REPORT OF THE CHIEF OF FORESTRY DIVISION.

SIR: I have the honor herewith to submit my third annual report on the work of the Forestry Division. In proportion to the provisions for this work, which have been measured as scantily as usual, the lines of investigation, commenced the year before, have advanced satisfactorily though slowly. No new lines of investigation have been begun, since limitation and not expansion is dictated by the appropriations granted by Congress.

It will be useless to call for "practical" work—whatever may be meant by this term—until adequate means are provided for such. The only possible practical work of this kind which directly encourages reforesting and which the Division, as at present equipped, might perform, namely, the distribution of plant material, had been attempted the year before on a novel and well-working plan, but had to be abandoned because with the funds at disposal this year no satisfactory arrangements in that direction could be made.

DISTRIBUTION OF PLANT MATERIAL.

I have dealt in my last report to you on the desirability of this method of encouragement, if carried out in a proper manner and in adequate proportions; and I may add, that distribution of plant material for agricultural and for forest planting differs in principle as well as in object. While seed distribution in the first case may be desirable for the purpose of introducing new kinds and improving the nature of agricultural crops, the distribution of forest plant material has a different object in view. It has less to do with the introduction of new kinds than with inducing the planting of a crop which without some special inducement would not be planted at all, while its existence and propagation is desirable for the community at large for several reasons. In our country especially, where immediate returns from an investment are more frequently looked for than in older countries and where the practice of forest planting and forest management is not yet established, this kind of encouragement seems quite legitimate, and if carried out on a judicious plan appears the only means for the General Government directly and practically to advance the practice.

In other countries, monarchical and republican in their constitution, this aid to forest industry is employed on a large scale and with great success. Not only do State and county governments resort to it, but societies and even private estate holders consider it within their sphere, and a proper direction of their funds and activity, to furnish plant material either free of cost or at nominal prices. I have given some statistics of this kind of forestry work in my last report and may add the following data, to impress not only the evident desirability of plant distribution but also to give an idea of the extent to which it must be carried in order to be effective:

In Bohemia (area, 20,000 square miles; inhabitants, 5,500,000) during the year 1887 were distributed to communities and small farmers by the council of agriculture 754 pounds of conifer and 152 pounds of deciduous-leaved tree seeds; by estate holders, 1,408,100 conifer plants, 12,450 broad-leaved plants, and 488 pounds of conifer seeds; by nurseries, with Government aid, 1,972,908 conifer plants; or altogether the free distribution amounted to 3,393,450 plants and 1,494 pounds of seed. In the spring season of 1888 these distributions amounted to 1,441,000 plants and 1,590 pounds of seed. The Society of Agriculturists also distributed to the members of the County Agricultural Society of Tepel 12,000 plants. The Bohemian Forestry Association has during the last thirteen years distributed 24,970,987 tree plants and 9,180 pounds of seed, partly free of charge and partly at nominal prices.

In Switzerland (area, 16,000 square miles; inhabitants, 2,700,000) during 1887 there were over 5,650,000 plants and 1,550 pounds of seed distributed, the council appropriating also $26,000 towards reforestation.

In Mæhren, Austria (area, 8,600 square miles; inhabitants, 2,200,000), during the spring of 1888, the government (state and county) distributed 5,954,584 plants; nurseries and estate holders, 1,769,000 plants; so that, as in the year before, nearly 8,000,000 seedlings were given to the small farmers.

In South Australia, a country situated very much like our own Western prairies and plains in regard to climatic and forest conditions, the forest department for several years past distributed large amounts of plant material with the greatest success, as I have more fully shown in my last report.

On this occasion I should not omit to express the obligations of the Department to the forest conservator of South Australia, Mr. John Ednie Brown, who very courteously furnished to the Department, free of charge, several hundred pounds of acacia seed for distribution in the southern parts of the country. It is also gratifying to note in this connection that the tree seeds, a few packages of which the Department was able to send from its stock in return for this courtesy, are reported as germinating very satisfactorily, showing that the complaints occasionally received in regard to the quality of the seeds are chargeable to the inappropriate handling of the same. The Department is also under obligations to Heinrich Ritter von Manner, a prominent grower of osiers in Austria, for a most valuable collection of some sixty varieties of osier, sent gratuitously. The cuttings were distributed among the State experiment stations for the purpose of testing the adaptability of the various basket willows to the different sections of our country. The results of this experiment have not yet been collected.

FORESTRY INTERESTS IN THE STATES.

During the past year it seems that the interest in forestry matters has not only grown more rapidly than before, but is taking practical shape in every part of the country. I have before me reports by the State Board of Forestry of California, by the Forest Commissioner of Colorado, by the Forest Commission of Michigan, by the Forestry Bureau of Ohio, by the Forest Commission of New York.

All of these documents exhibit an advance over the same kind of literature in former years, by becoming more definite in their contents and recommendations, and discussing directly questions of local forestry interest.

Since it is still the office of this Division to aid in bringing about a general appreciation of the objects of forestry, I consider it proper in this place to call special attention to the work of these commissions and to briefly review their reports.

California.—The second biennial report of the California State Board of Forestry constitutes a volume of nearly 200 pages. It is, perhaps, the most important and valuable report yet made by any State forestry board in this country. It is illustrated by twenty-four autotype representations of the characteristic conifers of California and contains six county forest maps, in continuation of similar maps in the previous report, which by shadings and appropriate marks and figures indicate at a glance the forest condition of the counties, the kinds of trees growing on each section of land, and the comparative density of growth.

The first third of the report is occupied with an account of the work of the commissioners during the last two years. One of their principal endeavors has been to effect a reform in the method of cutting the public forests both of the State and of the General Government. These had hitherto been greatly damaged and wasted by persons cutting timber wherever they could find it, without having secured any title to it by purchase. The action of the commissioners in exposing the extent of these trespasses and aiding to bring the depredators to punishment has had the effect of increasing the purchase of the timber lands, with a consequent decrease of unlawful cutting, and at the same time a more careful and economical method of lumbering. The timber entries during the year 1887 and the first third of the year 1888 constituted about one-third of all the timber entries hitherto made in the State. Many of the lumbermen are now adopting a conservative management which contemplates the continuance of the forests as a permanent source of supply and revenue instead of their being exhausted by a single cutting and then abandoned.

By posting in the mountains and wooded portions of the State warning notices, calling attention to the law against setting forest fires, and by the activity of agents of the board in securing evidence against setters of fire, the extent of forest fires has been much lessened. The commissioners estimate that more than ten times the cost of the protective service has thus been saved to the State.

The commissioners have not only endeavored to secure a conservative management of existing forests, but also to induce the planting of bodies of trees in places where they are deficient, and where the native flora is of but little value, by distributing plant material of trees not indigenous to the State. Among these are the catalpa and locust and some of the eucalypts from Australia, and also acacias furnished by this Department. Experiment stations have been established in the different climatic belts of the State, for the purpose of testing the growth of various kinds of trees, and thus ascertaining their desirableness and their adaptation to various situations. The generosity of individuals has made up for the lack of funds at the disposal of the commissioners, by the liberal gift of lands for experiment stations of the value of from seventy-five to a hundred thousand dollars. While testing the quality of trees at these stations, the commissioners have endeavored, by planting the stations in park form, to cultivate the taste of the people and encourage the production of beautiful as well as useful results by tree-planting.

Following the establishment of experiment stations for the purposes of practical forestry, the commissioners began last year the work of supplying a scientific and popular description of the forest trees of California. The larger part of the present report gives the result of this work, so far as relates to the pine trees of the State, which include the pines of the Pacific slope. The description of these trees by the botanist of the commission, Mr. J. G. Lemmon, and the well-executed autotype illustrations of the trees as they stand and also of branches and fruit, make a publication of a very interesting character and of permanent value.*

Colorado.—The biennial report of the forest commissioner of Colorado has been recently issued. One of the most valuable features is a forest map of the State, prepared by the commissioner with much care. It shows the drainage system of Colorado and the approximate location and extent of its forest and irrigated lands, as well as the intimate connection existing between the forests, streams, and irri-

* As this report goes to press it is learned that the energetic and efficient Board of Forest Commissioners, with Mr. Abbot Kinney as chairman, has had to make room for new appointees.

gation systems of the State. This map and the report as a whole should be of great service to the people of Colorado. It contains brief accounts of the native trees, and a statement in condensed form, by counties, of the forest conditions of the State. It shows what agencies are at work to destroy the forests, what means are now used for their preservation, and what further action by individuals and by the State and General Governments is needed for this purpose.

The report shows that the commissioner has been diligent in discharging the duties of his office. In addition to the compilation of the forest map, he has done much by means of circulars and other publications to extend information through the State in regard to the value of the forests and the necessity of preserving them. The great and unnecessary injuries inflicted by forest fires have been set forth. Public meetings have been held in various parts of the State for the purpose of discussing the forestry question in its local bearings. A greatly improved public opinion has already become manifest, which encourages the forest officers in the discharge of their duties, and is preparing the way for more advanced and effective legislation in behalf of the forests. Such legislation, in various particulars, is suggested briefly at the close of the report. The legislature of the State, at its last session, authorized the establishment of four forest experiment stations, in accordance with the provisions of the bill for that purpose which was passed by the last Congress. Two of these stations have been located already by the State Board of Agriculture, and a third will be located very soon.

Michigan.—The first report of the forestry commission of this State was published at the close of the year 1888. The commission was established by act of the legislature, in June, 1887, and organized in October of the same year, for the purpose of furnishing information necessary for the basis of legislation. The commissioners think that the prevention of forest fires is the most important subject for consideration in Michigan at the present time, and the principal work done by the commission during the first year seems to have been that of seeking information, by means of circulars, in regard to the extent and character of the forests in the several townships of the State and the extent of fires among them, the causes of the fires, and the methods of preventing and checking them which have been found most effective. The report contains some illustrations showing the effect of fires in retarding, if not entirely destroying, the after-growth of the forests. It contains, also, a list of the trees indigenous to Michigan, with brief description of their qualities and practical uses. One thousand lumber mills are reported, with a capital of $48,000,000 and a product of $60,000,000 in value, with a working force of 35,000.

New York.—The details of the report by the State Forestry Commission show a distressing condition of affairs, in so far as much of the land, which had lapsed to the State for nonpayment of taxes and forms the basis for the work of the commission, is now being redeemed at nominal prices and passes out of the control of the State, by whose action in the matter of forest preservation it has become valuable.

The forest commissioners urge the enactment of a law for the examination of claims in redemption, and redemption to be permitted only to actual occupant.

They also advocate the amalgamation of the game-protection and forest-protection service, which now requires two sets of officers. They dilate upon the difficulty of bringing timber thieves and incendiaries to justice under present laws of venue. As is only reasonable, they demand for the State the right to sell the old timber and bark, the purchase of wild forest lands, the power to lease small parcels to private individuals for residence, the exclusion of railways from State forest lands, etc.

Altogether, it seems that the State of New York, with the best opportunity for demonstrating a successful management of forest lands, loses this opportunity by inadequate legislation, which handicaps the executive in carrying out the spirit of the legislation.

Ohio.—The State of Ohio owning no forests or land adapted to forestry purposes, the forestry bureau of that State has directed its attention chiefly to the education of the people in regard to forestry matters, so as to induce the individual landowners to cultivate and protect properly their own forests. In the fourth annual report of the bureau attention is called to the general need of information on the subject, and the demand is made that forest botany and forest zoology be taught in the public schools and that, as a first step in this direction, these studies be introduced into all the normal schools and the State University without delay.

Tree planting, it is also urged, should be taught in the schools to a certain extent, and this may be done in connection with the annual Arbor Day celebrations. The secretary thinks the actual planting should not be done by teachers or pupils having no knowledge or experience in the work, but that the school authorities should engage experienced tree-planters to do the work in the presence of the schools.

It is further urged that the State University at Columbus should organize forth with a forestry department in connection with the agricultural college, for the education of professional foresters, of whom there is great need, both for the education of the young and for work in practical forestry.

There should also be a forestal experiment station in connection with the university, supplemented by primary and secondary stations in various parts of the State. The bureau, in connection with its other work, is now engaged in efforts to establish voluntary forestal experiment stations, with fair prospects of success.

It is also a sign of progress in forestry matters that the governor of Pennsylvania, Hon. James A. Beaver, has accepted the presidency of the American Forestry Congress, and in his message to the Pennsylvania State legislature takes special pains to refer to the forestry work of the congress as well as of the special commission appointed by him to examine and consider the subject of forestry in Pennsylvania.

As further illustrating the progress of forestry work in the country, it is necessary to report the doings of forestry and horticultural societies in various other States.

The people of Maine were manifesting increasing interest in the protection and conservative use of our forest wealth by holding, during the last year, a forestry convention, at which a committee was appointed for the purpose of urging the President to use his influence with Congress for the purpose of securing the withdrawal of the public timber lands from sale or occupation, and also to secure, by means of the next census, more ample and satisfactory information in regard to the forest condition of the country. The State Grange of Maine has also taken similar action.

In Massachusetts the Society for the Promotion of Agriculture has from time to time, for many years, offered premiums for the planting and cultivation of forest trees. Last year the society made an award of premiums, amounting to several thousand dollars, for the best plantations, and at the same time offered additional premiums for future planting.

The Pennsylvania Forestry Association, distinguished for its enterprise and efficiency, has done much during the past year, by lectures and the issue of its organ, *Forest Leaves*, to create a proper interest in forestry matters throughout the State. It has exerted what influence it could to induce appropriate measures by Congress for the protection of the public timber lands of the nation. It has undertaken to accumulate a permanent fund by means of which to employ a general agent, and so increase its efficiency. It has also determined to publish *Forest Leaves* regularly every month instead of at irregular intervals.

In Texas and Kentucky State forestry associations have been formed during the last year.

In Ohio interest in forestry has been stimulated during the past year by the exhibition of forest products which was made in connection with the Centennial Exposition at Cincinnati.

A forestry convention was held early in the year at Grand Rapids, Mich. The Michigan State Board of Agriculture was by legislative act constituted a board of forestry, for the purpose of devising and proposing needful forestry legislation. The report of this meeting and of the commission has been mentioned before.

It deserves to be mentioned that during the year a vigorous endeavor has been made to secure such a change in our public land laws as would protect and preserve the public timber lands as a source of permanent use and revenue. This had its initiation with the American Forestry Congress, as I have outlined in my last report. A bill for an act was presented to both Houses of the late United States Congress, the chief provisions of which were the suspension of the sale of timber lands pending a survey of the same, then the permanent reservation of such portions of them as might be deemed necessary for climatic and other reasons, the wood only being sold from time to time under a system of licenses, to be cut and removed under the supervision and direction of Government officers appointed for the purpose. Petitions in favor of the bill from various bodies and from influential persons in almost all parts of the country were presented to Congress, but without effect, and the work remains to be renewed at the assembling of another Congress.

One of the most important events of the year in relation to the forestry reform movement was the meeting in November of the American Forestry Congress and the Southern Forestry Congress simultaneously, at Atlanta, Ga. The two congresses were merged in one, henceforth to be the American Forestry Congress. Three days were occupied with the reading of papers and the discussion of forest topics. Committees were appointed for the purpose of securing appropriate legislation by the National Congress for the protection of the public forests, and by State legislatures for the promotion of the interests of forestry in the several States.

Lastly I should mention, as not the least—perhaps the most welcome—development of the year, the establishment of a journal in this country, which not only devotes a part of its space to the discussion of matters relating to the forest, but is bold enough to enter the name on its title.

Garden and Forest is a weekly journal of horticulture, landscape art, and forestry, published by Prof. C. S. Sargent, well known by his census work on the forest flora and forests of the United States. It has brought during the year a large amount of forestry reading of the first order; and while for reasons of finance it is still necessary to give to the discussion of matters relating to gardening and landscape architecture the lion's share, it is to be hoped that the readers of forest literature will so grow in numbers as to make this part of the paper more and more its prominent feature.

The little publication issued by the Pennsylvania Association, *Forest Leaves*, has also gone on in its modest way, reaching a class of readers and serving a purpose different from that of the more pretentious journal just mentioned. By the adoption of this publication as the organ of the American Forestry Congress, a means of communication will be established between the workers on the field of reform in forest economics.

The general and the scientific press have also brought forth considerable discussion on forestry matters during the year. The question of forest influences has been widely discussed, and especially the influence of forests on rain-fall.

FOREST INFLUENCES.

Since Government action with regard to forest preservation and reforestation is called for largely upon the claim that the forest cover has an influence upon climatic, soil, and water conditions, and thus making forest conservancy a matter of general and public interest, the discussion and settlement of questions relating to these influences should be among the first duties of this Division. Unfortunately, the Division is not placed in such a position as to enable it to do more than compilatory work; the establishment of stations with the special object of ascertaining forest influences, which was recommended in my former reports, is still, for obvious reasons, in abeyance. A thorough discussion and critical review of the knowledge and observations on forest climatic influences so far obtained in other ways has been contemplated, but, as yet, has not been completed.

One of the most notable discussions on the subject of the influence which forests exert on rain-fall occurred during this year in the Philosophical Society of Washington, lasting through nearly three meetings. This was called forth by a paper of the writer analyzing the methods employed in the discussion of this question. This paper was written in answer to an article by Mr. H. Gannet, geographer of the United States Geological Survey, aiming to prove the absence of forest influence upon rain-fall, which had unfortunately found wide circulation in the daily and weekly press. I say unfortunately, because while on the face of it the conclusions reached seemed to stand upon incontrovertible facts, and therefore the general public would be led to believe that a définite settlement of the question had been arrived at on a scientific basis, it was clearly shown in the discussions referred to that the conclusions were by no means justifiable and the flaws in the method and reasoning were made apparent.

Since Mr. Gannet's paper is among the few which refer in their treatment of the question to conditions prevailing in our own country, and since the readers of this report will be interested in seeing both sides of the controversy, it is proper that I should mention his method of dealing with the question and the discussions somewhat *in extenso.*

In the first place, as regards the choice of localities which were to be compared in regard to the amounts of precipitation during different periods, the prairie region comprising Iowa, northern Missouri, southern Minnesota, Illinois, and part of Indiana seemed to offer a proper field because, as it is asserted, during the last thirty years this great area has been considerably reforested by natural growth. On the other hand, Ohio, originally heavily wooded, has, as is known, been quite considerably deforested, and thus promises to yield valuable data for comparison. A third area was chosen, comprising New England and parts of New York, which, originally densely wooded, then almost entirely deforested, is said now to be largely grown up to wood again.

The author then attempts to solve the question whether these asserted changes in the soil-cover have been accompanied by changes in the amount of precipitation.

The rain-fall observations of twenty-four stations in the prairie region, varying in duration from ten years to forty years, are, for each station, divided into two equal periods and the amounts thus obtained for each of the two periods are added, when it is assumed that the sum of precipitation in the second period should furnish a larger number if the rain-fall had increased. It was found, however, that the sums were as follows:

Sum of annual precipitation:	
First half	8,375
Second half	8,032
Difference	—343

That is to say, the second half of the period showed a decrease in rain-fall, namely, 1.6 inch per year; only six stations showing an increase—the others a decrease.

In Ohio, where, according to the popular theory, the rain-fall should have decreased, observations of twelve stations covering periods varying from ten to forty-six years, were similarly treated, with the following result:

Sum of annual precipitation:	
First half	5,911
Second half	5,880
Difference	−31

Five stations showed an increase, seven a decrease. The average decrease was 0.21 inch per year, or so little that it could hardly prove the unfavorable influence of deforestation.

For New England, it is assumed that the period of deforestation lasted until the year 1860, during which time a decrease of rain-fall should be expected; after this time, with the assumed reforestation, an increase should be noticeable. The same operation as applied before, at eighteen stations before 1860 and at fourteen stations after 1860, gives the following result:

Sum of annual precipitation;	
Before 1860:	
First half	8,467
Second half	9,046
Difference	+579
After 1860:	
First half	4,582
Second half	4,582
Difference	0

The first period shows, contrary to expectations, a considerable increase of rain-fall (2.9 inches per year), while the reforestation after the period shows no influence.

Lastly, the author subjects twenty-six stations of the region west of the Missouri, with observations varying from six to twenty-six years, to this scrutiny and finds:

Sum of annual precipitation:	
First half	4,408
Second half	4,468
Difference	+60

Sixteen stations show an increase of rain-fall, but the total increase is not more than 0.4 inch. (The author does not recognize that the stations of longest record show the greatest increase; taking those with records of twelve or more years alone, the increase would be over 2 inches per year.)

The conclusions reached by the author are worded as follows: In regard to the negative results in the prairie region, he says: "I should be very slow to argue from this a deleterious action flowing from the increase of forests, but it seems to militate very strongly against a favorable action upon rain-fall." On finding the decrease for the Ohio region but 0.21 inch per year he says: "It is of course unnecessary to add that this change is too small to have any meaning." In regard to the New England figures, "deforesting seems to be accompanied by a decided increase in rain-fall." The increase of rain-fall west of the Mississippi is also considered too insignificant. The author then sums up in the following very positive deductions: "With these results in view, it seems idle to discuss further the influence of forests upon rain-fall from the economic point of view, as it is evidently too slight to be of the least practical importance. Man has not yet invented a method of controlling rain-fall." And in another place: "We may therefore dismiss as baseless the popular idea of an increase in rain-fall either annual or during the growing season."

In the discussion of this paper, referred to above, it was shown that these conclusions could not be drawn with such positiveness, for the following reasons:

(1) The method employed is inadmissible because it uses incongruous data for comparison, the periods of observations drawn together being of very uneven duration and therefore in their two halves not representing periods of different forest condition.

Most stations are of recent origin and furnish therefore no data for the conditions of older times; by adding half their results to those actually referring to earlier conditions, the tendency would be to equalize the results.

(2) It was doubted that the reforestation of the prairies, on the whole, had taken place to such an extent as to appreciably change its forest area. For the Ohio region it was to be remarked that the main deforestation took place at the end of the preceding and beginning of this century, while most of the stations are only ten or twenty years old (only three are older), and therefore do not present data covering a time of appreciably greater forest area. It was also doubted whether the waste lands of New England covered with a sparse brush-wood could be considered as forest areas exerting an influence.

(3) The material used for the discussion, granting that it presented reliable data, which was doubted, was inadequate for the reasons adduced.

(4) It was shown that periodical variations exist in the amount of precipitation, which can be expressed by a wave-line or curve with recurring high and low levels. By cutting any one period in these in an arbitrary manner, any result may be obtained that seemed desirable. It was therefore advisable to compare only periods relating to the same historic times, and of sufficiently long duration to equalize the secular variations.

(5) Lastly, it was shown that whatever observations of rain-fall we have are absolutely unreliable and useless for the discussion of forest influences, since it is not the rain-fall but the catch of different rain-gauges which we compare, and the rain-gauges which are or have been in use are liable to errors of very considerable magnitude.

The concurrence of opinion then recurred to the position which had been taken by the writer at the outset, namely, that we had no data upon which to discuss the question with precision and on a mathematical basis.

In regard to the last two points, I deem it of interest to reproduce in abstract the papers of Mr. A. H. Hazen and Prof. Cleveland Abbe, of the Signal Service, which were read during these discussions.

Mr. Hazen referred to the secular variations which are known to exist in every series of annual precipitation, and which are of such magnitude as to overshadow any influence like that of the forest. He also pointed out that deciduous forests, such as alone concern us in the regions under observation, can influence rain-fall only during the season of leaf; and if the other seasons are united with this the result will be masked as far as this influence is concerned.

We have several stations in the region referred to with a record of about forty-eight years. Taking the observations of these during May, June, July, August, and September, and summing up separately the precipitation during the first and during the second twenty-four years, we find as follows:

	Summer rain in inches.			
	St. Louis.	Madison.	Muscatine.	Marengo.
First twenty-four years	540	517	545	506
Second twenty-four years	453	451	471	449
Decrease second period	87	66	74	57

These results would lead us to conjecture a reducing influence of forests on rain-fall.

But it is found on projecting the curves of rain-fall observations that a minimum in the secular variation occurs about the year 1877 or within the last period of our observations, and this accounts for the smaller amounts or decrease in the last half of the period.

Besides, the writer argued from his own observations the reforestation claimed for the region in which the stations are situated has been so slight that it could not very well be considered as a factor of climatic influence. He argued further, from the observation that fogs linger much longer over a forest than over an adjoining field, that a greater humidity of atmosphere above the forest must be admitted, which tends to increase precipitation, and since the air is less desiccated over a forest than over an open field, rain-drops when formed in the upper strata are not dried up in their descent when reaching this air of greater humidity as they would be in the drier atmosphere above the field.

Professor Abbe showed that all observations hitherto made with rain-gauges at various heights above ground agreed in demonstrating a very decided diminution in the catch of the gauge, the diminution increasing with the height. The relation between the catch at any height and that of the normal gauge at the ground is, approximately:

$$\text{Deficit} = \frac{\text{Lower} - \text{Upper}}{\text{Lower}} = 0.07 \times \sqrt{\text{altitude of upper in feet}}$$

This deficit is due to the effect of wind in drifting the slowly falling particles of snow and fine rain out of, over, and away from the gauge. The numerical coefficient, 7 per cent., is an average for the winds, snows, and fine rains of Europe, and varies with the special character of every wind. The only practicable method of allowing for this effect, and one that really does give a sufficiently valuable correction to ordinary rain-gauge measures, consists in placing several gauges near each other and at different altitudes (h' and h'') and reading their indications at every storm (u' and u''), then by elimination deducing the reduction (x) to normal gauge of the readings for that storm. The equations are:

$$\frac{u'}{\text{normal}}=1-x\sqrt{h'} \qquad \frac{u''}{\text{normal}}=1-x\sqrt{h''}$$

Whence

$$x=\frac{u'-u''}{u'\sqrt{h''}-u''\sqrt{h'}}$$

And

$$\text{Normal rain-fall}=\frac{u'}{1-x\sqrt{h'}}-\frac{u''}{1-x\sqrt{h''}}, \text{ etc.}$$

The author showed that the shielded gauges devised by Prof. Joseph Henry in 1856 and Prof. F. E. Nipher in 1876, and the protected gauges used by Börnstein, Wild, and Hellmann, to a very considerable extent overcame in a mechanical manner the injurious influences of eddies at the mouth of the gauge caused by the wind, but they do not give much satisfaction in the measurement of snow.

The differences exhibited by a number of gauges scattered over an area of two square miles, as for example in the experimental rain fields near Berlin and the gauges scattered over the District of Columbia, are not entirely due to local geographical distribution of rain-fall, but also to local peculiarities of the strength of the wind by reason of which the catch is affected as above.

The chronological irregularities in the record of a single gauge kept for a long time in one locality are very largely due to chronological irregularities in the wind attending the rain and in the character of the precipitation, namely, fine rain or snow. Thus questions of the gradual change in climate as shown by rain-fall can not be intelligently discussed until the records of the rain-gauges are corrected for the insidious and, relatively speaking, enormous errors introduced by the action of the wind at the mouth of the gauge.

The author stated that already in Bavaria and in India, during the past two years, the importance of this correction has been realized, and the proper method of computing it, as above suggested, by two gauges at different heights, has been introduced. He added that, in order to rescue from condemnation the records of long-standing gauges in this country, it would seem proper to establish near each one another gauge at much lower or higher altitude, in order, by the comparison of the two, to obtain an approximate correction of the past records. At the present time there are no records of rain-fall in this country adapted to give satisfactory answer to any question involving variations in amounts of only 5 or 10 per cent. of precipitation.

Since it will aid the student of these questions to have before him a brief review of the methods that have been employed in discussing the influence that forests have on climate, I reproduce here such parts of my paper above referred to as seem appropriate.

While we may discuss to a certain limit, separately, the influence of the forest on any one of the different factors which we comprise under the collective name of climate, upon rain-fall, for instance, it must be apparent that such an intimate relation exists between the different factors of climate that it is almost impossible, at least impracticable, to confine the discussion to one factor or set of factors without reference to the others. From a practical stand-point the aggregate effect rather than that of its component parts is of significance, the total influence being that which is of practical value. What does it matter, for instance, whether it is by increased precipitation that the forest benefits the field or whether the same physiological effect is produced by greater frequency of rains, or by more seasonable rains, or by increased relative humidity in other ways, or by raising the water level and increasing or advantageously disposing of the available water supplies through favorable ground-water conditions or surface channels?

And when we come to discuss forest influences with a view to a national forest policy, the further mechanical influence which a forest cover exerts upon water supply and water distribution, upon soil conditions and health—influences very distinct from those on climatic conditions and often of greater importance—demands proper attention and investigation, and it will not do to divide and discourage the work of forest commissions and forestry associations, as has been done, because seemingly one of the influences upon which they base their activity remains unproven.

As is natural, the first suggestion that a relation between climate and forest area exists came from general observation.

Especially when history had reported fertile districts with favorable climate, surrounded by verdant groves, where now desert wastes, inhospitable climate, and treeless mountain sides are found, the conclusion lay near that there existed a relation between the forests on one hand and fertility and favorable climatic conditions on the other.

According to Humboldt (Kosmos, Vol. II, p. 322), the decrease of humidity and rain-fall was recognized as a consequence of forest destruction as early as the fifteenth century. Sully, in the sixteenth, and Colbert, in the seventeenth century, warned against forest devastation, and the examples adduced for the fact of its bad effects form a voluminous library. Among the eminent men who have used this method may be mentioned Du Monceau, Réaumur, Buffon, Humboldt, and Arndt.

This method of proving the proposition, which has been the most popular, and is still largely in vogue, may be called the historico-statistical. It can not be entirely dispensed with and its conclusions disregarded, but its results must be considered with great caution, for not only are the reports of the facts in many cases dubious, but the inferences are not always reasonable.

About the middle of this century, with the development of physical and especially meteorological science, a second method was applied. This method, which may be called the argumentative method, attempted, upon a theoretical basis, to discuss and reason out the assumed relation by employing the accumulated physical knowledge which, scanty at first, has lately, however, been considerably increased.

Among the prominent meteorologists who employed this method, the first was Becquerel. The result of this method has brought us considerably forward in the recognition of the direction in which an influence would be possible; and while it has not been able either to prove or disprove satisfactorily the existence of the same, nor to advance us in the knowledge of the degree and quality of the influence, if any, it has cleared the way for a more scientific consideration and investigation of the subject.

The theoretical positions and conclusions resulting from this method may be formulated in the following twelve theses:

(1) We must be clear as to what shall be considered as "forest." It is evident that, according to composition, height, and closeness of growth, and size and extent of the forest, etc., the conditions must vary considerably. The position towards prevailing winds, water surfaces, mountains, the altitude, distance from the sea, and other disturbing influences, and the seasons also must be taken into account.

(2) The inquiry must discern between mechanical and physical effects, climatic conditions of the atmosphere, and hydrologic and mechanical conditions of the soil. It must also discern between an inquiry on the one hand into the climatic conditions of the forest interior and the changes produced over the same area by deforestation, and on the other hand into the influence of a forest area on its surroundings.

(3) As regards the climatic conditions of the forest interior in comparison with the open plain, the following facts seem established: (*a*) The mean annual temperature and the temperature extremes or range of temperature of the forest air is lower; especially in summer the days are cooler, the nights warmer. (*b*) The relative but not the absolute humidity is greater. (*c*) Precipitation seems to be more frequent and greater in amount over forest areas.

(4) In order to effect any tangible influence a distribution of field and forest must exist which allows an exchange of climatic peculiarities, such exchange being possible only by diffusion vertically and by circulation of air currents, local currents, or general air movements horizontally.

(5) Local currents set up in the same manner as by large water surfaces, through the difference in the temperature of forest and field during clear sky and quiet air, bring in summer in the day-time cooler air from the forest to the lower strata of the field, and to the higher strata during the night warmer and moister air which tends to formation of dew and mist.

(6) General air currents may be influenced variously according to their quality and direction. A windward position of the forest is necessary to have its climatic peculiarities communicated to the field. The dry, warm currents of the summer seem to be best capable and likely to carry the influence.

(7) Active transpiration in summer must tend to increase humidity of the air above the forest, and air currents nearly saturated passing over it may be brought nearer to condensation while the open field tends the other way. The cooler air of the forest tends to condense any warm, moist currents passing over it. The cooler stems and branches in winter and the slower rise of temperature in the spring in the forest tends to condensation, while the mechanical retardation of air currents which have begun to deposit their moisture tends to increase the precipitation.

(8) The mechanical effect upon the horizontal movement of the air currents necessitates an upward movement, which has a cooling effect and consequently increases their relative humidity.

(9) The greater humidity above the forest tends to enlarge and multiply the rain-drops of a falling rain.

(10) Mountain forests in spring favor precipitation in their interior; in fall, when they are relatively warmer, the opposite tendency prevails. Mountain forests on the leeward side increase the tendency towards condensation of dry, warm, and of moist currents.

(11) The condensation and precipitation may take place above the forest and thus render the currents drier after passage, or else they may carry their increased stores of moisture to the field, the temperature and moist conditions of which will determine their utilization.

(12) The effect upon air currents in contact with the atmosphere above the forest reaches only the lower strata, while all the heavier rain-falls are precipitated from greater heights (1,500 to 2,500 meters).

A very able review of the theoretic considerations which bear upon the philosophy of the forest influences upon climate, lately published by Dr. Hornberger, summarizes as follows:

(1) Theoretically considered, a climatic influence of the forest upon its surroundings may quite reasonably be assumed, yet the same considerations which lead to this conclusion allow us also to prognosticate that this influence is not very significant (considerably less than is often believed).

(2) In regard to the quantity of this influence and the distance to which it extends we possess no positive data; those extant show at least the insignificance of this influence.

It is, however, undeniable that the data which the author recognizes as satisfactory to himself, upon which he draws his inferences, would prove him *a priori* biased in opposition to the accepted theory; and while he strives faithfully to explain the physical conditions, his inferences are certainly tinged by his bias.

The next step and method of demonstration employed was the mathematical one, using numerical data which had either accumulated independently of the question or were specially provided for the purpose.

We have here to distinguish two methods, a wholesale and a retail one, if I may so express it, or, more scientifically speaking, the one using large averages and comparing data from extensive areas, not specially supplied for the purpose, the other comparing directly data obtained in confined localities, by direct detail measurements within and without forest areas.

The latter method, which I call the retail one, is the one now largely adopted by German investigators.

The first attempt to obtain for the settlement of this question a series of exact methodical observations dates back to the year 1864, when Dr. Ebermayer, professor at the University of Munich, constructed the necessary apparatus, and, with the aid of the Bavarian Government and forest administration, established, in 1866, the first three double stations (a set of meteorological instruments being observed within a forest area and another set simultaneously in a field near by), with an extension in the following year to six stations. In 1869 Switzerland followed with three stations; in 1870 Italy established a station, and in 1874 to 1877 Prussia entered upon this field of work, having now sixteen stations in connection with the forest experiment stations; and to-day quite a number of such double stations are collecting data in all parts of the country.

A summary of the first results of the Bavarian stations was published in 1873, and at present monthly bulletins and an annual summary are published by the Prussian stations, the thirteenth annual being now due.

The object of these double stations, at which instruments are placed within the forest and in the open field, is to note—

(1) The temperature of the atmosphere within and without the forests.

(2) The temperature in the forest at 1.5^{m} above ground and in the tree-tops.

(3) The degree of humidity within and without the forests.

(4) Evaporation within and without.

(5) Quantity of precipitation reaching the ground.

(6) Temperature of soil at six different depths.

The points of observation at the Prussian stations are chosen 200^{m} distant from the edge of the forest both ways. An enormous amount of material has accumulated, but as yet has not been summarized or turned to account. It is difficult to see how anything else can be demonstrated by it than what is already known, namely, that the meteorological conditions within the forest are different from those prevailing without. Whether and how far this difference is communicated to the open field can certainly not be proved by the data obtained. By establishing points of observation in the field at varying distances it might have been possible to demonstrate the presence or absence of climatic interaction between forest and field.

In the wholesale methods, which use data obtained over large areas independently of the special object of this proposition, we may again discern two ways of manipulation. The one comparing the data found during various periods at the same stations and bringing them in relation with forest conditions existing at the various periods; the other comparing data obtained simultaneously from stations situated differently as regards forest conditions, but capable of being brought to a proper basis of comparison as regards other climatic influences.

Mr. Gannet's method belongs to the first class. I have spoken of it before, and shown that his arrangement of data—even if they were reliable—is inadequate and leads to no result.

A more advantageous application of this method has been attempted by Prof. Mark W. Harrington, and although he does not inquire into, or at least leaves doubtful, the question of the causation, his results seem to indicate an increase of rain-fall over the same area with which Mr. Gannet deals. His application of the wholesale method consists in comparing isohyetal lines constructed for two different periods, about thirty years apart. The main objection to the conclusiveness of this method is that in the present case it depended on too inaccurate data.

The second class of wholesale methods which compares simultaneous data of stations differently situated as regards forest conditions, has been lately employed by the eminent Russian climatologist, A. Woeikoff. He chooses his illustrations from the northern part of India where, as the author states, the temperature variations from south to north are exceedingly slight, being, between the nineteenth and thirty-first degrees of latitude, only 0.08 degree C. for each degree of latitude, and where the months of April to June represent the hot season and are very dry. Between the twenty-third and twenty-seventh degrees there exist treeless regions, especially the larger part of Bengal and the Northwest Provinces, while the provinces of Assam, Sylhet, and Cochar, etc., are densely wooded.

He shows by tables of meteorological data that in the wooded regions of Assam, even at a considerable distance from the sea—

(1) The hot season from April to June, which prevails on the open Gangetic plain, is absent.

(2) The mean temperature of the months of April to June (the hot season) is 4 to 6 degrees lower than in the treeless region at equal

distance from the sea (a difference which at such a latitude and such nearness of stations—550 kilometers in the plain—and the absence of mountain influences is nowhere else observed).

(3) The temperature maxima differ even more than the means, because in the forested area not greater than those of Southern or Middle Russia, while in the treeless part, even near the sea, temperatures of 40 and 45 degrees C. are frequent.

(4) The humidity of the atmosphere is great in the densely wooded part of Assam even in April to June, namely, 40 and more per cent. above the mean relative humidity of treeless stations equally distant from the sea.

(5) This may explain the earlier beginning and the regular increase of precipitations over the wooded areas, while in the west a sudden increase takes place.

(6) The relative humidity is also greater in the forested area during the dry months, especially December, although no precipitation may fall, the relative humidity being 82 per cent. as against 60 per cent. in the open country, at two stations equidistant from the sea.

The author admits that whenever the general climatic conditions of a subtropic country are opposed to precipitation, even over larger forest areas rain will not fall; for instance, when the wind is a constantly descending one or comes from cooler, drier regions, like the northeast winds in Assam from November to February.

His tables show the temperature, moisture conditions, and precipitation at ten stations within the twenty-second and twenty-seventh degrees of latitude, and the extreme differences of annual precipitation noted are 687^{mm} and $2,975^{mm}$, or a variation of $2,288^{mm}$; and if we take two stations equally distant from the sea for comparison, Patna and Goalpara, the difference is $1,370^{mm}$, a significant figure when we consider that the two stations are only 340 miles from each other.

Thus it would appear that, at least for subtropic regions, the effect of forest cover in reducing temperature and increasing precipitations may be accepted.

Woeikoff further investigates whether the influence of the forests upon climatic conditions of their surroundings may also be proved for latitudes of 38 to 52 degrees north—all the west European continent—and he proceeds as follows:

Taking the temperature of July as that of the warmest month, and assuming that on the whole the temperature at the Atlantic coast is lower and rises toward the interior of the continent, he compares the temperature of a number of places situated near the fiftieth degree, the observations being all taken outside of the forest. To bring them upon a uniform basis for comparison, he reduces the observed quantities by assuming the increase of temperature toward the south at 0.5 degree C. per degree of latitude, and for every 100^{m} of altitude he assumes a temperature difference of 0.7 degree; he does not, however, reduce to sea-level but to 200^{m} altitude, in order to avoid many reductions and so to lessen the possibility of error. Thus he obtains mean July temperatures for his line of stations reduced to fifty degrees north latitude and 200^{m} altitude.

He observes in this series a rapid rise of temperature from the Main River, then a considerable reduction in the eastern and western Bohemian stations, which is credited to large forest areas there prevailing, while in the Bohemian basin the temperature is higher, as it is also in Silesia, and again much lower in the well-wooded Carpathian Mountains of Hungary; the influence of these large wooded areas is still noticeable in East Galicia as far as Kiew, where the neighborhood of forest and morasses works in the same way; while in the steppes the highest temperature is reached.

In the same manner a series of stations lying on or near the forty-sixth degree are treated, reducing their July temperatures to the theoretical temperatures for the forty-sixth degree and 200^{m} altitude; and another series of stations is worked out for the forty-fourth degree in Croatia, Bosnia, Herzegovina, and Dalmatia; and here the heavily-wooded Bosnia is found from twenty-five to forty-five degrees cooler.

The results of these comparisons lead the author to conclude that in the western part of the continent large forest areas influence the temperature of neighboring localities and interrupt the normal increase of temperature which should occur in going from the Atlantic Ocean into the interior of the continent, to such an extent that even regions far in the interior have a cooler summer than those nearer the sea.

He concludes, further, not only that there exists a climatic influence of the forest, but that it exerts itself over considerable distances according to composition, size, and position of the forest area; that, therefore, *forest planting or deforestation offer a means of changing considerably the climate.* And he adds:

> Some people hold that since the forest increases precipitation it is only necessary that forests be planted to wipe out the deserts. But such an extreme position is not tenable. Although the forest economizes the precipitation that has fallen, storing it for a long time and increasing the quantity to a certain degree, yet many parts of the earth are too arid to bear forests (?), for forests need much water. On the other hand, thinly-stocked forests and those composed of trees with a foliage covered with a wax-like substance which decreases transpiration, while better capable of sustaining themselves in dry climates than denser forests and those composed of trees with more active transpiration, yet do not mitigate the heat and moisture in the same degree.

One may say in criticism of this method, that the factors of reduction are somewhat arbitrary and may not be correct, and that the divergence of the reduced temperatures may not be caused by the forest; and further that the difference is established (if at all) only for the summer temperatures, but not for the yearly or daily variations, therefore the data are insufficient to prove the propositions in their generality.

Mr. Henry F. Blanford, meteorological reporter to the government of India, also asserts that the difference of rain-fall in the two localities compared by Woeikoff may be attributed to other physical conditions. He thinks that a satisfactory solution of the question must await the production of a series of rain-fall records from a single region, which is forested for a time, and then deforested, or *vice versa,* and he contributes such an observation from the Central Provinces of India south of the Satpura Range, where five-sixths of an area of 61,000 square miles had been greatly deforested.

The records from the years 1865 to 1875, made during the time of deforestation, are compared with those of the following period, when, through government interference, systematic reforestation began. During the second period the rain-fall has progressively increased, until the mean for fourteen stations appears to be 20 per cent. more than it was for the first ten years.

Dr. Brandis, for a long time forest inspector-general of British India, also cites another example of the same kind from the Central Provinces north of the Nerbudda River, where the increase of mean annual rain-fall has shown a gradual increase of 6.2 inches or 12½ per cent. in ten years, after an area of 600,000 acres of woodland had been protected against fires and had grown up densely. He says:

The relations of forests and rain-fall in India are manifold and mutual. When thirty years ago forest management was systematically organized, it was mainly with the object of securing continuity of wood and other forest products, and in mountainous districts to secure the loose soil from washing off, to prevent the filling of the rivers with sand, and to check the floods. Later on, experience taught that especially in regions with an arid climate, and even moister regions during unusually dry years, the grass grew more luxuriantly in the woods and gave more plentiful pasturage than on unwooded lands.

But it had not been anticipated that forest preservation and reforestation would in any degree affect the annual precipitation. Yet during the last few years it has become apparent that in some sections an increase of the annual rain-fall has gone hand in hand with forest protection.

In that part of the Central Provinces which lies between the Nerbudda River and the plains of Nagour and Raipur, a total area of nearly 600,000 acres of forest has been protected for a series of years against the annual fires of the hot season.

The records of seven stations for eighteen to twenty years allow the following tabulation of mean annual precipitation:

Stations.	Precipitation for different periods.		Precipitation for 1876–1885.	Difference.
	Period.	Precipitation.		
Badnur	1867—1875	39.83	47.83	+ 8.00
Chindwara	1865—1875	41.43	48.48	+ 7.05
Seoni	1865—1875	52.07	54.76	+ 2.69
Mandia	1867—1875	53.58	56.32	+ 2.74
Burha	1867—1875	64.51	71.65	+ 7.14
Bilaspur	1865—1875	41.85	54.81	+12.96
Raipur	1866—1875	51.59	54.47	+ 2.82
Annual mean	....	49.27	35.47	+ 6.20

Blanford, who has recorded these observations in the above manner, adds that these results, of themselves, are not proof absolute for the influence of forest preservation, since possibly the earlier observations were less reliable than the later, but that these observations may be considered as addenda to the accumulating signs of the existence of such influence on rain-fall.

But even this method, which would class with my retail methods, although seemingly simple, before it can be admitted as conclusive, must, as the writer says, be guarded by those special precautions which are demanded by strict scientific inquiry.*

* The above figures were hailed with satisfaction by those who are bound to prove by statistics the forest influence on rain-fall.

Unfortunately, as this report goes to press, their value is entirely vitiated by the following statements made in the *Indian Forester*, January, 1889, which again admonishes us to be careful in placing too much weight on statistics:

"Mr. Blanford, in order to assure himself of the value of the rain-fall returns he employed in the discussion of the Central Provinces, wrote to the chief commissioner on the subject, to which the reply was received that 'the chief commissioner fears that these records of rain-fall previous to 1883 can not be accepted as altogether reliable.' The commissioner explains the reasons why the records appear unreliable, and adds: 'Hence one result of the unsystematic registration of the rain-fall in the Central Provinces is to postpone the decision of the influence of forests on rain-fall in that area for another twenty years. It is only one of the many cases of the worthlessness of unsystematic observations.'"

It is of interest also to note the following from the same source:

In the following extract from the same report Mr. Eliot refers to the observations recently undertaken in the forests of the Saharunpoor district. For the reader un-

Lastly, I wish to call attention to the latest, most valuable scientific work which has been done to decide the important but difficult question of the influence of forests on precipitation. I refer to the work of Dr. F. J. Studnička, professor of mathematics at the University of Prague, published under the title "Basis for a Hyetography of Bohemia," in which the results of many years of observation at seven hundred ombrometric stations are embodied, critically sifted and scientifically considered.

The author employs a wholesale method which is quite novel, complying with Woeikoff's idea that it is necessary to reduce the observed data upon a common basis for comparison.

To understand the significance of these observations an inspection of the map of Bohemia will be desirable, which shows it to be a basin surrounded on all sides by high mountains.

The work of ombrometric observations, although begun in Bohemia during the last century, was newly organized in 1879 or 1880, when a systematic net of ombrometric stations was instituted, and in 1885 and 1886 it was extended to over seven hundred stations, for the purpose of obtaining accurate data of the quantity and distribution of precipitation over the kingdom. Uniform ombrometers were used and very carefully placed. As at present organized, there is one station for every 75 square kilometers (about 30 square miles). No other country, I believe, can boast such a service. Although the time of observation at most stations has been short, and the averages would have been more accurately represented by an extension of observations for ten to twelve years, yet the last four years of observation, for which all stations furnish data, according to the author, represent two extreme and two average years, and are therefore quite useful.

The very large mass of material permitted a sifting out of doubtful observations without impairing the number of available ones for the construction of a rain-map of Bohemia, showing by isohyetal lines seven rain-belts or zones; the zones are arranged so that the lowest shows less than 500^{mm} rain-fall, the three following differ by 100^{mm} each, the fifth and sixth by 200^{mm}, and the seventh by 300^{mm}; the last showing, therefore, a rain-fall of $1,200^{mm}$ to $1,500^{mm}$.

The central basin divides itself into two halves by a line from north to south, running somewhat east of the middle Moldau, crossing the Elbe near the mouth of the Iser, and following the latter river; the western half showing the smaller amount of precipita-

acquainted with the Western Himalayas it is necessary to explain that a *rao* is a water-course issuing from the hills, and having, generally, a broad, shallow bed, which consists mainly of bowlders and shingle, and is therefore quite dry or almost dry, except after a continuous heavy shower. Mr. Eliot has not mentioned that in each *rao* levels are accurately taken every year along one and the same line, in order to note the changes that may occur in the section of the *rao* in consequence of the fire conservancy of the entire basin above.

"A different method has been introduced in the Saharunpoor forest division. Twelve representative *raos*, between the Ganges and Jumna Rivers, have been selected for purposes of observation by the inspector-general of forests and conservator of the school circle, and in each forest chowki a rain-gauge is suitably placed. Five of them are located in the forest of Sakrauda, which is neither closed to grazing nor protected from fire. The rain-fall measurements will be made by the forest guards, and the returns submitted to the meteorological department for critical examination. These observations will probably give a valuable series of data for testing the effect of different forest conditions in modifying the amount of rain-fall, and hence also probably throw some light on the general question of the influence of afforestation on rain-fall."

tion, namely, 500 to 600^{mm}; the eastern with 600 to 700^{mm}, continuing in a small belt along the foot of the Erzgebirge and the Boehmerwald encircling the first zone.

The other isohyetal lines do not embrace continuous areas, but follow in small belts the trend of the mountains. The largest amounts of precipitation are found in belts or islands in the higher altitudes of the mountains which surround this great basin. The continuity of the zones is much interrupted, so that it would be difficult to describe them without a map.

The maximum of rain-fall with over 1,200^{mm} is observed in the south near the sources of the Moldau and Motawa, in the north near the sources of the Elbe, Iser, and Aupa on the range of the Schneekoppe. In regard to the distribution through the months, the experience has been confirmed that with increasing absolute height the winter precipitation increases in greater proportion than the summer precipitation, while those of spring and autumn are nearly equal.

Sufficient material was on hand from which to calculate the influence of altitude on the increase of precipitations, although for altitudes above 500^{m} the material is not considered sufficiently reliable. Yet the general law is well shown that with the altitude the quantities of precipitation increase in a retarded progression. This progression is calculated by forming altitude zones from 100 to 100^{m}, grouping the stations in each, calculating the mean elevation and also the mean annual precipitation as observed for each class; then by dividing the difference of precipitation in the neighboring two zones by the difference of altitude the amount of precipitation which corresponds to each 1^{m} elevation within that class is found. With this figure the average amount of rain-fall which theoretically belongs to each station according to its absolute elevation can be approximated by adding to or subtracting from the mean precipitations of the class as many times this amount as the actual altitude differs from the mean.

An example will make this clear:

Tetschen, for instance, is situated 150^{m} above sea-level. According to the table the average elevation of thirteen stations of the lowest zone, to which Tetschen belongs, is 182^{m}, with an average precipitation of 506^{mm}. Now Tetschen has an elevation 32^{m} lower than the average; its normal rain-fall should therefore be $32 \times 0.79 = 25.4^{mm}$ less than the mean of the class; hence, theoretically, according to its altitude, the quantity of rain-fall for Tetschen should be $506 - 25.4 = 480^{mm}$; that is, 248^{mm} less than that actually found in an 8 years' average.

By using the figures for the two extreme zones and dividing by 100, the mean increase of precipitation for every 100^{m} elevation is found to be 69^{mm}.

And now comes the application of this method to our proposition. The author argues that if the actually observed rain-fall differs considerably from the theoretically determined, this is an indication that special agencies are at work.

He finds now that of the one hundred and eighty-six stations which he subjects to scrutiny (these offering the longest and most trustworthy observation), forty-eight show a considerable difference between the observed and the theoretically expected rain-fall, and he finds also that these stations are situated in the most densely wooded portions of the kingdom.

The increased rain-fall on the forty-eight stations is so considerable that a sufficient quantity may without losing significance be ascribed to other local causes, as for instance, height and form of a mountain range in front or back, etc. Besides, the greater amounts of rain-fall at these stations have been used in calculating the averages for the altitude zones, magnifying therefore these averages so that the actual difference between the calculated quantity and the actually observed one appears really smaller than if the quantities from deforested and forest areas are compared.

Expressed in percentages of the height of precipitation, an increased rain-fall is shown for several localities in very large quantities, which will allow considerable reductions for other influences without losing their significance for the main proposition.

Especially important appears the fact relating to two stations near the rain minimum, which also shows this influence of the forest.

Lastly, as a matter of interest I may state that the water balance is drawn for the whole kingdom, which is of special value because the political boundaries coincide with those of the Upper Elbe watershed; therefore it is easy to determine how much of the yearly rainfall is removed by the natural water-courses. According to the calculations made for the various zones by addition, the total precipitation upon the area of 51,955.98 square kilometers (about 20,000,000 square miles) of the kingdom is found to be 35,398,670 cubic meters, of which the Elbe carries about one-fourth or 10 cubic kilometers to the sea. This figure represents a mean rain-fall for the whole country of 681^{mm} while the mean of observation is 693^{mm}.

From the recital of these methods, their results and the difficulties attending their application, it would appear that no one of the methods employed will alone be sufficient to investigate such a complicated relation in its generality as that which they try to establish or refute. All of them, modified and provided with such safeguards as will exclude the many disturbing influences, will have to work together towards a solution of the question, which is by no means settled as yet.

It has been safely established by experiment that all soil covers, whether they consist of grass, agricultural crops, shrubs, or trees, derive very considerable quantities of water from the soil which they transfer to the atmosphere. The influence of a forest may therefore not be greater than that of any other vegetable cover—as long as the soil remains so covered—in increasing the humidity of the atmosphere, especially since the amounts of evaporated water from various forms of vegetation do not differ appreciably enough in quantity. An influence on the amount of rain-fall, which is very different from an influence on the distribution of rain-fall, may possibly be observed where deforestation takes place over wide areas and where the soil is not again clothed with vegetation, as has undoubtedly been the case in the arid regions and as may happen on mountain sides, where the earth is carried off by the waters after deforestation.

In regard to the influence upon amounts of precipitation, the question can probably be only between bare soil and soil covered with vegetation, but not between forests and other forms of vegetation.

I ought to make mention here of a most interesting account of the influence of deforestation in Australia, which has perhaps some bearing on our own conditions in the western treeless regions, and which tends to show that a forest may, under given conditions, exert very undesirable influences. It is published by R. von Lendenfeld. The writer premises "that the influence of forests in Australia differs from that in Europe." The opinion of the inhabitants is divided upon this point; the most general opinion is that with deforestation the climate becomes drier, while the squatters and sheep owners deny any influence.

Australia is very dry, and with the exception of the northern part, which is subject to tropical rains, and the eastern and southeastern mountainous shore, the rainfall is exceedingly small. Even near the coast of New South Wales and Victoria the average annual precipitation is only 8 inches.

All plants possess special apparatus for increasing the water supply from below, deep-root systems, and for diminishing transpiration.

Almost all trees and shrubs of the interior of Australia produce large amounts of etheric oil. This cools the leaves by its evaporation, and spreads itself in gaseous form over the forest. The air thus filled with ether is less pervious to heat rays than the pure atmosphere, and thus the tree protects itself against heat and rapid transpiration. The eucalyptus trees turn their leaves obliquely to the sun, in order to reduce the amount of insolation.

Besides these protected plants, there are many herbs and grasses which lack any protection, but, being prolific seeders, after every rain their seed lying in the soil germinates and quickly covers the bare ground with a fresh green, but as soon as the water of the superficial strata is consumed they die.

The trees, sending their roots into the depths, consume all the water of the lower strata, so that no grass is seen in the forest; the soil is smooth and hard like a stone.

When it rains in such forests the greater amount of the water flows off over the hard, smooth soil without being able to penetrate the closely-packed, impervious soil.

Therefore here the forest does not prevent the rapid flow of the water, and does not increase the humidity of soil air.

After deforestation the grasses spring up, utilizing the ground water, which now, by capillary attraction, can reach them from below. This vegetation makes the soil porous, and the flow of water after rain is impeded; and since thus the water is retained and evaporated gradually, the humidity of the atmosphere is increased.

We therefore conclude that in warm and dry regions, like the interior of Australia, deforestation brings increase and not decrease of humidity and precipitation.

One of the most important influences claimed for the forest cover is that upon the water conditions and drainage of the soil. In this respect the year has brought very valuable results of experiments by Dr. E. Wollny and E. Ebermayer, who independently determined the influence of vegetable covers of the soil upon temperature and water conditions, and have with these settled pretty thoroughly the question of these influences. I regret that lack of space forbids a recital of these experiments and results.

TECHNOLOGICAL INVESTIGATIONS.

The two main lines of independent investigation in which the Division has been engaged during the year have been a continuation in the studies of the life history of our important conifers, so that now monographs on the more important Eastern conifers are ready awaiting publication, and secondly an investigation into their technological characters and qualities and the conditions under which these qualities are attained; somewhat on the same plan which was pursued by the eminent German forest botanists, Dr. R. Hartig and Dr. O. Noerdlinger in regard to the German timber trees.

This investigation had been planned late in the year 1887. Through the courtesy of Prof. V. M. Spalding several students at the botanical laboratory of Michigan University were engaged in preliminary work, studying microscopically the structure of various pines under the direction of Professor Spalding. In the course of the work, however, it was found that the dimensions of the undertaking were such as to require the close and constant attention of one man exclusively, such as Professor Spalding felt unable to give.

In consequence, early in the year 1888, Mr. Filbert Roth, curator of the museum of the Michigan University, was engaged to conduct these investigations in timber physics.

As I have explained in my report for 1887, while forest biology contemplates the forest and its components in their *living conditions*, I have grouped under the name of "timber physics" the results of all investigations into the character of the *dead material*. It is the analysis of our crop which will lead us to understand better the conditions under which we may grow it, and therefore these investigations are of as much practical value to the forest planter as those into the life history of our trees.

It would be considered folly for an agriculturist to grow a crop, which though capable of existing in the climate in which he operates, does not produce the fruit for which the crop is grown or the qualities for which it is prized. Still more so is it necessary for the forester to know what are the qualities for which a special timber is prized and under what conditions it can be expected to produce those qualities. To determine these questions is the object of these investigations.

I have divided the investigations in timber physics into the following separate branches:

The *anatomy of woods* considers the interior structure of the wood material, the arrangement of the various cell elements, fibers, canals, etc., which make up the body of the timber.

The structure of the timber stands in relation to its quality as cause and effect, or premise and sequence. Although there can be no doubt in regard to the existence of this relation, there is but little known of the degrees of qualities as dependent upon the modifications in the arrangement of the cell elements in the wood structure; the differences of quality of the different timbers are not, either, known positively; what we claim to know in this respect is assertion, rather, and supposition, not resting on exact experiments and scientific investigation.

Under this head it is necessary to study under the microscope not only the elements that form the wood, and the relative amounts of each of them in given areas, and their position, but also the gross anatomy as represented in the growth of the annual ring, the size, and rapidity of development, and its appearance upon the transverse section and through the length of the tree.

The *chemical physiology* of woods will teach us the dependence of our forest trees upon the mineral constituents of our soils; also the derivatives which we may extract from them, the amount of charcoal which ought to be obtainable, and its quality, etc., and many other matters of practical importance rely on this knowledge. This part of the investigations is for the present neglected, as also investigations into the diseases and faults of timber. Only as far as the knowledge of the components of the wood, especially its water contents, affects the technical qualities and uses of timber our investigation will touch this chapter of timber physics.

The most attention is given to the determination of the *physical properties* of the woods, and hand in hand with this an investigation into the influences which determine such properties.

It is apparent that, in order to carry out such investigations, the selection of test pieces is of the greatest importance, and must be done with extraordinary care. To obtain such samples has been found quite difficult so far, partly for lack of proper persons to prepare them, partly for lack of funds to pay for the service properly.

Dr. Charles Mohr, the well-known botanist of Mobile, kindly supplied samples from the Southern pineries, and Mr. N. B. Pierce, of Ludington, Mich., a gentleman well versed in wood-craft, from the Northern pines.

The following instructions for taking test pieces accompanied the schedules for noting the data in reference to each test tree:

Instructions for taking samples of wood for technical investigations, and for notes concerning them.

(1) METHOD OF TAKING SAMPLES.

(*a*) Choose average representative trees; do not look for the largest or best nor the smallest or worst. Old trees are preferable.

When the tree is selected, mark with the ax the north and south sides. Before cutting off the bottom log, mark the north and south sides on the second cut, and so forth.

(*b*) At or near the butt-end of each log cut off a clear section 4 inches thick (rather less than more). Before cutting off the section indicate *on bottom of section*, with a thick pencil line, the *north* and *south* direction, writing the letter N on the north side and the letter S on the south side, both large and distinct.

Note on each section, as cut off, the *number of tree* corresponding to schedule with Roman numbers, and the *number of section*, beginning with number 1 at the base, with Arabic numbers. If the writing prove unsatisfactory, tack on a card with numbers in addition. This is to aid, not to replace, the marks on the wood.

If the section is heavier than 4 pounds (weight allowed in the mails), split some wood on each side of the N and S line, leaving a strip of at least 4 inches in width. If this is still too heavy, cut the piece in two through the center. If these pieces are still too heavy, cut them again in two halves between center and periphery. Split only if necessary, and never fail to write numbers and respective letter on every piece before splitting it off.

Weigh each piece and record weight in note-book. Measure carefully the distance from the ground to the first, second, etc., disk, and note them down at once.

(*c*) *Wrap* each piece separately in two separate wrappers of thin paper and one of thick oil paper. Let the paper be amply large, and well tied on with strong twine, so that no part can become in the least exposed.

(*d*) From one of the *large limbs* cut off disks like those of the trunk, one about 2 feet from stem and two more about 5 and 10 feet respectively from the first. Mark them with Roman number of tree, and Arabic numbers beginning with 1 for the piece nearest the stem. Besides the numbers, draw a line on the disk from the upper side of the limb to the lower side, and indicate the top side with a large T, the bottom with B; also note its position on trees as to exposure.

(*e*) From the base of the second log, or near it, cut off a 6-foot piece; let it be as free from knots as possible, and mark it in the same way as the sections. Cut another 6-foot piece from the base of one of the top logs; this piece also as clear as possible and at least 6 inches through. These pieces, while fresh, place in water and let them remain one week, then paint them at once at both ends, and stack them until called for.

(2) HOW TO DESCRIBE.

For each tree use separate sheet.

Write your name and full post-office address on back of each sheet.

Under *locality* note the place where the tree came from.

Under *description* give a general description of the locality; answers to questions like the following: Is the country level? If so, is it a low plain? High table land? Is it hilly, mountainous? In what direction do the mountains run? Is the country mostly wooded or cultivated land? Are the woods in large bodies? Are they deciduous or evergreen trees or are they mixed? Are the woods cleaned out (free from dead wood or under-brush)? Are any trees planted? If so, what kinds?

Under *site* is described the special situation of the tree. This comprises *geological formation*.

Lay of land.—State here whether the place where the tree stood is level, in a valley or on a slope (steep or gentle); mention angle of inclination if you can. State which way it slopes—to the north, south, etc. Is the place near the foot or near the top of the slope?

Soil.—State what color of soil, whether rich, middling, or poor. Is it clay, sandy loam, sand gravel, coarse or fine, and what kind of subsoil is there. How deep is the soil to the subsoil?

Moisture.—State if the place is swampy, wet, moist, dry: if near any water-course, a creek, or spring, and if ever overflowed.

Surface cover.—State if there is any grass or weeds on the ground. Is it mossy or bare? Is there any leaf-mold; if so, how deep? Is there any shrubbery? If so, name the principal kinds if you can.

Position and character of tree.—State whether the tree stood in a forest, in an open field, at the roadside. Has the ground been cultivated? If so, has the timber been planted; how long ago; how was it planted? Is the piece of woods large, dense, and what are the principal kinds of trees?

Here answer also the following: Is the tree large, average, or small compared with others of the same species? Was the crown large or small? Did it stand alone, in a cluster of the same kind of trees? How near to any tree? Was it higher than surrounding trees? Was it planted? If so, how? How was it cut?

In description, under *Position of test pieces* give distance of the base of each from the ground.

Under *Position of limb* state height from the ground on tree, and north or east, etc., side.

Remarks.—Here state anything which has not been stated and which may add to a full understanding of the conditions.

Tell of difficulties in finding, in cutting, in shipping or moving the wood; whether many trees are diseased, or other wise bad, and prevented your finding a suitable one.

Tell any peculiarities of the forest, as whether it is used as pasture; whether the dead wood is cleaned out; whether there is any systematic management of the forest, etc.

The timbers thus far brought under investigation by Mr. Roth have been, of Northern pines, *Pinus Strobus*, and partially, at least, *Pinus resinosa;* of Southern pines, *Pinus Cubensis*, *mitis*, *Tæda*, *glabra*, and also *Taxodium distichum*. The test pieces of *Pinus palustris* were unfortunately received before proper arrangements had been made to use them. Some interesting and some striking results, needing, however, further verification before generalization may be admissible and their value for the practice be recognized, have been already recorded, of which it may be proper to give a short résumé.*

It will be understood that the results and conclusions here presented from the work of Mr. Roth are of a preliminary nature, serving only to show the nature and progress of these investigations so far.

(*a*) *Density* or specific gravity; that is, quantity of ligneous substance in a given volume (usually the proportion contained in 100 cubic centimeters is stated).

The density in the wood of *Pinus Strobus* showed a rapid decrease from the base (41.4 grams) to a distance of about 19 feet from the ground (36 grams); from there to about 100 feet from the ground the decrease in density is more gradual.

The wood on the north side was invariably denser than that on the south side. In the case of *P. resinosa* the values were 70 near the base, decreasing to 60 and then increasing again to 72. In *Pinus mitis* and *Tæda* the same rapid decrease in density is observed near the base, in general, yet in more irregular stages than is exhibited by *Pinus Strobus*. The same irregularity is observed in these two southern

*As it is easier to make computations by the use of the metric system of measurement, this system has been employed in these investigations, and since no absolute but only relative values have so far been established, a translation of the results into English measure seemed to be uncalled for.

pines with regard to the relation of north and south side, sometimes the one and sometimes the other being the denser.

In *Pinus Cubensis* and *glabra* the decrease of density near the base is not nearly so rapid as in the other pines named, and while the minor irregularities in density observed in *Pinus Tæda* and *mitis* are found throughout the length of the tree the fluctuations are not nearly as great.

In *Taxodium* the relations of the different sections of the tree with regard to density differ very much from those observed in the pines. The density near the base showing 38 grams, it rises to 45 grams at about one-third of its height, then decreases again towards the top, where it was found to be 37 grams.

The density of the dry wood ranged as follows:

Pinus Strobus	41–32
Pinus resinosa	72–60
Pinus mitis	76–45
Pinus Tæda	61–40
Pinus Cubensis	59–40
Pinus glabra	54–40
Taxodium distichum	45–36

Shrinkage, that is the amount of volume lost by drying fresh wood at 100° C.

The shrinkage is very nearly proportional to the amount of organic substance or the density of dry wood, since it is due, as was found, to a loss of water not from the cell-lumen but from the cell-wall.

Pinus Strobus excelled in the regularity with which the capacity for shrinkage varies through the length of the tree. Beginning with 6 per cent. at the base, it rises to a maximum of 9 per cent. and then gradually falls again to 6 per cent. In *Pinus resinosa* the shrinkage proved very considerable, amounting to from 25 to 27 per cent. in the sap-wood and 16 to 19 per cent. in the heart-wood.

In the southern pines no such regularity as in the northern is observed, the values, if expressed graphically on the sides of a straight middle line, representing oscillating lines.

In *Taxodium* the curve of shrinkage is somewhat parallel to that of its density. It begins with 9 per cent., rising to 13 per cent. at about one-half of its height, and decreases again to 8 per cent. near the top.

The range of shrinkage percentages was as follows:

	Per cent.
Pinus Strobus	9–6
Pinus resinosa	27–16
Pinus mitis	20–12
Pinus Tæda	10–6
Pinus Cubensis	13–10
Pinus glabra	12–6
Taxodium distichum	13–8

The *amount of water* in the fresh wood of *Pinus Strobus* at the base was about 46 per cent., becoming smaller as we ascend the tree, until at about one-third of its height it has decreased to 40 per cent.; then it increases again to 48 per cent. at the top. It was also found that the same relation between north and south side of the tree exists as observed in regard to other properties; the north side showed a greater amount of water than the south side. *Pinus resinosa* ranged from 19 per cent. at the base to 39 per cent. in the last section.

In the southern pines the curve showing variations in the amounts of water contained in the wood begins with a minimum value near the base, increasing more or less gradually and reaching a maximum value near the top.

In *Pinus mitis* and *Tæda* there is again no constancy in the relations of north and south side, sometimes the one sometimes the other having the greater value.

In *Taxodium* the amount of water varies similarly to the density. Beginning with 53 per cent. at the base, it rises to 57 per cent. at mid-height, and falls again to 53 per cent. at the top.

The range of values was as follows:

	Per cent.
Pinus Strobus	46–40
Pinus resinosa	39–19
Taxodium distichum	57–53

In regard to the amount of *organic matter* or dry substance contained in 100 cubic centimeters of fresh wood, the following results were obtained: *Pinus Strobus* showed the largest amount (38 grams) at the base, falling very rapidly, so that the second section showed only 32 grams, then falling more slowly until a minimum value was reached near the top (30 grams). The north side excelled in the relative abundance of organic matter.

Pinus resinosa showed values of 43 grams at the base, decreasing to 33 grams in the third section.

In the southern pines the values were considerably larger, ranging in—

Pinus mitis, between 64 and 45 grams.
Pinus Tæda, between 54 and 40 grams.
Pinus Cubensis, between 52 and 41 grams.
Pinus glabra, between 48 and 38 grams.

The same irregularity and inconstancy in conditions of the north and south sides as were observed with regard to other properties prevailed also in regard to the distribution of organic substance.

The rapid decrease in values near the base, so conspicuous in *Pinus Strobus*, is also noticed in *Pinus Tæda* and *mitis*, but is hardly perceptible in the case of *Pinus Cubensis* and *glabra*.

Taxodium showed a curve similar to that which represents the densities, commencing with 34 grams near the base, increasing to 40 grams at three-eighths of its height, then declining to 34 grams near the apex.

The *air-space* contained in 100 cubic centimeters of fresh wood after the water was expelled was also determined.

In *Pinus Strobus* this was found 41 cubic centimeters at the base, increasing to 59 cubic centimeters at 33 feet from the ground, then decreasing to 49 cubic centimeters at the top. The values for the south side exceeded those of the north side.

Bearing in mind the great regularity seen in the relations of the several parts to each other, one is led to suppose that, for the wood of the same tree at least, the *shrinkage* stands in direct proportion to the amount of air-space. But that each relation does not hold in passing from one species to another, can be readily seen by comparing the results. For *Pinus Tæda* and *mitis*, results similar to those of *Pinus Strobus* were obtained. There is first a rise from 43 cubic centimeters to 53 cubic centimeters, and then a gradual decline to 41 cubic centimeters in *Pinus Tæda*. In *Pinus mitis* a rise from 26 cubic centimeters to 40 cubic centimeters, followed by a decline to 30 cubic centimeters. For *Pinus glabra* and *Cubensis* the values are considerably oscillating, lying between 30 and 35 cubic centimeters on the north, and between 35 and 40 cubic centimeters on the south side for *Pinus glabra*, and between 30 and 40 cubic centimeters for *cubensis*.

The range of values of air-space was as follows:

Pinus Strobus	41–59
Pinus resinosa	30–36
Pinus mitis	26–40
Pinus Tæda	41–53
Pinus glabra	30–40
Pinus Cubensis	30–40

Many other determinations of this nature were made, all of which when properly amplified, classified, and placed in relation will give us a large amount of information for practical use, hitherto a sealed book.

There were also made measurements of the changing width of the several test-pieces during seasoning, and of the annual rings.

The general form of the trunk in all pines being the same, it is chiefly a comparison of their development on north and south side that interests us.

In *Pinus Strobus* the north side constantly excels the south side in thickness with great uniformity.

In the southern pines, on the other hand, Mr. Roth claims to have discovered a constant change in the amount of diameter development from north to south. It was impossible to determine, with the test pieces on hand, whether this oscillation in the development curve is a spiral one around the tree or in one plane. The near-lying supposition that a direct proportionality would exist between density and amount of growth or width was not borne out by comparison of the results obtained.

In counting and measuring the annual rings, for the purpose of bringing time and increase of volume into relation, usually three zones could be distinguished, which were most marked in *Pinus Tæda* and *mitis*, less so in *Pinus Cubensis* and *glabra*, and least in *Pinus Strobus*.

Taking the third section from the base as representing probably average conditions, the relation of these zones was found as follows:

	First zone (inner).		Second zone (middle).		Third zone (outer).	
	Number of rings.	Average width.	Number of rings.	Average width.	Number of rings.	Average width.
		mm.		*mm.*		*mm.*
P. Strobus	9	2.6	95	1.8	35	2
P. Tæda	10	5.8	15	4	13	2
P. mitis	11	5.2	25	3.4	16	2.1
P. Cubensis	16	3	32 rings 3mm.			
P. glabra	9	6.6	20	4.5	12	3.1

In *Pinus Strobus* the second zone is not very sharply defined from the first; the rings in the middle zone are quite regular in width, the outer ones only becoming narrower and forming a transition into the outer zone, which consists of light-colored sap-wood.

This regularity in the middle zone indicates steadily increased growth, the width of the rings remaining constant for about one hundred and thirty to one hundred and forty years.

In *P. Tæda* this acceleration of the rate of growth is observed up to the thirty-first (?) year. The outer zone differs only by the width of its rings from the middle zone, but the transition is very abrupt, while the width of ring in either zone is quite constant. The inner zone is marked sharply by its darker colored wood. The same distinction is visible in *P. mitis*. In this tree a steadily increased accretion is noted for forty-five years.

In *P. Cubensis* the acceleration is continuous through the whole life of the tree under consideration.

In *P. glabra* the inner zone differs but slightly from the middle zone. Here, as in *P. Tæda* and *mitis*, there is an abrupt change in the rate of growth observable, which may be represented by an ascending curve, suddenly falling, and then ascending again in a direction parallel to the first incline.

Examining the width of rings in the different zones at different heights, we find, in general, the rings of the middle and outer zones steadily increasing in width from the base upward, becoming more and more nearly equal toward the top, until at last all difference vanishes, and with it the distribution of zones referred to before.

We may foreshadow some of the more practical results which seem to follow from these investigations by Mr. Roth, although the limited amount of material worked up will hardly warrant to base much generalization upon them.

While the other pines here considered grow far more rapidly when young, it seems highly probable that *Pinus Strobus* retains for a longer time the acceleration of growth in cross-section and is more regular in its total development.

It was stated before that the shrinkage is very nearly proportional to the amount of organic substance or the density of dry wood, since it is due to a loss of water, not from the cell-lumen but from the cell-wall. That this proportion is not always maintained is seen in the case of *Pinus Strobus*, where the density is greatest at the base, the shrinkage some distance from the base. The amount of water increases while the amount of organic substance decreases from base to top.

While in *Pinus Strobus* grown in the North the north side is more favorable to development than the south, the pines of the South do not show such relation to the direction of the compass.

Taxodium differs from the pines in nearly all the points determined. The growth is very slow—at least in the tree under observation—and appears subject to periodic changes of growth and rest. The rings show a great abundance of summer wood, which makes them appear as if containing several rings. These intermediate rings varied from three to five, making the counting difficult and uncertain.

There were also numerous analyses made of the growth of these trees, which it would lead us too far here to give in detail. Let it suffice to give the following:

Comparing the two trees of *Pinus Strobus* and *resinosa*, which are grown under nearly the same conditions and with equal rapidity of height growth, and taking the fourth section as representing an average, the ratio of amount of organic substance per unit of volume being as 33 in *P. resinosa* to 31 in *P. Strobus*, the following comparison may be made, which shows *Pinus Strobus* a superior grower:

	First twenty years.	Next fifty.	Next forty.	Next forty.
	mm.	*mm.*	*mm.*	*mm.*
Pinus Strobus	2.9	2.5	1.6	1.3
Pinus resinosa	3.6	2.5	.87	.5
Ratio of wood growth	$\frac{1}{1.3}$	$\frac{31}{33}$	$\frac{1.7}{1}$	$\frac{2.3}{1}$

What has been here recorded of this work, just begun, does not claim to represent any wonderful results or discoveries, but has been simply related to show in what direction it is necessary to investigate our forest flora before we can begin to speak with more authority and on more exact foundation, not only of the properties of the various timbers, but also of the proper timbers to be grown in various localities and the methods of managing them.

These investigations, abstruse and simply of pure scientific interest as they may appear at first, are fraught with the greatest practical bearing on forest planting and forest management. They are of such a nature as to require their conduct under Government control, and should be engaged in by the Division in a more generous and far-reaching manner.

METAL TIES.

The interest which was stirred up among railroad men by the publication of Bulletin I from this Division has been further taken care of by engaging Mr. E. E. Russell Tratman, civil engineer, of Brooklyn, N. Y., to gather all information possible with regard to the use of metal ties in foreign countries. His preliminary report has just been submitted.* It shows that in several countries the metal tie has been adopted far beyond the limits of experiment. There may be estimated from the reports not less than 10,000 miles of metal track of various types in the world, the lion's share of this number belonging to Germany, with 5,530 miles. Next comes India, with about 1,800 miles; the Argentine Republic, with over 1,000 miles; Austria, Switzerland, and Spain, with each from 200 to 250 miles; Holland and Belgium, with 125 miles, and England, France, Africa, Egypt, Algeria, Mexico, and other countries with smaller amounts.

*This report will shortly be issued in Bulletin No. III, which will also embrace other matter of interest to railroad managers.

Out of 162,634 ties on the Netherlands State Railway, not one had broken. Of this one type, the "Post tie," there were in use in different countries about 730,000 ties, or 36,500 tons. In Algeria the saving of maintenance with metal ties has been calculated at about one-fourth, or $60 per mile.

The United States seems the most backward in experimenting with metal ties. This apathy will, however, presently cease, as the cost of wooden ties increases and the cost of manufacturing metal ties is reduced.

A seemingly perfect tie, just patented in this country by a Frenchman, A. Durand, civil engineer, is claimed to be produceable at the low rate of $1, including the fastenings.

TRADE NOTES AND STATISTICS.

Agreeably to the expressed wishes of lumbermen's associations it had been proposed to direct the energy of the Division towards ascertaining the remaining stock of merchantable white pine. As this stock-taking was to be made as thorough as it could be done, an appropriation of $15,000 for the purpose had been asked for, a sum only barely sufficient to produce reliable results.

The appropriation, however, failed to be made, and no statistical work was therefore attempted by the Division.

Some notes and gleanings of interest from various trade papers are given, in addition to the statistical tables of exports and imports, which are, as usual, compiled from the reports of the Bureau of Statistics.

While the tariff bill and free lumber, or retention of the duty, has been discussed in this country, Canada has increased the export duty on pine and spruce logs from $2 to $3. This is claimed to be a prohibitory duty, and since many American lumbermen have purchased timber limits over the line with the intention of sawing the logs in their mills on this side, the feeling in lumbermen's circles is strongly against this measure. Canadian lumbermen are said to be as much opposed to this duty as American, and claim it to be unconstitutional.

With reference to this question of retaliatory duty, one of the lumber-trade journals purports to show from the statistics that the export of logs from the United States to Canada is so much more in amount, six or seven times as much as those from Canada to the United States. Unfortunately the statistics are chosen with the object of proving the proposition. As I have shown in a table contained in my last report, the interchange of logs and round timber between the United States and Canada is almost equal in amount. The above-mentioned journal selects for the Canadian exports only those referring to pine timber, while for imports the entire line of goods, including hemlock, spruce, oak, etc., is included. The Canadian statistics allow a division of their exports into the different kinds, while the imports are lumped together.

The following tables reveal the true state of affairs :

Comparative statement of imports and exports for home consumption of home-grown wood and its manufactures, and of forest products between Canada and the United States for the year 1888.

CANADA.

Articles.	Duty collected in Canada.	Imports from United States.	Exports to United States.	Duty collected in United States.
(*a*) Logs and round timber	$21,651	$279,872	$383,675 *(790,250)	
(*b*) Lumber and timber (duty free)		515,172	809,497 (877,219)	
(*c*) Lumber and timber and roughly manufactured wood (dutiable)	42,652	184,670	8,581,827 (7,911,204)	$1,253,574
(*d*) Fire-wood		3,294	337,806 (364,412)	
(*e*) Tan-bark		903	246,568 (290,261)	
(*f*) Other forest products		97,540	263,114	
(*g*) Manufactures of wood	244,215	877,726	403,362	†144,861
(*h*) Carriages, wagons, cars	59,954	177,880	10,528	
Total	368,472	2,136,057	11,036,357	1,398,435

*Includes all logs imported into the country. Discriminations are not made in regard to this item in the returns.
†Duty estimated with 35 per cent. rate.

The following tables give specifications of some of the items lumped together in the above table:

Specified exportations into the United States from Canada.

Articles.	Value.	Articles.	Value.
(*a*) Logs:		(*c*) Lumber and timber (dutiable):	
Elm	$106,519	Pine deals	$416
Hemlock	18,383	Spruce and other deals	81,761
Oak	34,171	Deal ends	174
Pine	3,875	Lath palings, pickets	329,971
Spruce	99,450	Planks, boards, joists	6,831,950
All others	121,277	Scantling	148,894
(*b*) Lumber and timber (free):		Staves and headings	160,593
Railroad ties	514,789	Shingles	289,005
Stave bolts	118,701	Shingle bolts	738
Hop and hoop poles; Telegraph poles	146,750	Other lumber	517,988
		Box shooks	156,296
Knees and futtocks	19,858	Other shooks	57,874
Masts and spars	9,204	Square timber	5,537
Basswood, butternut, hickory, etc., unmanufactured	195		

Specified importations into Canada from the United States.

Articles.	Total importations.	Importations from the United States.	Articles.	Total importations.	Importations from the United States.
(*b c*) Lumber and timber, planks and boards, sawn, not manufactured:			(*g*) Manufactures of wood:		
Box, cherry, chestnut, gum, hickory, and whitewood	$55,332	$55,332	Furniture	$238,745	$215,295
Oak	98,547	98,514	Caskets and coffins	3,498	3,498
Pitch pine	68,616	68,013	Hubs, spokes, parts of wheels	11,139	11,139
Redwood	246	246	Moldings, plain	4,180	4,180
Hickory	32,216	32,216	Moldings, finished	31,739	31,482
Walnut	258,250	258,250	Show cases	2,520	1,952
(*g*) Manufactures of wood:			Wooden-ware	41,186	41,135
Barrels	242,034	233,830	Picture frames	27,937	17,593
Clothes wringers	5,424	5,410	Pipes, tobacco (wooden)	104,138	7,888
Fishing rods	6,474	3,955	Veneers	38,268	38,268
			Other manufactures	431,743	373,305
			Total	1,702,232	1,501,501

NOTE.—The above tables are made up from the "Tables of Trade and Navigation for the Dominion of Canada." The figures in parenthesis are from the reports of the United States Bureau of Statistics and differ somewhat from the Canadian returns.

The position, then, of the lumber trade between Canada and the United States at present appears from these and the subsequent tables to warrant the following statements: The bulk of forest products and wood manufactures which we import comes from Canada, while we return less than 10 per cent. of our own exports of the same kind to that country. This export consists in nearly equal shares of raw material and manufactures. Of the latter we supply almost all that Canada can take, our exports of this class of goods representing nine-tenths of the total importations of the same into Canada. Our importations from Canada represent about 50 per cent. of all exports of the kind from Canada and consist mainly of manufactured lumber. All the wood material thus imported does not count up to 75,000,000 cubic feet, or, very roughly speaking, not to one-third of 1 per cent. of our total consumption. As to logs on which duty is collected, only spruce logs cut any figure, with less than $100,000. The kind of logs imported into Canada from the United States is not specified, but assuming that all going to Ontario and Manitoba are pine, these represent the value of $255,406, or the largest share of the log trade.

Comparison with the condition of trade ten years ago shows an increase of Canadian imports of forest products to the United States of 137 per cent., while exports from the United States to Canada have hardly changed perceptibly during that time.

Altogether it would appear that while Canada has every reason to encourage lumber trade into the United States, she does not offer a sufficient market to influence our forest policy.

It is also admissible to argue that the one and a quarter million dollars of tariff duty which our people pay on eight or nine million feet of lumber coming from Canada can have but little significance and offer but small protection to an industry producing not less than (round) 10,000,000,000 feet of lumber, which may be estimated to represent the cut of white pine and spruce together—the only kinds with which Canadian imports come into competition.

As regards the "inexhaustible" white pine supplies, the lumbermen's papers are becoming more and more doubtful. The *Northwestern Lumberman*, the paper which led the opposition to all "denudatic" theories, lately brings the following significant editorial:

> The great study nowadays on the part of lumbermen in Michigan, Wisconsin, and Minnesota, while the pine is fading away, concerns the avoidance of waste and the utilization of all the timber in some way. Even wormy pine is being cut in large quantities by Saginaw Valley lumbermen this winter. Its manufacture into lumber is a special industry in itself, as the product can be readily marketed for certain purposes to which it is adapted, including glass-box shooks, heads for crockery casks, coarse fencing, etc. A large demand for this class of lumber is found at Pittsburgh, Pa.

The paper quoted above also states that "the quality and size of pine is depreciating in ratio with the progress of cutting and manufacture." "The time is not far distant when good pine will be positively scarce."

Another paper expresses itself as follows:

> If anything were lacking to demonstrate the fact that 'the beginning of the end' of the pine timber of Michigan has become a fixed and palpable reality, a single glance at what may be termed saw-logs, for compliment's sake, as they are towed down the Saginaw River from the Tittabawassee boom to the mill booms, would at once supply the missing link in the chain of evidence amounting to an ocular demonstration. Many of these rafts are composed of veritable poles which are hardly worthy the name of saw-logs and barely sufficient in size to produce a piece of 4 by 4 timber.

The same paper remarks on the celebrated Muskegon supplies:

Two years ago or thereabouts, the prediction was made that 1886-'87 would be the last one in which a big cut of logs would be made on the Muskegon River. It is plain now that it will be abundantly fulfilled. Present estimates of the coming winter's input on that stream indicate that the cut will fall from 60,000,000 to 80,000,000 behind last year, and will probably but little exceed 400,000,000 in all. As a matter of fact it can be easily discerned that the beginning of the end is already at hand on the Muskegon, and that its history from this time forward will be that of a more or less slowly decreasing production. There is practically no standing pine to be bought tributary to its waters. The probability is, that within a couple of years mills will have finished their work there, to make a difference of nearly 50 per cent. in the output as compared with the minimum figure reached. This decrease will be missed seriously, for there is no source from which an equivalent supply can be drawn to make it up, unless the Georgian Bay region of Canada should be thrown open by a removal of the duty.

The increasing value of pine lumber may be pretty accurately understood when the price of culls is considered. Within two years culls have actually doubled in value, and it is not very many years since culls were burned under salt-pans which would bring big money to-day.

The present year (1888) has seen the largest cut of white pine lumber as yet experienced. According to the compilations of the *Northwestern Lumberman* it amounts to 8,388,716,460 feet, B. M., and 4,514,646,801 shingles. This is an increase of $7\frac{1}{2}$ per cent. over last year's cut, which is a larger proportionate increase than has been observed since 1882.

There is a great deal of activity developed in getting hold of the timber growing on Indian reservations, the desire of obtaining this valuable property at low rates animating one side, and the desire of protecting the Indian in his rights and securing to him a fair return the other side; these two aspects being the only considerations which seem to count in the policy to be pursued. The desirability of keeping these lands as Government forest reserves, which has been advocated by some wise and patriotic men who contemplate something else than the mighty dollar as a nation's interest, seems to have no place in the discussion or disposal of this question.

The above mentioned paper relates a conversation with a manufacturer of butter packages, stating that it had become difficult to procure sufficient northern white ash, and adds:

This man's need of course cuts but very little figure in the general demand for ash, but his declaration emphasizes the fact that northern ash is getting scarce, that future supply must come from the South.

The growing scarcity of hickory and ash for suitable carriage manufacture has induced the Carriage Manufacturers' Association to appoint a committee for the purpose of investigating the condition of these supplies.

A writer conversant with southern timber resources calls attention to the rapidly increasing demands upon yellow pine supplies, and says: "Ere twenty years expire we may look around with cold statistics to back us in vain for these vast and rapidly disappearing forests of pine."

Another man, who knows whereof he speaks, thus dilates upon the Southern pine forests:

We need help in the development of the South, yet I could wish and it would be justice itself, if those of us who have borne the burden of these times of depression in the South could hold on to enough of our natural wealth to make us independent of this incoming tide of investors. * * * Further investigations will show that the general estimates as to the quantity of the yellow pine and other timber in the South have been exaggerated, and a canvass of the timber tracts will show a lesser average number of feet to the acre than has been universally reported.

I believe those people who have gotten into their heads the idea that the supply will be unlimited for the coming generations will arrive at a wiser conclusion as the days and years of their lives come on apace.

In regard to the timber resources of the Pacific coast, which have only just begun to be appreciated, we hear the following from the editor of the Humboldt, California, *Standard*, situated in the heart of the redwood operations:

How the mighty have fallen! The 200-feet-to-first-limb-straight-as-a-ship's-mast-to-a-height-of-300-feet-7-foot-in-diameter trees are not so plenty as they once were; the once common 40-foot-in-diameter redwood trees no longer thickly stud our forests. Alas! our matchless redwood forests are melting away before the woodman's ax and the ravenous tooth of the saw, like snow under the tropical sun. A score of years hence scarcely a vestige will be left, and our people will know and appreciate its great value.

The lumber export business from the Pacific coast is increasing every year. Redwood forms the great staple of San Francisco shipments. During the year 1888, according to "*Wood and Iron*," the shipments amounted to 27,656,941 feet, B. M., valued at $749,923. Most of this goes to Australia and Pacific islands, the market for redwood in the Eastern States being still of small dimensions. Overland shipments to the East amounted to 4,379,961 feet, valued at $131,370.

The shipments from Puget Sound are somewhat larger, consisting mainly of red fir and Port Orford cedar. The total output of lumber for the year 1888 is computed at 409,961,270 feet, mostly rough lumber, valued at $6,759,580. Australia forms the best export market.* Local demand for box factories, furniture, and wagon manufactures is brisk. California, especially San Francisco, takes the largest share of the coastwise trade, and Denver, Salt Lake, Ogden, and small towns in eastern Oregon, Washington, and Idaho, take over 20,000,000 feet. Ship-building is reported as very active at the sound, twenty vessels with a tonnage of 4,225 having been completed this year, and the business outlook for lumbermen is bright. The exports have increased about 50 per cent. during the year, amounting in 1888 to $1,091,148, representing besides shingles, laths, pickets, and spars, 113,775,000 feet of boards.

*The shipments to Australia this year amounted to 55,487,694 feet, B. M., as against 24,515,087 feet, B. M., last year.

*Imports of forest products and manufactures of wood, and increase or decrease of the same for the years ending June 30, 1878, and 1888.**

Articles.	1878. Quantity.	1878. Value.	1888. Quantity.	1888. Value.	Increase. Value.	Increase. P. ct.	Decrease. Value.	Decrease. P. ct.
Free of duty.								
Fire-wood ....cords..	117,746	$225,759	181,263	$364,413	$138,654	61.4	....	......
Logs and round timber ..	....	168,665	....	790,251	621,586	368.5	....	......
Railroad ties..............	....	176,057	3,234,391	663,242	487,185	276.7	....	......
Shingle and stave bolts..	....	27,809	....	137,787	109,978	395.5	....	......
Ship timber........tons..	3,515	20,687	....	39,758	19,071	92.2	....	......
Ship planking............	....	13,278	....	30,548	17,270	130.	....	......
Hop poles................	....	....	....	5,884	....	....	....	......
Wood pulp	....	268	....	21,263	20,995	7,834.	....	......
Charcoal......... tons..	35	170	6,571	50,832	50,662	29,801.	....	......
Hemlock bark. ..cords..	106,781	412,259	62,926	290,261	....	....	$121,944	29.5
	....	1,044,952	....	2,394,239	1,349,287	129.1	....	......
Dutiable.								
Wood, unmanufactured, not elsewhere specified.	....	6,321	....	14,238	7,917	125.	....	......
Timber.........cubic ft..	61,534	7,799	23,720	3,283	....	....	4,516	57.9
Lumber:								
Boards, planks, deals, etc........... ..M. ft..	279,700.75	2,752,632	536,195,349	6,526,172	3,773,540	137.	....	......
Clapboards.........M..	979.43	8,254	3,113,546	43,809	35,555	430.5	....	......
Hubs, posts, lasts, and blocks....	....	53,953	....	39,561	....	....	14,392	26.6
Laths ....M..	108,975.37	97,416	246,373,791	306,121	208,705	214.2	....	......
Pickets and palings. M..	3,053.87	21,185	7,374,628	58,973	37,788	178.3	....	......
Shingles............M..	47,610.19	97,501	160,313,117	331,329	233,828	239.8	....	......
Shooks and packing boxes ....No..	....	14,774	....	185,314	170,539	1,154.3	....	......
Staves...........do....	547,989	8,733	....	419,925	411,192	4,708.6	....	......
Bark extracts, chiefly hemlock	....	5,244	....	1,094	....	....	4,150	79.
Sumac:								
Ground ....lbs..	15,068,581	508,247	13,735,984	276,209	....	....	238,038	46.8
Extract	....	9,048	2,600,324	92,678	83,630	924.3	....	......
Matches..................	....	2,437	....	20,567	18,130	744	....	......
Casks and barrels........	....	2,259	....	1,985	....	....	274	12.1
Cabinet ware and furniture	....	97,284	....	355,116	257,832	265	....	......
Osiers and willows.......	....	15,966	....	18,366	2,400	15.6	....	......
Osier and willow baskets, etc..............	....	91,445	....	334,007	242,562	26.5	....	......
All other manufactures..	....	507,187	....	498,057	....	....	9,130	1.8
	....	4,307,685	....	9,526,804	5,219,119	121.1	....	......
	....	5,352,637	....	11,921,043	6,568,406	122.7	....	......
Free of duty.								
Cabinet woods:								
Box	....	30,137	....	51,440	21,303	70.6	....	......
Cedar	....	160,540	....	361,106	200,566	124.9	....	......
Ebony	....	41,875	....	37,361	....	....	4,514	10.78
Granadilla	....	351	....	898	547	155.8	....	......
Lancewood	....	4,002	....	17,566	13,564	338.9	....	......
Lignum-vitæ..............	....	56,124	....	40,735	....	....	15,389	27.4
Mahogany	....	80,165	....	605,875	525,710	656.2	....	......
Rose	....	93,000	....	21,624	....	....	71,376	76.7
Sandal	....	138	....	4,217	4,079	2,956	....	......
Satin....................	....	....	....	9,237	....	....	....	......
All other cabinet woods	....	188,813	....	266,683	77,870	41.24	....	......
Cork-wood or bark, unmanufactured	....	495,316	....	1,063,861	568,545	114.8	....	......
	....	1,150,461	....	2,480,603	1,330,142	115.6	....	......
Total..............	....	6,503,098	....	14,401,646	7,898,548	121.4	....	......

*By the act of March, 1883, the cost of transportation, shipment, transshipment, with all the expenses included, from the place of growth, production, or manufacture, to the vessel in which shipment is made to the United States; the value of sacks, crates, boxes, etc., in which the merchandise is contained, commission, brokerage, export duty, and all other usual charges which prior to that act formed a part of the dutiable value of imports, are excluded from the same. This needs to be taken into account in comparing the value of goods imported prior to and subsequent to that date. It would probably carry the valuation of imports for 1888 to $18,000,000, or nearly three times that of 1878.

Exports of forest products and manufactures of wood, and increase or decrease of the same, for the years ending June 30, 1878 *and* 1888.

Articles.	1878.		1888.		Increase.		Decrease.	
	Quantity.	Value.	Quantity.	Value.	Value.	P. ct.	Value.	P. ct.
Fire-wood ....cords..	2,837	$9,469	3,164	$10,511	$1,042	11.	....	......
Boards, deals, and planks, M. ft..........................	313,143	4,531,741	447,423	7,322,249	2,790,508	61.6	....	......
Joists and scantling......do...								
Hoops, hoop-poles, etc	....	377,137	....	161,853	....	......	$215,284	57.
Laths ....M..	3,050	9,233	10,579	27,231	65,640	711.	....	....
Palings, pickets, and bed-slats, M............................			1,897	47,642				
Shingles ....do.	46,518	154,533	33,932	104,362	....	......	50,171	32.5
Shooks, box	....	142,610	....	157,637	15,027	10.5	....	......
Shooks, other ....No..	....	3,778,196	668,972	830,113	....	......	860,545	22.8
Staves and headings......do..	....		....	2,087,538				
All other lumber	....	520,454	....	1,756,083	1,235,629	237.4	....	......
Timber, sawed .....cub. ft..	18,361,915	2,662,784	*187,780	2,331,050	638,708	24.	....	......
Timber, hewed ....do....			5,813,175	970,442				
Logs and other timber	....	352,104	....	2,027,496	1,675,392	475.8	....	....
Total raw material and partly manufactured..	....	12,538,261	....	17,834,207	6,421,946	51.2	1,126,000	8.9
Rosin, tar, and turpentine, bbls	1,042,183	2,329,319	1,533,323	2,349,801	20,482	0.87	....	......
Spirits of turpentine ...galls..	7,633,568	2,333,569	10,585,942	3,580,106	1,246,537	53.4	....	......
Bark and tanning extracts....	....	111,335	....	254,204	142,869	128.3	....	......
Total by-products	....	4,774,223	....	6,184,111	1,409,888	29.5	....	......
Hogsheads and barrels, empty, No............................	82,402	159,420	....	502,556	343,136	215.2	....	......
Household furniture	....	1,961,522	....	2,335,569	374,047	19.	....	.....
Wooden ware	....	237,861	....	293,064	5,203	1.8	....	......
Doors, sash, and blinds†	....	....	....	323,023	323,023	......	....	......
Moldings, trimmings, etc......	....	1,714,140	....	102,220	102,220	......	....	......
All other manufactures	....		....	1,699,695	....	......	14,445	0.84
Matches	....	143,219	....	72,371	....	......	70,848	49.4
Agricultural implements.No..	31,397	2,575,198	....	2,645,187	69,989	2.7	....	......
Musical instruments	....	756,477	....	908,540	152,063	20.1	....	.....
Carriages, carts, and parts of.	....	979,003	....	1,381,291	402,288	41.	....	......
Cars, railroad, passenger, and freight ....No..	657	532,840	794	862,465	329,625	61.8	....	......
Billiard tables and apparatus .	....	18,983	....	31,670	12,687	66.8	....	......
Total manufactures	....	9,128,663	....	11,157,651	2,114,281	23.1	85,293	0.93
	....	....	....	....	9,946,115	37.62	1,211,293	4.58
Total	....	26,441,147	....	35,175,969	8,734,822	33.03	....	......

* Thousand feet.

† Until 1884 the reports of doors, sash, blinds, moldings, trimmings, etc., are included by the Bureau of Statistics in "All other manufactures," and can not be given separately.

Imports of forest products and manufactures of wood, and countries from which imported, during the year ending June 30, 1888.

Countries.	Logwood in sticks.	All other dyewoods in sticks.	Gums.	Cork, wood or bark.	India rubber and gutta-percha.	Sumac.	Bark, hemlock, and extracts of.	Wood, unmanufactured, not elsewhere specified.	Boards, plank, deals, etc.	Shingles.	Other lumber.	Cabinet-ware and furniture.	All other wood, manufactured.	Amount from each country.
Africa		$23,477	$109,195		$195,987			$12,388						$341,047
Australia			1,227,224					452	$90				$310	1,228,076
Austria		217	169,136			$258		5,136				$68,514	54,205	297,466
Brazil	$6,360	8,665	269		10,811,952			36,204						10,863,450
British North America	170	17	5,618		1,799		$290,261	2,055,995	7,497,078	$331,299	$1,066,997	1,576	121,157	11,381,967
British Guiana			1,351		2,397			620						4,368
Central American States		2,496	5,697		1,092,465			19,593				291	15	1,120,557
Dutch Guiana					36			609						645
East Indies		1,354	2,027,694		392,338			576,453				1,915		2,999,754
Ecuador					327,477									327,477
England		8,734	949,327	$1,794	1,916,790	1,388		108,152	2,532		531	84,249	12,702	3,086,199
France			285,455	15,151	107,400			88,360			1,109	136,344	162,308	796,118
Germany			37,504	414	229,844			66,003			119	18,613	585,285	937,782
Hawaiian Islands													411	411
Italy			12,802	304		261,519		13,970			1,445	20,847	15,175	326,062
Japan			258,906					18,318				466	67,518	345,208
Mexico	99,073	61,324	295,539		131,224			537,600	514			152	739	1,126,165
Netherlands			17,178		229,078			1,280				1,474	6,623	255,633
Portugal			346	806,546	189,035							18		995,945
Spain		677		253,442								229	471	254,819
Turkey			39,765					5,681				634	1,830	47,910
United States of Colombia		3,554	381		388,691			47,592					194	440,412
Venezuela		10,849	375		22,688			31,609					46	65,567
West Indies	1,429,706	14,840	14,384		27,089		400	498,045	15,489			390	1,235	2,001,578
All other countries			65,943	2,123		1,563		41,813			1,207	9,153	84,664	206,466
Total	1,535,309	136,204	5,524,089	1,079,774	16,066,290	264,728	290,661	4,165,873	7,515,703	331,299	1,071,399	344,865	1,124,888	39,451,082

Exports of forest products and manufactures of wood, and countries to which exported, for the year ending June 30, 1888.

Countries.	Agricultural implements.	Bark, and extract of, for tanning.	Matches.	Turpentine and rosin and spirits of turpentine.	Boards, deals, and planks.	Joists and scantling.	Hoops and hoop-poles.	Laths, palings, pickets, etc.	Shingles.	Shooks, box.	Shooks, other.	Staves and headings.	All other lumber.
Argentine Republic	$877,519			$137,949	$1,313,801	$48,961		$2,919	$582	$16,137	$36,423	$2,680	$30,512
Australia	239,439	$2,169	$6,725	121,431	809,798		$420	36,188	2,852	4,029		9,021	127,494
Austria	4,539			99,867	1,107							1,445	
Belgium	5,670	23,976		399,291	115,637						84	19,438	2,250
Brazil	20,354		589	98,310	290,840	2,974	452			4,237	705	617	591
British North America	99,012	240	4,169	126,783	267,134	768	680	211	153	10		60,306	124,472
Central American States	5,817		5,306	8,375	51,282	196	6	187	6,596	3,670	270	75	3,626
Chili	65,891			39,415	182,424	148		1,388		3,600	180	21,671	4,304
China				10,961									210
Denmark	4,712			7,300			175					440	2,960
England	359,619	71,425		2,495,602	723,001	715	488	153		6,762	58,361	358,526	556,370
France	235,731	39,588		11,907	186,089							61,635	5,846
Germany	198,609	75,600		677,385	126,162		1,400			900		31,920	84,600
Hawaiian Islands	9,296		1,090	1,482	158,845			978	21,592	1,168		1,536	3,447
Hayti	188	183	5,479	4,216	150,290	2,203			7,043	4,399	450		8,374
Italy	16,901	655		147,011	165,688					51,392		125,091	5,121
Japan	2,536	605	1,452	6,955						100			
Mexico	25,365	346	2,438	5,793	362,129	27,808	170	532	12,838	9,489	141	647	407,431
Netherlands	7,914	21,252		617,930	109,903							54,465	19,213
Peru	9,676		30	22,265	65,418				12	4,323	150	8,032	6,668
Portugal	4,333	3,350		19,114	31,555	308					76	316,110	910
Russia	97,140		8,334	169,546									
Scotland	26,646	10,844		263,838	153,548	13,225					280		134,308
Spain	285			22,143	118,278	13,378	1,000			2,457	1,444	541,782	3,986
United States of Colombia	2,537		14,003	12,528	236,264	96	46	24	2,558	2,085	47	65	16,192
Uruguay	66,788			49,211	324,110	6,531		3,757		25			39,269
Venezuela	1,300	124	1,845	20,434	13,634	397	312	23		455	687	1,285	3,636
West Indies	50,924	3,781	11,327	47,046	828,455	38,198	155,669	1,270	46,859	32,342	695,150	261,125	59,561
All other countries	445,784	19	9,584	285,986	372,687	6,344	1,033	12	3,274	10,017	35,470	143,921	105,332
Total	2,884,525	254,157	72,371	5,930,074	7,161,079	162,250	161,851	47,642	104,359	157,597	829,918	2,021,833	1,756,083

Exports of forest products and manufactures of wood, and countries to which exported, for the year ending June 30, 1888—Continued.

Countries.	Timber, sawed.	Timber, hewed.	Logs and other timber.	Doors, sash, and blinds.	Moldings, trimmings, etc.	Hogsheads and barrels, empty.	Household furniture.	Wooden-ware.	All other.	Total to each country.
Argentine Republic	$62,978			$1,406	$1,949	$4	$279,469	$9,260	$31,931	$2,854,480
Australia	217,113		$1,110	135,074	20,365	266	165,546	54,864	242,097	2,196,001
Austria	7,978						200		1,355	116,491
Belgium	12,755	$32,382	164,817			163	34,789	1,352	8,594	821,198
Brazil	4,012		7,160	361	320		54,375	4,134	13,717	503,748
British North America	76,778	309,418	161,829	21,225	12,883	13,183	260,955	24,875	245,079	1,810,163
Central American States	35,312		6,181	6,364	735	203	62,892	1,194	26,371	221,658
Chili	320		300		1,266		38,742	2,982	22,170	384,801
China	1,302			973			6,358	14	547	20,365
Denmark			1,142				5,112	243	4,181	26,265
England	745,765	390,672	586,548	30,650	33,806	11,111	376,674	108,859	408,028	7,323,135
France	118,886	70,205	74,289			351	95,672	3,032	41,124	944,355
Germany	41,912	19,829	788,725		874	5,600	175,413	13,719	144,238	2,386,286
Hawaiian Islands	10,452		1,137	10,392	3,134	1,146	62,576	4,740	36,441	329,452
Hayti			56	1,134	140	856	46,338	1,880	6,746	239,975
Italy	169,263	13,347	16,293				36,134	785	7,528	755,209
Japan							16,388	19	4,215	32,270
Mexico	222,228	115	34,097	12,899	3,834	6,554	138,322	6,299	34,593	1,314,068
Netherlands	117,557	38,150	32,809			643	8,323	999	18,456	1,047,614
Peru			4,587		1,438	335	12,242	643	4,712	140,531
Portugal	41,765	7,041	40				2,785	48	700	431,135
Russia	79						1,883		5,302	282,284
Scotland	259,800	47,104	110,385	516	1,926	12,811	23,505	15,638	108,002	1,182,376
Spain	10,805		495				4,711	787	4,587	726,138
United States of Colombia	23,270		18,346	8,295	2,422	190	88,012	11,413	48,194	486,587
Uruguay	3,895				698		26,853	880	6,364	528,381
Venezuela			6,100	319	412	1,434	29,090	1,868	13,111	96,466
West Indies	12,732	232	3,803	6,509	10,560	445,511	161,173	17,827	107,054	2,997,108
All other countries	134,093	41,947	7,247	86,906	5,458	2,195	121,037	4,710	104,258	1,927,314
Total	2,331,050	970,442	2,027,496	323,023	102,220	502,556	2,335,569	293,064	1,699,695	32,128,854

England leads the list of countries to which we ship the largest amounts, closely followed by the West Indies; the Argentine Republic comes next, and then Austria, Germany, and Canada, with almost equal participation in our export trade.

In wood manufactures, which form less than one-quarter of our exports of forest products, agricultural implements and household furniture alone are of significance, each with about $2,000,000 worth.

England, France, the Argentine Republic, Austria, and Germany together take over two-thirds of our wood manufactures. France and the Argentine Republic are the best markets for agricultural implements.

The cooperage industry finds its best customers in the West Indies with over $1,000,000 worth of goods. Spain and Portugal come next with together three-quarters of a million, and England with somewhat less than half a million. It is noteworthy that we furnish to France, which imports yearly from 35,000,000 to 40,000,000 staves, not as much as $100,000 of our cooperage, while Italy, through whose territory by way of Trieste and Fiume France receives the largest part of her need of staves, from Hungary, yet allows us to dispose of almost $100,000 of cooperage to her.

Our imports have increased during the year by somewhat over $1,000,000, without specially noteworthy features in the distribution of this increase.

The table of imports from various countries shows that British America is the only country which comes into competition to any extent with our native forest products in raw shapes, while Germany, Austria, France, and England send us somewhat over $1,000,000 worth of wood manufactures. Nearly two-thirds of our imports of forest products are, like India-rubber, gums, cork, dye-woods, cabinet-woods, not produced in our country.

Our exports have increased during the year by over $3,500,000, or 12½ per cent. This increase is largely represented in raw material, logs, and hewn timber to the amount of $200,000; boards, deals, etc., $1,300,000; while manufactured articles take part in the increase with only (round) $800,000.

The largest exports of raw material are in manufactured lumber and in naval stores; the next largest in cooperage, timber, and logs.

The shipments of lumber to Great Britain have been considerably above those of former years. According to the trade reports of that country we shipped the following quantities to England during the under-mentioned years:

Years.	Quantity.	Value.
	Cubic feet.	
1886	15,514,350	$4,570,515
1887	14,403,300	4,485,930
1888	17,475,000	5,714,670

Walnut shipments were especially heavy, often of doubtful quality and therefore sold at a sacrifice. Hamburg, Germany, imported of this staple over 10,000,000 feet or almost double the amount of last year.

If we add cooperage to lumber and timber, the West Indies prove almost as good customers as England, the latter country swelling the amount by its large importation of naval stores, which represents almost 40 per cent. of its importation of forest products from us, and also nearly 40 per cent. of our total exports of naval stores; Germany, the Netherlands, Belgium, and Brazil, together taking another 36 per cent.

The total imports of sawn and hewn timber into Great Britain for the last four years, according to the detailed statistics given by the *Timber Trades Journal* of London, England, were as follows:

	Cubic feet.
1885	308,248,950
1886	268,059,600
1887	275,451,000
1888	311,008,450

Of these amounts, we furnished 7 and 6 per cent., respectively, in 1887, 1886, and 1885; but, although we have shipped more lumber and timber to England this year, our proportion of the whole importation has fallen below 6 per cent. Nearly one-half of this comes from our southern ports in the shape of yellow-pine timber and lumber, namely, from Pensacola, Fla., alone, 8,105,450 cubic feet. From the same port there were shipped, in addition, to other countries and coastwise, nearly 14,000,000 cubic feet.

CULTURAL NOTES.

During the year a great many letters asking specific advice in regard to the cultivation of different trees, methods of starting groves, management of natural growth, etc., have to be answered by the Division, and give rise to the collection of notes and information on subjects, some of which are here embodied.

Perhaps the most notable advance in the field of forest culture which has been made lately is the application of mechanics to tree-planting. It may indeed prove the turning-point for practical forest planting in the prairies and plains that a machine has been invented capable of breaking the ground and setting and planting from 20,000 to 30,000 seedling trees, all in one motion.

This machine is of exceedingly simple construction, and in its results, having been tested for two years, seems to be superior not only in the quantity but also the quality of work.

It was in its first form a child of necessity. Thomas A. Stratton, a farmer near Lincoln, Nebr., originally from the Buckeye State, having a tree claim in southwestern Nebraska, at Stratton, 70 miles west of the one hundredth meridian, found himself, in the spring of 1886, with 100,000 two and three year old seedlings on hand and no chance of hiring the labor for planting the same. He devised and constructed the tree-planter with his own hands, and begun planting on April 17—planting, with the aid of one man, and five horses abreast, the entire 100,000 trees in eight days, most of the ground being unprepared, a small part only having been back-set.

The 22d of April was Arbor Day, and Mr. Stratton set 11,200 trees, handling every tree himself in order to obtain the premium "for the greatest number planted by one man." Of these, according to affidavit of witnesses, 95 per cent. were alive and growing in October of the same year (see Annual Report Nebraska State Board of Agriculture, 1886, p. 49) and are now (1888) in thrifty condition. On other days, when driver and feeder changed hands, as many as 15,000 trees were set, and with the improvements since made one man has set, in nine hours, 15,272 ash seedlings—on Arbor Day, 1888. With more help and further improvements, now made, the machine will be capable of preparing ground and planting in a thorough manner from 20,000 to 30,000 plants or more.

The machine is drawn by five horses abreast. The coulter and coulter-plow (C and D) cut the prairie sod in advance of the large furrow-plow (D^4) which opens a furrow 6 inches wide (or wider if wanted) and from 10 to 15 inches deep, the depth being regulated by means of a lever (N) operated by the driver, and the furrow being kept open by extension of the landsides. By the side of the planting-wheel, which is propelled by walking on the ground as the machine moves (walking sticks G), are seats for the feeders (R and R^1), and by their side are boxes for carrying plant material (P) enough to plant a row half a mile long, 4 feet apart. The plants are fed to automatically-acting grapples or clamps (G^3) attached to the planting-wheel. The distance of the plants is regulated by the number of grapples on the planting-wheel which are being used. In the new machine, the grapples on each spoke, which are to receive the plants, are kept open by means of a disk and springs until they pass a given point on the upper side of the wheel; before this is reached the plant is inserted with the roots pointing upwards into a holder (I) where it is found by the grapple which takes it up and closes, holding the plant until it is brought around and down into the furrow, when the grapple opens automatically and drops the tree. At that moment two shovels (J), following closely, fill soil around the plant and close the furrow. The hind wheels represent two 6-inch-face rollers, set somewhat obliquely to press the earth firmly against the plants. The superior success of the planting by this machine on raw prairie as against ordinary methods on prepared ground, which has been observed, must be ascribed to these rollers, which bring roots and soil in closest contact, the most essential requisite in tree planting, most especially in a dry climate.

It is of course not necessary, as was done in the first instance, to plant into the raw prairie, although this experience has shown that it can be done successfully. The better plan would be, where the ground is light and dry and covered with buffalo-grass, as in the western parts of Nebraska and Kansas and in eastern Colorado, to cut the sod in the spring as soon as the ground is in condition, and break the ground with a coulter-plow, following with a disk-harrow to break the sod fine, then do the planting at once in trenches or with the planter.

In this way the plants are placed in a soil which has had no chance of drying out; all rains penetrate easily and collect in the trench in which the plants stand, and the sod forms a mulch which helps to prevent evaporation. The new ground being free from weeds, makes cultivation unnecessary, and the plants, if planted 4 feet apart and of good growth, will soon cover the ground sufficiently to subdue the incoming weeds. This method of planting, which I proposed two years ago, after having inspected the conditions of tree planting in the West, though probably not applicable to all conditions, has been fully proved correct by the experience of Mr. Stratton during the last two years, since he used his tree-planter. He writes: "I would rather plant trees on new ground in the above manner and let them remain uncultivated than to plant trees in old ground deeply cultivated, full of weed seeds, and then to cultivate the trees; the result would be in favor of new ground and no cultivation."

Fig. 1.

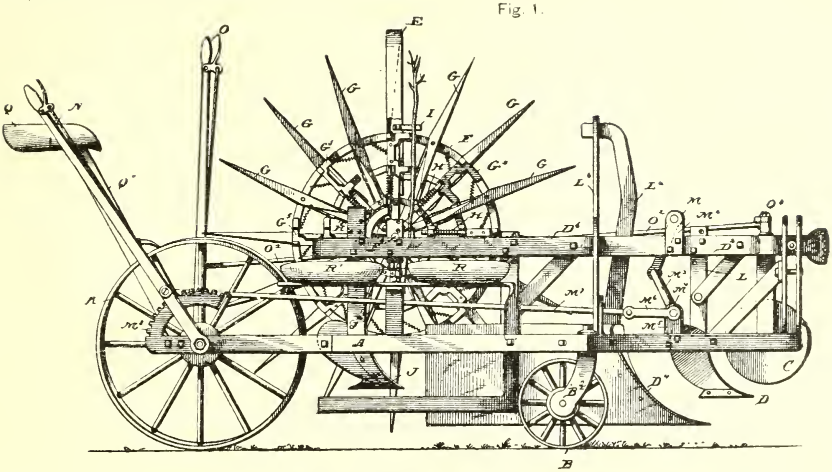
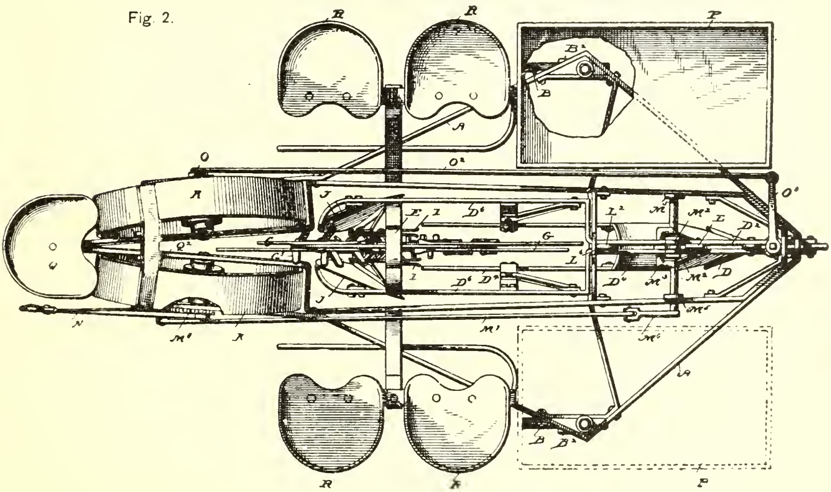


Fig. 2.



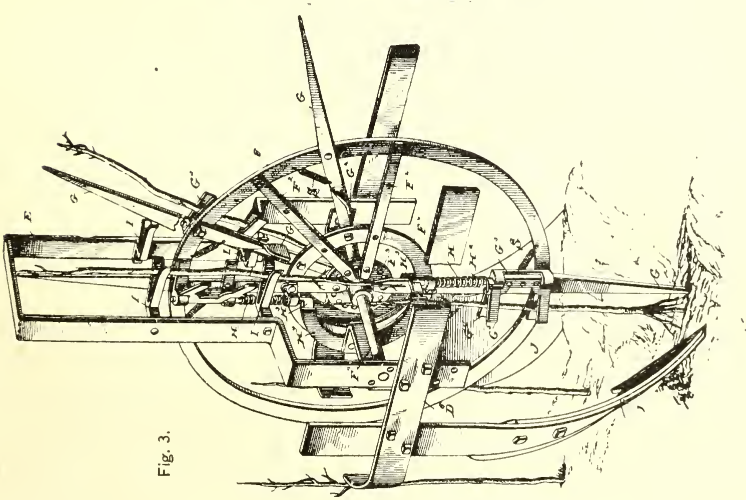


Fig. 3.

Mr. Stratton figures that one ordinary traction-engine arranged for drawing plows will operate 3 plows, 1 harrow, and 1 tree-planter, attended by two men only, planting trees 4 feet apart each way, at the rate of 6 acres per day, if properly managed. And as there are ordinarily at least sixty days in the spring time for tree planting, two men can plant 360 acres during the spring season with this machinery; with more help the amount of planting could, of course, be increased within limits.

That this tree-setting machine may be adapted to the planting of tobacco, cabbages, beets, etc., need not be further elucidated.

At present writing the machine is not yet in the market, but it is understood that during the coming summer its manufacture will be begun.

FOREST FARMING.

There are several methods in vogue of combining agricultural use of the soil with forest planting, with a view both of cheapening the planting and benefiting the plants.

Probably the need of agricultural lands for the poorer population rather than any other consideration has in Germany early given rise to this combination of forestry with a temporary agricultural use of the forest land.

That such use of clearings before their reforestation may prove an advantage to the new forest growth and be employed to cheapen and facilitate reforestation was probably an after-thought. In devising methods for prairie planting this practice deserves more consideration than it has hitherto found.

Such agricultural use of the land either precedes reforestation or is continued for a time after the tree-planting has been done. We may call the first plan "fore-farming," the second plan "between-farming." The "fore-farming" is usually carried on for one to six years, the "between-farming" up to six years.

A common rotation of crops is rye, potatoes or millet, oats; and then oak, pine, and spruce sown with the oats or planted on the stubble. By sowing the tree seeds with the oats or rye or millet, the seedlings derive a three-years' protection from the crop, and afterwards from the stubble.

No exhaustion of soil is anticipated from a three to four years' fore-farming. Reforestation by these methods has been practiced in all parts of Germany. About 5,000 acres are farmed in this manner, and about 75,000 acres of forest which originated in this way exist in the western provinces of Germany. It has been especially in vogue in Hesse ("Roederbau") for more than a century with the greatest success, as is testified by over 5,000 acres of finely grown pine, spruce, fir, and beech forest up to one hundred and twenty years old, with a yearly average accretion of 90 cubic feet per acre, a remarkable production.

Here the practice is, after a crop of potatoes, to sow pine and oak together with rye and oats; or else to plant the oak and pine, and farm between the rows, on better soils for four years, with a rotation of potato, rye, potato, rye, or for two years with potato followed by rye on poorer soils (conifer soils). By this method sometimes a surplus over and above the cost of reforestation and cultivation of $12 to $14 per acre was obtained.

Another method was to crop the ground with potatoes, and then for one year between-farming with grain, trees being introduced by seed or planting.

A somewhat different management is the temporary use of a coppice for agriculture ("Hackwald," "Hauberg"). About 17,000 acres are annually so used in western Germany and probably a larger amount in France. After the coppice is cut, which is often done in early fall because the brush with the leaves on gives more ashes, the brush and soil cover is burnt over; and by piling an extra amount of brush on the stumps of undesirable kinds these are exterminated, the ashes are evenly distributed, and rye is sown and covered with the hoe. In the spring fail-places are stocked with oak, either by sowing or planting the roots (stumps).

This method may be of some use in the oak coppices which are grown for the tan-bark, as quality and value of the latter are said to be enhanced by the fertilization with ashes. It is, on the other hand, sufficiently well proved by experiments that an advantage to the forest as such does not accrue from such management; on the contrary, deterioration of forest conditions is unavoidable from the use of fire.

PARIS EXPOSITION.

In conclusion, I should mention that much time was not unprofitably consumed by the Division in preparing an exhibit for the Ohio Centennial Exposition, and again for the International Exhibition at Paris. The exhibit at the latter place, which will form the subject of a special report, may claim to be the first forestry exhibit from our country which deserved such a name, holding itself strictly to matters of forestry as an art by itself, and not attempting to make a display of the various manufactures which rely upon this art and promiscuously of the many woods, important and unimportant, which make up our forest flora. In subsection A, Forest Botany, of the four hundred and twenty or four hundred and thirty species of timber trees which are found in the United States, a selection of one hundred and twenty was made, which represent those probably of importance to forestry. These were exhibited in hand-specimens of wood blocks and botanical specimens, arranged in groups and provided with descriptive labels, so that the beholder could at once study the species in all its aspects. The labels, showing on a small map of North America the field of distribution of the species, were mostly furnished by the Museum of Natural History in New York, from the well-known Jessup Collection. Through the courtesy of the Massachusetts Society for the Promotion of Agriculture, the entire set of colored plates contained in Michaux's North American Forest Flora is exhibited.

There are also photographs showing the characteristic trees of our forest flora. To show the anatomy of our woods, microscopic sections, transverse, radial, and tangential, of twenty species were enlarged one hundred times and photographed, forming a novel and most instructive exhibit.

A collection of the seeds of one hundred species of forest trees leads the exhibits in subsection B, Forest Culture, and a neat model of the tree-planter above referred to shows the manner in which we shall presently clothe our prairies and plains with a verdant growth.

The most unique exhibit, however, is a collection of some fifty sets of sections taken from as many trees at different heights, which show

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