of the new town of Fairbanks on the Tanana River, where they have found some excellent mines, and there is a rapidly growing town. At that place, a number of people have gone there, they are making truck gardens very profitable. We have this year opened a station between Chena and Fairbanks, and Professor Jordan says, he found early in August ripe wheat and oats and barley that had been self-sown, growing right there where there had not been any cultivation of the soil, and he sees no reason why it should not be done.

The President—Where did they come from, self-sown?

Dr. Evans—From manure and feed, right on a trail. That is where the seed came from. That is how it got there. These were not selected varieties. There were many things taken up there to feed the animals, and the animals had sown them. There had been no care given them, but a portion of them had ripened. They found a number of instances. He left Tanana in August, so they had plenty of time to mature. The valley is not a high one. It is undulating and it has a plentiful rainfall. Last year we had but 1½ inches rainfall during the entire growing season, and then Jack Frost came along and succeeded in putting to the bad about all our crops, but we went to work and cut them for hay, and sold this to the mail contractor at $200 a ton. That sounds like a very big price for hay, but we paid Indians $6 a day to help make that hay, and after we had sold this to the mail contractor, there was a very vigorous protest came through the Secretary of Agriculture from people who had a ranch along this same trail, and they protested in a vigorous way, as vigorously as they could, against the sale of hay by the Government to the mail contractor, and particularly, as they could not compete with the government selling hay at $200 a ton! (Laughter.)

Secretary Barron—In regard to the cabbages, you say it is the New Jersey Wakefield type?

Dr. Evans—Yes.

Secretary Barron—Have you any information about the varieties of the Little Pixie type? I wonder if they would do in that climate better than the larger headed varieties?

Dr. Evans—I don't know.

Secretary Barron—I know in some parts of Europe, the little cabbage grows much better than the big drumhead type, but over here, around New Jersey and New York, I have found that the Little Pixie type always becomes woody. I found it absolutely impossible to cook it into a tender condition.

The President—It is only a question of having a short season for development.

Dr. Evans—In the interior, yes. On the coast, they have a climate not as vigorous as here. The fall temperature at Sitka is between that at Washington and Richmond. Many people have an idea it is all snow and ice up there. Last winter, the lowest temperature—the lowest since we have had our station located there—was four degrees below zero. That is, the lowest temperature, at Sitka, has been since 1898, between this and ten degrees or more above that, but the long summer season has hardly ever a maximum temperature in Sitka along the coast region, of over 80 or 82 degrees. In the interior, at Copper Centum, we had maximum temperatures of 96½ degrees. We also had a minimum temperature of 70 degrees below zero, but there was a fairly good covering of snow, and it did little damage. In the Yukon Valley, where there is more moisture than in the Copper River valley, the snow has been sufficient to protect the winter sown cereals every year.. The snow falls ordinarily in October, and lays there until the latter part of April, when it goes off with a rush, and then there is a succession of twenty-four hour days of sunshine with an occasional rain to keep things watered until the middle of September, when things begin to meet with frost, and by the 1st of November, it is frozen up again, and there has nearly always been during the years we have been located at Rampart sufficient snow to protect the winter cereals.

The President—Of course, there is one thing that affects vegetation in the Arctic regions that we must always bear in mind, and that is, when you get twenty-four hours of sunshine in a day, you have got something that is affecting things in a most potential way. You could not get the vegetation that grows in the Arctic region without it.

Dr. Evans—I perhaps should have been more conservative in the matter of sunshine, but we do get twenty-two hours of sunshine and twenty-four hours of daylight, from the early part of June until late in July.

The President—We sometimes, those of us who go up in Canada, find the effect of sunshine which seems to us remarkable.

Dr. East—I would like to ask what the effect of such an amount of sunshine is on the plant growth, in relation to the amount of darkness?

Dr. Evans—I don't know, as far as our station is concerned. No investigation has been made along that line. There was one carried on some years ago, in connection with the station in Finland, but the result was rather inconclusive, but it is a subject well worth studying. We know very little about why it is that this longer time will have any effect, except that we suppose that if ten hours will produce a certain result, then twenty hours will do twice as much, but whether it does or not, we are not certain.

The President—Dr. Hansen, in your investigations, have you looked into it at all, the effect of a long day upon vegetation?

Dr. Hansen—As near as we can get at it, that is what saves time. In the long interior, the midnight sun is only for a short time, so that the plants do get a certain amount of rest during most of the growing season.

The President—It involves the question of the necessity of rest for plants, whether there is anything in it—do plants require rest?

Dr. Britton—We think the matter to be determined accurately, would have to be taken up in some such region as that spoken of by Dr. Evans. Of course, we could not determine that experimentally, except under the natural conditions. It would be impossible to attempt it anywhere else. So far as I know, there is no information on it.

The President—Can you give us the statement in regard to the period of twenty-four hours in which plants make their greatest growth?

Dr. Britton—I cannot tell you that.

The President—We will now ask Mr. Hays to read his paper.

The following paper was read by W. M. Hays:

Plant Improvements Needed in Specific Cases.

By W. M. Hays,
Assistant Secretary of Agriculture.

We have in the United States probably $5,000,000 worth of animal and plant products whose value could be increased 10 to 20% by breeding. The organization of public cooperative and private breeding establishments of sufficient magnitude to thus add $500,000,000 to $1,000,000,000 to our plant and animal production does not seem overdifficult. Effective methods have been devised and large results have been achieved which warrant that the plant-breeding work being organized in the United States Department of Agriculture and that being developed in the State experiment stations and in branch experiment stations be greatly increased. Seed farms, nursery farms, special plant-breeding farms and private individuals, both professional and amateur, have reason to increase their equipment and their energies along this line. Cooperation between the United States Department of Agriculture and the State experiment stations and the cooperation of these institutions with farmers and individual plant breeders and growers of purebred seeds and plants is developing rapidly. The American Breeders' Association with its forty-odd committees, meetings like this Conference on Plant Hardiness and Acclimatization, seed and plant breeders' associations, including associations for breeding specific crops, as seed corn breeders' associations, are doing very much to bring together in groups men to do team work in extending this vast enterprise.

The detailed studies of our soils and mapping of our agricultural regions according to soil, climatic and crop conditions are dividing up the territory of the American States into innumerable varietal districts. A thousand varieties of corn are needed for as many local conditions. There are scores, if not hundreds, of local conditions requiring varieties of wheat specifically adapted to the respective conditions. Even in strawberries, where a variety like the Wilson may be successfully grown in twenty or thirty States, the work of the plant breeder is proving that the profits come from varieties adapted to special regions. All along the line our cereal, cotton and other field crops, some of which yield hundreds of millions of dollars; our fruit and vegetable crops, also representing vast sums of wealth, and even some of our forest crops, are ready to be made over to suit each local soil, climate, system of agriculture and market.

Until recently much of the plant breeding was done by amateurs. There was no organization to emphasize the greater importance of new values in crops representing immense wealth, and there was little systematic thought concerning the organization of our American plant breeding as an establishment of mighty import to our nation. The two first American commonwealths to begin the organization of State plant-breeding establishments were Ontario and Minnesota. Each of these States can show for the expenditure of forty or fifty thousand dollars in breeding field crops, products directly traceable to the work of plant improvement of forty or fifty million dollars. In no other of America's largest economic enterprises is there opportunity to make public funds so productive as in the improvement of our economic plants. Along some of the lines of least resistance in which improvements can easiest be made in crops of largest value, a dollar can be made to earn a thousand dollars and even in rare cases a million. It seems a fair and conservative estimate to state that our $3,000,000,000 worth of annual plant products can be changed by breeding alone into $3,300,000,000, at a cost of less than $3,000,000, one dollar earning on the average more than $100. Those who have had most experience in this line believe that the present organization of this work could be enlarged in ten years so as to be on the basis of expenditure and results last mentioned.

The breeding of corn throughout the upper Mississippi Valley, and for that matter throughout the entire United States, illustrates what is needed in the breeding of all our economic plants. Men in every State, in every group of agricultural counties, in many individual counties and even on particular soils within counties, are breeding corn peculiarly adapted to their local conditions. For the most part varieties are being perfected so as to yield more of grain per acre, with some attention being paid to the quality of the grain. In some instances special attention is paid to secure more protein or more fat to give a grain with a higher feeding value or to suit the needs of some particular manufacture, as in the case of corn oil or wheat with stronger gluten. In other cases, the effort is to so breed varieties as to push the dent corn belt northward, to push the fodder corn belt northward, or to breed corn better suited to regions where droughts are severe. While in the middle West the varieties bearing one ear per stalk are believed to be best, in some sections of the South, where corn is planted wide apart, the evidence seems to be that breeders should produce corn with two ears per stalk. Some sections devote themselves to the production of seed of varieties peculiarly useful in distant regions, as for purposes of thickly growing silage and dry fodder for dairy cows farther north than corn for grain is profitable. One county in Missouri is said to have 10,000 acres of corn which has been bred for large, dense cobs for the making of cob-pipes. Popcorn suited to different localities is bred to expand larger in the popper.

In wheat breeding the production of varieties peculiarly suited to each local condition presents problems unique in themselves. In Minnesota, for example, with spring wheats, the effort is to produce sorts which will be so highly rust-resistant that this disease will not be able to reduce yields 10 to 60% annually. In the case of winter wheats for Minnesota the need is for varieties bred to greater hardiness that they may endure the winters often not well covered with snow and very cold, and thus carry northward the larger yielding ability of this class of wheats. Durum spring wheats which yield well need to be so bred as to have gluten of tougher quality and the grains to be made less flinty, so as to be more easily ground into high-class flour. There is need of hybrids of these three varieties of wheat, taking out of each parent kind and combining into new varieties the desirable qualities of the several parent varieties. Improved classes of wheats are needed for the black prairie soils of southern Minnesota, for the sandy soils of northern Minnesota and for the very fine clay soils of northern Minnesota, also the very fine clay soils of the Red River Valley, that the yield for the State be raised from fourteen bushels to twenty bushels. In Kansas varieties are needed which are hardier in winter, varieties whose chaff more tightly holds the kernels so that the grain need not be harvested the day it is ripe; also varieties which will thrive under the drouthy conditions of the western part of the State. In Washington and surrounding States varieties are needed which combine hardiness or ability to live over winter with high yielding power and ability to stand erect and not shell out for days or even weeks after ripe until harvested; with higher content of superior gluten which will otherwise increase the value per acre of this crop on distinctive soil and climatic areas, as in the Willamette Valley, in the Yakima Valley, in the Sacramento Valley, and in numerous other localities distinctive in soil, climate and in the system of farming into which the wheat must adapt itself.

Commercial apples need to be bred not only for the great apple regions of New York, Michigan and Missouri, but for every region in the country where it is practicable to raise apples for family use. Where we have hundreds of successful varieties we could have thousands, that we might better adapt varieties to localities and also that we might throw away many that are not now adapted to the regions in which they are grown.

The breeding of plants is a long-time proposition. The elements of the work are men with a genius for creative breeding, the unit characters to be blended into new varieties or species, and means and organization for long-continued efforts. We need to develop a class of highly trained breeders who, through long and extensive experience, will become highly efficient in turning public and private dollars into double eagles, and even pennies into dollars.

The work of men like Mendel, DeVries, Bateson, Davenport, Castle, and Webber in discovering the laws of heredity is of immense benefit, and for generations men of this class will continue to add to our knowledge facts of large practical value in the improvement of our plants and animals. Their work should be supported most liberally, that they may rapidly learn the needed truths useful to those who create new economic and artistic values. Of no less value is the work of men like Vilmorin, Burbank, Neilson and Garton, who produce new values which give not only inspiration to breeders but which lead legislative bodies, firms and individuals to invest the necessary sums of money to reap the full possible profit represented by the hundreds of millions mentioned above. If the faith of plant breeders is truly placed—that every agricultural district would respond to varieties especially bred for its conditions,—we have only touched the fringe of the possibilities for creating wealth by breeding plants.

All the students of theory and all the practical creative breeders, so far as I know, believe that in each species there is one plant among very many which has peculiar breeding power, peculiar projected efficiency, peculiar variety-forming values along needed lines, and that the bulk of the everyday work of breeding is in finding these "Shakespeares of the species."

The work of creating still greater Shakespeares of the species through hybridizing may prove to be the more important, as it is the more interesting; but the bulk of the expense of our needed Federal, State and private breeding establishments must be in the work of "mingling art and statistical methods" in ferreting out the occasional individuals with peculiar value, segregating their "blood," and in giving them a chance to prove themselves adapted to increasing production in broader or lesser areas.

The efforts of the American Breeders' Association through several dozens of committees and sub-committees to secure team work in the making of plans for breeding each species of plants and animals is beginning to bear fruit. There is value in friendly rivalry, and men who, like Mr. Williams in his statement of methods for breeding corn, are securing the applause of their fellows, are appreciating the recognition for public service well done. The making and the execution of specific plans for breeding each species so that it will better serve in its present habitat, and will be adapted to habitats which it cannot now quite succeed in, are as much questions of the hour as the discovery of additional limitations to Mendel's law, or as are other general questions of the theory of heredity.

The President—Any remarks to be made on Mr. Hays' statement?

Dr. Hansen—I would like to ask if you met with any objection by the nurserymen?

Mr. Hays—I would like to say that I heard one of our leading nurserymen say that he did not know anything that might help the nurserymen more than this, because they only shipped a small number of plants, as many of them were often taken up by growers who never grew before, and our nurserymen stand right by us. We do not mean to antagonize them and the nurserymen seem to have no objection. Of course, they are all looking for orders for this plant, but we select from some nurserymen whom we know to be reliable, and whom we know by experience will put up a plant as we want him to. At first, we tried it by tender, but at last we got down to one man who does the work for us. There is no objection whatever on the part of the nurserymen to the work. In fact, it has been a help.

Mr. Southwick—I would like to call the attention of the gentlemen present to the educational value of this work. That is very important, the educational value of this work, to the people of this province or any section.

The President—The subject is one which has great economic value and has a bearing also upon the subject of hardiness and acclimatization. We would ask Mr. Hicks now to present his statement on "Plants from East Asia and Western Europe on Long Island."

The following paper was read by Henry Hicks:

Plants from East Asia and Western Europe on Long Island.

By Henry Hicks, *Westbury, L. I., N. Y.*

Foreign plants will succeed best in the vicinity of New York City if from regions of equal or greater annual variation of temperature and a similar January mean temperature or isotherm. They should also be from a region subject to moderate drought, but not from a desert region.

The January average of New York City is about 30° F.; the July average 70°; the annual range is therefore 40°.

The countries where these two lines pass are northern Japan, Caspian Sea, Caucasus Mountains, southern Russia, Austria and eastern Germany. These two lines cross here and in northern Japan and plants from there thrive best here.

In Colorado and Korea the line of 30° January average is crossed by 50° equal annual range, and conifers from there and northeast China are not injured by our extremely severe winters even when our native conifers are injured, because they are accustomed to a more severe or widely and suddenly variable climate than our natives. The Colorado conifers are subjected to a more brilliant winter sun than ours, therefore they show no damage from the winter sun which burns our pines, hemlocks and arbor vitæ. The Colorado conifers are accustomed to a more severe, dry winter wind when the frozen ground does not supply moisture, therefore they are not killed back as occasionally happens with the hemlock, red cedar, white pine and arbor vitæ. But in a hot June the tips of the new growth of the Colorado evergreens is killed. This trouble I have not seen described. It does not affect the conifers of Korea and Manchuria and northern Japan, and they are the best foreign conifers.

Evergreens from the Caucasus, from the Taurus Mountains in Asia Minor and from Austria and the Balkan Peninsula thrive here. That region has an annual range of 30 to 40° and a January average of 30° or a little below.

Evergreens from the mountains of North Carolina thrive here. Linville, North Carolina, has 31° January mean, and about 40° annual range.

Evergreens from Maine, the Adirondacks and Michigan thrive here, except a few slightly dislike our warmer periods in winter, alternating with cold, dry northwest winds. In other words, they do not like to be awakened in winter by bright sun and a temperature of 65°. They like steady cold.

The above applies to regions whose conifers thrive here. Evergreens from the two west coasts do not permanently thrive here.

The line of 20° annual range passes through Spain, France, England and Norway, and through California, Oregon, Washington and the coast of British Columbia, the southern slope of the Himalayas and southwestern China.

Isothermal lines and latitude are not a guide to the introduction of plants from the two west coasts. The isotherm of 50 passes through here and through southern England, Ireland and the State of Washington.

Prof. W. M. Davis, of Harvard, from whom this map is copied, says that the reason for the small range of temperature along our Pacific coast and the western coast of Europe, and the area of strong range along our eastern coast, and the eastern coast of Asia, is the combined action of ocean currents and the winds, particularly in the control of the distribution of temperature by the winds.

In temperate latitudes the prevailing course of the winds is almost from west to east.

The above statements have been made mostly with coniferous evergreens because they are awake all the year and record the whole climate of their native country and where introduced, except drought. They generally require only a fraction as much water as deciduous trees.

Deciduous trees and shrubs go to sleep in winter by dropping most of their evaporating surface, and if their foliage is damaged in summer it is born anew the next spring. The evergreens are more severely handicapped by their injuries.

With few exceptions deciduous trees, shrubs and vines from western Europe are not happy here. They suffer more from fungus diseases than our natives, and the bark and trunk are more liable to crack when the temperature goes below zero. The foliage often feels softer, less leathery, less able to stand drought, darker green and arranged more at the ends of the branches so that looking up into the trees is as into a hollow dome.

Most of the fruits brought from Europe to the eastern coast of the United States is less healthy than the native trees. Fortunes have been spent trying to introduce fruits that failed. We hear of these European fruits thriving better on the Pacific coast.

There should be a series of experiments along the east coast of the United States to introduce the economic and ornamental plants of eastern Asia and other regions of similar climate, and carry on extensive plant breeding with them and with the native plants and the more highly improved plants of Europe.

The above conclusions have been reached from observations on plants mostly growing on Long Island, northern New Jersey, New York State, the vicinities of Boston, Philadelphia, Washington and Norfolk, Virginia. Long Island has been probably the oldest and most extensive testing-ground for European and Asiatic plants. From the Prince Nursery or Linnean Botanic Garden were distributed many foreign trees in Colonial days. Later the Parsons Nursery introduced the Hall and the Hogg collection of Japanese plants. The Charles A. Dana collection is on Long Island. Nursery stock imported from Europe and Japan has been very extensively used.

Dr. Asa Gray's discovery of the close relation of the floras of eastern Asia and eastern North America led me about seventeen years ago to begin noting the behavior of those plants here. At that time we were importing a large part of our young nursery stock from France and Scotland. Later I imported most of the species offered by the German, French, English and Japanese nurseries, and collected seed of native species. The latter is the predominant policy at present.

These conclusions have been corroborated by Prof. C. S. Sargent in "Notes on Cultivated Conifers," in *Garden and Forest,* October, 1897, and "Classification of Climates," by W. Koppen, in *Bulletin American Geographical Society,* August, 1906.

There are many exceptions to the above conclusions. Many Japanese plants fail to be hardy in severe winters, many suffer from summer drought and some have bark killed in winter. This I assume to be due to the more equable and humid or oceanic climate of Japan. Some Japanese plants are severely attacked by San José scale, as Japanese quince and Japanese plum. The San José scale is severe here only on *Rosaceae* from humid or equable climates.

From western Europe several trees thrive here, as the beech and Norway maple.

The President—Mr. Hicks' paper seems to me to be of very great interest. It is now before the Conference for discussion.

Dr. Hansen—I believe this conference can bring out some fundamental truths and conditions. It is a conference on Acclimatization of Plants. If we can bring out evidence enough to show that acclimatization of plants is an impossibility in human hands, it is the most fundamental thing that has ever occurred in American horticulture. I want to come just as near making that a positive statement, that acclimatization is an impossibility for human hands, as I can; that is, by selection alone—that is, to adapt a plant to a greater degree of heat or cold by selection alone—that is an impossibility, and that is the platform that fundamentally affects all our experimental work. In the same way, it might be true that acclimatizing plants from the far north to the far south or from a humid section to a dry section, or vice versa, is an impossibility. Here is something that goes to bear out that truth, that for several years past we must take what Nature gives us and not attempt to perform the work of twenty thousand years in a generation.

The President—We have had the fond theory that we could cooperate with Nature.

Dr. Hansen—Yes, by hybridization, but not by acclimatization.

The President—In relation to the statement by Mr. Hicks, that our native plants, trees, etc., are not only more vigorous in various ways, the contrary also seems to be true when he says that the foreigners are more subject to diseases than to enemies. Now, I have noticed this year for the first time, that my English oaks are badly infested with scale. Some fine specimens have been destroyed. I have never seen any scales on our native oaks. The royal oak was the oak that saved his Majesty when he took refuge in the royal oak, and it was destroyed this season by the scale. Of course, one swallow does not make a summer, but so far as it goes, it is in line with his remarks. I think the practical value of these observations that Mr. Hicks has presented to us is very great.

Prof. Munson, of West Virginia—Relative to the remarks of Dr. Hansen with reference to the change of character of a plant without hybridization, it is very generally attempted, among horticulturists, who believe, for instance, that a peach grown in Michigan will stand a much lower degree of temperature, than will a peach, the same variety, if it was grown in Alabama, though of course, the propagation of peaches in Alabama is only by florists; but a peach grown in Alabama would be killed by a climate that would have no injurious effect upon it whatever if it was grown in Michigan. It would seem true that there is a distinct modification of the character of the individual.

Dr. Hansen—Commenting on that, I believe it is a fact well known to nurserymen that there is such a thing as trees being too soft for certain soils, and therefore a peach tree raised farther north, for instance, would be too hardy for Texas, hardier than one raised on the Gulf Coast, for instance, and this temperature effect did not save the peach orchards of Michigan last winter. There were hundred of thousands of peach trees killed last winter in Michigan. I do not wish to discourage, by any means. I just throw it down as a sort of challenge to be picked to pieces by all of you who so desire. I do not wish to discourage any effort at importation. In fact, I have had a little to do with that sort of thing myself, but the thing to be observed in this matter is that we must study ecology more than we have. I am pleased to see Mr. Hicks has done so much in that direction. We must study the climate in various parts of the world, as a guide to our importation work. An attempt to acclimate a plant that is much softer is a rather difficult task, whereas, if we pay some attention to the native habitats of plants in making our selection, we will save an immense amount of money. That is the only point I wish to make, but in addition to that I stand here to say that we can acclimate plants by hybridization, that is, carrying over this inherent hardiness, whatever it is, and helping it by heredity.

The President—In following the statement of Prof. Munson in regard to the peaches grown in Michigan of the same variety being hardier, even though cultivated from the bud, it calls to my mind that the hardiest peach stocks in America are on the elevated lands of Tennessee and nurserymen send to Tennessee to get the seed. It is a great business, the peaches grown at that high elevation, which means northern climate. Now, why are those peaches grown there and have been grown there for we do not know how long? The question whether they were not introduced from Mexico and got there in that way so that they are more thoroughly Americanized and acclimatized than any other peaches in the Continent, is something we cannot decide. There are wild peach forests in Wisconsin and they could only have got there by the Indians receiving them from the Mexican settlers about four hundred years ago. Now, if these peaches have become as near indigenous as it is possible for a foreign thing to come to in Tennessee, and have got stamped on them the requirements of the American continent—if that is the case, as I believe it is—why, it is the hardiest peach stock in America and in the world, outside of Manchuria. Doesn't it conflict then, with Dr. Hansen's claim? Now, so far as I know, no other reason is advanced for the extreme hardiness and vigor, so that nurserymen avail themselves of it, of this peach stock of Tennessee, in this high elevation. There is no reason for it except the fact that that elevation gives it not longer than the historic history period—unless it is in the wild peach of Wisconsin—I would like to have it explained.

Dr. Hansen—In answer to the question: I would say I have tried some of those hardy peach stocks and also the common peach pits. I have had the hardy peaches of Iowa that they have been raising for years from the hardiest stocks, and after a hard winter, I never discovered any difference. One might be deader than the other—they were both dead! I have had the French crab from the side hills of France, and I have had the Vermont plant seedlings, and those from Vermont are supposed to be the hardiest on the American Continent, but the same observation could be applied to both; they were both dead after a hard winter.

Mr. Macoun—Gentlemen, I regret very much I was too late to hear this paper, because it is a subject I am very much interested in, but it seems to me the question Dr. Hansen has brought up is a very complicated one. The question of mere temperature alone, I think is a small factor —not exactly a small factor, but it is only one of the factors regarding hardiness. For instance, I understand experiments have been carried on at places, among them, the Department of Agriculture, Washington, for testing the seeds at different temperatures. Some were submitted to very low temperatures and they survived the temperature. It seems to me that the question of humidity, ripeness of wood and various other causes also influence the hardiness of plants, and when we introduce plants from over the seas, we do not know exactly the way they lived there. We do not know whether they are woodland species or not. They may be a species that thrived in very different conditions. We found in our experience at Ottawa, with our own native hemlock, when we transplanted it from woodlands where it thrived at home, that it is very difficult to get it to thrive in the open, and in the case of four or five other trees, I think they have shown a great deal more vigor than some other species which correspond with them. There is the northern species P. excelsa. We have no other tree which has a more rapid growth than the Norway spruce, and no other which is less subject to disease. Then there is the European which is much stronger than our own species, but I don't think it is much more subject to insects than our own. We also have the Scotch Pine which is a hardy tree. There is also the Norway maple which is an exceedingly rapid growing tree. Now, in regard to fruit, there is the question of protection, bending down and covering the soil—but the mere protection of other trees is a very important factor in influencing hardiness; and I know in Manitoba, where it is very difficult to grow apple trees, some of our most successful nurserymen grow the trees between rows of celery. I suppose this protection which they might find in no other place, has enabled them to grow these trees.

Dr. Britton—Mr. Chairman, as having perhaps a remote bearing on this subject, I would like to call your attention to the Century Plant in the Island of Jamaica, from which I have just returned. That is a species which is in Jamaica, very abundant, in all the arid southern portions of the Island. Now, that plant has a diametric range of five thousand feet in temperature. That is, it extends right from the shore on the dry side of the island right up to the tropical station on the mountain side towards the south, and that evidently is subject—you see the same species is there—to all the variations from the highest to the dryest kind of tropical temperature up to the temperate zone, which is the temperature at Cinchona, because Cinchona is one of the most delightful places for residence in the world. It occurs right on those mountain sides, apparently not affected by temperature, but apparently influenced by humidity. This is an example of the species which goes according to the humidity, but does not seem to care very much about temperature. As bearing also on the subject, in a less degree, there is the same history in the case of Jamaica in the Pilocereus. The species which I found in other lands, is the same. I have found it in other places just the same as this. It grows on the south side to a height of two hundred feet, higher, in fact, than any other species of Pilocereus in Jamaica that I have observed. Instances might be multiplied, I am sure, showing the great latitudinous range on the south side of the island, apparently regardless of conditions of temperature.

The President—It has been suggested that the most profitable way to spend the afternoon would be to look around the garden and see specimens growing here that would illustrate many of the things that are under discussion at our meeting.

It was then moved by Mr. A. L. Willis, seconded by Prof. N. E. Hansen, that the thanks of the Conference be given to the American Institute, and to the New York Botanical Garden, for the courtesies accorded them.

There being no other business before the Conference, adjournment was then taken.

Papers Read by Title

Cooperative Methods of Ascertaining Hardiness in Fruits.

By Prof. H. L. Hutt,

Ontario Agricultural College, Guelph, Ontario.

Hardiness is largely a matter of locality. In speaking of any particular fruit we may say it is hardy in a certain district, although it might be quite tender in another. For this reason, the determination of hardiness of any kind of fruit is more or less of a local problem and cannot be ascertained at any one experiment station for all parts of the country. This question of hardiness and adaptability of the various kinds of fruits to the different sections of the Province was one of the problems which confronted the Ontario fruit-growers a number of years ago, and has been more or less definitely solved by cooperative methods during the past ten or twelve years. When we began this method of testing we already had two Government Experiment Stations, one at Guelph and one at Ottawa, where extensive tests were being carried on with the fruits that could be grown in these localities; but in addition to these, fourteen prominent fruit-growers were selected in as many different parts of the Province to carry on experimental work in the testing of fruits most largely grown in their districts. These Fruit Experiment Stations were not purchased by the Government, but were left in the hands of the private owners, who were furnished with large collections of varieties of the fruits most grown in their locality upon which they could make careful observations and report results.

This cooperative experimental work is under the management of a Board of Control, composed of the President and Horticulturist of the Ontario Agricultural College, the Horticulturist of the Central Experimental Farm at Ottawa, and three representative fruit-growers appointed by the Provincial Fruit Growers' Association.

In the selection of the experimenters men were chosen who had the confidence of the growers of their district and who already had under cultivation more or less extensive plantations of the various kinds of fruits, and were thus prepared to make reports from the very first upon the varieties they already had in fruiting.

Each experimenter makes a full report each year to the Secretary of the Board of Control, who classifies and prepares the reports for publication.

As a result of all this testing during the past twelve years, Bulletin No. 147 was published last year, giving lists of the fruits recommended for planting in the various parts of the Province. This little bulletin of ten or twelve pages contains in a condensed form information which is of incalculable value to the fruit-growers and farmers of Ontario, because it is a reliable guide to planters, and is well worth all the money that has been expended upon the Fruit Experiment Stations.

The cost of this work has not exceeded $1,800 per year, and this has been expended principally for the purchase of trees and plants for testing; for the annual allowance, varying from $50 to $200, paid to the experimenters for their reports, and cost of publication of the same.

As an outcome of this work, the Department of Agriculture has just published a beautifully illustrated and descriptive volume on the "Fruits of Ontario." The descriptive work has been done largely by Mr. L. Woolverton, Secretary of the Board of Control, and has been carefully revised by the members of the Board. It is expected that it will be a standard for reference for Ontario fruit-growers for many years to come.

For fuller information regarding this work, I need only refer to the Annual Reports of the Fruit Experiment Stations published by the Ontario Department of Agriculture, which are distributed free upon application.

Another phase of cooperative experiments in fruit-growing which has been productive of great good in Ontario, is that carried on by the Horticultural Department of the Ontario Agricultural College. This work is conducted through the agency of the Experimental Union, an organization managed by the officers, students, and ex-students of the College, but every resident of Ontario interested in horticulture is invited to join in the work and benefit by the results of the experiments. This co-operative testing has been in progress many years with farm crops. The work with fruit-growing began fourteen years ago with sixty experimenters, to whom were sent small collections of strawberries, raspberries, or currants for testing. The following table gives a good idea of the scope and progress of the work, as it shows the nature and number of experiments undertaken since its inception in 1894:

COOPERATIVE EXPERIMENTERS.

Nature of Experiment	Number of Experimenters														Total
	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	
Strawberries . . .	15	20	20	50	100	100	100	116	143	119	166	222	244	713	2,128
Raspberries . . .	15	20	20	20	25	25	25	35	48	44	46	69	93	206	691
Black Raspberries	15	20	20	20	25	25	25	35	52	43	53	46	67	185	631
Blackberries . . .	—	—	20	20	25	25	25	35	32	47	42	42	32	72	417
Currants	15	20	20	20	25	25	25	38	48	29	39	48	31	85	468
Black Currants . .	—	—	—	—	—	—	—	—	—	43	47	50	53	110	303
Gooseberries . . .	—	20	20	20	25	25	25	50	47	39	40	55	71	137	574
Grapes for Southern Ontario . .	—	—	—	—	—	—	—	—	—	—	—	—	82	178	260
Grapes for Northern Ontario . .	—	—	—	—	—	—	—	—	—	—	—	—	69	96	165
Apples for Southern Ontario . .	—	—	—	—	—	—	—	—	—	—	—	—	144	281	425
Apples for Northern Ontario . .	—	—	—	—	—	—	—	—	—	—	—	—	264	329	593
Total . . .	60	100	120	150	225	225	225	309	370	364	433	532	1,150	2,392	6,655

From this it will be seen that a total of 6,655 lots of plants have been distributed for testing. These experimenters are so scattered that they are found in every township and district in the Province.

We may briefly outline the method by which this distribution is carried on. Early in the year a circular is distributed, and announcement is made in all of the leading papers of the Province that plants will be given free of charge for testing, on the understanding that each experimenter who receives the plants will follow the instructions furnished with them, will carefully look after the plants, and will report each year upon the yield and growth of the plants upon blank forms furnished annually for this purpose.

The following is a list of the experiments, showing the class of fruits and varieties of each offered for planting. These varieties make a good general collection for home use and in most cases cover the season from early to late. They have been selected after years of careful testing at the various Government Fruit Experiment Stations as the ones most likely to give good results throughout the Province.

Experiment No. 1. Strawberries—Splendid, Fountain, Ruby, and Parsons—12 plants of each.

Experiment No. 2. Raspberries—Cuthbert, Golden Queen, Marlboro', and Columbian—6 plants of each.

Experiment No. 3. Black Raspberries—Gregg, Kansas, Palmer, and Older—6 plants of each.

Experiment No. 4. Blackberries—(Adapted only to *southern sections of Ontario) Agawam, Eldorado, Kittatinny, and Snyder—6 plants of each.

Experiment No. 5. Currants—Fay, Red Cross, Victoria, and White Grape—2 plants of each.

Experiment No. 6. Black Currants—Champion, Lees, Naples, and Black Victoria—2 plants of each.

Experiment No. 7. Gooseberries—Downing, Pearl, Red Jacket, and Whitesmith—2 plants of each.

Experiment No. 8. Grapes—(For *Southern Ontario) Concord, Wilder, Niagara, Lindley, Brighton, and Vergennes—1 vine of each.

Experiment No. 9. Grapes—(For *Northern Ontario)

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*This division of the Province into North and South may be approximately made by a line running from Collingwood to Kingston.

Champion, Worden, Winchell, Delaware, Lindley, and Moyer —1 vine of each.

Experiment No. 10. Apples—(For *Southern Ontario) Primate, Gravenstein, McIntosh, Blenheim, Rhode Island Greening, and Northern Spy—1 tree of each.

Experiment No. 11. Apples—(For *Northern Ontario) Transparent, Duchess, Wealthy, McIntosh, Scott's Winter, and Hyslop Crab—1 tree of each.

The plants for this distribution are purchased from nurserymen who make a specialty of growing good plants and putting them up in good condition for distribution by mail. We are obliged to make use of the mail, because in many cases the experimenters live so far from express offices that it would not be practicable to send the plants in that way. Applications for plants are filed in the order in which they are received until the appropriation for the purchase of plants is exhausted. When sufficient applications have been received to make up the lists of those to whom plants will be sent, circulars are sent acknowledging receipt of application and informing the applicant that plants will be sent by mail in proper time for planting. Special directions are also furnished for conducting the experiment with each kind of fruit and blank forms are furnished upon which to report results at the end of the season.

For a copy of these cultural directions for the various fruits and more general information regarding the work, we must refer our readers to the last Annual Report (1906) of the Experimental Union.

A record is kept in the office of the Horticulturist giving the name and address of each experimenter, the kind of plants sent him for testing, and a brief record each year of his report upon the same. Naturally, many experimenters who receive plants fail to report after two or three years, although there are many who have been engaged in this work almost from its beginning and have been sending in regular reports. In this way we have a list of careful experimenters all over the Province,

*This division of the Province into North and South may be approximately made by a line running from Collingwood to Kingston.

whose results are of value, not only to themselves, but to those in their neighborhood.

Upon receipt of the reports at the end of each season, they are summarized and a general report of the work is presented each year at the Annual Meeting of the Experimental Union held at the College usually during the first week in December.

This work is of great educational value to those engaged in it, and the greatest value naturally accrues to the individual experimenters who receive plants and carefully conduct the experiments. It is valuable also because it affords a means of distributing the leading varieties throughout the Province, and many are thus given a start in fruit-growing who had never before given it any attention. The educational value, too, of the cultural directions furnished with plants is helpful, enabling growers to adopt the best methods in their fruit-growing. This work, although conducted on a scale calculated more to help the grower in his supply of fruit for home use, is also having a marked effect on the commercial fruit-growing of the Province.

Similar work was begun this year with vegetables, and seeds of a few of the leading varieties of beets, carrots, lettuce, and tomatoes were distributed to about fifteen hundred experimenters. Reports upon this work are now coming in, and one of the most striking features in connection with it has been the eagerness with which it has been taken up by the various schools of the Province, where school gardens have been instituted, and probably in no other place could it have a greater educational value.

Factors Affecting Hardiness of the Peach.

By U. P. Hedrick, *Geneva, N. Y.*

The peach affords a striking example of a plant undergoing acclimatization. In the wild state, this species is endowed with a constitution fitted to endure the heat of climates almost subtropical. Under domestication it is gradually becoming inured to climates far to the north of its habitat and so cold that at first it could not have lived in them. It may be that this change is somewhat due to the acclimation in which the plant is naturally or spontaneously becoming habituated to cold; but the peach can now grow in colder climates than formerly, chiefly because of the efforts of man to secure this change in the species. What are the means by which man can aid in acclimatizing a species or a variety to a climate at first injurious to it?

I have made two efforts to find some explanation of the varying behavior of peach trees during freezes and frosts, working at the problem from the standpoint of the horticulturist, and the information obtained in these investigations shows some of the means by which man is helping to acclimatize the peach and by which possibly other species might be acclimatized. In the spring of 1905 I addressed letters to about one hundred of the best peach growers in Michigan, asking for their experience as to the hardiness of the peach in tree and bud. In the spring of 1907 about the same number of letters were addressed to peach growers in New York. This paper is a brief review of the answers obtained. In making these investigations I have visited the orchards of many of my correspondents, and have noted the condition of the trees under consideration and have a personal knowledge of many of the conditions discussed.

The factors considered in the investigation fall under two heads:

I. Cultural treatment, which increases the ability of the individual trees to withstand cold.

II. Variations in the species favorable to greater hardiness to cold.

In presenting and discussing the information obtained, I shall advance few or no theories but shall simply set forth the facts that have been reported to me.

I.

The factors of environment and of cultural treatment noted as affecting acclimatization are as follows:

INFLUENCE OF SOIL ON HARDINESS.

It is usually held that trees are hardiest on sandy, gravelly or stony soils. In the peach orchards of Michigan the growers consulted held this to be the case almost without exception. But in New York the kind of soil seems to make but little difference, providing it is warm and dry. If these two factors be favorable peaches seem to thrive in any of the soils of New York. The difference in opinion between the peach growers of Michigan and New York arises from the fact that the great belt in which peaches are grown in the first-named State has a sandy soil, and growers there have scarcely tried the peach on clays, loams or shales upon which some of the best orchards in New York are located.

But this point is made clear: *the peach must have a warm, dry soil* to secure the greatest possible hardiness inherent in the species. Only in such a soil can trees make a strong, firm, well-matured growth that seems to be conducive to hardiness.

Many growers in both States speak of the desirability of a gravelly subsoil to secure a hardy tree. Such a subsoil seems to be conducive to the warmth and dryness of roots and it is probable that so far as hardiness is concerned it matters little whether this subsoil be overlaid with sand, gravel, loam, clay or combinations of these.

DOES THE AMOUNT OF MOISTURE IN THE SOIL IN WINTER AFFECT THE HARDINESS OF THE PEACH?

The evidence as regards this point is clear. Either extreme of moisture—excessive wetness or excessive dryness—gives favorable conditions for winter-killing. A wet soil is conducive to sappiness in the tree and also freezes deeply. Severe cold, especially alternating with warm weather or accompanied with dry winds, causes evaporation of water from trees, and if the soil be so dry as not to furnish moisture to replace the evaporated water, harmful results ensue. Several experiences were given in Michigan in which trees were injured far more from winter freezes in a dry than in a wet soil. The statement was made by several growers that twigs and buds which are more or less shriveled in winter from lack of water or lack of maturity are almost invariably winter-killed.

WHAT EFFECT DO FERTILIZERS HAVE ON TREE GROWTH AND HENCE ON SUSCEPTIBILITY TO COLD?

It has always been held in theory that fertilizers with any considerable amount of nitrogen, as barnyard manure, cause trees to make a heavy, rank, soft growth susceptible to freezing. The majority of the peach growers consulted in this investigation still hold that such is the case, but a very considerable number of them, among them some of the best growers in the two States, hold that trees are more likely to suffer from cold if underfed than if overfed. Their experiences indicate that vigorous, vegetable growth in early summer can be made of great service in counteracting cold and that half-starved trees, or those which have been allowed to bear too heavily, are apt to suffer most from freezing. Fertilizers properly used do not, in the experience of these growers, necessarily induce a rank, soft growth. By using properly balanced fertilizers, by stopping cultivation at the right time, and by judicious pruning, it was maintained that the growth could be kept firm, the top of the tree compact, and the branches well set with buds, all conditions favorable to hardiness. Practically all of the growers report that late fall growths are susceptible to winter injury of both wood and bud.

DO COVER CROPS PROTECT TREES FROM COLD?

There were no conflicting opinions on this point. Growers who had planted cover crops, and nearly all had, were agreed as to the value of this method of protecting trees from winter freezing. Many individual cases were cited of orchards having cover crops surviving this cold winter or that when nearby orchards without the covering crop holding a muffler of leaves and snow were killed. The peach growers in the two regions consider the cover crop the most effective treatment of their orchards to avoid winter-killing, holding that they protect the roots from cold, cause the trees to ripen their wood quickly and thoroughly, and assist in regulating the supply of moisture.

ARE SEEDLING TREES HARDIER THAN BUDDED VARIETIES?

Seedling peach trees are popularly supposed to be hardier than budded varieties. Most of the correspondents in this investigation state that such is the case but none give reasons for the supposed greater hardiness of the seedlings. The statements made are in no way convincing and the greater hardiness of the seedlings can be proved only by carefully conducted experiments. Two hypotheses should be tested in determining whether there is a difference in hardiness between budded and seedling trees: 1. Budding may decrease hardiness. 2. Seeds for the stocks of the budded trees come from the South and these may produce more tender trees than would northern-grown seeds from which seedlings come.

IS THERE ANY DIFFERENCE IN HARDINESS BETWEEN LOW-HEADED AND HIGH-HEADED TREES?

All growers in both States prefer low-headed trees, claiming that both trunks and branches are more often injured in high-headed trees. Buds, however, often survive on the higher branches and not on the lower ones. The reasons vouchsafed for the difference are: the effects of winds in drying out the wood of high-headed trees; low-headed trees are usually most vigorous; and lastly, better protection to the trunk from the sun and hence from sunscald, one of the effects of freezing and thawing. Attention is called by several growers to the fact that buds on high-headed trees usually suffer less from spring frosts.

ARE WINDBREAKS A PROTECTION TO TREES OR TO BUDS?

There was much difference of opinion. From the experiences given it seems that the value of a windbreak depends largely upon the topography of the land. A windbreak so situated as to form still air can only be detrimental so far as cold is concerned. So planted as to deflect or cause air currents they become of value in keeping off frosts. More often than not, however, it was claimed, they seriously check atmospheric drainage and the damage by frost is increased. Another disadvantage is, should the windbreak be to the north, the buds on the trees thus sheltered are forced and are therefore more liable to injury by late frosts. The testimony was for most part unfavorable to windbreaks.

WHAT DEGREE OF COLD WILL KILL PEACH TREES?

There was a most surprising uniformity in the answers to this question. Nearly all of the correspondents set 20° below zero as the temperature that will kill the peach tree under normal conditions, though some had known them to withstand temperatures of from 20 to 30°, depending upon the condition in which the trees went into winter. The following are the conditions unfavorable to withstanding cold and about in order of the frequency in which they are mentioned: lack of maturity of wood; lack of protection of roots by snow or cover crops; poor soil drainage; overbearing in the preceding crop; lack of vitality from ravages of insects or fungi; and the susceptibility of the variety to cold.

WHAT DEGREE OF COLD WILL KILL PEACH BUDS?

From the answers to this question we are forced to conclude that much more depends upon the condition of the buds than on the temperature, assuming of course a temperature below zero and not greater than 25°, which seems to be the limit that peach buds can stand even under most favorable conditions. The chief factors influencing tenderness of buds are: maturity of buds; variety; and the time at which the buds of a variety finish their resting period and become ready to grow. Some of the factors influencing temperature are: lay of the land; proximity to water; stresses of changeable weather; altitude; latitude; and currents of air.

ARE TREES FROM NORTHERN NURSERIES HARDIER THAN THOSE FROM SOUTHERN ONES?

Many opinions were expressed, but few men had grown trees from different latitudes under such conditions as to answer the question fairly. The answers were in no way decisive and the question is still an open one to be settled only by direct experimentation with trees of the same varieties from North and South grown under identical conditions.

II.

The following variations in the species favorable to hardiness to cold were noted:

DOES THE CHARACTER OF INDIVIDUAL TREES HAVE ANYTHING TO DO WITH HARDINESS?

Answers to this question were very indefinite and often conflicting. It was held by some, and with a fair show of experience to confirm the contention, that trees naturally high-headed with few branches, long, spindling trunks, branches and twigs, have soft wood and are therefore more susceptible to freezing. On the other hand, that individuals having naturally short bodies, a goodly number of branches starting low, with short-jointed wood, bright and clear when cut, and thickly set with buds, were the least easily injured by cold. One tree of a variety may be supposed to be slightly more hardy to cold than another through inherent variation, but whether such hardiness can be detected through the character of the growth would have to be determined by carefully conducted experiments and can hardly be proved by such observations as my correspondents are able to make.

ARE THE SMALL-GROWING VARIETIES WITH COMPACT HEADS HARDIER THAN THE FREE-GROWING SORTS WITH LARGE HEADS?

Practically all growers say that the compact growing sorts are the hardiest. As would be expected the small-headed varieties are those with the least succulent wood. The following varieties are named as being the most compact growers and hence hardier than the average: Hill's Chili, Crosby, Gold Drop, Barnard, Kalamazoo, Triumph, Wager and Fitz Gerald.

IS THE WOOD OF SOME VARIETIES MORE SUCCULENT THAN THAT OF OTHERS MAKING SUCH SORTS SUSCEPTIBLE TO COLD?

Every experienced orchardist or nurseryman knows that there is a great variation in the texture of peach wood. Some varieties have a much more succulent growth than others grown under the same conditions. Succulency of growth is in some cases a well-marked varietal character and one that can be avoided in selecting sorts to plant where hardiness is a requisite. Summarizing the answers from New York and Michigan, the following are the sorts most often named as having the softest and sappiest wood growth: Early Crawford and Late Crawford are named by practically all correspondents as being most succulent in growth, following which, named in order of degree of succulency come: Chair's Choice, St. John, Niagara and Surprise.

ARE YOUNG OR OLD TREES HARDIEST?

Beyond all question young trees suffer most in severe winter freezes. Practically all of my correspondents in both New York and Michigan agree to this, and as a proof many of the Michigan growers give their experience in the several severe freezes that have occurred in that State during the past few years, in which young trees universally suffered most. It is probable that young trees are injured most because they make a much greater and much ranker growth than the older ones and hence more sap remains in them during the winter. The formation of buds in the older trees is helpful, too, in maturing the wood. There are, however, many exceptions to the statement that young trees are less hardy to cold than old ones. Old trees can be forced to produce large quantities of new wood susceptible to winter-killing, while on the other hand the superabundant growth of young trees can be kept down by orchard treatment. It is fair to assume, too, that old trees possessing very low vitality are less hardy than vigorous young trees. Thus it was often noted that old trees which had suffered from the ravages of borers, or fungus parasites, as curl-leaf or shot-hole fungus, were easily killed by cold.

While young trees are more susceptible to freezing than old ones, yet they are much more likely to recover, if recovery is possible, and their return to the normal condition is more rapid. This is probably true because of the greater vigor of the younger plants and because of the possibility of an entirely new covering of bark for small trees often impossible with larger ones.

NAME THE FIVE VARIETIES OF PEACHES MOST HARDY IN WOOD.

There was, as would be expected, great difference of opinion as to the sorts most hardy. In New York the following five sorts, in order named, were considered most hardy: Crosby, Hill's Chili, Stevens' Rareripe, Gold Drop and Elberta. In Michigan practically every grower considered Hill's Chili most hardy in wood, followed closely by Crosby, then Gold Drop, Kalamazoo and Barnard. It was interesting to note that Elberta, Smock and Salway, considered fairly hardy in New York, are somewhat tender in Michigan. The three upon which growers agree in both States as being hardest are, Hill's Chili, Crosby and Gold Drop. Wager, Jaques Rareripe, Carman, Belle of Georgia, Hale's Early, Champion, and Greenboro, none of them in the lists of five hardiest, are hardier than the average.

NAME THE FIVE VARIETIES MOST TENDER IN WOOD.

Here, too, opinion differed, but not so much as in naming the lists of hardy sorts. In New York the list runs: Early Crawford, Late Crawford, Chair's Choice, St. John, Niagara. In Michigan the first four are as in New York, Early and Late Crawford, Chair's Choice and St. John, followed by Smock, which, strange to say, is considered a fairly hardy sort in New York. Michigan growers consider Salway tender in wood, while in New York there was an even division as to whether it was hardy or tender. Elberta came within a vote of tying Smock for the list of tender varieties in Michigan.

NAME FIVE VARIETIES OF PEACHES MOST HARDY IN BUD.

The New York growers named more than a score of varieties as being hardy in bud and were agreed only upon two sorts as being preeminently hardy, namely: Crosby and Hill's Chili, with Triumph, Gold Drop, Steven's Rareripe and Kalamazoo having an equal number of votes for hardiness. The Michigan growers gave their opinion most decidedly for the five following sorts, scarcely any others being named: Hill's Chili, Gold Drop, Crosby, Kalamazoo and Barnard, with a few scattering votes for Triumph, Early Rivers, Wager and Salway.

NAME THE FIVE VARIETIES OF PEACHES MOST TENDER IN BUD.

Growers in the two regions agree as to the sorts most tender in bud. Not only are the same varieties given but in exactly the same order, namely: Early Crawford, Late Crawford, Chair's Choice, Reeve's Favorite and Elberta. Among other sorts named as being tender in bud in one or the other or both States are Old Mixon, St. John, Smock, Niagara, Surprise, Globe and Mountain Rose.

In summarizing the results of the investigation it appears that the peach is certainly influenced as to hardiness by the cultural treatment given. The presumption is, upon philosophical grounds, if we accept neo-Lamarckism,—and most horticulturists do,—that the external influences of orchard management have a permanent effect upon hardiness of the peach and that the horticulturist is thus slowly but surely acclimatizing this species to greater degrees of cold than it could once stand. It appears, too, that there are favorable variations in the peach as to hardiness of wood and of bud, from which the horticulturist can select and breed varieties capable of withstanding the vicissitudes of climates which in its wild state this plant could not have borne. We have, in cultural treatment and selection, means at the command of the horticulturist to acclimatize plants, and I have tried to set forth in their relative importance the chief factors as these means are now being used in the acclimatization of the peach.

The substance of the following paper was given by George V. Nash, during the course of an inspection, by members of the Conference, of the collections of the New York Botanical Garden, at the conclusion of the Conference:

Observations on Hardiness of Plants Cultivated at the New York Botanical Garden.

By George V. Nash,
New York Botanical Garden.

During a number of years past there have been grown in the collections of the New York Botanical Garden a large number of species and varieties of shrubs and conifers, and it is observations made upon these that it is desired to place on record here. The unusually severe winter of 1903-1904 will long be remembered by plant lovers in this region, and it has been thought best to disregard in great measure the effects produced by that extraordinary test, considering the various species from the standpoint of their adaptability to ordinary conditions. A detailed account of the effects of this winter upon the shrubs at the Garden was given in the *Journal* of the New York Botanical Garden for July, 1904.

The collection of shrubs which forms the basis of most of the conclusions offered below is located on a flat plain to the northeast of the Museum Building. Here have been brought together over fourteen hundred plants, representing about six hundred species and varieties. The soil is rather light and is underlaid with gravel, so that drainage conditions are excellent. On opposite sides of this tract are depressions of considerable extent, markedly lower than the surface of the plain, thus insuring air-drainage, so that masses of cold air do not collect here. The region is, however, subject to the sweep of the cold winter winds, excepting in the vicinity of a boundary border and bridge-approach on the northwesterly side. It is necessary to describe these conditions that the remarks offered below may be available for the use of others.

It will not be possible to refer to all the plants brought together in this collection. For a detailed account of the behavior of a large number of these during the winter of 1903-1904 the reader is referred to the *Journal* above referred to.

As this collection is for study purposes, it is arranged in botanical families, following the sequence of Engler and Prantl. For this reason, the shrubs will be considered in family groups.

The genus Berberis, the barberries, furnishes a number of species which are perfectly hardy. Among these are B. vulgaris and its purple-leaved form; B. amurensis, from Manchuria and north China; B. aristata, from the Himalayan region; B. buxifolia and its variety nana, from the southern Andes; B. Neuberti, of hybrid origin; and the ever and deservedly popular B. Thunbergii, perhaps the best barberry ever introduced into cultivation. The beautiful little barberry, B. concinna, from the Himalayan region, kills back somewhat at the tips. In a more sheltered situation it would almost surely prove hardy. It is a dainty little species and colors beautifully in the fall.

In the hydrangea family there is Hydrangea quercifolia, from Georgia and Florida, which kills back partly at times. Duetzia crenata and its derivatives are unstable, sometimes killing back to the ground, while D. gracilis and its derivatives are much more hardy. All of the genus Philadelphus, including all of the commoner forms offered in the trade, have proved perfectly hardy.

In the gooseberry family nearly everything is satisfactory. Ribes sanguineum, from the west coast, however, is apt to succumb to exceptional cold, and always is a little unstable. One member of this family of comparatively recent introduction is Ribes curvatum, from the southern Alleghenies. It has proved entirely hardy during our coldest winters. It is most desirable from a decorative point of view. Its branches are long, slender and spreading, giving the plant a very graceful appearance, much resembling in habit Stephanandra flexuosa. During the early summer it is covered with a multitude of dainty white flowers.

In the witch-hazel family Corylopsis spicata, from Japan, and Fothergilla Carolina and F. major, both from our Southern

States, endure our climate well. Hamamelis Virginica, being a native, is of course hardy, but the Japanese representative, H. arborea, is not fitted to our conditions. In the rose family most of the spiræas are satisfactory, a notable exception being Spiræa canescens, from the Himalayan region, which kills back badly, a regrettable fact, for its graceful habit would make it a desirable ornamental shrub.

In the apple family, Pomaceæ, there are many desirable things. Nearly all the thorn apples, excepting those from the extreme south, are available out of doors. In the genus Cotoneaster, however, there is a wide difference in the hardiness of various species. Of those from the Himalayan region there have been grown here: C. Nummularia, C. bacillaris, C. microphylla, C. buxifolia, C. rotundifolia, and C. thymifolia. The first two mentioned have proved hardy, while the remainder are very unstable, even when protected by straw. Perhaps the explanation of this is in the fact that the two first are deciduous, while the others are evergreen, thus presenting a much greater transpiring surface which must act to their undoing in the changeable climate of our winters.

Coming from Schipka Pass, high up in the Balkan Mountains, Prunus Laurocerasus Schipkænsis is tolerable of this climate, but I fear the alternations of freezing and thawing would be its undoing in exposed situations. Of the three species of Cercis grown, the only one which is not satisfactory is the European species, C. Siliquastrum, the other two, C. chinensis and C. canadensis being entirely hardy.

There are so many delightful things in the Papilionaceæ, or pea family, that it is regrettable so few of them are satisfactory in our climate. Caragana Chamlagu, from northern China, and C. arborescens, from Siberia and Manchuria, are desirable sorts. Colutea arborescens, from southern Europe, is also hardy. The European Cytisus capitatus can also be relied upon. Lespedeza bicolor, from Japan, although a showy and desirable shrub, is not quite satisfactory, often killing back badly. While the furze, Ulex europæus, and the broom, Cytisus scoparius, are not at all desirable from the standpoint of hardiness, both killing back badly, even in mild winters.

Of course the Rutaceæ, the orange family, present few species which are hardy in our climate. Notable examples of hardy forms are Ptelea trifoliata and Xanthoxylum americanum. The trifoliate orange, Citrus trifoliata, is just on the borderland, and in this vicinity needs a sheltering hedge for pretection to make it at all permanent.

The boxes, Buxus, do not stand well in exposed places. While some of the forms of the common box, Buxus sempervirens, are better than others, they all do much better when in a protected situation.

To the Anacardiaceæ belong the sumacs, the genus Rhus. Many of these are perfectly satisfactory, including, of course, our native species, R. hirta, R. glabra, and R. copallina. The Chinese R. Osbeckii is especially desirable for foliage effects, owing to its entire hardiness.

The holly family, Ilicaceæ, has some species which are hardy. The Japanese Ilex crenata has proved a most desirable plant with us, even in exposed situations, its dark rich green leaves remaining all winter. Ilex opaca, the American holly, does better when protected, not taking kindly to a wind-swept area. The English holly is, of course, out of the question here.

The Celastraceæ present a varied lot as to hardiness. Euonymus alatus, from China and Japan, is very desirable, both from its beauty and from its ability to stand successfully the rigors of our climate. E. europæus and the American E. atropurpureus are both available. E. japonicus, from southern Japan, as might be expected, is not hardy in exposed situations, requiring considerable protection, while E. radicans, from the middle and northern portions of the same country, can be relied upon.

Stuartia pentagyna, from the southern mountains, really needs the protection of a hedge to be a success, and S. Pseudocamellia, from Japan, is no more hardy.

The Oleaceæ furnish many things which are hardy, the privets as a rule being among this class. The California privet, Ligustrum ovalifolium, was for years considered hardy, but the winter of 1903-1904 proved its Waterloo, plants during that period being killed entirely to the ground in exposed situations, while it suffered severely even in more sheltered places. L. Quihoui, a shrub with widely spreading branches and thick green leaves, is hardy under normal conditions.

The species of the genus Buddleia, belonging to the Loganiaceæ, are always more or less uncertain, excepting in protected situations. They come up readily from the roots, however, so if they are occasionally killed back they are worth growing, for some of them are very handsome, notable among these being B. variabilis.

Most of the Verbenaceæ, the verbena family, are quite uncertain as to hardiness, but as many of them readily sprout from the roots when killed back, they are of use horticulturally. Vitex Agnus-castus, from the Mediterranean region, Callicarpa Japonica and C. purpurea, the latter from China, Clerodendron trichotomum and C. serotinum, and Caryopteris Mastacanthus, belong here.

The honeysuckle family, Caprifoliaceæ, is almost synonymous with hardiness, for there are many species in the genera Viburnum, Lonicera, Weigela, Diervilla, Symphoricarpos and Sambucus, which even the severest winters do not harm. Abelia chinensis, another member of this family, is not quite hardy, unless in well-protected situations. It is a beautiful little shrub and is well worth giving a protected place.

The collection of conifers is located on a series of ridges and valleys, those requiring some protection being placed in positions which will afford such conditions. The plants are placed singly, instead of in groups, a condition which perhaps must be borne in mind in considering the following remarks upon their hardiness here.

The genus Picea is located on a slope which faces mainly to the northeast, with no protecting fringe of trees on the exposed side, from which direction come the prevailing cold winds of winter, so that the plants are here subjected to as severe a test from this source as could be imposed in this latitude. The area is underlaid with rock, so that the drainage is excellent, with the exception of that portion at the base of the slope to the northeast, where water is apt to accumulate and stand for some time in winter and after heavy showers in summer. In this lower portion those plants are located which prefer moisture. In this area have been grown for the past three or four years the following: Picea Ajanensis, P. Engelmannii, P. excelsa and many of its horticultural forms, P. Mariana, P. Maximowiczii, P. Omorika, P. orientalis, P. pungens and its horticultural varieties glauca and pendula, P. polita, P. Sitchensis, and P. Smithiana. From our own country come P. Engelmannii, P. Mariana, P. Sitchensis, and P. pungens. Of these the black spruce, P. Mariana, is the only eastern representative which has been grown in the pinetum. It is not entirely at home, although removed but a few miles from a region where it is wild, the unstable temperature of winter here, with the alternate thawing and freezing, apparently not suiting it. The other two referred to are from the west, and are more satisfactory. This is especially true of P. pungens and its varieties. This tree is found at elevations from 6,500 to 10,000 feet in the Rockies in Colorado, eastern Utah, and as far north as Wyoming. It is one of the most desirable American conifers for this latitude, making a fine appearance at all times, not browning in the least during the winters, and in the early summer the glaucous foliage of the young shoots, which is much intensified in the variety glauca, gives a beautiful grey-blue tinge to the whole tree. Picea Engelmannii, reaching its perfection much further north, where conditions are quite different from those prevailing here, is hardy, but does not present that vigorous appearance presented by P. pungens. It grows at an altitude of about 5,000 feet in its northern limit, Alberta and British Columbia, to about 11,500 feet in its southern limit, northern New Mexico and Arizona. In the region where P. pungens is at home, therefore, it grows at an altitude of 1,500 to 2,000 feet higher than that species. This could easily account for the difference in adaptability to this climate. Picea Sitchensis of the northwest coast of North America attains its best development near the sea. That it is not a success in this latitude is not a cause for wonder, the drier conditions here proving a severe check to it. Picea excelsa, widely distributed in Europe, excepting the extreme southern portions, does very well. This has been so long in cultivation that little need be said about it. In Norway, in latitude 63°, it grows at an elevation of 2,500 to 2,900 feet, while in the Tyrolese and Swiss Alps it reaches an altitude of 6,500 feet. Some of the dwarf forms of this are not as hardy as the type.

Picea orientalis, from the Caucasian region, while hardy, has proved a slow grower. I use the word hardy somewhat advisedly, as of the eight or nine plants set out in 1903, all but three or four died during the succeeding winter. All the plants which survived were derived from one source, perhaps originally from seed from trees growing in a climate more nearly approaching that here. Another species of Europe, with an extremely limited range, is Picea Omorika, confined to the mountains of southwest Servia and the spurs leading therefrom. It grows at an elevation of from 2,000 to 4,000 feet. It is odd in having its nearest botanical relatives in P. Sitchensis, of northwestern North America, and P. Ajanensis, of Japan. Five plants of it have been in the pinetum since the spring of 1903. They have proved perfectly hardy in an exposed situation, having passed through two unusually severe winters during that period. They are trim in habit, a clean green, and keep their branches right down to the ground.

From Japan come two of the species in cultivation. These are P. Ajanensis and P. polita, the former also extending to the mainland in the Amur region. Picea Ajanensis is found in Japan mainly on the island of Yezo, and on the island of Saghalin and the Kurile Islands to the northward, extending southward to about 35° in the island of Hondo. It is said to be particularly at home in the cold swampy plains of the western side of the island of Yezo, and this perhaps accounts for its lack of interest in our climate. With us it has been a slow grower, its location here perhaps being too dry. Picea Maximowiczii, which is said by some to be a form of P. obovata, has proved hardy. Its origin is somewhat obscure, but it is said to have come from Japan. Its nearest relative, however, is apparently P. obovata, a Siberian species. P. polita, now exceedingly rare in a wild state in Japan, but extensively cultivated there, has proved adapted to this climate. Its range, as indicated by the few remaining trees in a wild state, appears to have been in the mountains from the southern part of Japan to as far north as about 38°. Picea Smithiana, from the temperate Himalayas, has not succeeded well with us up to the present. It grows at an elevation of 6,000 to 11,000 feet, chiefly on the western and northern slopes. It is a curious fact that it frequently occurs with Cedrus Deodara and Pinus excelsa, the first of which has proved a very doubtful proposition in this region, while the latter is hardy.

In the nurseries of the New York Botanical Garden, which are located on ground sloping to the southeast, other species have been grown. But even in this sheltered position Picea Breweriana is a failure. Plants which came into the collections in 1901 have remained almost at a standstill, and are but little larger than when they first arrived six years ago. P. brevifolia, P. Canadensis and P. obovata have proved satisfactory in this nursery. They were moved into the pinetum the past spring, and it will require at least one winter to indicate their fitness for this region.

The genus Abies has essentially the same conditions to meet in the pinetum as has Picea. There have been growing there for the past few years the following species: Abies balsamea, A. Cephalonica, A. Cilicica, A. concolor, A. firma, A. Fraseri, A. homolepis, A. lasiocarpa, A. nobilis, A. Nordmanniana, A. Numidica, A. Picea, A. Sibirica, and A. Veitchii. Abies Veitchii, from an elevation of 7,000 to 8,000 feet, and also known from the Manchurian mainland, and Abies homolepis, from central Japan, at an elevation of 4,000 to 5,000 feet, appear perfectly adapted to this climate. Even the past winter, when some conifers, which had hitherto been looked upon as suitable, turned badly, these two kept green. Abies firma, from further south in Japan, does not show that vigor here that those mentioned above have done.

Abies Sibirica, extending its range as far north as 66°, has a most extensive range. It is found from the northeast part of Russia and eastward through the entire length of Siberia to Kamschatka and the Amur region. This is perhaps a more extended range than is enjoyed by any other species of this genus, but the whole area of its range is known as one of extreme and continued cold during the winter, with sudden transitions from winter to summer and vice versa. Coming from this region of continuous cold, it is perhaps the alternate thawing and freezing which is destructive to this species. It certainly cannot be the cold here, for in its native home it is subject to far more severe conditions of this kind. It has been tried several times in the pinetum, with poor results.

Abies Nordmanniana has proved quite satisfactory. It is a native of the central portions of Transcaucasia, where it forms large forests in the valleys at elevations ranging from 3,500 to 6,000 feet. It extends as far west as Trebizond, southeast of the Black Sea, in practically the same latitude as is New York City. In passing I would remark that Picea orientalis, which is said to be frequently associated with Abies Nordmanniana in Transcaucasia, is quite variable as to hardiness. Plants derived from some sources have proved perfectly hardy, while others will not stand our winters. These plants were secured from nurseries, and unfortunately it is impossible to obtain data as to where the seeds from which they were raised were originally secured.

Of the firs from western North America three have been under cultivation in the pinetum for several years. These are Abies concolor, A. nobilis, and A. lasiocarpa. The latter is an alpine plant, and like all such plants does not find a congenial home here in New York, the long periods of drought during the summer and the alternate freezing and thawing during the winter militating against them. It is not satisfactory, although able to live through the winters. Abies concolor, much resembling it in color, is much more satisfactory and is one of the best of American conifers for this vicinity. Its ability to withstand heat and dryness, makes it especially valuable. Previous to the past spring, I do not recall its having shown any signs of browning, but some of the specimens did brown rather badly the past winter, while others kept their beautiful gray-green without a blemish.

Abies nobilis, which attains a height of 150 to 250 feet in its native home, the Coast and Cascade ranges of Washington and Oregon, is a very slow grower here, perhaps being drawfed by the drier climate of this region. It is perfectly hardy, however, even in exposed situations, not browning nor killing back in any way during the most trying winters.

The two firs of the eastern parts of North America have both been under cultivation at the Garden for several years. Both of these, Abies balsamea and A. Fraseri, the latter restricted to the southern mountains, are not desirable as ornamental trees. With us they are slow growers and of doubtful stability, the alternate freezing and thawing, perhaps, being the cause of this.

Abies Cephalonica, from elevations of 2,500 to 5,000 feet in Greece, stands the winters well. A. Cilicica, from altitudes of 4,000 to 6,500 feet in Asia Minor, is also hardy. This is another example of the strange difference in hardiness in this latitude of two plants which are often associated together in a wild state. Abies Cilicica and Cedrus Libani are said to be constantly found growing together, and yet the latter has proved entirely unfit to stand our winters, while the Abies has been grown in an exposed situation with success for the past four years. Abies Numidica, an associate of Cedrus Atlantica in the Atlas Mountains, has been represented by a single specimen in the pinetum for the past four years. It is still in good condition, but it does not grow very fast. Abies Picea, or A. pectinata, as it is more frequently called, is the common silver fir of central and southern Europe. It is said to attain its greatest development in the humid mountain tracts of central Europe, a reason, perhaps, for its unsatisfactory behavior here. It comes through the winters alive, but it is apt to brown badly, and does not grow rapidly.

Pseudotsuga mucronata, which has, perhaps, as wide and extensive a range as any American conifer, is one of the best for this latitude. Its wide range indicates its ability to adapt itself to a variety of conditions, and it makes one of the best and handsomest trees in this neighborhood, not even the most severe winters harming it in the least. Its dark green foliage is a delight in the winter time, and in the spring the fresh green of the young shoots in contrast with the dark green of the older branches, makes it most attractive.

The pines, often residents of dry or cold regions, lend themselves more readily to cultivation in this region than do most other conifers. Among the white pines, Pinus excelsa, of the Himalayan region, growing at an elevation of between 6,000 to 12,500 feet, is perhaps the best. Its leaves are longer and more graceful than are those of our own white pine, Pinus Strobus, and it is less subject to disease. Pinus Koraiensis, the Corean white pine, and said also to grow in Japan and China, is a rather slow grower, but perfectly hardy. Pinus parviflora, ascending the mountains to about 5,000 feet in central and southern Japan, thrives well here, and is desirable where a slow-growing tree is wanted. Pinus Cembra, of central and northern Europe, and Pinus Peuce, of Macedonia and Roumelia, are both hardy but slow growers.

Among the red pines, Pinus Thunbergii, of Japan, and also said to occur in north China and Corea, rivals Pinus Austriaca in hardiness. It much resembles it in general shape. Another desirable Japanese pine is Pinus densiflora, of central Hondo, where it grows among deciduous trees at an elevation of 3,000 to 4,000 feet. Pinus Laricio, P. Austriaca, and P. Pallasiana, of the mountains of southern Europe, the latter two often considered but as varieties of the first, stand well here. Pinus Banksiana, P. montana Mughus, P. pungens, P. resinosa, P. rigida, and P. sylvestris all thrive. Pinus ponderosa is not really at home, at least the plants we have, some six or seven, are not vigorous. Pinus Taeda is barely hardy in sheltered places, the young growths often killing back.

Cedrus Deodara, growing in the Himalayan region at elevations of 3,500 to 12,000 feet, barely survives, although Pinus excelsa, with which it is said to be associated in Cashmere, is perfectly hardy. We have plants in the pinetum which came to us in 1900 and which are still small, showing a tendency to kill to the snow line in severe winters. Cedrus Atlantica, from the Atlas Mountains, where it ranges between elevations of 4,000 to 6,000 feet, is much better adapted to this climate. Here we have an interesting case of two species of the same genus, in practically the same latitude, about 32° north, one in the northwestern part of Africa, the other in the northeastern part of India, the African species being much more hardy in this climate than the Indian species, although it grows at a lower general altitude.

In the genus Larix, as might be expected, Larix leptolepis, from the mountains of northern Japan, is most satisfactory. The severest winters we have had have not touched it. The common European larch, Larix decidua, and the American one, Larix laricina, are, of course, hardy. Pseudolarix Kæmpferi, of China, has proved suited to the climate in this neighborhood. As both Larix and Pseudolarix are deciduous, they are better adapted to stand the alternate thawing and freezing they encounter here, for the transpiration surface is reduced to a minimum.

It is unfortunate that Cryptomeria Japonica is not hardy here. We have tried it several times, and only once have we found a single individual that would live at all, the others being killed every winter. This plant has now been in the pinetum for five or six years, is in a very sheltered place, and has managed to survive; it does not present the neat symmetrical appearance it does in the conservatories. It has borne cones and even the hard winter did not harm it more than usual.

Sciadopitys verticillata, from the mountains of Japan, withstands the winters well, rarely if ever browning in any way. Thujopsis dolabrata, as is the case with nearly all plants from southern Japan, is not hardy here. Chamæcyparis pisifera, and its numerous varieties, also from southern Japan, is a little tender sometimes. Even here there is a great difference in individuals, some withstanding the winters better than others, perhaps being derived originally from seed from more northern localities. Chamæcyparis obtusa, and most of its varieties, are about as hardy.

None of the species of Cupressus are hardy. The members of the genus Chamæecyparis from our northwestern country, C. Nootkatensis and C. Lawsoniana, can only be grown in sheltered situations. Coming from a region where the annual precipitation is greater than it is here, our long dry spells seem to militate against them.

Among the cedars, Juniperus chinensis, J. nana, J. Sabina, J. prostrata, and of course the native J. Virginiana, are perfectly hardy. While J. rigida, one of the most graceful of all, at least in a young state, from southern Japan, is only capable of a struggling existence, and winter-kills badly.

Thuya occidentalis is hardy, excepting in wind-swept situations, where it often kills badly and browns. Thuya gigantea, from the northwestern coast of America, where humid conditions prevail, will not stand here at all, and Thuya orientalis, of China, is precarious excepting in sheltered localities.

Taxodium distichum and T. imbricarium both thrive, whether grown in wet or dry soil.

Tsuga canadensis, of which a fine grove is to be found along the banks of the Bronx River in the New York Botanical Garden, is of course hardy. T. carolina, of the southern Alleghenies, is equally hardy. T. Mertensiana has been tried twice and both times it failed, the plants when set out being in an apparently healthy condition, the first winter being fateful to them.

Ginkgo biloba thrives vigorously, the coldest winters not killing even the smallest branches. This cannot be said of the genus Taxus, however. The common European yew, Taxus baccata, needs a protected situation to enable it to pull through a severe winter. The Japanese yew, Taxus cuspidata, however, is perfectly hardy, and during the severe winter of 1903-1904, when the European yew was killed, in many cases to the snow line, T. cuspidata, growing immediately alongside of it, was not hurt in the least, but kept green and intact the whole winter.

Cephalotaxus is represented in the collections by two species, C. drupacea and C. Fortunei, the former from Japan, the latter from China. C. drupacea grows in the mountains, at elevations of 1,000 to 3,000 feet, from southern Hondo to central Yezo, often forming a part of the undergrowth in woods. C. Fortunei is from the northern part of China. Both these species can only be grown in this neighborhood in protected situations, and even then present rather a scraggly appearance.

In this connection, as associating the data with horticultural matters, I desire to place on record the following, compiled from the records kept at the New York Botanical Garden for a number of years. The precipitation is given for what may be called the eight growing months of the year, from March to October, inclusive. This may throw some light upon the problems of hardiness of certain species, when more is known as to their individual environment.

	1901	1902	1903	1904	1905	1906	1907
March	6.89	5.63	5.96	3.82	4.47	4.15	2.31
April	8.96	3.73	3.49	5.00	2.88	6.50	4.93
May	8.08	1.85	.34	4.11	1.05	4.61	4.05
June	1.04	5.65	8.28	2.6	4.01	1.71	3.85
July	11.76	4.12	5.34	3.59	4.13	4.12	1.66
August	8.56	5.75	5.94	6.52	6.04	3.78	2.59
September	2.23	5.83	3.6	4.06	6.09	2.53	7.93
October	3.21	7.31	8.98	2.77	2.87	5.81	
	50.73	39.87	41.93	32.47	31.54	33.21	

It will be noted from the above that from 1901-1906 a period of unusual dryness has visited this region either in the latter part of May or during June. In 1907, however, this drought appeared later, coming in July. It would seem that it is this dry period which militates so strongly against growing plants here from a humid region, such as many parts of the Pacific coast, and if we can but tide our plants over this period each year by carefully watering them, we may eventually succeed in establishing many a plant which otherwise would succumb to the dry conditions of its first year of residence, and eventually perhaps establish a vigor which may perpetuate it. This is particularly true of conifers, for it is just about this time that such plants are transplanted in the vicinity of New York. One can readily imagine the effect which would be produced upon a conifer which was transferred from a nursery to a new situation just previous to the commencement of this drought. Perhaps many of our failures with conifers is due to this cause. A conifer handicapped with such conditions for several weeks after transplanting has but a poor chance to recuperate and lay up reserve force to carry it through a severe winter. I can recall one excessive visitation of this drought in 1903, when the precipitation for fifty-two days, from April 16th to June 6th, was but 0.37 of an inch. This was followed by the extraordinarily severe winter of 1903-1904, and the resulting havoc in shrubs and conifers will be long remembered by many a lover of hard-wooded plants. The results upon shrubs at the Garden have been already referred to.

The alternate thawing and freezing of this vicinity must also play an important part in the hardiness of plants here. Alpine plants, or those from regions of perpetual cold during the winter, do not therefore adapt themselves readily, nor do they take kindly to the succeeding fierceness of our summer sun, after a winter of subjection to thawing and freezing.

There is hardly sufficient data as yet on which to base a statement as to what plants are hardy in the vicinity of New York. Not until many investigators have recorded the results of numerous experiments in various localities, and not until we know more about the individual environment of a given species, can we with any certainty explain the apparent contradictions which seem to exist in the matter of plant hardiness. In so far as the shrubs and conifers are concerned, it may be said that, as a general rule, species from the Alleghenies and from the regions somewhat to the north of New York are hardy here, the belt of hardiness extending across the northern border of the United States to the Rockies, and extending southward down them at elevations of medium height; while plants from the Pacific coast, even as far north as Washington and Oregon, lead a very precarious existence in this latitude. In Asia, hardy species come from northern and middle Japan, northern China, Manchuria and Siberia, with a few from the Himalayan region. In Europe, of course many of the plants from the northern and middle portions adapt themselves to conditions here, and from the high mountainous regions of the southern portions come some of our best conifers, while but few plants from the region of the Mediterranean survive long.

Observations in the Region at the Head of Lake Michigan.

By Jens Jensen, *Chicago, Illinois.*

Generally speaking the topography of the district under discussion in the following notes is level. Geologically the region at the head of Lake Michigan consists of the following formations:

First.—Alluvial Deposit.

Second.—Glacial Drift.

Third.—Morain.

The *Alluvial Formation* consists of a series of sand ridges that form sand dunes toward the northern part with intervening spaces, still inundated or here and there raised up above the Lake level by decaying vegetation. All of the dry lands are covered with forest growth.

The *Glacial Drift,* known to geologists as Lake Chicago, but commonly termed "Prairie," consists of a heavy blue clay, and was entirely treeless before the arrival of the white man in this section. Judging by its name it is almost level, and has a poor natural drainage.

The *Morain* borders on Lake Michigan north of Chicago, here known as "Lake Border Morain," and also borders the "Prairie," or "Glacial Drift," described before. This formation consists of a yellow, pebbly clay, and was originally covered with forest growth, part of which still exists where the axe has left it alone.

The elevation over Lake Michigan of these three different formations varies from a few feet to 180 feet, the Morain being the highest, with the exception of a few sand dunes that perhaps reach still a greater height, but which will not be considered here.

From the foregoing description of the formation of the lands at the head of Lake Michigan it at once becomes evident that there exists a difference in the vegetation covering these areas. Nevertheless, leaving everything but the arborescent flora out of consideration, the difference is very slight, from the standpoint of the great variation in soil, which will be seen later.

For convenience sake the vegetation will be divided into three groups:

First.—Vegetation indigenous to the above described area.

Second.—Vegetation indigenous to the area, but introduced from one formation to another.

Third—Vegetation introduced to the region.

The greater variety is found on the alluvial soil, and some species are found here of more than common interest. Especially is this true of the deciduous group, there being very little difference in the Conifers, all of the latter having been practically exterminated by the soft-coal smoke of the city of Chicago where manufacturing has encroached upon adjacent territory. Originally the same vegetation as now found in the southern border of the city extended along the present water-front of Chicago as far as the northern part of the old city limits.

Of those species indigenous to the Alluvial Formation that will be discussed here are:

Liriodendron Tulipifera.
Nyssa multiflora.
Nyssa sylvatica.
Sassafras officinale.
Fraxinus quadrangulata.

Sassafras is found for about three miles beyond the northern limit of the Alluvial Deposit on the "Lake Border Morain."

Fagus ferruginea is a native of both the eastern and western borders of Lake Michigan, but only two groves are found on the "Lake Border Morain" in the State of Illinois, and also sparsely found in the northern part of the Alluvial Formation on the Michigan side within the limits of the area here discussed. Farther north on both sides of the lake large groves of well-developed trees exist.

Of the Morain vegetation of interest here are:

Acer saccharinum,
Acer rubrum,
Prunus serotina,

all of which are indigenous on the Alluvial Formation, but less vigorous and of smaller growth there.

On the Glacial Drift (Prairie) as mentioned before, the present vegetation has been introduced. Perhaps a lonely cottonwood might have made its home in suitable situations on these plains, as we still find them to-day seeding themselves along ditches and roadways; still it is problematical whether the young sapling would have been able to withstand the annual fires that with great fury passed over these flat lands.

Of course, groves of trees and shrubbery vegetation originally existed along the bluffs of the Chicago River, but these have long ago disappeared with the exception of those along the north fork of the Chicago River, most of which passes through the Morain Formation.

Referring to the second group: those species introduced to the Morain from the Alluvial Deposit will first receive attention. To my knowledge the tulip tree (*Liriodendron Tulipifera*) has been planted as far north as Waukegan, which is about thirty-five miles from Chicago. Sassafras and Nyssa multiflora have also been introduced, but no species of any size worth mentioning exists outside of its natural distribution.

Some healthy species of the tulip tree are found within a short distance of Lake Michigan, and especially noteworthy are the two remaining trees in the cemetery in the city of Waukegan, planted by the late Robert Douglas about forty years ago. The sister specimen of these trees once decorated the beautiful grounds of Mr. Douglas, but was winter-killed in the winter of 1898 and 1899. One large specimen of sassafras, more than twelve inches in diameter, is found directly at the foot of an old lake beach where the Alluvial Formation and the Morain join north of the city of Chicago. As this tree stands in a private garden it is evident that it was planted perhaps between thirty and forty years ago; but native specimens are still found in this district, yet nowhere over ten to fifteen feet high, and this size very sparsely. The tree referred to is protected toward the north and west by the bluff and a group of conifers.

Nyssa multiflora is not found in well-developed specimens outside of the Alluvial Deposit; a few specimens have been reported from the northern section of the Alluvial Deposit in Illinois. Whether those growing in the northern part of the city are native, or have been introduced, I do not know.

Of the vegetation introduced to the Prairie indigenous to the region, I desire to mention:

Fraxinus quadrangulata.
Tulip Tree.
Acer saccharinum.
Acer rubrum.
Prunus serotina.

We will now come to the third group—Introduced Vegetation.

Referring to the Morain,—

Magnolia hypoleuca,
Gleditsia triacanthos,
Ulmus campestris,
Acer platanoides,

have been introduced with more or less success. The magnolia can be found in specimens almost twelve inches in diameter in old gardens as far as Waukegan on the "Lake Border Morain." Gleditsia triacanthos is also found in large specimens, and the Norway Maple grows very rapidly, and attains an enormous size on this formation. Ulmus campestris is dying out after about thirty years of growth, but disseminating itself through seeds before it succumbs to natural conditions deadly to its existence.

On the Plain or Glacial Drift the same varieties have been introduced, and those specimens still remaining show the hard struggle they have to make for existence. Magnolia hypoleuca grows very slow, and as no specimens exist over fifteen years old it is impossible to state at this time how long they will be able to live on this formation. Acer saccharinum succeeds very poorly, and Acer rubrum after a few years of trial succumbs. Acer platanoides (Norway Maple) struggles along and has so far succeeded in holding its own under favorable conditions, but does not attain a height over 25 or 30 feet.

Prunus serotina is not much better off than Acer rubrum. Gleditsia triacanthos grows into large specimens, and seems to succeed as well on this formation as any other tree if we except the cottonwood, yet in the cold winter of 1898 and 1899 referred to before a number of beautiful specimens of Gleditsia triacanthos were winter-killed on these lowlands. Fraxinus quadrangulata, after a period of thirty-five years, is not more than from nine to ten inches in diameter, and about 18 to 20 feet high, but seemingly healthy, only dwarfed. Nyssa multiflora and Fagus ferruginea die out after a few years of struggle. As most of this formation is within the influences of the smoke of the city of Chicago, no reference will be made to evergreens, as all of them succumb after a longer or shorter period.

In discussing Introduced Vegetation I also desire to call attention to a specimen of yellow wood *(Cladrastis tinctoria)* that stands on the top of the Morain about sixteen miles west of Chicago. This tree is more than twelve inches in diameter, and the only one found of any consequence in the entire region. Introduced to the Glacial Drift it lingers along for a few years and then succumbs. That no reference has been made to Introduced Vegetation on the Alluvial Formation is largely due to the fact that these formations have either been covered with manufacturing, or with the homes of the laboring man where inhabited, and consequently no large gardens are found in this district that naturally would contain a variety of Introduced Vegetation.

Most of the species introduced to the Glacial Deposit are found in the parks of Chicago. I may also here mention the attempt made of introducing Rhododendrons and Azaleas to our parks and gardens, but always with failure, even when the greatest care and study as to soil and natural growth have been considered.

CONCLUSIONS.

Generally speaking, as referred to before, all the species under discussion are found both on sandy and clay soil, consequently the soil conditions need not be considered as to the life of the tree. If we examine the vegetation mentioned on the Alluvial Formation more closely we will find that, following the shores of Lake Michigan from the north on the eastern border toward the head of the lake, the specimens become smaller in growth, and less vigorous. Almost identically like the red cedar, which in the Middle and Southern States is a large and vigorous tree, gradually becomes smaller and smaller toward the north until it disappears as a low scrubby specimen.

Those trees referred to appear also more sparsely toward the head of the lake. Reference is here made to the Sassafras, the Tulip Tree, Nyssa multiflora and the Beech. Tulip Trees introduced into the more fertile Morain are winter-killed, except when planted under very favorable conditions, and even then are subject to being killed by frost at any time. Sassafras comes under the same class.

That the two trees in the Waukegan Cemetery survived the winter of 1898, and the one on the grounds of Mr. Douglas was killed, was due to the fact that this killing freeze was followed by severe rains. The Douglas tree stood on level ground, and consequently had a wet foot. Those in the Waukegan Cemetery were planted near the gutter of a roadway considerably lower than the point at which the trees stood, and the soil absorbed but little of the rain that fell. It is also evident that where the trees have been planted closer to the shores of Lake Michigan, and thereby subjected to the lake and the moist-bringing lake fogs, they survive better than those farther inland. A study of the natural vegetation within a few hundred feet of the shores of Lake Michigan will tell the story.

The Beech *(Fagus ferruginea)*, found in groves twenty or more miles north of the Wisconsin State line, has been distributed toward the head of Lake Michigan within a short distance of Chicago. The two groups, one west of Waukegan, and one at Highland Park, twenty-four miles north of Chicago, are supposed to be native. The other tree referred to is found in a private garden, and smaller specimens are found in gardens farther toward the head of the lake.

The late Thomas Douglas, who was born in Waukegan when Indians still existed within a short distance of the city, at that time a village, was of the opinion that the Beeches at Highland Park had been brought there by the pigeons which at that time, and still later, infested these forests by the millions. The pigeons were fond of beech-nuts, and it is not at all improbable that nuts could have been dropped by the birds, but why do we not find groves of Beeches or scattered specimens farther south? The pigeons were plentiful everywhere at the head of Lake Michigan in those days, and even many years later, but there are no Beeches except what have been planted by man. Another story has it that those trees were planted by the Indians, and I am of the opinion that the Highland Park grove, and those west of Waukegan, were planted by the Indians who frequented these regions very much, and at Highland Park held council. The trees stand close together in a small grove, and cannot be compared with the natural groves north of the State line in height or dimensions. I do not think any of them measure twelve inches in diameter.

The tree referred to farther south within a few miles of Chicago is still smaller and more scrubby in growth, and after forty years has attained a height of less than twenty feet, showing that as we advance toward the head of the lake the Beech becomes smaller and finally disappears.

Referring to the yellow wood mentioned before, its existence is partly due to the fertile and well-drained Morain, and partly to shelter toward the north and west.

Considering the Glacial Drift in the lowlands, we must soon come to the conclusion that this kind of heavy, poorly-drained soil is not adapted for a great variety of trees and shrubs. These lands have not been subject to oxidation for as long a period as the Morains, that have been above water long before the plains arose above the surface of Lake Michigan.

We have seen that the nearer we get to the head of Lake Michigan the less possible it becomes for those specimens described before to live, whether these are planted on the same formation or not. So it is with the Beech and Tulip Tree, native to this region, and many other species introduced; and why is this so? Study for a moment the map of the lands bordering Lake Michigan, and consider that our hot winds come from the southwest across the plains, and our cold winds from the northwest, also across the plains. That these winds crossing great land areas must be dry is evident. The farther we move to the north on either side of Lake Michigan away from the head of the lake, the more we receive these winds across the lake, and especially is this so on the eastern side of the lake, where both the southwest and the northwest winds must cross the lake. That the lake will have a tempering and a moisture-bringing influence on these winds must be evident.

That the changes brought about are remarkable we all know, and that part of southern Michigan bordering on Lake Michigan would never be the fruit-bearing country it is to-day if it were not for the effects as stated before. The Beech and the west side of the lake is benefited in the same way, and more so where the influences of Lake Superior are perceptible, thereby changing the character of the northwest winds, and this is where we extend into the so-called White-Pine Belt. That the better-drained Morain and the greater fertility of these lands must be considered when compared with the low, poorly-drained plains, and the low, fertile, sandy lands is evident, and the foregoing notes have shown this fact. That the Tulip Tree at the head of Lake Michigan has reached its western limit in this latitude must be conceded, and this is true with many other introduced species. So it is that Rhododendrons and Azaleas that beautify the Eastern parks and gardens are barred from our plains, not on account of colder climate, not on account of soil conditions, but on account of the dry winds in extreme cold and extreme hot weather that sweep across our western plains, and this is the only reason that so many beautiful trees and shrubs are barred from our parks and gardens.

INDEX TO PLANT NAMES

(3)