U. S. DEPARTMENT OF AGRICULTURE.

REPORT

OF THE

CHIEF OF THE DIVISION OF FORESTRY

FOR

1893.

BY

B. E. FERNOW.

FROM THE REPORT OF THE SECRETARY OF AGRICULTURE FOR 1893.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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REPORT OF THE CHIEF OF THE DIVISION OF FORESTRY.

SIR: I have the honor to submit my eighth annual report upon the work of the Division of Forestry, including also a presentation of the methods of German forest management as illustrated at the World's Fair.

Very respectfully,

B. E. FERNOW,
Chief.

Hon. J. STERLING MORTON,
Secretary.

WORK OF THE YEAR.

OFFICE WORK.

The increase in the correspondence of this division, in answer to inquiries for information on general and specific subjects, as noted in former reports, has continued during the present year. The demands thus made on the time of the writer and of the office force in general can of course be met only by neglect in other directions, namely, the pursuit of special lines of investigation and the preparation for publication of such material as has accumulated. Hence many reports and bulletins, the publication of which has been contemplated and promised from year to year, still await the editorial hand to fit them for publication. The delay in this latter respect may not always be considered detrimental, since with new information added in the course of time the reports can be made more complete and satisfactory, but it is annoying sometimes, when information asked for exists on file in manuscript and can be furnished only by typewritten copy, absorbing much time of the clerical force. The need, alluded to in the last report, of an increased office force in the direction of experts who can give advice in technical matters and are, in addition, endowed with a sense of that literary perspective which renders them fit for editorial work, still exists and in an increased degree.

TIMBER INVESTIGATIONS.

The major part of the funds of the division has been devoted, the same as last year, to the timber investigations, for which an increased appropriation had been granted, and which have continued to present the most practical and useful work for the division to undertake.

The first results of the investigations have been made public in a progress report, being Bulletin 8, or Part II of the series which is to be continued under the caption of "Timber Physics." It comprises

some of the results of mechanical tests on longleaf pine, and also of chemical analyses and other inquiries designed to determine the influence of turpentine orcharding on the timber of that species. While these results are of interest and conclusive as far as fixing the range of strength of the species, establishing beyond doubt the influence of the degree of seasoning as well as that of specific weight on strength, determining also beyond question the absence of influence on strength of the heartwood due to bleeding, in other directions they must be taken only as indications by no means definitive, and the discussion of the results is only tentative and an earnest of what is to follow when the data can be more carefully correlated.

In work so comprehensively planned and carried on with such a small force, the accumulation of data alone necessarily occupies the longest time, and generalizations from the same must be delayed rather than hastened, lest the mistakes of the past which it is proposed to correct be thereby repeated. The main result of this year's work, then, resumed after several months' discontinuance for lack of funds, has been the accumulation of additional data on the pines of the South. There have now been collected and in part tested and examined altogether 370 trees, from 16 different stations. Of these, 24 are Northern pines, 65 oaks of 7 different species, 23 bald cypress, and the balance of 258 belongs to the four important Southern pines (longleaf, shortleaf, loblolly, and Cuban), with collections from Arkansas, Texas, Louisiana, Alabama, Georgia, and South Carolina; the longleaf pine receiving the lion's share, with 117 trees, from 9 stations and 10 different sites.

Thanks are again due to the various railroad companies, whose generosity in transporting test material free of charge has made it possible to handle much larger amounts than our funds would otherwise have permitted. Especially are we under obligation to the management of the Louisville and Nashville Railroad, over whose lines nearly all material collected enters St. Louis. Not less generous support has been given by the East Tennessee, Virginia and Georgia Railroad Company from the East, while the Iron Mountain and Southern Pacific roads kindly furnished the transportation from the Southwest.

The results of physical examinations of the longleaf pine for 43 trees from four sites have been compiled by Mr. Roth and will be ready for publication shortly. The principal points of interest brought out so far may be summarized as follows:

The rate of growth in height of this pine (*P. palustris*) is similar to that of the white pine (*P. Strobus*); it is greatest between the fifteenth and fiftieth year; the height of the ordinary merchantable trunk, 60 to 70 feet, is usually attained at or before the age of 60 to 70 years, while 90 to 100 feet may be regarded as a fair average height for this species. The rate of growth in volume of the timber is fairly constant after the age of 60 to 70 years, but of course the increase in diameter becomes correspondingly slower with age, so that old trees add but about one-half as much to their diameter each year as do trees of 125 years and less—an observation of economic value to the operators of large tracts of pine lands. From these and other considerations it appears that the species may possibly be managed with an average rotation of about 100 years, producing then the largest amount of good milling timber per acre, while for heavier timber the rotation would have to be extended to 160 years.

It also appears from numerous determinations, measurements, and tests that the position of the European foresters in maintaining as a

general law that coniferous wood of slow growth is better than that of rapid development does not apply to this species. It also appears that the wood produced by young trees, 50 to 100 years old, is of better quality than that laid on by trees 200 or more years old, much excelling it in its specific weight and consequently in its strength and resistance.

In selecting lumber of this kind for particular purposes the proportions (or relative width) of dark brown bands of summer wood marking the outer part of the yearly rings will be found the safest criterion for the specific weight and the strength of both the sap and heart wood, so that, with the exception of so-called "light wood," the weight and strength of seasoned wood varies with the color effect, the wood of the lightest color being also lightest in weight and inferior in strength. In the same way the wood in the interior of an old tree is heavier and stronger than that near the periphery. The wood of any given period of years decreases in weight upward, so that the wood of the upper logs of the same period of growth is lighter and furnishes less durable and weaker material as was indicated in published results of the preliminary examinations. Water forms about 16 to 20 per cent of the weight in the fresh heartwood and 45 to 50 per cent of the sapwood. It appears to be more abundant in the sapwood of old than that of young trees and also more abundant in the sapwood of the upper parts of the trunk than of the lower.

The shrinking and swelling of this wood in drying or in soaking is found to be greater in the sapwood than in the heartwood, greater in heavy than in light wood. The average values, from which there are many slight exceptions, indicate that the shrinkage as a per cent of the fresh volume is—

In heartwood about 15 per cent of specific gravity × 100, in sapwood about 20 per cent of specific gravity × 100; i. e., if the specific gravity of a piece of heartwood is 0.60, the shrinkage per cent may be placed at 15 per cent of 60 = 9 per cent, and if the piece were sapwood, its shinkage per cent would be 20 per cent of 60 = 12 per cent.

These generalizations seem warranted by the results of experiments on carefully prepared pieces measured with caliper, and also determinations on microscopic sections, which latter especially leave no doubt as to the influence of weight—amount of substance in a given volume—on the shrinkage of the tissue, notwithstanding the contrary opinions expressed, even of late, and by such acknowledged authority as Dr. Nördlinger and others.

This timber-investigation work has met with the highest appreciation and praise, not only from those concerned in its results, from the domestic technical press, and from a special committee of the jury of awards at the World's Fair, but also by the reviewers of the same in foreign technical journals, one of whom, himself in charge of similar work for the Prussian Government, uses the following language in the leading forestry journal (Danckelman's Zeitschrift, 1893, p. 536):

This plan of work is as remarkable for its scope as for consistent pursuit of an eminently practical result. Although Germany has accomplished a great deal in some directions of this field, especially in investigating the laws of growth and wood structure, we are yet far from having such a comprehensive and indispensable knowledge even of our most important timbers. We must admit, with a certain sense of humiliation, that the Americans show us what it is we really ought to know, and that they have already by far surpassed us in the elaborate organization for these investigations.

Nevertheless, it has become apparent that in the practical execution of the plan there are discrepancies which necessitate some changes

in methods. The local separation in three different places of the test work, the physical examination, and the direction, which occasioned friction, delay, and lack of mobility, has in part been remedied by the transfer of Mr. Roth to Washington, where, however, only temporary and insufficient facilities for the physical laboratory can yet be secured.

The growing collection of study material, unique in the world, is too valuable to be left, as now, in a wooden shed, liable to conflagration at any time; nor are the accommodations and facilities available for the work sufficient or suitable. These disadvantages should be removed as soon as possible. It has also become apparent that a more careful division of the test work will have to be made into what might be called wholesale or commercial testing and testing for the finer correlations, especially between structure and qualities. This last necessitates a careful subdivision of the test material according to judgment in each case, which can not be reduced to strict rule. Hence, at least part of the testing will finally have to be done under the immediate control and personal supervision of the investigator of the physical properties here at Washington. This is the more desirable when certain special minor investigations are to be instituted from time to time as called for. Of such investigations the following have been continued, begun, or planned during the year:

CHEMICAL ANALYSES OF WOODS.

In continuance of the work on the influence of bleeding for turpentine there have been made, under the direction of the Chemist of the Department, some 1,000 analyses of bled and unbled timber to verify the conclusions already reached, with results which leave no doubt as to the correctness of the former deductions. The material used for these analyses having been from collections that had been exposed to the air for a length of time, hence losing by evaporation unknown quantities of resinous matter, a new series of experiments has been instituted to determine the actual amounts and behavior of resins in the living tree, thereby furnishing data not only for a better knowledge of the physiology of resins, but also indications for a more rational method of turpentine orcharding.

The work on tannins has also had further attention. The opportunity afforded by the World's Fair of becoming acquainted with the tanning value of many materials, hitherto not at all or little known to the trade, led to the making of analyses of such materials exhibited. Some 70 materials—barks and woods—mostly from South America, were collected and in part analyzed. Materials of domestic origin have also been collected and are awaiting investigation.

There has of late years come about a change of methods in the construction of large storage houses, mills, etc., wood being substituted for iron or steel girders, because of the experience that the latter are more apt to lead to total loss of the building by fire than when wood, stone, or brick is used; the heat bending the metal beams out of shape, thereby occasioning a collapse, while burning wooden beams will remain in shape until their carrying power is destroyed. It is, of course, desirable in such structures to employ such kinds of wood as most resist destruction by fire, combining with this quality the necessary strength and the existence of available quantities and sizes. There have never, so far as we know, been any systematic experiments made to determine the relative inflammability and combustibility of various timbers; hence an investigation of these questions, appearing of considerable practical importance, has been planned and will presently be carried out.

Investigations into shrinkage and swelling, and into the effect of different modes of seasoning, are also in progress.

TREE MEASUREMENTS AND ACRE-YIELD DETERMINATIONS.

In addition to these laboratory investigations there has been begun a line of field work which branches over into the field of forest biology. This is a series of tree measurements and acre yield determinations, which are to serve the purpose of ascertaining the rate of growth of various timbers under various conditions at various ages. This investigation is carried on in connection with the collection of test material in the forest, and supplemented by measurements on the test material itself at the laboratory. Besides on the pines of the South, such measurements have been begun on the spruce and white pine in Maine, where the division was fortunate enough to find a competent man available for the work in Mr. Austin Cary.

Coöperation with the New York State forest commission in this line of investigations has been initiated, and it is hoped that further coöperation in other localities can be obtained, in order to cover as much territory as possible.

Without the knowledge obtained in this manner we shall never be able to discuss forestal operations intelligently, least of all the question of profitableness of forest management, which can be answered only when knowing the productive capacity of the various species under different conditions.

Since some of the readers of this report may desire to make measurements of this kind for their own sake, or for the benefit of this division and forestry knowledge in general, the schedules used in the work, which have proved practical in the woods, are subjoined on the following pages. Blank schedules can be furnished by this office on application.

BOTANICAL WORK.

The botanist of the division was principally occupied with preparation and installation of exhibits for the World's Fair, and spent most of the time, while the Exposition lasted, in charge of the exhibit. The herbarium of the division has grown during the year by an addition of 500 specimens, and without any specific expenditure is gradually becoming valuable in the matter of series of material for comparative study of climatic influences in native and exotic forest trees. He has also prepared the material for and supervised the artists who are working on the plates which are to illustrate the monographs of timber trees so often promised and so long delayed in publication. It is hoped that they can be published, now much amplified, during the year.

The manuscript of the elaborate account of the endemic and exotic arborescent flora found in the District of Columbia, especially in the parks of the city of Washington, which was undertaken with assistance of funds from the National Museum, has in part been revised and is also to be published soon.

The revision of the nomenclature of North American trees, also completed in manuscript, still requires the attention of the botanist for eventual changes as new knowledge comes to light. It has been thought best to delay the publication until the need of possible changes grows less and a more settled policy as to the rules of nomenclature to be followed has been adopted by botanists. To turn this delay into an advantage it is proposed to add to the synonymy descriptive matter, which will make the publication more widely useful.

SCHEDULE FOR MEAS-

Strip No. *2.*
Station *B.*

Species.	Diameter, classes	Over 36 inches.		30–36 inches.		24–30 inches.		18–24 inches.	
		Over	Under	Over	Under	Over	Under	Over	Under
	Height, classes	120 feet.		100 feet.		100 feet.		80 feet.	
Pine	Number of trees		IIII				I	IIII	
	Diameter and height of timber.		*31×75* *35×75* *38×80* *40×80*				*25×60*		
	Merchantable lumber, feet, B. M.		*1,200* *1,300* *1,800* *2,900*				*900*	*300* *450* *450* *500* *350* *300* *300*	
	Crown and bole development.		*Large, but open, boles straight.*				*Good, full crown, bole crooked.*		
	Totals { Numbers		*4*				*1*	*7*	
	Totals { Mass		*7,200*				*900*	*2,650*	
Birch	Number of trees	I, *about 70 feet high.*						I, *about 60 feet high.*	
	Diameter and height of timber.	*38×25*							
	Merchantable lumber, feet, B. M.	*1,000*							
	Crown and bole development.	*Large, open crown.*							
	Totals { Numbers	*2*						*1*	
	Totals { Mass	*1,000*							
Maple	Number of trees								
	Diameter and height of timber.								
	Merchantable lumber, feet, B. M.								
	Crown and bole development.								
	Totals { Numbers								
	Totals { Mass								

URING ACRE-YIELD.

Site *a*.

14–18 inches.		10–14 inches.		6–10 inches.		3–6 inches.		Under 3 inches.		Remarks.
Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
80 feet.		80 feet.		60 feet.		40 feet.		20 feet.		Totals, numbers, and mass.
						𝍸 III	III		𝍸 𝍸 𝍸	
									𝍸 III	
						Clustered, but full crown.			*Dense, well limbed.*	
						8	*3*		*18*	*41 10,750 feet*
							III		IIII	
							•			*There is also a cluster of small balsams, 11 in number, about 3 inches diameter by 12–15 feet height.*
							Small, straight.		*Light, open, straight.*	
							3		*4*	*10 1,000 feet.*
					III				𝍸 I	
					Thin crown, slender.				*Quite thin, slender.*	
					3				*6*	*9*

BIOLOGICAL INVESTIGATIONS.

[Blank to be filled by collector.]

NAME OF SPECIES ——— ——— LOCALITY ——— ———

TREE NO. ——— POSITION: Crown free; partly free; crowded; SURROUNDING SPECIES: ——— ———

Dimensions.	Feet.	Inches.	Description.
Total height			The neighboring trees are
Length of timber			
Length of crown			
Length of leader for the last five years			and stand ..... feet away respectively. The timber of the tree is sound; defective; straight; crooked; wind-shaken; clear; knotty.

Diameter at—	Inches.
feet.	
4	
8	
12	
16	
20	
24	
28	
32	
36	
40	
44	
48	
52	
56	
60	
64	
68	
72	
76	
80	

Cross section.	Height of section from ground, feet.	Diameter of sections, centimeters.	Distance (in millimeters) from periphery to the limit of Groups No—										Sap-wood.		Thickness of bark, millimeters.	Total number of rings on section.
			1	2	3	4	5	6	7	8	9	10	Width, millimeters.	Number of rings.		
No.																
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																

NOTE.—For measurement of ring-growth across section metric measure is used to avoid fractions.
Name of collector: ——— ———.

Reduced results.

[Not to be filled out by collector.]

Age of tree.	Height from the ground.			Height.		In the—
Years.	Feet.	Inches.		Feet.	Inches.	Year.
			Here paste the graphic description.			10
						20
						30
						40
						50
						60
						70
						80
						90
						100
						120
						130
						140

INSTRUCTIONS.

Number trees measured in same camp and conditions consecutively; underscore descriptive words where given, whether standing free or crowded, or note briefly

other conditions of position and give surrounding species. Use 4-foot rule and gauge. In all cases, if possible, take two measurements of diameter at right angles and note average.

(1) Make notes as to crown and neighboring trees.

(2) Measure the total height.

(3) Measure the length of timber from stump to first crown-forming limb.

(4) Measure the diameters with calipers every 4 feet from the ground up.

(5) Count the rings on the stump, and on top of each log section, beginning at the periphery and marking every 10th one with pencil, and note for each cross-section:

(*a*) Height from ground and diameter.

(*b*) Total number of rings.

(*c*) Thickness of bark.

(*d*) Width of and number of rings in the sap-wood.

(*e*) Lay on the rule and note the distance from the periphery of the wood (not bark) to the limit of the 1st, 2d, etc., group of rings, or to the 10th; to the 20th; to the 30th, etc., rings.

NOTE.—If the rings are over 2 mm. wide, measure them in groups of 10 rings; if less than 2 mm., measure in groups of 20 rings.

DISTRIBUTION OF HAND COLLECTIONS.

The exhibit of American woods at the World's Fair started quite a demand for hand collections by public institutions and private individuals. To satisfy such demand as far as the means of the division allowed, the blocks of wood remaining over from various collections (some 4,000) stored at the Department were shaped into small pieces and were properly labeled, divided into a number of collections, and distributed, the object of this distribution being to stimulate interest in the study of our timber wealth, especially in schools and colleges. Full collections were exchanged for similar favors with the Forestry Institute of St. Petersburg, Russia; Tokio, Japan; and Eberswalde, Prussia; and in addition some fifteen sets were sent on application to public educational institutions and individual applicants. Some few sets remain for future disposal.

SEED AND SEEDLING DISTRIBUTION.

Under the provision of the law directing the distribution of "valuable economic tree seeds and plants," some 300 pounds of various seeds in 4,000 packages were distributed to 500 applicants, mostly from the prairie and Western States. In addition some 5,000 cuttings of superior strains of osier willows were sent to State experiment stations and to some one hundred individual applicants. Some 5,000 seedlings of black walnut, grown for the Department on the grounds of the Maryland Agricultural Experiment Station, are now available.

As has been repeatedly urged, the practical results derived from this provision of the law, at least in its present form, are of little value in proportion to the expenditure of money or energy—outlays which appear almost wholly a waste.

The object of such distribution can be only twofold, namely, to encourage forest-planting and to test the adaptation of certain kinds to certain climatic or soil conditions. There is no doubt that the supply of plant material could be made an effective incentive to the settler on the treeless plain; not that the cost of the material is of so much moment to the settler in many cases, but the inconvenience of procuring it and the uncertainty of obtaining proper material often deters him. But since forest-planting means planting on large areas and requires a large number of plants to the acre, the scale on which such

an adequate distribution must be made appears at once as a practical barrier to a successful use of the scanty appropriations set aside for this division. As shown elsewhere, even if the distribution had been confined to the timber-claim planters—an unjust discrimination—and not more than enough material for 1 acre were furnished (a small enough encouragement), the amount to be spent in that direction would have to be not less than $150,000.

Other countries much smaller than ours use this means of encouraging forest culture, with a full realization of the fact that to be effective it must be on a tolerably large scale; thus, the Prussian forest department furnishes from its nurseries some 40,000,000 seedlings free of charge and 24,000 pounds of seed at nominal cost; the council of agriculture in Bohemia (5,500,000 inhabitants), in coöperation with agricultural and forestry associations and individual estate-holders, distributes from 3,000,000 to 4,000,000 plants and 1,500 pounds of seeds. The cantonal governments of Switzerland (2,700,000 inhabitants), besides giving subventions for reforestation to the amount of $25,000, furnish also 5,000,000 to 6,000,000 plants and 1,500 pounds of seed.

In addition to the impracticability from a financial point of view, there is also an objection on the ground that many kinds of tree seeds are apt to spoil quickly and do not bear storage and delayed shipment; and, on the other hand, seeds and young plants are often not properly handled by the inexperienced planter. Finally, the tardiness of results from the time of sowing to the appearance of the plants and their first growth will tax the patience of many beyond endurance, and discouragement rather than success is commonly the consequence.

On the other hand, if experiment with the introduction of new kinds or with the adaptation of well-known species to new localities is the object, it would be better to have this done by the experiment stations, which are better prepared to do such work, the permanency of which insures more continued observation, and their public character, moreover, warrants more effectual dissemination of any experiences gained. The only proper manner, then, it appears, of complying with the provisions of the law is not a promiscuous distribution of plant material, but a coöperation by this Department with the various State agricultural experiment stations, or, since these are mostly well enough endowed to work in their own way, the same method is available as was pursued in the forest-planting experiment on the sand hills of Nebraska. Reference to this experimental planting was made in the last two reports of this division, in which it was pointed out how the division, in coöperation with private individuals who furnish land and labor free of charge, may undertake *bona fide* experiments, the division supplying plans and material. A number of such stations distributed through several States would eventually furnish object lessons and experiences in proper proportion to the expenditure.

PUBLICATIONS.

The annual report of the Chief of the Division of Forestry for the year 1892, containing a brief history of the forestry movement in the United States and an extensive discussion of the turpentine industry, was published in a separate issue to the extent of 15,000 copies.

The following reports or bulletins remain in manuscript and unpublished, partly on account of the difficulty, alluded to in the beginning of this report, of finding the needed time for editorial revision: Mono-

graph of the white pine (*Pinus Strobus*), by V. M. Spalding; Monographs of the longleaf (*Pinus palustris*), shortleaf (*P. echinata*), loblolly (*P. Taeda*), and Cuban pines (*P. heterophylla*), by Charles Mohr; Monographs of the pitch pine (*P. rigida*) and red pine (*P. resinosa*), by William F. Flint; Monograph of the black spruce (*Picea Mariana*), and white spruce (*P. Canadensis*), by Kate Furbish; Monograph of the hemlock (*Tsuga Canadensis*), by A. N. Prentiss; Report on consumption of wood in the charcoal iron industry, by J. Birkinbine; Report on consumption of timber in mines, by F. P. Dewey; Report on physical and biological observations on timber of the longleaf pine, by F. Roth; Revision of nomenclature of North American forest trees, by G. B. Sudworth; Handbook of the arborescent flora of Washington City. An effort will be made to bring these long delayed materials to publication during the ensuing year.

Besides Bulletin 8, as progress report on timber physics, referred to above, there was published a bulletin (No. 7) on forest influences, which contains an extensive review of the systematic observations at forest meteorological stations in Europe and elsewhere, as well as a discussion of the influence which forests have upon waterflow and sanitary conditions.

A circular (No. 10) to lumbermen was issued, calling attention to the condition of forest supplies, pointing out the need of coöperation of those most interested in the perpetuation of these supplies in improving present methods of treating the same, and the manner in which this might be done, especially by legislation looking towards better protection of forest property against loss by fire and otherwise, a draft of a bill embodying the principal features of such legislation being added.

In reply to some statements in the public press by Mr. H. Gannett, of the U. S. Geological Survey, which were calculated to mislead the public as to the true condition of our forest areas and forest policy, the chief of this division had the honor of addressing to the Secretary of Agriculture a letter which was published in circular form. Since, however, correspondence from many parts of the country shows that this reply has not been as broadly disseminated as the original statements, which it is important to discredit, it is deemed desirable to give further publicity to the refutations of Mr. Gannett's statements, especially as they are accepted as true by ill-informed persons, to the detriment of the work of this division and the forestry movement in general.

Letter to the Secretary of Agriculture regarding forest growth and timber consumption.

ON BOARD S. S. ALLER, *April 5, 1893.*

DEAR SIR: Just as I was starting on my journey for the purpose of collecting an exhibit for the World's Fair, illustrative of the methods employed in German forest departments, a friend handed me an article published April 1 in the Evening News of Washington, over the signature of Henry Gannett, the chief geographer of the U. S. Geological Survey, in which the writer undertakes to show that efforts to bring about a more conservative and rational forest policy in the United States are unnecessary, because the relations of forest growth to climatic, soil, and water conditions are presumably of no practical significance, and because in his opinion the timber growth in the United States is certainly renewing itself much faster than it is being consumed.

Lest the assertions of this writer be given circulation without contradiction and thereby assume the dignity of authoritative statement, which may to some render it doubtful whether the work of the Forestry Division or of the American Forestry Association has been directed in the right channel, I take the liberty of addressing this letter to you, to be published if you see fit. The official position which I hold renders it incumbent upon me to arrest, so far as I may be able to do so, the promul-

gation of such false statements and inferences as are contained in Mr. Gannett's article; and since the tendency of the article is undoubtedly to throw discredit on the work of the forestry movement, and of the Forestry Division in particular, justice to them and to the division seems to require that public refutation be made.

That there is a certain amount of truth in Mr. Gannett's statements and arguments makes them only the more dangerous, for this little truth hides from ready discovery the misstatements and the flaws in the argument, and the public—not over critical—too readily inclines under their authority to erroneous conclusions. In the case of Mr. Gannett's statistics, the misfortune is that they can not indeed be met positively with absolutely correct data on the other side, but only negatively with the certainty of their incorrectness.

Briefly, regarding the status of our timber supply, Mr. Gannett states that the wooded area of the United States covers approximately 1,113,000 square miles (712,320,000 acres); that each acre produces annually 40 cubic feet of wood; that we consume annually between 20 billion and 24 billion cubic feet of wood (accepting the estimate made by the Forestry Division); that, therefore, no shortage is to be feared, but that an overproduction of from 6 billion to 10 billion cubic feet of wood takes place on this area.

Mr. Gannett has become more conservative regarding the forest area than he has been in former statements. He has asserted that 50 per cent of the United States is wooded; he now comes down to 37 per cent. The Forestry Division, by correspondence with well-informed residents in each State some years ago, ascertained the area under forest to be below 500,000,000 acres. But we may readily concede the larger area, simply remarking by the way that the failure to arrive at more certain figures is perhaps chargeable to Mr. Gannett's voice in shaping the policy of the last census, for he it was who objected to the present writer's contention that it would be proper for the census to gather forestry statistics.

As far as Mr. Gannett's estimates and calculations of woodland areas are concerned, they are wholly irrelevant to the question at issue, namely, the question of timber supply; for he overlooks entirely the character of such wooded lands as timber producers. The merest tyro in forestry matters, or any observant logger or timber looker, will be able to point out to Mr. Gannett the difference between waste brush lands, such as to my own knowledge are figuring in the estimates of the Geological Survey as woodland, and timber-producing forest growth. The one is occupied by woody growth, to be sure, but of kinds which do not grow to useful size or useful quality and which prevent by their very existence the occupation of the area by desirable timber-producing kinds, becoming thus a positive hindrance to useful forest growth. Here is one considerable element of uncertainty which Mr. Gannett entirely overlooks, thereby exposing an utter lack of knowledge regarding timber production. Again, the merest tyro in the science of wood growth is well aware that 40 cubic feet of annual growth of such character as enters into our wood consumption, and to which the accepted estimate of consumption of 20 billion feet refers, has nowhere been known, at least in the temperate zones, and, as an average, over an area of more than 700 million acres.

With more knowledge than Mr. Gannett in these matters, I venture to say that his figure exceeds at least three times the possibilities. How he arrived at his extravagant figures I am at a loss to understand. Since this question of wood growth per acre per year is of considerable general interest, I will explain its conditions more fully and cite statistics of more than usual reliability, which are fortunately available to me.

In the well-managed forests of Prussia (some 35,000,000 acres), largely stocked on poor land, the average total production of wood per acre for a long series of years has not been more than 21 cubic feet, but this includes branch wood, brush, and roots, which are not used in our country. Of this only 14 per cent, or hardly 3 cubic feet, represents material fit for the industrial uses; and we should add that in the United States firewood is also made from such material. In the Government forests of Prussia (some 8,000,000 acres), exemplary in their management, the production reaches nearly 6 cubic feet. The highest wood production in German forests is reported from Baden (over only 4,330,000 acres of forest) with somewhat over 50 cubic feet of wood per acre per year. Assuming also a larger per cent of sizable timber, namely 20 per cent, we would here find the annual production per acre of such material as we are in the habit of using at the rate of 10 cubic feet per acre. Competent writers on the subject, who believe that the Government reports understated the annual growth, have calculated the same to be as high as 55 cubic feet per acre (see report of Forestry Division, 1886, p. 184), of which they assume 27 per cent to represent wood over 3 inches in diameter; even this larger figure would bring the product of sizable wood to less than 15 cubic feet per year. And I repeat what is well known, that in the United States we hardly use the smaller sizes even for firewood.

To come now to more familiar measurements, we can figure out the possibilities or probabilities in the following manner, leaning toward extravagance rather than con-

servatism: Any lumberman acquainted with the various forest regions of the United States will admit that, leaving out the exceptional conditions on the Pacific coast, a cut of 20,000 feet (board measure) per acre from our virgin forests would be an absurdly large average estimate; this would represent, with excellent practice in the preparation of the material, say 2,000 cubic feet of round forest-grown timber, and since the trees cut to yield such material are at least 150 years old—they are in reality mostly over 200 years—the annual production would appear under such conditions as 14 cubic feet per acre per annum, or about as much as the most advantageous results reported from well-managed German forests.

Apply this most extravagant figure to the area as given by Mr. Gannett, and we find that our consumption at present is from 10 billion to 14 billion cubic feet in excess of what the area could possibly produce as an annual crop; or that we are cutting into our capital to the extent of more than 50 per cent of our consumption, and not, as Mr. Gannett would have it, that we are laying up for the future, which, by the way, increases the demands for wood material at the rate of more than 35 per cent every decade.

The above statements show clearly how utterly untenable is Mr. Gannett's position, and how evidently lacking he is in knowledge of the subject he discusses. Regarding his knowledge of the relation of forest cover to climate, soil, and water-flow, the same lack of familiarity with the real facts and their significance is apparent. As these will be fully brought out in a publication of the Division of Forestry (Bulletin 7) now in press, I will forego arguments in proof of this accusation, in order not to lengthen this letter.

One can not but deeply regret that men whose position before the public imposes upon them the responsibility of leading public opinion intelligently and upon the basis of well-established facts should thus be found ignoring their responsibility. I am encouraged to hope, however, that your well-known views regarding the rational and conservative use of our forest resources and the extension of forest areas where desirable will be strengthened rather than weakened by such groundless and unwarranted assertions by advocates of a policy of *laissez faire* in this matter.

Respectfully yours,

B. E. FERNOW,
Chief of Division of Forestry.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

CONSUMPTION AND SUPPLY OF FOREST PRODUCTS IN THE UNITED STATES.

Regarding the supply of forest materials, which may be drawn from the virgin forests still in existence, we have no data. The difficulties of obtaining even the crudest approximations, except for certain species, as the white pine, the longleaf pine, the whitewood, etc., are not only great in the first place, for many reasons, but are still further increased by the fact that the methods of using the supplies change with their waning, with methods of transportation, and with other economic development. Thus the statistics of white pine and longleaf supplies, given by the Tenth Census in 1880, were as approximately correct as could be expected, adverse criticisms notwithstanding; but the lengthening out of the supplies, especially of the white pine beyond the time, when those figures foretold their practical exhaustion, has been possible only through the reduction of the average merchantable log by from 27 to 57 per cent—i. e., while during the census year in Wisconsin (Wausau) for instance, the average log was, say, 200 feet per log or 18 inches in diameter, in 1893 it had dwindled down to 84 feet or 13 inches in diameter. While the census statistics were based on the then practice of taking nothing less than 10 inches in diameter, the lumbering is now extended to logs as low as 5 or 6 inches in diameter.

No more striking statement of the decline in white-pine supplies could be made than to cite the number of feet in logs which passed the nine leading booms in the lower peninsula of Michigan in 1887, namely 2,217,104,985 as against 505,134,656 feet in 1893, a decrease of nearly 80

per cent, chargeable no doubt in part to other modes of transportation, but nevertheless foreshadowing unmistakably the practical exhaustion of supplies.

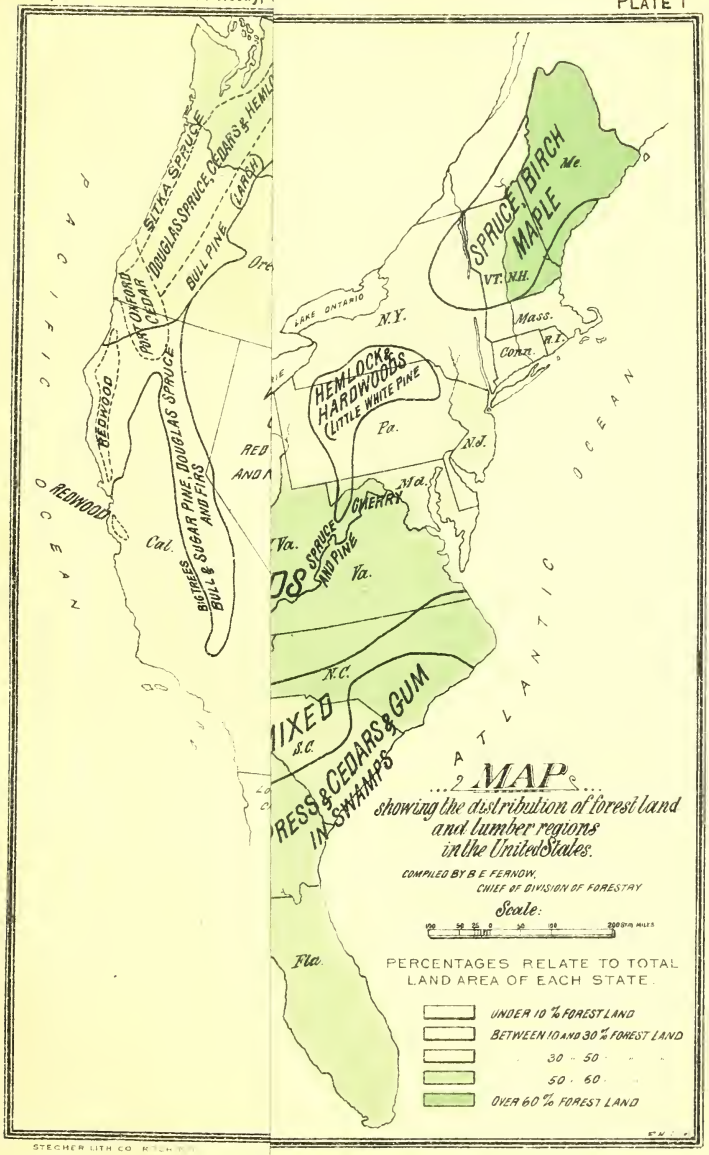
EXTENT OF FOREST AREAS.

While we can not then with any degree of even approximate accuracy speak of the amounts of standing and growing timber, we have somewhat better (although far from accurate) data of the forest areas, from which at least the capacity of wood production may be surmised, as has been done in the above-quoted letter in reply to Mr. Gannett's statements. But here, too, absence of knowledge as to the condition of these areas makes a statement of the actual supplies possibly on hand or growing mere guesswork. Not only are there to be distinguished the timber areas which contain supplies ready for the axe and for present consumption, but in the so-called second growth we must distinguish the areas which promise new supplies of value and those brush lands which are not only not growing a new timber crop, but on the contrary prevent the growth of timber and will for generations to come be mere waste lands, as has been pointed out in the above-quoted letter.

It will appear astonishing to those who have not paid attention to the question of the settlement of this country to learn from the subjoined table that while of the total country only 18 per cent is improved, the better developed eastern part (east of Colorado) shows only 29 per cent improved, and even the long-settled Atlantic coast which we are apt to consider fully occupied, still possesses 65 per cent of unimproved land, of which we estimate 43 per cent as woodland, while the percentage of woodland for the whole country is 25. There would be woodland enough to satisfy our needs for many decades if attention were but paid to its rational use and to the recuperation of the cut-over areas; but the condition of the wooded areas, which have been culled, is well known to be so poor, as far as market supplies are concerned, that for generations to come they must be left out of consideration.

The following table, compiled from the most reliable sources of information attainable and correcting any previous statements made by this division, is intended to give information as to approximate relation of improved land, forest and waste land, while the accompanying map (Plate I) shows by various grades of color the approximate relative proportion of forest to total area, and the character of the merchantable kinds of lumber that are derived from the different regions is indicated.

A second map (Plate II) shows more in detail the condition of that section of the country west of the 97° of longitude, which being largely situated in the dry region requires greatest attention to conservative forest use and contains still large areas of public timber lands. The information is derived from members of the U. S. Geological Survey and others acquainted with the region. It must not be overlooked, however, that these are not accurate surveys but approximations, and that a large per cent, often from 25 to 50 per cent of the area falling within the timberland or brushland area, is prairie, open country, waste land, or in cultivation. The location and size of the national forest reservations made under the act of March 3, 1891, have also been outlined on this map, suggesting a desirable extension of this policy.



STECHER LITH. CO. ROCHESTER

MAP

showing the distribution of forest land and lumber regions in the United States.

COMPILED BY B. E. FERNOW, CHIEF OF DIVISION OF FORESTRY

Scale:

PERCENTAGES RELATE TO TOTAL LAND AREA OF EACH STATE

- UNDER 10 % FOREST LAND
- BETWEEN 10 AND 30 % FOREST LAND
- 30 - 50 " "
- 50 - 60 " "
- OVER 60 % FOREST LAND

SPECHLER LITH. CO. PHILA.

Report o

MAP SHOWING DISTRIBUTION OF FOREST-LAND, BRUSH-LAND AND OPEN COUNTRY WEST OF LONGITUDE 97 NATIONAL AND FOREST RESERVATIONS.

COMPILED IN THE DIVISION OF FORESTRY, U.S. DEPARTMENT OF AGRICULTURE

- FOREST-LAND.
- BRUSH-LAND.
- OPEN COUNTRY.
- NATIONAL FOREST RESERVATIONS
- NATIONAL PARKS

Improved and forest land in the United States.

	Area.		Per cent.				
	Total land surface.	Improved land in farms.	Improved land.	Brush, forest, and waste land.	Probably forest.	Brush land.	Open country.
	Acres.	*Acres.*					
UNITED STATES	1,900,800,000	357,616,000	18	82	26		
Maine	19,132,000	3,044,000	15	85	64		
New Hampshire	5,783,000	1,727,000	29	71	62		
Vermont	5,846,000	2,655,000	45	55	42		
Massachusetts	5,155,000	1,657,000	32	68	29		
Rhode Island	694,000	274,000	39	60	40		
Connecticut	3,100,000	1,379,000	44	55	29		
New England States	39,710,000	10,736,000	27	73	52		
New York	30,376,000	16,389,000	54	46	30		
Pennsylvania	28,799,000	13,210,000	45	65	24		
New Jersey	4,671,000	1,999,000	42	58	41		
Delaware	1,254,000	762,000	60	40	24		
Maryland	6,310,000	3,412,000	54	46	32		
Middle Atlantic States	71,401,000	35,772,000	50	50	28		
Virginia	25,680,000	9,125,000	35	65	48		
North Carolina	31,089,000	7,828,000	25	75	54		
South Carolina	19,308,000	5,255,000	27	73	45		
Georgia	38,647,000	9,582,000	24	76	50		
Southern Atlantic States	114,724,000	31,790,000	27	73	49		
ATLANTIC COAST	225,835,000	78,298,000	35	65	43		
Florida	34,713,000	1,145,000	3	97	58		
Alabama	32,986,000	7,698,000	23	77	53		
Mississippi	29,658,000	6,849,000	23	77	44		
Louisiana	29,069,000	3,775,000	13	87	45		
Gulf States	126,426,000	19,467,000	16	84	50		
Texas	167,808,000	20,746,000	12	88	23		
Michigan	36,755,000	9,865,000	26	74	50		
Wisconsin	34,848,000	9,793,000	28	72	47		
Minnesota	50,691,000	11,128,000	21	79	36		
Northern lumbering States	122,294,000	30,786,000	25	75	43		
Ohio	26,086,000	18,338,000	71	29	16		
Indiana	22,982,000	15,107,000	65	35	15		
Illinois	35,840,000	25,669,000	71	29	10		
Northern agricultural States	84,908,000	59,114,000	69	31	13		
LAKE STATES	207,202,000	89,900,000	43	57	31		
West Virginia	15,772,000	4,554,000	28	72	52		
Kentucky	25,600,000	11,819,000	46	54	43		
Tennessee	26,720,000	9,362,000	35	65	55		
Arkansas	33,949,000	5,475,000	16	84	60		
Missouri	43,990,000	19,792,000	45	55	36		
Central States	146,031,000	51,002,000	35	65	48		
Iowa	35,594,000	25,429,000	71	29	13		
North Dakota	45,308,000	4,658,000	10	90	1		
South Dakota	49,696,000	6,959,000	14	86	2		
Nebraska	42,998,000	15,247,000	34	65	3		
Kansas	52,288,000	22,303,000	42	58	7		
Oklahoma	24,960,000	564,000	2	98			
Prairie States	250,754,000	75,160,000	30	70	4		
INTERIOR STATES	396,785,000	126,162,000	32	68	20		

Improved and forest land in the United States—Continued.

	Area.		Per cent.				
	Total land surface.	Improved land in farms.	Improved land.	Brush, forest, and waste land.	Probably forest.	Brush land.	Open country.
	Acres.	*Acres.*					
Montana	92,998,000	915,000	1	99	18	20	61
Wyoming	62,448,000	476,000	0·7	99	12	16	71
Colorado	66,332,000	1,823,000	2·7	97	16	21	60
New Mexico	78,374,000	263,000	0·3	99	6	21	72
Eastern Rocky Mountain region	300,154,000	3,477,000	1	99	13	20	66
Idaho	53,945,000	606,000	1	99	20	40	39
Nevada	70,233,000	723,000	1	99		9	90
Utah	52,601,000	548,000	1	99	16	27	56
Arizona	72,268,000	104,000	0·1	99·9	14	12	74
Western Rocky Mountain region	249,047,000	1,981,000	0·7	99·3	8	22	69
Rocky Mountain region	549,201,000	5,458,000	1	99	10	21	68
California	99,827,000	12,222,000	12	88	18	27	43
Oregon	60,518,000	3,516,000	6	94	34	28	32
Washington	42,703,000	1,820,000	4	96	55	21	20
Pacific coast	203,048,000	17,558,000	8	92	30	27	35

NOTE.—The authority for the area of improved farm land is furnished by the census of 1890. The areas of forest, brush, and waste lands were ascertained by subtracting the area of cultivated land from the total land areas of the several States, and are placed as per cent of the total areas in column 4. The part of these supposed to be forest is estimated on information obtained by various agencies. For the western section of the country the further subdivision into forest, brush, and open country is based partly on statistics gathered by Col. Ensign and published in Bulletin 2 of this division, partly on the map prepared as stated before and here published, and partly on timber estimates of the Puget Sound Lumberman.

INADEQUACY OF FOREST SUPPLIES.

In regard to the consumption of forest supplies no full statistics are available, yet we have a better basis for estimates. In the report for the year 1892 it was stated that the total annual consumption can not fall short of 22,000,000,000 cubic feet, or 350 cubic feet per capita, of all kinds of wood. This figure was arrived at by a series of careful estimates, the basis for which was stated. With additional information furnished by the Eleventh Census, it may be readily increased to 24,000,000,000 feet. The consumption of mill timber (sizable logs) was stated as about 4,000,000,000 cubic feet (now found to be an understatement by 15 per cent), representing about 30,000,000,000 feet, B. M., or between 20 and 25 per cent of the total consumption—a proportion which may be readily admitted to represent a rather extravagant average for the "millable" part of the forest growth, indicating that if we assume the annual growth of such timber per acre at 10 cubic feet (see Gannet letter), at least 400,000,000 acres of fully stocked forest are necessary to furnish this part of our consumption. Add the consumption of firewood, which is largely made of sizable timber, and it is safe to say that three times that area is necessary to furnish the amount of present consumption by its annual growth. From this statement alone, which is highly favorable to those who claim sufficient and "inexhaustible" supplies, the inadequacy of our forest area to meet growing demands will appear.

QUANTITY AND VALUE OF FOREST PRODUCTS.

The Eleventh Census statistics of lumber production, ably and conscientiously gathered by Mr. George A. Priest, agent of the census have not yet been published. Like all statistics of this kind, the figures given must be incomplete, always remaining somewhat short of the truth and requiring estimated additions. Nevertheless, they furnish gratifying proof that the above estimates by the writer are within bounds.

By the courtesy of the Superintendent of the Census, the Hon. Carroll D. Wright, the writer is permitted to produce, in advance of the regular publication by the census, a summary statement, prepared in part by Mr. Priest and supplemented by canvass and estimates of this division, showing approximately the variety, quantity, and value of forest products used in the United States during the census year.

Amount and value of forest products used during the census year 1890.

Classes of products.	Quantity.	Estimated cubic contents of forest-grown material.[2]	Value.
I. Mill products:[1]		*Cubic feet.*	
Agricultural implement stock ..... feet, B. M..	30,000,000	.....	$582,000
Bobbin and spool stock ..... do....	49,000,000	.....	688,000
Carriage and wagon stock ..... do....	66,000,000	.....	1,306,000
Furniture stock ..... do....	94,000,000	.....	1,435,000
All other sawed lumber ..... do....	27,630,000,000	.....	310,818,000
Total sawed lumber ..... do....	27,869,000,000	4,000,000,000	314,829,000
Lath ..... pieces..	2,365,000,000	.....	3,709,924
Pickets and palings ..... do....	110,000,000	.....	750,000
Shingles ..... do....	9,276,000,000	200,000,000	17,000,000
Staves ..... do....	1,178,000,000	300,000,000	7,762,000
Headings ..... sets..	183,000,000	175,000,000	4,934,000
Total lumber and cognate products, directly from logs	.....	4,675,000,000	348,984,924
II. Railroad construction:			
Ties[3] ..... pieces..	80,000,000	400,000,000	.....
Round and hewn timber used for bridges and trestles	.....	80,000,000	.....
Telegraph poles	.....	5,000,000	.....
Total	.....	485,000,000	40,000,000
III. Exported timber not included in subdivision I:[4]			
Hewn timber, 6,900,000 cubic feet	.....	9,000,000	1,230,000
Logs and round timber	.....	2,500,000	2,000,000
Rived staves, stave and bolts	.....	500,000	1,500,000
	.....	12,000,000	$4,730,000
IV. Wood pulp:[2]			
300,000 tons ground paper pulp	.....	75,000,000	3,550,000
80,000 tons soda pulp	.....		
60,000 tons sulphite pulp fiber	.....		
50,000 tons pulp for other purposes	.....		
V. Miscellaneous mill products other than lumber manufactured directly from logs or bolts[5]	.....	80,000,000	20,765,000
Total materials requiring bolt or log size	.....	5,327,000,000	418,029,924
This last figure of "miscellaneous products" is a very considerable underestimate, based upon census returns and we are entirely safe in rounding off the total of sizable timber used and its value to	.....	5,500,000,000	450,000,000
VI. Fuel[6] in the shape of wood	.....	18,000,000,000	450,000,000
In the shape of charcoal	.....	250,000,000	7,000,000
VII. Wood used for dyeing extracts and charcoal for gunpowder[5]	.....	16,200,000	437,000
Total amount and value of wood consumption	.....	23,766,000,000	907,437,000

Amount and value of forest products used during the Census year 1890—Continued.

Classes of products.	Quantity.	Value.	Total value.
VIII. Naval stores[5]—			
Turpentine.....barrels..	346,544	$5,459,115	.....
Rosin.....do....	1,429,154	2,413,757	$7,872,872
IX[5]. Wood alcohol.....gallons..	2,000,000	1,750,000	.....
Acetic acid in acetate of lime.....	.....	360,000	2,110,000
X. Tanning materials[5]—			
Hemlock bark.....cords..	1,056,000	6,925,000	.....
Oak bark.....do....	322,150	2,783,500	.....
Hemlock and bark for extract.....do....	64,200	307,500	.....
Sumac leaves for tanning.....tons..	3,300	198,000	.....
Sumac leaves for extract.....do....	3,750	112,000	.....
Various not accounted for.....	.....	74,000	.....
			10,400,000
XI. Maple sugar.....pounds[5]..	32,952,927	3,300,000	.....
Maple sirup.....gallons[5]..	2,258,376	2,200,000	5,500,000
Total value of forest by-products.....	.....	.....	25,882,872
Total value of all forest products.....	.....	.....	933,319,872
Add 10 per cent for omissions and under estimates[2].....	.....	.....	93,331,987
Total value of wood and forest products at original place of production, estimated to have been used during census year, 1890.....	.....	.....	1,026,650,859

[1] These data have been compiled by Mr. Priest from the reports of 21,011 establishments (representing probably 70 per cent in number and 95 per cent in value of product), of which 18,064 manufactured sawed lumber as principal product, 702 manufactured shingles exclusively, 438 manufactured staves and headings exclusively, and 1,807 used logs or bolts in the manufacture of the various classes of products stated under the head of "Miscellaneous," and corrected by the inclusion of the quantities used for customs sawing not given in the census figures.

[2] Estimated by the Division of Forestry.

[3] Canvass of Division of Forestry.

[4] From returns of Bureau of Statistics, U. S. Treasury Department.

[5] Based on figures of the 11th Census.

[6] Based on figures of the 10th Census and canvass of Division of Forestry.

The following interesting separation of mill products according to regions and kinds is given by Mr. Priest, the quantities being based on various returns, and hence somewhat at variance:

Lumber, of different kinds, sawed during census year 1890.

Kind.	Feet, board measure.
White pine.....	11,300,000,000
Spruce and fir.....	4,483,000,000
Hemlock.....	3,390,000,000
Hard pine, cypress, etc.....	5,516,000,000
Redwood.....	317,000,000
Hardwoods and all other.....	5,517,000,000
	30,593,000,000

Amounts and value of lumber sawed, in different sections of the United States, during census year 1890.

Region.*	Amount (M feet).	Value.
Eastern group.....	4,808,761	$51,939,519
Central group.....	3,129,988	44,407,296
Lake group.....	8,250,702	98,110,488
Southern group.....	4,926,331	46,790,542
Pacific group.....	2,027,848	22,466,088
Miscellaneous.....	866,796	11,306,807
Total.....	24,010,446	272,020,740

* Eastern group comprises the New England and North Atlantic States; Central group, Ohio, Indiana, Illinois, West Virginia, Kentucky, Tennessee, Missouri; Lake group, Michigan, Wisconsin, Minnesota; Southern group, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Texas; Pacific group, California, Oregon, Washington; miscellaneous, all other States and Territories.

Imports of wood and wood products for home consumption during the years ending June 30, 1892 and 1893.

Articles.	1892.		1893.	
	Quantity.	Value.	Quantity.	Value.
Free of duty.				
Firewood.....cords..	198,850	$411,482	199,187	$403,601
Logs and round timber	.....	1,188,797	.....	2,164,273
Railroad ties.....number..	748,520	131,295	619,235	97,857
Shingle and stave bolts	.....	44,387	.....	53,505
Handle and head bolts	.....	59,573	.....	53,129
Ship timber	.....	31,721	.....	29,865
Ship planking	.....	79,622	.....	8,404
Hop poles	.....	18,412	.....	38,968
Wood for pulp-making	.....	230,959	.....	332,244
Charcoal	.....	48,395	.....	51,634
Cabinet woods; cedar, ebony, mahogany, etc	.....	2,234,003	.....	2,662,658
Cork bark	.....	1,368,244	.....	1,641,294
Hemlock bark.....cords..	53,018	256,346	50,699	241,244
Bamboos, rattans, canes, etc	.....	1,198,813	.....	922,529
Briar root or briar wood, and the like, partially manufactured	.....	39,185	.....	40,470
Ashes	.....	54,855	.....	76,306
Fence posts	.....	31,351	.....	31,051
Tar and pitch of wood.....barrels..	768	3,352	1,179	6,376
Turpentine, spirits of.....gallons..	9,337	3,470	10,273	4,077
Turpentine, Venice .....pounds..	36,642	3,992	20,694	2,365
Pitch, Burgundy .....do....	281,430	4,386	207,220	3,558
Total free	.....	7,442,640	.....	8,865,408
Dutiable.				
Wood unmanufactured not specially provided for	.....	32,655	.....	25,952
Timber—				
Used for spars, wharves, etc .....cubic feet..	12,295	2,301	9,432	943
Hewn and sawed .....do....	445,804	54,570	1,419,484	62,868
Squared or sided not specially provided for.do....	14,036	1,392	65,139	492
Lumber:				
Boards, planks, deals and other sawed lumber.....M feet..	482,339	5,588,948	529,263	6,283,805
Sawed lumber, not otherwise specified....do....	150,184	1,416,331	162,955	1,533,274
Sawed boards, planks, deals—cedar ebony, etc ..	222	5,117	366	24,205
Clapboards .....M..	6,259	99,187	7,072	113,988
Hubs, posts, laths and other rough blocks	.....	29,823	.....	28,227
Laths.....M..	259,157	327,359	327,442	462,140
Pickets and palings .....M..	3,157	22,679	5,483	36,700
Cedar poles, posts, and railroad ties .....No..	2,115,986	259,583	1,815,949	271,236
Shingles.....M..	362,551	731,299	470,001	916,759
Shooks	.....	62,981	.....	45,746
Staves	.....	551,557	.....	646,613
Manufactures, all others—				
Barrels or boxes containing oranges, lemons, etc., apart from contents	.....	467,514	.....	555,987
Casks and barrels, empty	.....	919	.....	531
Chair cane or reeds manufactured	.....	181,337	.....	173,967
Cabinetware and household furniture	.....	411,712	.....	382,199
Osier or willow, prepared for manufacture	.....	82,633	.....	64,427
Osier or willow, manufactures of	.....	123,820	.....	125,916
Wood-pulp.....tons..	41,141	1,831,231	63,633	2,909,097
Veneers of wood	.....	8,264	.....	750
Bark extract, for tanning .....pounds..	12,973	408	672	71
Sumac.....do....	12,724,703	294,744	7,244,132	398,400
Corks and cork bark manufactured .....do....	671,064	321,480	703,063	351,731
Matches	.....	83,157	.....	133,152
Frames and sticks for umbrellas	.....	*92,437	.....	*117,258
All other manufactures of wood or of which wood is the component of chief value	.....	1,277,644	.....	1,397,155
Total dutiable	.....	14,364,100	.....	17,163,589
Total imports	.....	21,806,740	.....	26,028,997

*Including other materials.

Exports of wood and wood products from United States for twelve months, ending June 30, 1892 and 1893.

Articles.	1892.		1893.	
	Quantity.	Value.	Quantity.	Value.
Agricultural implements:				
Mowers and reapers		$2,373,938		$2,873,897
Plows and cultivators		397,735		644,390
All other, and parts of		1,024,310		1,139,046
Bark and extract of, for tanning		239,708		232,269
Carriages and horse cars, and parts of		1,944,170		1,605,801
Cars, passenger and freight, for steam railroads ..No..	1,680	1,320,265	1,801	969,871
Ginseng ..lbs..	228,916	820,529	251,205	792,928
Matches		73,666		67,974
Oranges ..No..	11,856	772,582	12,518	897,870
Rosin ..bbls..	1,950,214	3,418,459	2,059,407	3,333,367
Tar ..do..	22,377	52,417	20,042	40,244
Turpentine and pitch ..do..	8,739	18,336	8,926	20,254
Turpentine, spirits of ..galls..	13,176,470	4,500,721	13,415,459	3,893,436
Fire wood ..cords..	423	1,604	1,920	5,877
Boards, deals, and planks ..M feet..	592,596	9,672,493	629,355	9,642,599
Joists and scantling ..do..	16,131	228,513	13,475	171,025
Hoops and hoop poles		88,222		40,350
Laths ..M..	7,893	17,717	3,461	8,663
Palings, pickets, and bed slats ..M..	640	6,259	387	3,854
Shingles ..M..	31,198	87,992	22,938	72,562
Shooks:				
Box		195,618		238,605
Other ..No..	412,308	585,919	385,863	702,403
Staves and headings		2,211,716		2,499,520
All other lumber		1,051,397		1,443,537
Timber:				
Sawed ..M feet..	235,550	2,673,154	214,198	2,320,123
Hewn ..cub. feet..	6,736,446	983,574	7,836,921	1,188,353
Logs and other timber		1,923,604		2,270,072
Doors, sashes, and blinds		295,918		273,455
Moldings, trimmings, and other house furnishings		202,589		208,002
Hogsheads and barrels, empty		290,113		218,880
Household furniture		3,090,146		3,112,291
Woodenware		356,553		328,817
All other wood manufactures		1,827,470		1,917,451
Total		42,729,407		43,097,786

Exports of wood and certain wood products during the year ending June 30, 1893, by districts of country from whence exported.

	Districts.*				
	I.	II.	III.	IV.	Total.
Raw material:					
Boards, deals, planks, etc	$3,890,776	$1,883,450	$2,736,440	$1,131,933	$9,642,599
Joists and scantling	7,341	98,452	60,179	5,053	171,025
Hoops and hoop-poles	39,376	903	13	58	40,350
Laths	1,983	67	30	6,583	8,663
Palings and pickets	10	755	676	2,413	3,854
Shingles	18,909	35,792	16,556	13,015	72,562
Shooks	884,711	6,477	8,113	41,707	941,008
Staves	1,039,654	448,751	1,010,776	839	2,499,520
All other lumber	1,061,189	16,162	327,130	39,056	1,443,537
Timber (sawed)	147,052	352,633	1,441,565	378,873	2,320,123
Timber (hewn)	443,613	36,936	707,804		1,188,353
Logs and other round timber	928,393	1,028,092	303,763	9,824	2,270,072
Firewood	3,546		2,331		5,877
Rosin	615,028	2,711,032	14,366	2,941	3,333,367
Tar	27,585	11,546	1,045	68	40,244
Turpentine and pitch	17,291	2,212	63	688	20,254
Spirits of turpentine	431,717	3,455,904	664	5,151	3,893,436
Bark and bark extract	75,353	144,891	25	12,000	232,269
Total raw material	9,633,527	10,234,058	6,631,539	1,640,202	28,139,326

* District No. I includes all of the United States north of Baltimore and east of Rocky Mountains. District No. II includes the territory having its outlet by the South Atlantic ports. District No. III includes the territory adjacent to the gulf ports. District No. IV embraces that portion of the United States on the Pacific coast.

Exports of wood and certain wood products during the year ending June 30, 1893, by districts of country from whence exported—Continued.

	Districts.				
	I.	II.	III.	IV.	Total.
Manufactures:					
Agricultural implements	$4,504,914	$9,685	$106,469	$36,265	$4,657,333
Carriages and horse-cars	1,490,784	2,050	61,725	51,242	1,605,801
Cars, passenger and freight	790,771	.....	179,100	.....	969,871
Matches	57,852	80	3,689	6,353	67,974
Organs	875,877	13,560	3,220	5,213	897,870
Doors, sash, and blinds	206,304	5,522	6,547	54,082	273,455
Moldings, trimmings, etc	203,554	221	1,159	3,068	208,002
Hogsheads and barrels, empty	211,919	394	4,849	1,718	218,880
Household furniture	2,803,662	31,696	106,860	170,273	3,112,291
Woodenware	311,786	13,890	2,038	103	328,817
All other wood manufactures	1,628,170	144,842	82,736	61,703	1,917,451
Total manufactures	13,085,593	221,940	558,392	390,020	14,255,945
Total exports	22,719,120	10,455,998	7,189,931	2,030,222	42,395,271

FORESTRY EXHIBIT AT THE WORLD'S FAIR.

A large amount of the time and energy of the office force was occupied during the year in the preparation, installation, and care of the exhibit which formed a part of the Government exhibits at the World's Fair in Chicago. The subject of forestry, thanks to the active and intelligent interest of Mr. W. J. Buchanan, chief of the Department of Agriculture and Forestry, received a most important impetus at the Fair, which can not fail to advance the forestry interests of the country at a more rapid pace than hitherto.

By the construction of a separate artistically and characteristically designed building for forestry exhibits, the name of the subject, hitherto unknown to thousands or misunderstood, has become familiar, while in the elevation of the subject to the dignity of a department coördinate with the other large departments at the Fair, recognition was given to the great importance of the subject and a series of forestry talks, instituted by the chief of the Department, and a Forestry Congress under the auspices of the American Forestry Association, were designed to familiarize the visitors with the many aspects of the same.

This congress is especially worthy of note on account of the earnestness and thoroughly practical nature of its discussions, and particularly in the presence and participation, almost for the first time, of representatives of the lumber trade, with the result of opening their eyes wider than ever to the fact that the forestry movement is essentially vital to the interests of that trade.

This is not the place to dwell at length upon the many object lessons which were found in the Forestry and other buildings, an account of which is to form a part of a separate report by the jury of awards, of which the writer had the honor to be a member. The exhibit of this division, which is described somewhat in detail in another part of this volume, was designed, according to the law appropriating the funds for Government exhibits, to illustrate its functions. These are not of an executive character. Hence the division has nothing to do with any administration of the public or any other forests, being restricted to the study of the same and of all phases of forestry, with the duty of reporting results and giving such advice for the treatment of forest resources and refor-

estation as may be asked. It is, therefore, a bureau of inquiry and information, like most of the other branches of the Department of Agriculture.

ADVANCE OF FORESTRY INTERESTS DURING THE YEAR.

The year has been fruitful of signs which point to promising results in the near future of the efforts to establish a rational forest policy in this country. The policy of establishing forest reservations on the public domain has been further extended by the President's proclamation of the Sierra Nevada and Ashland Reserves, aggregating 4,511,360 acres. This makes the total acreage of forest reservations established under that title 17,564,800 acres.

List of national forest reservations and national parks of the United States.

No.*		Established.	Area.
			Acres.
1	Yellowstone National Park timberland reserve (Wyo.)	Sept. 10, 1891	1,239,040
2	White River Plateau timberland reserve (Colo.)	Oct. 16, 1891	1,198,080
3	Pecos River forest reserve (N. Mex.)	Jan. 11, 1892	311,040
4	Sierra forest reserve (Cal.)	Feb. 14, 1893	4,096,000
5	Pacific forest reserve (Wash.)	Feb. 20, 1893	967,680
6	Pike's Peak timberland reserve (Colo.)	Mar, 18, 1892	184,320
7	Bull Run timberland reserve (Oreg.)	June 17, 1892	142,080
8	Plum Creek timberland reserve (Colo.)	June 23, 1892	179,200
9	South Platte forest reserve (Colo.)	Dec. 9, 1892	683,520
10	San Gabriel timberland reserve (Cal.)	Dec. 29, 1892	555,520
11	Battlement Mesa forest reserve (Colo.)	Dec. 24, 1892	858,240
12	Afognak Forest and Fish Culture reserve (Alaska)	Dec. 24, 1892	Unknown.
13	Grand Canyon forest reserve (Ariz.)	Feb. 20, 1893	1,851,520
14	Trabuco Canyon forest reserve (Cal.)	Feb. 25, 1893	49,920
15	San Bernardino forest reserve (Cal.)	Feb. 25, 1893	737,280
16	Ashland forest reserve (Oreg.)	Sept. 28, 1893	18,560
17	Cascade Range forest reserve (Oreg.)	Sept. 28, 1893	4,492,800
	Total acreage of forest reserves		17,564,800
	NATIONAL PARKS		
18	Yellowstone National Park	Mar. 1, 1872	2,142,720
19	Yosemite National Park	Oct. 1, 1890	967,680
20	Sequoia National Park	Oct. 1, 1890	161,280
21	General Grant National Park	Oct. 1. 1890	2,560

* The numbers refer to those used on map, Plate II.

The present great need of providing protection and suitable administration for these reservations is to be met by the enactment of a law (H. R. 119) which, while less comprehensive than that contemplated in the Fifty-second Congress (S. 3235), contains the essential features for a first step toward a more thorough organization, and recommends itself on account of its simplicity. Having been reported favorably by the Committee on Public Lands and placed on the calendar, its early passage, which is so necessary to a clinching of the policy expressed in the proclamation, is hoped for. This bill provides in the first place the use of the Army for protection of the reservations. Experience in Yellowstone Park and elsewhere points out the efficiency of such a service, which is also satisfactory to the officers and troops, as it breaks the monotony of camp life, furnishes useful occupation, and keeps the troops in practice for field work.

The next important provision lies in the authority given to the Secretary of the Interior to regulate the use and occupancy of the reservations, thus settling their legal status. The sale of ripe timber from

reservations and other public timber lands under such supervision as to insure the inviolability of the forest cover is also permitted, in the discretion of the Secretary. This provision, which has been severely criticised, is most important and essential to any kind of successful forest policy. Its absence from the statutes hitherto has been the fruitful source of depredations and forest destruction, for the resident population must be provided with wood material, and, in the absence of legal methods and fair means to do so, it is driven to supply its necessities by unfair means. As soon as a value is placed on the timber of the public domain it will be possible not only to dispose of it advantageously, but also to control the manner of its use without injury to the forest conditions and the future, and an interest in the same will grow up. In this or a similar provision, which attempts a rational use of the forest resources, lies the only salvation of our Western forests and of the soil and water conditions dependent on the same.

The funds derived from the sale of ripe timber and other income are to be set aside for the purpose of establishing gradually a more amplified and effective system of forest management, so that the forest itself shall pay for its own protection.

State Governments are also becoming more active in regard to their forestry interests. New Hampshire acted in part upon the recommendations of its investigating forestry commission, by making the same permanent (with a new personnel), constituting the selectmen of the several towns firewardens with power or allowing the commissioners to appoint special firewardens, the expense to be charged to town or county.

New York has passed new legislation having in view the final establishment of a compact State forest and also introducing some methods designed for the utilization of the spruce in the present State forest reserve. This last provision is faulty in that it is based on the misconception that restriction of the cutting to certain sizes is sufficient to preserve acceptable forest conditions.

Pennsylvania has passed a law establishing a well-considered plan of examining into the condition of its forest cover, especially at headwaters of rivers, with a view of formulating further action. The Pennsylvania Forestry Association, which represents by all odds the most active, business-like, and intelligent element in the forestry movement, has made this action possible; the association is thriving, increasing its membership constantly, and with the publication of its now nearly regularly issued "Forest Leaves" is the most powerful ally of the national association.

New Jersey is promising to enter the ranks of those States which recognize the importance of their forest areas, the first step being an examination by a committee of the State board of health into the needs of forest preservation on the highlands, the director of the Geological Survey having furnished the basis and first suggestion for such action.

Maine having inaugurated a tolerably satisfactory fire law, the northeastern Atlantic States seem to be in a fair way of establishing a forest policy.

In the West we have to note rather a retrograde movement. California found it necessary to abolish for political reasons its forestry commission, inaugurated eight years ago with so much promise, warranted by the eager and intelligent work of the first commission. Colorado also has practically abandoned its first attempts at a forest policy

by leaving the competent and useful forest commissioner without salary and means to proceed in his work.

Wisconsin has entered the ranks of forestry States by the inauguration of a forestry association starting upon a practical basis, which has in view the active coöperation of lumbermen.

The most notable event in the forestry movement, however, was, as in many other movements, its treatment at the World's Fair in Chicago.

GERMAN FOREST MANAGEMENT.

In addition to preparing the forestry part of the United States Government exhibits, it became one of the pleasing duties of the chief of this division to collect and install another forestry exhibit, to be placed in the Forestry Building for the German Government.

Upon the joint invitation of the Commissioner General for the German Empire and the chief of the Departments of Agriculture and Forestry at the World's Fair, and with the sanction of the Secretary of Agriculture, by whom the necessary furlough was granted, he undertook the honorable mission of collecting materials from the various forestry institutions of Germany, which might illustrate the methods and means of forest management and the status of forestry as a science and art in that country, acknowledged as leading in this particular branch of economics. The object of such an exhibit was more to acquaint our people with superior forestry methods than to attempt to show the progress and perfection to which forestry in Germany has attained. It was in the main to be an object lesson to our people and in that sense the coöperation of this Government in the manner indicated was readily given.

Accordingly the writer early in April visited the forest departments of Prussia, Saxony, Saxe-Weimar, Bavaria, Wurtemberg, as well as the leading forest academies and forestry schools (Eberswalde, Münden, Tharandt, Giessen, Eisenach, Tübingen, Munich, and Zürich) and selected such materials as would serve the purpose in view. In this undertaking, which on account of the short time left for it necessitated unusual expeditiousness, the writer received the most courteous, ready, and generous assistance from all the officers in charge of and in connection with the institutions above named, so that in less than two weeks the material was selected and within six weeks began to arrive in Chicago. There was of course no time to prepare anything specially for the purpose and only material on hand in the archives or study collections could be hurriedly gathered, to be finally shaped into an organic whole, representing a picture of the forest management of Germany. The cost of this journey and installation was borne jointly by the German Government and the World's Fair authorities.

A description of the exhibit, as finally installed by the writer, may serve the purpose of elucidating somewhat the methods of forestry as practiced abroad, and which, in principle at least, will have to be imitated in time by our people, as they have been by other nations.

MAP WORK AND FOREST DISTRICTING.

The first requirement in the management of any property is that all its conditions should be known and recorded. Hence a topographic survey of the forest district to be placed under management is the first requisite. Such survey refers not only to the boundaries and topo-

graphical features of the district itself, but also to the surroundings, especially with reference to connections with markets, and finally the geographical position of the forest areas in general grouped according to ownership. As illustrations of this last class of surveys there were exhibited:

Forest map of Bavaria;
Forest map of Wurtemberg.

These show in three different colors the forest areas belonging to the Government, to communities and institutions, and to private owners. From these it could be seen not only that the three classes of proprietors share about equally in the ownership of the forest area, but that the Government owns mainly the forests on the mountains where forest management must be carried on, not for profit, but for indirect benefits in the preservation of favorable soil and water conditions which therefore makes the permanent, well-organized management "by and for the people" necessary. Contrary to the notion to which currency is so often given in the United States, the various governments of Germany do not own more than 35 per cent, exercising partial control (so as to prevent destruction and waste) over only 15 per cent in the hands of communities and institutions, and leaving the balance of 50 per cent of the forest area in private hands almost entirely without restriction.

Sometimes the contours of the country are also indicated on the maps, which serves the useful economic purpose of permitting ready reference of the forest areas to the topography. As an instance of such work there was shown a

Relief map of Hesse.

On this the forest areas were indicated in green color.

For the sake of orderly administration, the whole country is separated into forest divisions or inspections (sometimes both) each of which forms a separate unit of administration. To indicate this subdivision there were exhibited:

Forest division map of Wurtemberg.
Forest district map of three forest inspections in the Spessart Mountains of Bavaria.
General forest map of forest inspection Bamberg-East, Bavaria.

It is to be understood that we are now speaking only of the Government forests, which are under a uniform general administration.

The administration of the Government forests is usually assigned either to the finance department (as in Bavaria) or to the department of agriculture and forestry (as in Prussia), with one director and council directly in charge under the supervision of the minister or secretary. The position of the director (Oberlandforstmeister) corresponds somewhat to that of our Commissioner of the General Land Office, except that, an extensive technical knowledge being needed in the position, the incumbent is promoted through all positions from the lower grades. Again, each forest division is placed under a separate administrative body consisting of an administrator (Oberforstmeister) with a council of forest inspectors (Forstmeister), each of whom has supervision of a number of the final units of administration, the forest districts (Oberfoersterei, Forstamt). The district officer (Oberfoerster, Revierfoerster, etc.), with a number of assistants, rangers (Foerster), and guards (Schutzbeamte), is then the manager and executive officer in the forest itself, while the higher supervising and inspecting officials are located at the seats of government.

SURVEY OF THE FOREST DISTRICT.

The survey of each forest district is carried out to the utmost minutiæ. To illustrate the methods pursued in Prussia we find first:

Special survey map of district Mühlenbeck.
Special survey map of district Rheinwalden.

These maps on the scale of 1:5000 appear in portfolio sheets, representing a careful survey by theodolite of the boundaries of the district, the permanent differences of soil and occupancy (roads, waters, fields, meadows, moors, etc.), and the division of the district into smaller units of management. This kind of map, of which only three copies are made, is then, for purposes of use in daily routine, reduced to a scale of 1:25000 on one sheet, and printed. The first matter of interest that strikes us on these blank or base maps is the division lines by which the district is divided into parcels or compartments. In the plain these lines divide the district into regular oblong compartments (Jagen) of about 60 to 75 acres each, with sides of 100 and 200 yards respectively, separated by openings or avenues which we may call "rides" (Gestell, Schneisse), so that the whole makes the appearance very much like the map of an American city regularly divided into blocks. The rides (from 8 to 40 rods wide) running east and west and north and south are lettered, the former, broader ones (main avenues) with capital letters, the latter (side avenues) with small letters, while the compartments are numbered. In the forest itself at each corner a monument of wood or stone indicates the letters of the rides and numbers of the compartments, rendering it easy to find one's way or direct any laborer to any place in the forest. The rides are often used as roads and serve also the purpose of checking fires, etc.

In the hill and mountain districts this regular division becomes impracticable and the lines of compartments conform to the contour, while the opening of the avenues is restricted to those which can be readily transformed into roads; roads, indeed, determining the division lines wherever practicable. To illustrate these various methods of subdivision there were exhibited:

Blank district map of Rüthnick, Prussia.
Blank district map of Mühlenbeck, Prussia.
Blank district map of Schulenburg, Prussia.

The first is a pine-forest district in the plain with rectangular compartments, the second a beech forest in the hill country, and the third a spruce forest in the Harz Mountains.

In hill or mountain districts topographic or contour maps become necessary, especially for the purpose of rational road construction, a matter on which in modern times great stress is laid and to which we shall refer later on more in detail. Such contour maps are sometimes executed in papier maché or gypsum models for readier reference. This class of work was shown by:

Relief model of range Buchholz, in district Mühlenbeck, Prussia;
Relief model of range Sonnenburg, in district Freienwalde, Prussia;
Relief model (small) of forest district Schulenburg, Prussia, with the corresponding contour maps;
Contour map of forest inspection Maut-West, Bavaria.

The instrument used in this work is one that would recommend itself for similar work in this country for expeditiousness, combined with sufficient accuracy (0·4 per cent); namely, the

Tachymeter, construction Fennel, with projecting apparatus.

The instrument, which was exhibited, is most compact and simple to handle, permitting direct survey of both distances and vertical contours in one motion, without any calculations; the former by means of a Reichenbach distance measurer, with stadia, the latter by a projecting apparatus (rectangular triangle) giving the horizontal distance, while a limb with nonius permits the reading of the azimuth.

For rapid preliminary work, such as the trial location of roads, various instruments are devised, which can also be used for measuring heights of trees, etc., of which the universal dioptra, construction Stoetzer, was exhibited. These are usually simple pendulum instruments.

Of late years a further refinement in the methods of reducing to paper the conditions of forest areas has been begun in Bavaria by the construction of soil maps.

Soil map of forest district Hauptmoorswald (Bavaria).
"The soil map and its significance for forest management," by A. Bauman.

These exhibits gave notice of this new departure. The above map, comprising 8,000 acres on a scale of 1:20000, shows by colors the kind of soil, and by signs its quality and depth of surface soil, character of subsoil and depth to ground water; black dots show the points actually examined. The notation is so simple that the conditions on any part can be readily read.

For instance, finding in one place of yellow shade, which denotes sand, the reading $\frac{\text{A. S. 190,}}{\text{G. W.}}$ we know at once that it is alluvial sand, 190 centimeters deep to ground water; while in the same area $\frac{\text{H 40}}{\text{A. S. 30,}}$ would tell us that the alluvial sand is overlaid by 40 centimeters of humus mold, and that the subsoil at 30 centimeters below the sand is impenetrable "Keuperletten" (clay).

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PRINCIPLES OF MANAGEMENT.

The fundamental principles upon which the German Government forests and most of the communal and private forests are managed is briefly expressed in the idea that the forest growth is to be treated as a crop to be reproduced as soon as harvested, involving continuity of crops. To carry this principle into effect most advantageously the management must take care to husband the natural forces and conditions upon which thrifty forest growth relies, which leads to the second principle, that of highest efficiency of crops, or the two leading principles combined, to produce the largest amounts of material (or revenue) in the shortest time without impairing the condition and capacity for reproduction of the forest, perpetuating valuable forest growth wherever this is the best crop or where soil conditions make a forest cover desirable. In government forests in addition the financial principle prevails of treating the forest as a permanently invested capital, from which only the interest is to be used, making the amount harvested or the revenue derived to be as nearly alike from year to year or from period to period, and as nearly corresponding to the annual accretion, as it is possible to make them.

The present Oberlandforstmeister, or director, of the Prussian forest department uses the following language in laying down the principles upon which the government manages its forests:

The Prussian state forest administration does not accede to the principles of a continuous highest soil rent based upon compound interest calculations, but believes, in contradistinction to private forest management, that it can not avoid the obligation in the management of the state forests of keeping in view the welfare of the

whole community of citizens, and therein taking into consideration the need for continued supply of wood and other forest products as well as the other objects to which in so many directions the forest is subservient. The administration does not consider itself entitled to pursue a one-sided financial policy, least of all to submit the government forests to a pure money-making management strictly based on capital and interest calculations, but considers it its duty to so manage the forests as a patrimony belonging to the whole nation that the present generation may be benefited by the highest possible usufruct in satisfying its wants and deriving the protection which the forest renders, and that to future generations may be secured at least as large usufruct of the same kind.

To carry out these principles the intimate knowledge of the conditions of the property, referred to above, is necessary and is obtained by a careful forest survey as a basis for a systematic administration and forest regulation. As samples of the manner of acquiring and recording this knowledge the following exhibits served:

Manager's map of forest district Ruthnick, Prussia, representing conditions (pine forest in plain) and working plan in 1889.

Manager's map of forest district Muhlenberg, Prussia (beech forest in hill country), representing conditions and working plan in 1891.

Manager's map of forest district Schulenburg, Prussia (spruce forest in Harz Mountains), representing conditions and working plan in 1891.

Set of 4 timber maps of district Hauptmoorswald, Bavaria, showing conditions, respectively, in 1843, 1855, 1868, 1880.

Set of 6 timber and manager's maps of district Cunnersdorf, Saxony, showing conditions and working plans in 1829, 1854, 1862, 1872, 1884, 1890.

Set of 6 timber and manager's maps, reduced on one sheet, of forest district Timmlitz, Saxony, showing changes in conditions since 1822.

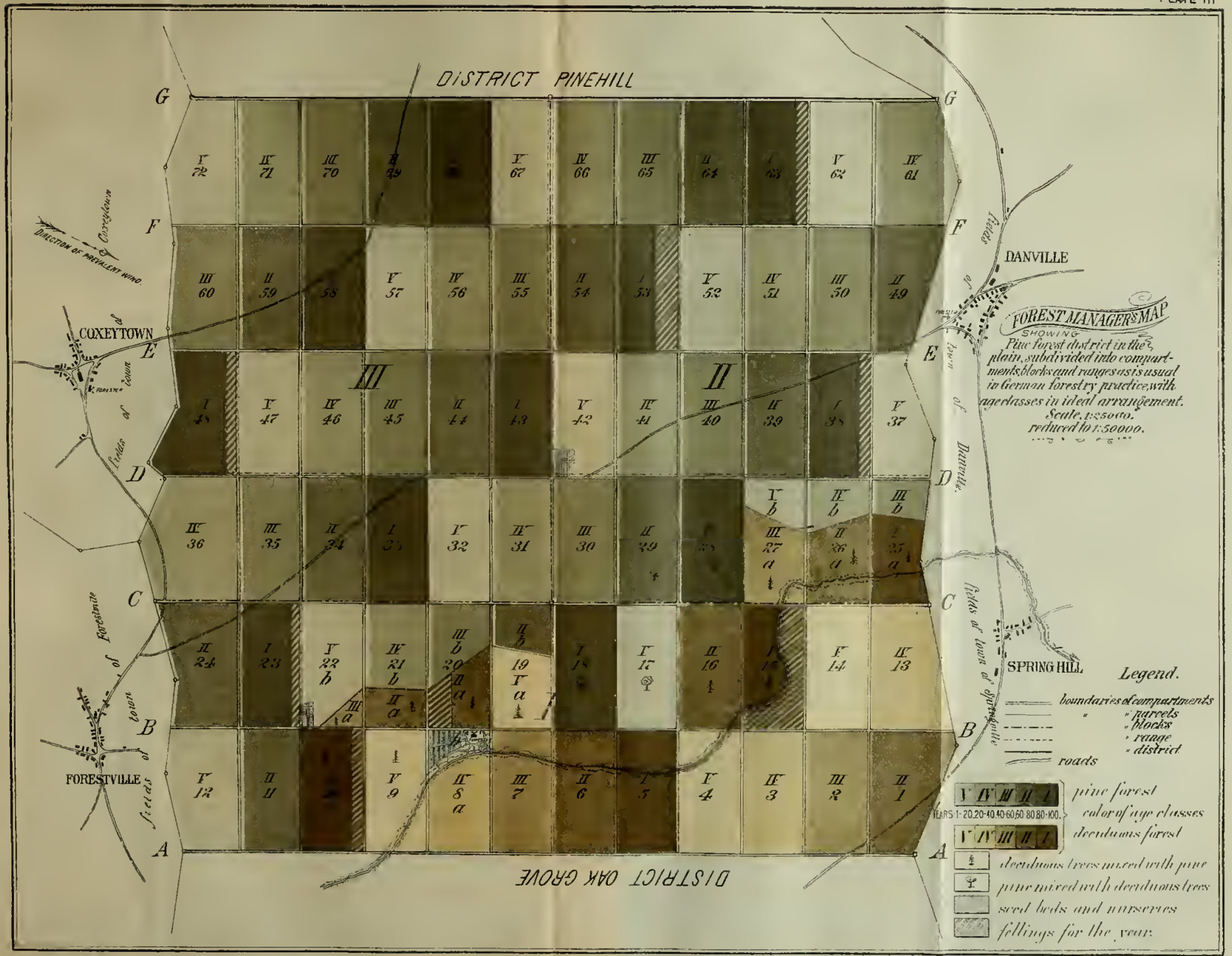
Forest survey, valuation, and regulation work, with plans of management and maps, of forest district Hinternah, Prussia (Thuringian Mountains), showing all changes and revisions from 1822 to 1880. Six volumes of manuscript and 7 maps.

The blank maps described above are used to denote on them all the data which the manager should have before him to readily determine the details of his management; that is, a description as complete as possible of the forest growth and its condition and the proposed manner of utilizing and reproducing the same.* This information—after further subdivision of the compartments where needed on account of differences in soil conditions or growth—is given by means of different colors, differences in shade, numbers, figures, marks, and signs. These maps, which are prepared after a most painstaking forest survey, and which we may call "manager's map" (Plate III), show at a glance not only the nature of soil conditions and what the principal kind of timber and its admixtures are in each compartment or subdivision, but also how old the growth; whether it is to be treated as a coppice, standard coppice, or timber forest; at what period in the rotation it is to be cut, and such notes as the manager himself may add from year to year, as, for instance, the yearly fellings, plantings, movable nurseries, new road projects, etc.

One of the most instructive exhibits in this direction was that showing the changes in Timlitz forest, Saxony. The map of the district in 1822 presented about the condition of one of our mismanaged Michigan forests of pine and hardwoods mixed, from which all the good timber had been culled, leaving it to inferior kinds with few groups of straggling pines and more valuable hardwoods, without symmetry or system in the distribution of kinds or age classes. At the same time a map was constructed showing ideally how the forest was to look after eighty years' well-planned management. We can then follow in the

* Each state government pursues somewhat different methods of mapping. Sometimes two sets of maps are made, one to show the conditions, which might then be called a timber map, the other to show the working plan; but these are now mostly combined into one.


GG
F
F
Coxeytown
DIRECTION OF PREVALENT WIND.
Fields of
DANVILLE
FOREST MANAGER'S MAP
SHOWING
Pine forest district in the plain, subdivided into compartments, blocks and ranges as is usual in German forestry practice, with age classes in ideal arrangement.
Scale, 1:25000.
reduced to 1:50000.
COXEYTOWN
E
Town of
F. FORESTER
Town of
Fields of
Beattie
D
D
C
C
Forestville
Fields of town of Springville
SPRING HILL
Legend.
boundaries of compartments
" parcels
" blocks
" range
" district
roads
B
B
Town of
FORESTVILLE
Fields of
A
V IV III II I
RS: 1-20, 20-40, 40-60, 60-80, 80-100.
pine forest
color of age classes
deciduous forest
deciduous trees mixed with pine
pine mixed with deciduous trees
seed beds and nurseries
fellings for the year


DISTRICT PINEHILL
DISTRICT OAK GROVE
COXEYTOWN
FORESTVILLE
DANVILLE
SPRING HILL
DIRECTION OF PREVALENT WIND.
FOREST MANAGER'S MAP
SHOWING
Pine forest district in the plain, subdivided into compartments, blocks and ranges as is usual in German forestry practice, with age classes in ideal arrangement.
Scale, 1:25000.
reduced to 1:50000.
Legend.
boundaries of compartments
" " parcels
" " blocks
" " range
" " district
roads
pine forest
color of age classes
deciduous forest
YEARS 1-20 20-40 40-60 60-80 80-100.
deciduous trees mixed with pine
pine mixed with deciduous trees
seed beds and nurseries
fellings for the year

maps made every ten or twenty years the changes in appearance under the hand of the forester. During the management new information and experience have dictated modifications of the original working plan, giving rise to a new manager's map; the approach to which appearing in the timber map for 1885 leaves no doubt that at the end of the period of regulation we will have a well-grown pine forest, with deciduous trees mixed in or confined to the more suitable situations, so disposed over the area that annually or periodically the same amount, or nearly so, of valuable material can be harvested.

The painstaking methods of surveying, describing, measuring, calculating, planning, bookkeeping, and repeated revising of all the work from decade to decade were shown in the regulation work of the district Hinternah, Prussia, contained in six large folio volumes of manuscript, continued from the year 1822 to the last revision in 1890. We can only briefly indicate what this work involves, which was briefly summarized in the following exhibit:

FOREST REGULATION.

PROGRESS OF WORK REQUIRED TO BRING FOREST AREAS UNDER RATIONAL FOREST MANAGEMENT.

I. *Geodetic and topographic survey and mapping.*

II. *Forest survey* in connection with I, noting all areas distinguished by quality of soil, composition, and age of timber; general description of forest conditions, of climatic conditions, of surrounding conditions, of possible dangers, of market conditions, means of transportation, etc.

III. *Forest districting.* Division of forest into parcels or lots and aggregation of lots into blocks and ranges. In the plain, rectangular lots, divided by cleared lines called rides (Gestell), are customary; in hilly and mountainous country division lines follow the configuration of soil. Differences of soil or character of growth within lots give rise to formation of sublots.

IV. *Forest yield valuation* (assessment). Ascertaining amounts of timber standing, rate of growth on various sites, determining capability of production and future yield in material and money.

V. *Determining plan of management* (working plans). General plan for all time; special plans for period of ten to twenty years. Determining length of rotation; amounts annually to be cut, designating lots to be cut, with a view to obtaining favorable distribution of age classes; thinnings to be made; methods to be used in felling and cultures.

METHODS OF FOREST REGULATION.

In Prussia it was Frederick the Great who first ordered a regulated administration of the government forests, soon after the beginning of his reign. The first simple prescriptions of dividing the forests into equal areas and cutting every year a proportionate area were followed up with more elaborate ordinances having in view a closer equalization of the amounts of material harvested and revenues obtained, besides other considerations of management for continuity, until finally the basis for present methods of regulation was reached in the ordinance of 1836, since modified in its details, under which "the preservation, revision, and perfection of the work of forest valuation and regulation" is carried on.

The *modus operandi*, similar in principle in all government forest administrations, is about as follows:

Let us assume that the government has purchased* a new forest district, comprising, say, 10,000 acres, the average size of the existing districts. The necessary surveys and blank maps, as explained, have been made and the boundaries carefully established in the field, the

*Prices for forest soil vary, of course, according to their location and condition, just as in our country. In 1849 Bavaria sold 27,000 acres of her state forests at $68 per acre. In Prussia the government has lately (1884–1887) paid prices ranging

division into compartments or parcels, larger or smaller according to the need of a more or less intensive management, have been noted on the maps and marked on the ground (the avenues perhaps partially opened), and for the sake of satisfactory administration a number of the parcels have been combined into subdistricts, "blocks," or ranges; and thus the first—purely geometrical—basis for a rational administration has been established. Now the arithmetical basis is to be ascertained. For this, in the first place, a general description of the district in its present condition is desirable, parts of which, however, can be furnished only after the more thorough measurements described later. Such a description recites all needful knowledge regarding the extent, the manner of division, the boundaries, and the legal rights. Next follows a description in general terms of topography, climate, and soil conditions, and of the forest growth, being a condensation of the special description by parcels. The manner of treatment hitherto, the market conditions, current market prices, and usual wages are noted. Then after recital of the processes and methods by which the information in the following detail work has been obtained, the principles adopted for the management and its motivation are stated, forming a general guide for the manager for all time.

These principles are formulated by a commission, after sufficient general knowledge of the condition of the district is obtained. In this important part of the general description, not only the territorial partition of the district into compartments and blocks or ranges is determined, and reasons given for it, but also the system of management for each block or parts of blocks, whether coppice, standard coppice, timber forest, etc.,* and the length of rotation, i. e., the time within which a block is to be cut over and reproduced; furthermore, the principles according to which the fellings are to progress, reproduction is to be secured, thinnings are to be made, the annual yield to be expected,

from $5 to $60 per acre, and for a round 70,000 acres the price per acre was $21 average. These were mostly devastated waste lands in the northern plain. In Thuringia, where prices for wood and land are higher, the price for forest land is from $20 to $60 and as high as $80. These prices do not, of course, include any timber growth, the value of which, if present, is calculated according to well-known careful methods of determining "expectation values." According to a calculation by Dr. J. Lehr, based on the net income as representing interest at a 3 per cent rate and assuming a ninety-year rotation of the forest growth for the entire German Empire, the forest land was worth $25 per acre and the wood on it $156 per acre.

*NOTE.—Timber forest (Hochwald; high forest) is a forest in which trees are allowed to grow to maturity and reproduction is effected either by natural seeding from the old growth in various ways or by planting or sowing after removal of the old growth; it is usually managed in rotations of 70 to 120 years.

Coppice (Niederwald; low forest) is a forest in which reproduction is expected by sprouts from the stumps; this is usually managed in rotations of 10 to 40 years.

Standard coppice (Mittelwald; middle forest) is a combination of the two former, the standards being allowed to grow to maturity and reproduction being secured both by seed and sprouting.

Determining the rotation.—Our friends who are attempting to bring about a more rational treatment of our forests have often a mistaken notion as to when timber should be cut, when it is ready for the harvest. This can not be determined by any set period, as in the ripening of fruit in agriculture, or by any more or less defined age, much less by any diameter measure. The determination of the "felling age" (Haubarkeitsalter) or of the length of "rotation" (Umtrieb) depends on the use to which the crop is to be put, the manner in which it is to be reproduced, and the amount of material that can be produced or the amount of profit that can be derived from it. This determination is one of the most difficult, requiring both careful financial calculation and knowledge of forest technique.

The "sylvicultural rotation" is that which considers mainly the forest technique, being the time when perfect natural reproduction is most surely attainable, i. e., fullest seed production in timber forest, highest sprouting capacity in coppice forest; or, when preservation of the productive capacity of the soil, avoidance of damage

and the time within which the forest is to be brought into a regular systematic order of management—in short, all the general framework of the management, as far as determining a set policy into which the special working plans should fit. Before this report can be made final, however, the work of the valuator or examiner must have proceeded to some extent.

VALUATION WORK.

The valuator or estimator upon whose work as a basis the general and special working plans depend, begins by examining and describing briefly the conditions of the soil, its productive capacity, and the kind and appearance of the growth in each compartment (or subparcel, if conditions of growth or soil make such subdivision desirable). In the description the dominating kind of timber or, if mixed in equal proportions, that upon which the management is to be prominently based, is named first and the average age of the growth* with special reference to the dominating timber is ascertained for the purpose of ranging the parcel into an "age-class," which comprises usually twenty years, so that the growth of 1 to 20, 21 to 40, 41 to 60 years, etc., form each an age-class or period. The density of the growth and larger openings devoid of tree growth are specially noted. The valuator at the same time is expected to form, from general appearances, an opinion as to the best treatment of each parcel in the near future, and note it and especially whether the growth is to be cut during an earlier or later period, than its age would warrant considering the likelihood of its thrifty or its unsatisfactory growth. He also estimates the amounts to be taken out in thinnings for the next twenty years.

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from windfalls, diseases, etc., are uppermost considerations. These considerations of course also influence in part the determination of any of the following rotations, which we may call "economic rotations."

The "rotation of greatest material production" is that which allows the forest to grow as long as the average annual accretion is at a maximum. This differs, of course, with species, climate, soil, etc. If for the mass of material we substitute its money value and strive to so arrange that the time of rotation coincides with the largest money returns, we have a "financial rotation."

Various points of view lead to different kinds of financial rotations:

"Rotation of the highest harvest value" or "Technical rotation" which attempts to produce certain desired sizes and qualities in largest quantity with a view of obtaining thereby the largest money return for the crop under the circumstances (management for telegraph poles, fence posts, osier holts, tan-oak coppice).

"Rotation of the highest forest revenue" when the growth is to be harvested at the time of its maximum average annual net money value; this time is influenced both by the amount of material and the price paid for better sizes and quality of wood. In this rotation no regard is paid to the original capital invested in the soil; when this latter factor is introduced into the calculation we arrive at the true "Financial rotation" or "Rotation of the highest soil (or ground) rent," in which the forest is to be cut at a time when the capital invested in soil, stock, and management, furnishes the highest interest rate. This capital as far as the soil is concerned may be represented by its actual cost, or by its market value, or else by its capacity for production (Bodenerwartungswerth; soil-expectation value), which is found by adding the values of expected returns at harvest discounted to the present time and deducting the expenses incurred up to the time of harvest, similarly discounted.

To determine this value, experience tables must give the data. Local conditions and prices and the rate of interest applied of course influence the length of the financial rotation. It is shortest for a firewood management (in Germany say 60 to 70 years), for spruce and pine at an interest rate of 2 to 3 per cent a rotation of 70 to 90 years, with oak 120 years, appear as profitable rotations; where small sizes, mining timber, posts, poles, etc., are bringing good prices, the most profitable financial rotation may be shorter. It stands to reason that the length of this rotation as well as of all others can be only approximately calculated. The forestry literature of Germany is most prolific just now with regard to determining financial rotations, and the highest mathematical skill is employed in the discussion.

*Growth (Bestand;—stand) is here and farther on used in the collective sense of the word to denote an aggregate of trees; for which also the word "stand" may be employed.

With this information established, a table may be constructed, in which the area of each parcel is entered, according to its average age or "age class," modified by considerations of productive capacity and from this a "timber map" is made, showing the present conditions of the forest; the kind of dominating timber in each parcel being denoted by a color, intermixed timbers by signs, and the age by the shade of the color in 4, 5, or 6 gradations according to the number of age classes, as shown in the accompanying ideal map.

ARRANGEMENT OF AGE CLASSES.

Now follows the determination of the future arrangement of age classes, the object of which is to have, when the forest is regulated, in each period of the rotation an approximately equal or equally producing area to be cut. It therefore becomes necessary to shift the distribution of age classes, in order to attain the equality of the sum of areas in each period. In addition to the mere equalization of areas, there are several other considerations guiding the valuator in arranging the age classes. The oldest timber, as well as that which for some reason has ceased to make satisfactory growth, is of course to be cut first; hence the conditions of the areas are more specially examined regarding health, density of cover, soil, vigor, etc. In coniferous growths, especially in the plain, the danger from windfalls, if one parcel is cut and thereby the other exposed to the prevailing storms, necessitates such an arrangement in the location of the fellings (or age classes) that the removal of an old growth will leave behind it a young growth which is less liable to be thrown. This local distribution of the age classes by which, in the direction of the prevailing winds, no two neighboring growths are assigned to the same period is also desirable from other considerations. By avoiding a series of extensive fellings side by side the danger from fires is lessened, and liability to spread of diseases and insect attacks, danger from frost, and drought to young growths, is confined or reduced. Hence an arrangement of the age classes as near as possible after the following scheme has been generally adopted, in which the Roman figures denote the age classes, I standing for the oldest growth, containing, if the rotation has been set at 100 years, timber of 80 to 100 years, to be felled within the first twenty years, II for that to be felled within twenty-one to forty years from the present, and so on, V to be felled in from eighty to one hundred years.

	V	III	I	IV
	IV	II	V	III
Prevailing winds →	III	I	IV	II
	II	V	III	I

FIG. 1.—Diagram showing arrangement of age classes.

In mountainous districts, where the topography influences the expense of transportation, fellings are often more concentrated and the higher parcels used and reproduced before the lower, in order to avoid injury to the young growth by a reversed condition when the

material from above would have to pass through the young growth below. Various minor points may also dictate exceptional arrangement. In coppice growth, needed protection of the stocks against cold north winds makes it desirable to have the fellings progress from the south and west towards north and east. Altogether it will have become apparent that the distribution of successive fellings is an important matter, not only from the standpoint of regulated administration, but also of successful culture.

In the accompanying map (Plate III) we have attempted to give an idea of the matter in which a "manager's map" is constructed, and how ideally in a forest of the plain the arrangement of age classes would appear when the forest regulation is perfected.

Portrait of G. L. Hartig, Oberlandforstmeister of Prussia (1811 to 1836).

This portrait was exhibited to represent the father of the methods of forest regulation in vogue at the present time, as developed in his "Instruction for the valuation of forests," 1795. He was also one of the most fertile writers in forestry literature.

YIELD CALCULATIONS.

When the distribution of areas has been effected in accordance with the considerations set forth, the yield calculations are made. These are computed after careful measurements and by various methods of

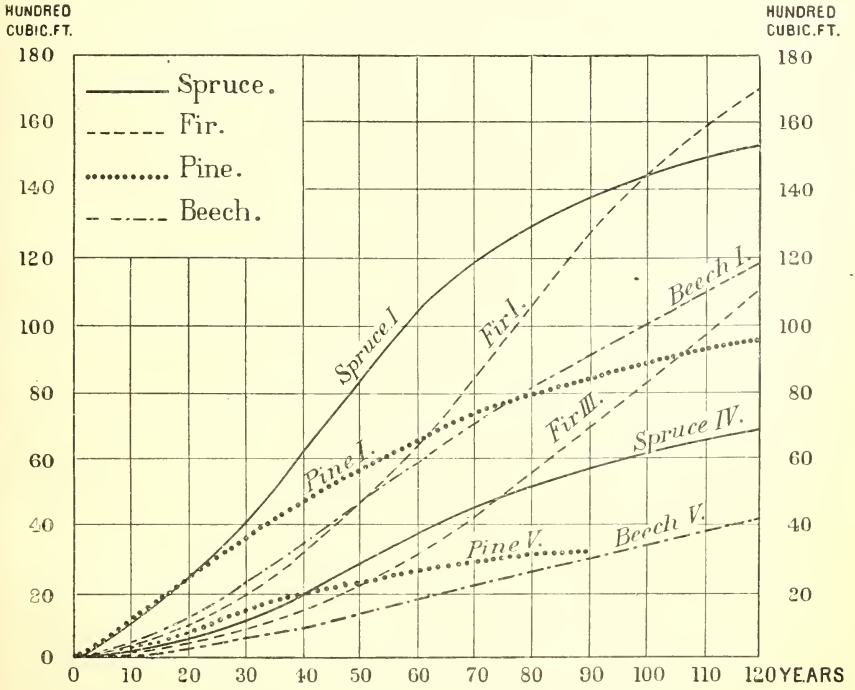

FIG. 2.—Diagram showing comparative progress of yields of spruce, fir, pine, and beech on best and poorest site class.

calculation, which have been developed after much experience during more than one hundred years.

Since the different compartments are cut at different times, not only the present "stock on hand" needs to be measured, but also the accretion for each age class from the present to the middle of the period in which it is to be utilized as to total quantity (decreasing in arithmetical proportion as the stock on hand is diminished by fellings), when by adding the two quantities and dividing the total by the number of years in the rotation or time of regulation the equalized yearly quota to be utilized or "felling budget" (Haubarkeitsertrag or etat) can be calculated.

The determination of existing stock is made by measuring diameter breast high by means of calipers, estimating the average height and calculating contents with the aid of tables which give the corresponding volumes of timber wood (above 3 inches diameter). These tables are constructed after numberless detail measurements from which the "factor of shape" for each species, soil, or climate is derived; for, since the tree is neither a cylinder nor a cone, which could be calculated from the base and height, the modification from either of these two forms, the "factor of shape," must be determined experimentally in order to arrive at the approximately true contents. These measurements are made somewhat like those for which schedules are given on page 310 of this report. In very irregular growths and with skillful valuators a simple estimating of contents or the use of so-called normal yield or "experience tables," which give for the various species, soils, and climates the amount of wood that would normally be produced per acre at a given period, is not excluded.

Normal yield table for spruce.

[Main growth (exclusive of thinnings) per acre.]

Age.	Number of trees.	Cross-section area of all trees breast high.	Average height.	Wood above 3 inches diameter.	Wood, total mass.	Age.	Number of trees.	Cross-section area of all trees breast high.	Average height.	Wood above 3 inches diameter.	Wood, total mass.
Site class I.		*Sq. ft.*	*Feet.*	*Cu. ft.*	*Cu. ft.*	*Site class III.*		*Sq. ft.*	*Feet.*	*Cu. ft.*	*Cu. ft.*
10 years ...	.....	49·2	4·9	86	715	10 years ..	.....	18·3	1·9	.....	200
20 years ...	2,591	114·4	16·7	1,101	2,174	20 years ..	.....	53·7	6·6	100	772
30 years ...	1,700	159·5	29·2	2,603	4,204	30 years ..	3,772	86·6	15·7	472	1,617
40 years ...	1,065	188·4	47·6	4,748	6,378	40 years ..	2,412	130·1	25·6	1,244	2,760
50 years ...	724	209·7	62·6	7,222	8,623	50 years ..	1,580	154·9	36·7	2,574	4,247
60 years ...	515	225·8	76·7	9,209	10,625	60 years ..	1,056	171·8	48·2	4,004	5,634
70 years ...	390	237·1	88·2	10,582	12,198	70 years ..	724	185·3	59·0	5,219	6,893
80 years ...	321	244·9	97·4	11,655	13,213	80 years ..	500	196·2	67·9	6,220	7,994
90 years ...	269	250·9	105·3	12,555	14,043	90 years ..	424	205·2	74·1	7,093	8,866
100 years ..	243	258·4	112·5	13,299	14,715	100 years .	380	214·9	79·4	7,922	9,638
110 years ..	229	264·5	117·7	13,971	15,272	110 years .	346	223·2	83·0	8,694	10,296
120 years ..	226	269·7	121·4	14,586	15,730	120 years .	320	230·6	85·6	9,324	10,725
Site class II.						*Site class IV.*					
10 years ...	.....	26·1	3·2	.....	415	10 years ..	.....	11·3	1·6	.....	157
20 years ...	.....	77·9	11·5	315	1,201	20 years ..	.....	36·5	4·6	.....	500
30 years ...	2,364	89·9	22·6	1,187	2,460	30 years ..	.....	72·2	10·5	140	1,044
40 years ...	1,619	151·8	35·1	2,502	4,018	40 years ..	3,161	107·9	18·0	515	1,830
50 years ...	1,161	180·1	47·2	4,176	5,791	50 years ..	1,968	130·1	26·2	1,287	2,788
60 years ...	842	200·1	59·7	6,220	7,851	60 years ..	1,276	143·5	35·1	2,231	3,761
70 years ...	639	213·6	71·8	7,808	9,481	70 years ..	864	154·9	42·6	3,089	4,519
80 years ...	484	222·7	83·0	9,295	10,725	80 years ..	648	162·6	51·5	3,790	5,248
90 years ...	356	231·3	91·5	10,359	11,683	90 years ..	554	172·3	57·1	4,361	5,763
100 years ..	301	239·2	97·7	11,125	12,398	100 years .	500	181·5	61·3	4,848	6,249
110 years ..	293	246·5	103·0	11,740	13,013	110 years .	464	187·0	63·3	5,305	6,707
120 years ..	291	252·3	106·6	12,269	13,585	120 years .	.....	191·4	66·6	5,720	7,150

In very regular growths trial areas only are measured. To indicate this phase of the regulation work there were exhibited of the many instruments in use:

G. Heyers' perfected calipers (best construction).
A. Treffurth's triangular calipers.
Hypsometers (height measurer), construction Faustman, Weise, Wild, Stoetzer.
Accretion borer, construction Pressler, Neuhofer, and Matthes.

These last instruments are most convenient for ascertaining the rate of growth on standing trees, a hollow augur of small diameter (one fourth inch) taking out of the trunk a core 2 or 3 inches long, which allows the measuring of the width of annual rings, and therefrom, by aid of tables, the calculation of the rate of mass accretion for the past five to ten years, from which a judgment of the probable future accretion can be formed. The more usual manner of determining the rate of accretion, however, for purposes of yield calculation, is by felling sample trees of each class, dissecting and measuring the accretions of past periods, as indicated in schedules on page 310.

In modern times the exact measurements are mostly confined to the growths that are utilized during the first or first two periods of twenty years.

FELLING BUDGET.

After all these data for each compartment have been booked, and the yield of branchwood and roots—for even these are mostly utilized—as well as the probable amounts to be taken out in thinnings, have been estimated and recorded, and after the likelihood of decreased accretion in the different compartments has also been determined from measurements and experience, the "felling budget" is determined as a sum of the stock on hand and the amount of annual accretion multiplied by the time, during which it is allowed to grow, i. e., in the average to the middle of the period in which the compartment is placed, divided by the period of rotation. Thus a growth of eighty-five years, which showed a stock on hand of 3,825 cubic feet per acre, and hence had an average accretion hitherto of $3,825 \div 85 = 45$ cubic feet per year, which is likely to be reduced on account of gradual reduction in stock and other untoward conditions to 30 cubic feet, would yield during the first period $3,825 + 30 \times 10 = 4,125$ cubic feet. And if the compartment contained 50 acres it should be credited in the working plan in the column for the period I with $4,125 \times 50 = 206,250$ cubic feet. By adding up the amounts of the yield of all the compartments placed in the first period and dividing by 20 (the length of the period) the annual budget which should be felled during the period, is found. If, however, it is desired to equalize the fellings more or less through a longer period—for instance, the time of rotation—then the amounts in all the periods must be summed up, and these sums as nearly as possible equalized by shifting the position of the compartments from one period into another (necessitating always new calculations of the accretion) until the equalization in the periodic sums is effected.

Even then, however, before finally determining the annual budget, a calculation is made to see whether the area contains as much timber as it normally should; if more, the budget may be increased; if less, a saving must be made in order to bring up the stock on hand to the normal. If, for instance, we know from the experience tables that our forest should normally yield 50 cubic feet per acre a year in a 100-year rotation, then the normal stock would be $100 \times 50 \div 2 = 2,500$ cubic feet per acre. This is the average amount of wood per acre which we

should strive to keep in stock in order to get the full benefit of the productive capacity of the soil and insure an equal growth and equal annual cut for all time. In reality, this ideal is, of course, never reached, but this so-called normal forest, conceived in ideal condition, serves as a guide in the working plans, and the conception is a most useful and important one. To put it into practice we must either save at first on the annual cut until normal condition is attained, or we may increase the cut if more old timber than necessary for normal stock is on the ground. Additional reserves may also be provided for to avoid any unforeseen shortcomings in the budget due to insect ravages, mistakes in calculations, etc.

We can not here enter into the details of all the work of the valuator, being satisfied by having indicated in general the methods pursued. In coppice management, of course, all these fine calculations become unnecesary, and the periodical or annual cut is determined by area mainly.

From the general plan thus elaborated the special plan for the first period or half period of the management is worked out in detail both for fellings, cultures, and other work, road-building, drainage, etc. This special plan, then, is the basis on which the local manager finally makes out the annual plans of work, which are submitted for revision and approval to the controlling officers. Thus, while the general and special working plans lay down the general principles, the annual plans, into which enter considerations of immediate needs and financial adjustments, permit such deviations from the general plans as may appear needful from year to year. Every ten or twelve years, or at other stated periods, a careful revision of the whole regulation work is made, in which the carefully noted experiences of the manager are utilized to correct and perfect the plans.

In addition to the maps explained before, there were exhibited all

Schedules and instructions used in forest regulation work of Prussia.

The results of such careful administration and the methods in detail, as practiced in Bavaria and Prussia, were exhibited in the following volumes:

The Forest Conditions of Prussia, by O. v. Hagen, 2d edition by K. Donner, now Oberlandforstmeister.

Forest Laws and Executive Orders of Bavaria. Explained by Aug. v. Ganghofer, ministerial councilor; small edition for use of employees.

Forest Survey and Forest Regulation, by Ad. Runnebaum.

The following condensed table was prepared to give at a glance an idea of the profitableness of government forestry in the leading German states:

Forestry statistics of certain German forest administrations showing average cost of administration, gross and net income per acre.

States.	Forest area.	Total expenditure.	Revenue.		Expenditures and revenues per acre of forest.						
					Expenditures.						Net revenue.
			Gross.	Net.	Total.	Per cent of gross income.	Administration and protection.	Marketing crop.	Cultivation.	Roads.	
	Acres.										
Prussia	6,000,000	$8,000,000	$14,000,000	$6,000,000	$1.33	58	$0.48	$0.30	$0.14	$0.06	$0.96
Bavaria	2,300,000	3,150,000	5,880,000	2,730,000	1.37	53	.64	.37	.11	.11	1.19
Würtemburg	470,000	1,025,000	2,260,000	1,235,000	2.17	45	.87	.92	.22	.33	2.63
Saxony	416,000	1,040,000	2,750,000	1,710,500	2.50	37	.65	.81	.11	.21	4.11
Baden	235,000	404,000	1,090,000	686,000	1.54	40	.22	.83	.15	.12	2.90
City of Zürich	2,760	14,000	26,000	12,000	5.00	54	1.14	2.10	.16	1.14	4.40

The average cost of administration is 40 per cent of the gross yield; of this 30 to 40 per cent goes to salaries, 30 to 40 per cent to wood-choppers, 15 to 20 per cent to roads and cultures, 0 to 25 per cent for sundries.

In fourteen state forest administrations, covering 10,000,000 acres, the cut during ten years was 55 cubic feet per acre per year, of which 27 per cent, or about 15 cubic feet, was lumber wood, equal to about 120 feet, B. M.

An idea of the conservative management of the state forests may be gained from the statement that, while in Prussia in the years from 1829 to 1867 the cut increased from 28 to 37 cubic feet per acre and to 46·7 in 1880, the proportion of the old timber over 80 years has during the last twenty years increased from 23 to 27 per cent, the cut in 1880 being 31 cubic feet per capita, valued at 37 cents per cubic foot cut in the forest ready to be hauled.

STATISTICS OF FOREST DISTRIBUTION.

To these statements we may add for convenient reference the following statistics on the forest distribution:

The forests of the German Empire occupy about 35,000,000 acres, or nearly 26 per cent of the total available area, or about three-fourths of an acre per capita of the entire population. In the southern, and more mountainous states it occupies 33 per cent; in the hilly and mountainous districts of middle Germany, including the most densely populated states—Saxony and Hessen—it forms 31 per cent; while in the north German plain it occupies but 24 per cent, and in the seaboard plains but 15 per cent of the entire area. Half the forest is private property in Prussia, Bavaria, and Saxony, besides in some minor states; about one-third is state property in all the more important states except Baden, while in the entire Empire about one-half is private, one-third state, and one-sixth communal property.

In Prussia the state is principal proprietor in the eastern provinces, where state forests occupy 50 to 60 per cent; private or communal ownership prevails in the densely populated western and southern districts, the former (private ownership) far exceeding the latter in most provinces. The communal forests are especially noteworthy, forming as they do often the most valuable resource and relief from taxation. The small town of Goerlitz, in Silesia (62,000 inhabitants), possesses such forest areas of 75,000 acres extent under four managers. As regards the different species, pine predominates in the north and northeast, oak and beech in the west and southwest, spruce, fir, and larch in the south, while the central portion contains them all mixed in varying proportions. The proportionate composition is as follows: Coniferous growth, 65·5 per cent of the total forest area, namely, 42·6 per cent pine, 22·6 per cent spruce and fir, 0·3 per cent larch; deciduous growth, 34·5, of which beech occupies the largest part, namely, 14·7 per cent, oak timber forest 3·5 per cent, while to the standard coppice 6·5 per cent are devoted and the balance to mixed forest and coppice.

METHODS OF HARVESTING AND TRANSPORTATION.

Turning now more directly to the management of the districts in detail, we may begin our survey at the end, as it were, by first glancing at the methods of harvesting and transportation.

As far as practical means and methods in felling and logging oper-

ations go, we can learn but little from Germany, except that more care in the utilization of the timber would be profitable here as it is abroad. Yet it may be of interest, and not entirely devoid of suggestive value, to briefly recite the practices followed in most government forests.

The location of fellings for the year having been determined with due consideration, the rangers engage and control, under supervision of the district manager, the crew of wood-choppers under a foreman, who are mostly men living in the neighborhood of the range or district and accustomed to all kinds of forest work.* A contract, which contains conditions, regulations, and a scale of prices, is made with them, which they sign. The men are paid by the job, the prices per unit differing, of course, in different localities and being graded according to the kinds of timber, size, etc.

To cite one example we may take the schedule prices paid at the city forest of Goslar, as this will interest us further on. There are 40 men nearly permanently employed either in wood-chopping, planting, or otherwise, and their average earnings during three years have been about 80 cents per working day. The prices for cutting spruce, including moving to roads and barking, and the average prices obtained for ten years were as follows:

Cost of cutting.	Average price obtained in the woods.	
	Lowest class.	Highest class.
Sawtimber, above 5 inches in diameter (5 classes) 85 cents per 100 cubic feet	$9.50	$16.20
Long poles (3 classes), from 84 cents to $1.68 per 100 cubic feet	5.90	7.90
Small poles (4 classes), from $1.37 to $3.07 per 100 cubic feet	3.60	5.80
Firewood, split, 70 cents to $1 per cord	3.60	4.30
Firewood, brush, $1.10 per cord		1.60

In Prussia the average cost of lumbering (wood-cutting and bringing to roads) for all kinds and dimensions is 65 cents per 100 cubic feet; that is to say, the wood choppers' bill on the 300,000,000 solid cubic feet of wood harvested annually in the Prussian government forests amounts to $1,950,000. It will appear from the prices for wood cited that often the harvesting is more expensive than the price obtained, as, for instance, for brushwood, which will hardly sell for half the cost of cutting, but its removal is necessary from cultural considerations. The wood-choppers are also sometimes expected to move the cordwood at least to the neighboring roads, so as to obviate the driving of teams through the woods or young growth.

If the felling is to be a clearing, a strip is assigned to each gang of 3 men, 1 with an ax and 2 with saws (felling with the saw, of course, is the rule); if a regeneration cutting or thinning, the trees to be taken are carefully selected by the ranger or manager and marked with a marking hammer. As a rule, all fellings are done during winter, and all trees, except in the coppice and small poles, are felled with the saw close to the ground. In the pineries of the North German plain, where the root wood is salable, they are even dug out and then sawed off close to the root, thus saving a good piece of log timber, which in Saxony increases the wood value of the harvest by fully 3 per cent. Which parts of the log are to be cut into firewood and which into lumber wood or special timbers, and the length of the same according to the

*In the census of Germany for 1881–'82 there were reported as engaged in forestry, hunting and fishing 384,637 persons. Unfortunately, no division of the three occupations was made.

best use that can be made of the stick, are determined by the foreman, or in valuable timber by the ranger or manager himself. A scale of sizes and classes of timber (sortiment) exists: in general, all wood over 3 inches diameter is called Derbholz (coarse wood or lumber wood), all below 3 inches is brushwood (Reisholz), with which root wood (Stockholz) is classed. These last two grades are used as firewood, with which is also classed body wood or split wood (Scheitholz), split from pieces over 6 inches diameter at the small end, and round billet wood (Knüppelholz) of 3 to 6 inches diameter.

The wood to be used in the arts, called timber wood (Nutzholz), may appear either in bolts, corded, or in logs. The diameter measurement of logs is made by the ranger with calipers at the middle of the log. Every cord and every log is numbered and the diameter and length noted on the log, and a list prepared in which the cubic contents are calculated. From this list the manager checks off the result of the felling, marking each piece or cord with the marking hammer, and after advertisement sells at public auction, in the woods or at some public place, the single pieces or cords to the highest bidder over and above the government rate, which for the different grades is established every three years on the basis of, but below, current market prices. The sale of logs is made per cubic foot, and the size of the log influences the rate or price, heavier logs being disproportionately higher in price.

PRICE OF WOOD IN THE FOREST.

During the years 1884–'87 the following prices were obtained by the Prussian forest administration for wood in the forest. This is practically for stumpage, cut and marked, the buyer hauling it from the woods:

Price per 100 cubic feet of wood in Prussia.

Pieces containing 18–36 cubic feet.	Lowest price.	Highest price.	Average price.
Timber:			
Oak	$8.50	$17.30	$12.00–14.00
Beech, ash, elm, maple	5.50	12.25	7.50– 8.50
Spruce	4.75	11.65	7.00– 8.00
Pine	4.75	11.00	6.25– 6.35
Firewood:			
Beech (ash, elm, maple)	.75	1.75	1.00– 1.20
Spruce	.40	1.50	.70– .85
Pine	.45	1.30	.80– .90

To gain an idea of the appreciation of the wood product, without reference to kind, size, and quality, the following series of figures will serve:

Average price per 100 cubic feet of wood realized by the Prussian Government for its entire crop (about 300,000,000 cubic feet).

Years.	Price.
1850	$3.27
1855	3.66
1860	3.69
1865	4.71
1870	4.35
1875	5.21
1880	4.47
1885	4.30
1890	4.40

The highest price for any district was obtained in 1888, being $8.49, while the lowest was $2.82. The lower prices in later years are explained by the large importations of wood, especially from Hungary, Russia, and Sweden; for while our misinformed forestry friends point to Germany as the El Dorado of forestry and proclaim the proportion of forest area there maintained, namely, about 25 per cent, as the ideal and necessary for self support, and, therefore, to be maintained also in this country, they overlook the fact that Germany imports not less than $60,000,000 worth of wood and wood manufactures, mostly of the same kind as grown or manufactured in that country. This represents about 10 per cent of the total consumption of Germany, while the importations of the United States, which imports from Canada alone competing classes of forest products, represent not more than 1 per cent of our probable consumption.

The exports of forest products from Germany, on the other hand, are nearly 50 per cent of her imports and represent mostly manufactures, while in the United States the reverse is the case; that is to say, the United States exports twice as much as it imports, and that mostly raw materials, namely, twice as much in value of raw material as of manufactures.

The countries from which Germany imports raw or partly manufactured wood are mainly Russia, Austria-Hungary, and Sweden, which furnish nearly five sixths of the total importation, while Holland, England, Denmark, Belgium, France, and Switzerland draw about $14,000,000 worth of raw material from Germany.

To protect the forest-owners of Germany, a tariff on importations was imposed in 1885 and increased later. Of the effects of this last measure a government report says that as a financial measure these tariffs have had excellent success, for the revenue from these duties increased from $646,000 in 1880 to $1,732,000 in 1886. But for the forest-owner the hoped-for results did not become apparent; the Austro-Hungarian railroads and shipping interests lowered their rates so as to largely equalize the duty charges. The duties on unmanufactured materials being very low, the lack of results in the market of these is still more noticeable. Yet a salutary effect is stated to be a prevention of still lower prices, and because otherwise there would have been a lack of useful occupation for labor finding remunerative employment in the manufacture of the raw material, which, without the increase in duties, would have been imported in manufactured condition.

PRICE OF MANUFACTURED LUMBER.

The following samples of schedules for manufactured lumber, always delivered at the railroad station, may serve to give an idea to our lumbermen how nearly prices compare with those prevalent in our country. We choose those of eastern provinces, which are in sharpest competition with Russian and Hungarian imports:

Province of Posen.

Timber (7-8·5 inch square):			
Pine	per cubic foot	$0.20 to $0.22	
Spruce	do		.16
Pine (Scotch):			
Plank (2–4 inch), 3 classes	per 1,000 feet, B. M	27.00	38.00
Plank (1½–1¾ inch), 3 classes	do	26.00	31.00
Flooring (1-inch), 3 classes	do	17.00	22.00
Flooring (1½-inch), 3 classes	do	20.00	26.00
Spruce, rough boards, not edged (4–5 inch)	do		12.00
Spruce (1½-inch), edged, 12–18 feet	do	20.00	22.00

Delivered at Berlin.

Oak (clear), 82 cents per cubic foot, or $68 per 1,000 feet, B. M.
Elm, 78 cents per cubic foot.
Railroad ties—pine, 45 cents; oak, 90–95 cents.

It will be seen that prices for some grades are as high as and higher than in New York. The manager is expected to secure at least the government rate, and has discretion in conducting the sales to the best advantage of the government. Under certain circumstances sales by contract without auctioneering, and, lately, selling on the stump, are permitted.

The transportation from the woods is usually left to the buyer; rarely does the administration float the timber or cordwood out, or carry it to a depot or woodyard to be sold from there, or engage in milling or other operations. On the other hand, it has been recognized during the last twenty-five years that good roads and other ready means of transportation increase the price of the wood disproportionately. A good road system is, therefore, considered the most necessary equipment of the administration, and an extension of permanent and movable logging railroads is one of the directions of modern improvement. This phase of the management was exhibited by the following items:

Models of movable logging roads.
Models of movable loading apparatus.
Set of photographs, showing methods of felling, measuring, and transporting spruce for pulp wood.
Illustrations of a simple logging road and shutes operated in city forest of Zürich.
The Logging Railroads, by Ad. Runnebaum, 1886.
Model of the communal forest of Goslar and surroundings, showing configuration, location of age classes, and perfected road system, with statistics.
Model of macadam and telford road construction.

The interesting, important, and practical features to us in the logging railroads exhibited were their movable character, being divided into sets of pairs of short (2 to 5 yard) rails (12 to 16 pounds per yard) attached to from two to four cross ties, wood or metal, the light sets weighing 75 to 100 pounds (heavy sets up to 166 pounds), so that one workman can readily carry them; the ready connection of sets, one hooking at once into the other without separate mechanism, forming a sufficiently satisfactory joint; the simple "climbing switch," which is applied on top of the track, permitting ready transfer from side track to main track and ready relocation. These roads can be readily laid down without much or any substructure and readily relocated. The cost is shown in the following statement:

For a fully equipped road, 24 to 28 inches width, and 6 miles length, for rails and ties	$9,000
For earthwork, if any, and laying	50 to 500
For rolling stock and apparatus	2,500
	12,000

Or $2,000 per mile at the highest.

Upon a basis of 800,000 cubic feet (about 7,000,000 feet B. M.) to be transported, it is calculated that the cost of transportation by railroad, stone road, and dirt road will be about as 1 : 2 : 6, the cost on the first being about 3 cents per 1,000 feet B. M. per mile as against 18 cents on dirt roads.

Comparing the cost of construction it is stated that the ratio between corduroy, gravel road (13 feet wide), macadam, and movable track is as 1 : 1.25 : 2.35 : 1.17, placing the last among the cheapest.

GOOD ROADS.

A most instructive exhibit in many ways, especially at the present time, since the movement for better roads in this country has begun, was the model of the city forest of Goslar, a small town (13,300 inhabitants) in the Harz Mountains, whose citizens from this piece of property, a spruce forest of 7,368 acres extent, derive not only their pure drinking water, healthful enjoyment in hunting, and refreshing coolness in summer, but also a net income, amounting in round numbers to $25,000 ($3.40 per acre), towards payment of city taxes. This is the result of careful management, which permits an annual cut of 350,000 cubic feet of wood. Of this only 50,000 cubic feet goes into firewood, and 46 per cent, or 160,000 cubic feet, is saw timber, which sells at 10 to 16 cents per cubic foot; while smaller dimensions, poles, etc., sell all the way down to below 4 cents, and firewood at $1.60 for brush to $4.30 for split or round wood per cord. (See page 340 for prices paid to wood-choppers.) Until 1875 the district was without proper roads. By an effort of the competent manager the city fathers were persuaded to locate and build a rational system of roads on which altogether, until 1891, there was spent for building and maintenance about $25,000. The greatest interest attaches to the statistics carefully gathered by the district manager, Mr. Reuss, since it is always difficult to determine the money value of such an expenditure in dollars and cents.

The proper location of the roads is the most important feature. The roads are ranked according to their importance; the width and manner of finish depend on their rank. Main roads are macadamized; roads of third rank, which are used for occasional hauling of wood, are dirt roads.

These statistics were exhibited in a neat table, as follows:

STATISTICS OF ROAD SYSTEM IN FOREST DISTRICT OF CITY OF GOSLAR (HARZ MOUNTAINS, GERMANY).

Properly located, graded, and built roads reduce cost of logging, hauling, and advance the price for wood.

Area, 7,368 acres spruce forest; annual cut, 350,000 cubic feet; road building begun in 1875; total mileage of improved roads in 1891, 141 miles; cost of road system and maintenance until 1891, $25,000.

Cost of logging reduced by good logging roads.

[Daily wages remaining constant at 60 cents.]

Year.	Length of well-built logging roads.	Cost of logging per 100 cubic feet.
	Miles.	
1877	7·5	$1.93
1878	12	1.61
1879	27	1.54
1880	37	1.45
1881	46	1.15
1882	50	1.23
1883	52	1.15
1884	54	1.23

Saving per 100 cubic feet..... $0.70
Saving on annual cost of 350,000 cubic feet... 2,450.00

Cost of haulage reduced by good wagon roads.

Price per load remaining constant at $3.60. Full load, before improvement, 85–100 cubic feet; after improvement, 175–250 cubic feet.]

Years.	Cost of haulage per 100 cubic feet.
1871–1877 before road improvements	$1.52
1878–1884	.98
1885–1891	.80

Saving per 100 cubic feet	$0.72
Saving on annual cut of 350,000 cubic feet	2,520

Price of wood influenced by road improvements.

[Comparison of prices paid at Goslar and at other Harz districts.]

Year.	Length of improved wagon roads.	Prices for wood per 100 cubic feet.		
		At Goslar.	At other Harz districts.	Difference in favor of Goslar.
	Miles.			
1877	22	$8.25	$8.18	$0.07
1878	34	8.65	8.04	.61
1879	42	9.59	8.44	1.15
1880	55	9.79	8.44	1.35
1881	64	9.05	7.78	1.27
1882	68	8.45	7.43	1.02
1883	71	8.65	7.63	1.02
1884	77	10.17	8.18	1.99
1885	78	8.88	8.24	.64
1886	79	9.59	9.39	.20
1887	81	11.12	9.71	1.41
1888	82	11.12	9.98	1.14
1889	83	11.39	10.58	.81
1890	85	11.72	10.92	.82
1891	87	13.13	11.80	1.33
Average for fifteen years		9.91	8.98	.93

Increase in price on total cut of 350,000 cubic feet	$3,255
Total profit from improved road system in reduced cost of logging and hauling, and in advance of price received for wood, per annum	8,225

Or nearly 33 per cent on investment.

Saving their cost in two years.

Cost of road (marked X on model), macadamized in 1885, $6,960; maintenance for one year, $480; total, $7,440. During 1885–'86 hauling 470,000 cubic feet requiring on old road 4,273 loads of 110 cubic feet average, at $3.60, $15,282.80 (or $2.70 per 1,000 feet B. M.); on improved road, 2,652 loads of 177 cubic feet average, at $3.60, $9,547.20 (or $1.70 per 1,000 feet B. M.), saving of $1 for every 1,000 feet B. M. Total saving in haulage, $5,735.60, or 77 per cent on cost of road in one year.

FOREST PROTECTION.

In this country the greatest danger to the forest, besides the indiscriminate cutting, is to be found in fires. How little this scourge of American forests is known in Germany may appear from the statistics of fires in the government forests of Prussia (representing 60 per cent of the German forest area), 56 per cent of which are coniferous, which show that railroading may be carried on without the necessity of extra risks, if proper precautions are provided. During the years 1882–1891 there had occurred 156 larger conflagrations—96 from negligence, 53 from ill will, 3 from lightning, and only 4 from locomotives. Seven years out of ten are without any record of fire due to this last cause.

From 1884 to 1887 fires occurred in Prussia on 3,100 acres, but only 1,450 were wholly destroyed; i. e., 380 acres per year, or 0.005 per cent of the total area of government forests. In Bavaria during the years 1877–1881 only 0·007 per cent of the forest area was damaged by fire, and the loss represented only 0·02 per cent of the forest revenues. During the unusually hot and dry summer of 1892 only 49 fires, damaging more or less 5,000 acres, occurred.

Besides the thorough police organization and the compartment system, which permits not only ready patrolling but also ready control of any fire, the system of safety strips, described in the report of this division for 1892, where a fuller discussion of this subject may be found, prevents the spread of fire from locomotives.

A much more fruitful cause of damage to the cultivated forests of Germany is found in insect ravages. The annual expenditures in fighting and preventing these in the Prussian government forests in ordinary times, amount to about $50,000. Caterpillars and beetles eat the leaves, and thereby reduce the amount of wood produced and the vitality of the tree; bark beetles follow and kill it; borers of all kinds injure the timber. Hence entomology, the study of life habits of the injurious insects and the methods of checking their increase, forms part of the forester's work. To indicate this branch of forestry there were exhibited:

Injurious insects, bark beetles, pine moths, oak-borers at work and in different stages of development, with their enemies (4 cases).

Set of photographs, showing the development, methods of work, result of the ravages, and methods of fighting the "Nun" (*Psilura monacha*).

This last pest set the forestry world of Germany in consternation two years ago. The most effective method of counteracting its progress was found in the application of "insect lime," a glue made of tarry substances, which is applied in a ring around the trunk, by which the caterpillars are prevented from ascending the tree—the smell seemingly deterring them from crossing—and are readily gathered and killed.

Fungus growth and decay kill the standing tree and injure the cut timber. The study and methods of counteracting this injury form, therefore, part of the work of the forester.

Studies of the decay in oak timber caused by various fungi, specimens and drawings (2 cases).

This exhibit, prepared by the well-known mycologist, Dr. Robert Hartig, one of the most fertile workers and writers on forestry matters, served to indicate this function of the forester.

Series of sections, showing the effects of bad and good pruning.

This exhibited one of the directions in which by proper methods this damage can be avoided.

FOREST CROP PRODUCTION OR SYLVICULTURE.

While we have so far considered mainly the administrative and managerial features of German forestry practice, we come now to the most important and truly technical branch of the art, namely, the forest crop production or forest culture. This part we may call forestry proper, for while the methods of forest regulation, forest utilization, and forest protection, which may be comprised in the one name, "forest economics," are incidental, and may differ even in principle in various countries and conditions, the methods of crop production or forest culture, being based on the natural laws of the interrelations of plants to

soil and climate, must, at least in principle, be alike all over the world. Here pure forestry science finds its application and development.

While the study of soil physics and soil chemistry and the study of climate are accessory sciences to this branch of forestry and must be understood to explain phenomena of tree growth and furnish a basis for the practice, forest biology, which occupies itself with the life history of trees in their individual and aggregate life (consideration of the growing crop), and timber physics, which occupies itself with considerations of the crop after it is grown, in order to establish knowledge upon which the practice can proceed, are the two principal directions in which forestry science works. From forest biology we learn what are the various conditions under which forest trees and forests develop as living beings; from timber physics, we learn what are the results in the wood material of the influence of various conditions. In the practice, then, or art of forestry the knowledge gained from these sciences is applied to attain certain proposed results, to produce a desired crop, which in quantity and quality correspond to the capabilities of soil and climate, and to the art of man in directing the same to best advantage.

Forestry science, like medical science, has until recently been developed mainly by empiric methods; experience has directed the practice rather than knowledge, and only within the last thirty years have exact scientific methods begun to furnish the basis from which general principles applicable everywhere are to be deduced. It was not possible to keep science and practice separated in the exhibit or to cover the important field with any degree of completeness.

The following exhibits served the purpose of bringing to the minds of the beholder the means of artificial afforestation, the methods of natural regeneration, the development of accretion under varying conditions, and especially the study of the influence of light on the same, based upon which is the practice of thinning:

H. v. Cotta, "the father of modern forestry," 1763-1844. Bust and likeness; also photograph of his grave in the woods at Tharandt.

F. W. L. Pfeil, foremost expounder of modern forestry, 1783-1859. Likeness and photograph of the monument in the woods of the Harz Mountains.

Forest planting tools—models of forest plows, subsoil plows, planting dibble, Butlar's planting iron, Wartenberg spade, Solling tree-lifter, wooden transplanting spade, various iron transplanters, Spitzenberg's section spade, screw spade, Hollberg's plant box.

Nursery tools—Hackert's transplanting machine; hand drills, construction Spitzenberg.

Pruning tools—climbing-frame, chain pruning-saw system.

Development of root system of seedlings from seed to 2-year-old plants under varying conditions, 10 sheets from the herbarium of forestry school Giessen.

Album of photographs of groves of American trees grown in Germany for forest purposes.

Sections of American trees grown for forest purposes in Germany.

Accretion rule, system Baur.

Studies in accretion—sections of trees, showing extraordinary accretion; comparative study of the progress of accretion in spruce and fir, from base to top; influence of pruning on accretion of spruce; influence of seed production on accretion of beech; influence of light on accretion, 1 frame and various sections showing the so-called light accretion.

Tree analyses, 1 volume in manuscript; influence of thinnings of varying degree on the accretion of trees, charts and sections taken at different heights; comparative study of the influence of thinnings of varying character in old beech growth, 3 charts and sections.

Tree classes, chart showing comparative height and crown development of trees as basis for selection in thinnings.

v. Seebach method of management in beech forests by underplanting, 2 charts of descriptive matter and 5 tree sections, showing results.

Nördlinger's wood sections for anatomical study.

To every German forester the names of Cotta, Pfeil, and Hartig, are household words, full of meaning as those of the three great men who at the end of the last and beginning of this century, laid the foundation for the modern development of forestry. Hence it seemed appropriate to present some memento and record of their potent influence. All three were prolific writers, and American students of forestry should study their works, which were written at a time when specialization had not yet encumbered the empirical rules of forestry with bewildering detail. Our own conditions at present, as far as forestry is concerned, being not altogether unlike those prevailing at the time when these clear-headed men wrote, their simple manner of expounding the art of forestry may more readily come home to us.

As explained in previous reports and bulletins, the creation of the young forest growth which is to grow into a crop may take place either by means of "artificial reforestation," namely, sowing seed or planting seedlings or cuttings (clearing followed by cultivation), or else by "natural generation," securing reproduction from the seed falling from the old growth, from mother trees left on the ground or from neighboring growths (management in echelons), or by sprouts from the stump.

PLANTING.

Seemingly the simplest and easiest way of reproducing the crop is that practiced in agriculture, namely, removing the entire mature crop and sowing or planting a new crop. But this method, which has been so largely practiced in Europe and admired by our countrymen and writers on forestry, has its great drawbacks, which have of late become more and more apparent, and the tendency now is to return more and more to the "natural reproduction." While the simplicity of the method of clearing and planting recommends itself for a routine or stereotype management, it has not always proved as successful as would be expected. The large clearings which the young planted seedlings are unable to protect from the drying influences of sun and wind bring about a desiccation and deterioration of the forest soil and an enormous increase of insect pests, while other dangers in later life from wind and disease have been largely the result of these uniform growths. And when it is understood that to secure a desirable stand the plantings must be gone over and fail places replanted five, six, and more times, it becomes apparent that the method is extremely expensive, and hence the proper treatment of the natural crop with a view to its reproduction by natural seeding is the most important part of forest culture. Yet under certain conditions, and where no natural crop to manage is found, planting or sowing becomes a necessity and various methods and tools have been developed to meet various conditions.

It would exceed the limits of this report to describe these various methods; we can refer to only one of the simplest and cheapest with which every year many millions of small 1 or 2 year-old pine seedlings are set out in soils which do not need or do not admit of preparation by plow or spade. The instrument used is an iron dibble (Fig. 3); the shoe, with one rounded and one flat side, in shape like a half cone, 8 inches long with 3½-inch base; the handle, a five-eighths-inch rod, 3½ feet long, is screwed into the base of the shoe and carries a wooden crossbar, by which the instrument is handled. The modus operandi is to thrust this iron dibble into the ground; then by moving it lightly back and forth to somewhat enlarge the hole and withdraw it; a boy or girl puts the plantlet in the hole to the flat side, the dibble is thrust again into the

ground 1 to 1½ inch back of the first hole somewhat slantingly towards the bottom, and pressed forward to fasten the plant in its stand, then by irregular thrusts the last made hole is obliterated. Two planters with a boy, carrying the plants in a mixture of loam and water, to keep the roots moist and also heavy for better dropping, may set 5,000 plants in a day.

INTRODUCTION OF EXOTICS—WHITE PINE YIELDS.

The valuable species of trees indigenous to Germany which are subject to special consideration in forest management are but few. The most important forest-forming ones are 1 pine, 1 spruce, 1 fir, 1 larch, 1 oak, 1 beech, 1 alder. In addition we find of broad-leaved trees a blue beach, 1 ash, 3 kinds each of elm, maple, and poplar, in some parts a chestnut, and 2 kinds of birch and linden, and several willows, together

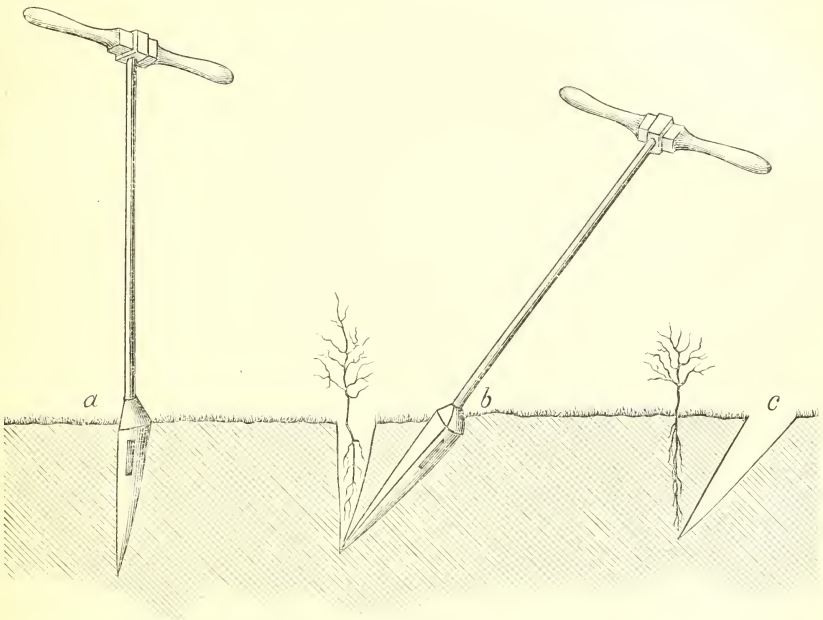

FIG. 3.—Iron dibble used in setting out small pine seedlings.

with some 8 or 10 kinds of minor importance, while of conifers in certain regions 4 other species of pines are found. Some years ago the attention of European foresters was forcibly turned to the richness of the American forest flora, and a movement set in to introduce exotic tree species which might be more productive or show better qualities than the native. Our white pine, a good-sized section of which was exhibited, had been quite extensively planted in the beginning of this century, and these plantations, some 80 or 90 years old, are now coming into use. The quality of the wood, however, has not as yet found much favor, but the quantity per acre exceeds that of any of the native species. Records are extant which show, at 70 years of age, a yield of 14,000 cubic feet of wood containing about 50,000 feet of lumber, B. M., per acre.

On moderately good forest soil in Saxony a stand 78 years old contained over 400 trees per acre, of which three-fourths were white pine,

the rest spruce, larch, beech, and oak. Only 5 white pine trees were under 70 feet high, the majority over 80. Notwithstanding the crowded position, only 45 trees were under 8 inches diameter, the majority over 12 inches, the best 28 inches. The total yield was 12,880 cubic feet of wood per acre, besides the proceeds of previous thinnings. The rate of annual accretion in cubic feet of wood for white pine in the last years amounted to 2·5 per cent of the total contents of the trees, or about 0·4 cubic feet per tree. Of the trunk wood at least 90 per cent could be utilized for lumber, since the shape of these trunks was so nearly cylindrical as to be equal in contents to one-half a perfect cylinder of the height and diameter of the trees taken breast high.

A stand 82 years old on poor land produced 12,500 cubic feet of wood, indicating an average yield for the eighty-two years of 212 cubic feet of wood per annum, of which about 700 feet of lumber B. M. could be calculated. On very poor soil and planted very thick without admixture of hard woods it produced trees 24 feet high and 5 inches thick in twenty years; and on fairly good soil trees 54 feet high, 11½ inches thick, in thirty to thirty-five years, excelling in either case the native spruce (*P. excelsa*) both in height and thickness.

It is also of interest to mention in this connection that a plantation of about 7 acres in the city forest of Frankfort-on-the-Main during the eighteen years ending 1881 brought $115 rent per year for the privilege of seed collecting alone; failing to produce seed only three out of the eighteen years and yielding a maximum of $500 rent during one of the eighteen years; much of the seed finding a market in the United States.

Besides the white pine, the black locust has also for quite a long time found a home in the plantations of Europe, but the species which are now propagated in large quantities, having after trial shown superior advantages in behavior and growth, are our Pacific coast conifers, the Sitka spruce, the Douglas spruce, the Lawsons cypress, and the Port Oxford cedar, sections and photographs of which, grown in Germany, were exhibited, as well as of black walnut and hickory. These trees are now used to plant into fail places or openings, in groups or single individuals, and are especially prized for their soil improving qualities and their rapid growth.

The methods of management for natural reproduction are generally divided into three classes, namely, the coppice, when reproduction is expected from the stumps; the standard coppice, when part of the growth consists of sprouts from the stump, and another part of seedling trees; and the timber or high forest, when trees are grown to maturity and, unless harvested and replanted, reproduction is effected entirely by natural sowing.

COPPICE MANAGEMENT.

This practice is employed for the production of firewood, tan bark, charcoal, and wood of small dimensions, and is mostly applicable only to deciduous trees. The capacity of reproduction from the stump is possessed by different species in different degrees, and depends also on climate and soil; shallow soil produces weaker but more numerous shoots than a deep, rich soil, and a mild climate is most favorable to a continuance of the reproductive power. With most trees this capacity decreases after the period of greatest height-growth; they should therefore be cut before the thirtieth year, in order not to exhaust the stocks too much. The oak coppices for tan bark are managed in a

rotation of from ten to twenty years. Regard to the preservation of reproductivity makes it necessary to avoid cutting during heavy frost, to make a smooth cut without severing the bark from the stem, and to make it as low as possible, thus reducing liability to injuries of the stump and inducing the formation of independent roots by the sprouts.

It will be found often that on poor and shallow soil trees will cease to thrive, their tops dying. In such cases it is a wise policy to cut them down, thus getting new, thrifty shoots, for which the larger root system of the old tree can more readily provide. This practice may also be resorted to in order to get a quick, straight growth, as sprouts grow more rapidly than seedlings, the increased proportion of root to the part above ground giving more favorable conditions of food supply. It must not be forgotten, however, that this advantage has to be compensated somewhere else by a disadvantage; sprouts, though growing fast in their youth, cease to grow in height at a comparatively early period, and for the production of long timber such practice would be detrimental.

Regard to the preservation of favorable soil conditions, which suffer by oft-repeated clearing, requires the planting of new stocks where old ones have failed. Mixed growth, as everywhere, gives the best result. Oaks, walnut, hickory, chestnut, elm, maples, birch, cherry, linden, catalpa, and the locust also, with its root-sprouting habit, can be used for such purpose.

If, when cutting off the sprouts, at the age of from ten to twenty years, some trees are left to grow to larger size, thus combining the coppice with timber forest, a management results which the Germans call "Mittelwald;" and which we may call standard coppice management.

STANDARD COPPICE.

This is the method of management which in our country deserves most attention, especially in the Western prairie States, where the production of firewood and timber of small dimensions is of first importance, though the timber forest, for the production of larger and stronger timbers, should not be neglected. The advantages of this method of management, combining those of the coppice and of the timber forest, are:

(1) A larger yield of wood per acre in a short time.
(2) A better quality of wood.
(3) A production of wood of valuable and various dimensions in the shortest time with hardly any additional cost.
(4) The possibility of giving closer attention to the growth and requirements of single individuals and of each species.
(5) A ready and certain reproduction.
(6) The possibility of collecting or using for reforestation, in addition to the coppice stocks, the seeds of the standards.

The objections to this mode of treatment are the production of branches on the standards when freed from surrounding growth, and the fact that the standards act more or less injuriously on the underwood which they overtop.

The first objection can be overcome to a certain extent by pruning, and the second, by proper selection and adjustment of coppice-wood and standards. The selection of standards—which preferably should be seedlings, as coppice-shoots are more likely to deteriorate in later life—must be not only from such species as by isolation will grow into more useful timber, but, if possible, from those which have thin foliage, thus causing the least injury by their cover to the underwood. The

latter should of course be taken from those kinds that will best endure shade. Oaks, ashes, maples, locust, honey locust, larch, bald cypress, a few birches, and perhaps an occasional aspen, answer well for the standards; the selection for such should naturally be from the best-grown straight trees. The number of standards to be held over for timber depends upon the species and upon the amount of undergrowth which the forester desires to secure. The shadier and the more numerous the standards, the more will the growth of the coppice be suppressed. From a first plantation one would naturally be inclined to reserve and hold over all the well-grown valuable saplings. The coppice is of course treated as described above.

As before mentioned, on account of the free enjoyment of light which the standards have, they not only develop larger diameters but also furnish quicker-grown wood (which in deciduous trees is usually the best) and bear seed earlier, by which the reproduction of the forest from the stump is supplemented and assisted. Any failing plantation of mixed growth, consisting of trees capable of reproduction by coppice, may be recuperated by cutting the larger part back to the stump and reserving only the most promising trees for standards.

If equally well-grown coppice and standards are desired, a regular distribution of the standards, mostly of the light-needing, thin-foliaged kinds, should be made; if prominence is given to the production of useful sizes, the standards may be held over in groups and in regularly distributed specimens, in which case those of the shade-enduring kinds are best in groups.

THE TIMBER FOREST.

In the timber-forest management we may note various methods: The method of selection (Plenterwald), in accordance with which only trees of certain size are cut throughout the whole forest, and the openings are expected to fill up with an after-growth sown by the remaining trees. This method prevailed in former ages, but was finally almost everywhere abandoned because of the difficulty of organized administration and control of such an irregular forest containing trees of all ages, and because the after-growth is apt to progress but slowly with forward-grown trees surrounding and overshadowing it, or may consist of worthless kinds. Of late a revival of this method with various modifications designed to meet the objections is noticeable; the advantage of keeping the soil constantly shaded and thereby preserving the soil moisture also recommending this method. More uniform growths, more regular distribution of age classes, and a more regulated administration was possible by various "regeneration methods," by which a certain area—a compartment—would be taken in hand and the cutting so systematically directed that not only a uniform young growth would spring up through the whole compartment, but by the gradual removal of the mother trees light would be given to the young growth as needed for its best development. This method (Femelschlag) is almost exclusively practiced in the extensive beech forests, somewhat in the following manner:

REGENERATION METHODS.

In the first place it is necessary to know the period at which a full seed year may be expected. This differs according to locality and kind. One or more years before such a seed year is expected the hitherto dense crown cover is broken by a preparatory cutting of the inferior timber, enough being taken out to let in some light, or rather

warm sunshine, which favors a fuller development of seed, the increased circulation of air and light at the same time hastening the decomposition of the leaf-mold and thus forming an acceptable seed bed.

As soon as the seed has dropped to the soil, and perhaps, in the case of acorns and nuts, been covered by allowing pigs to run where it has fallen, a second cutting takes place uniformly over the area to be regenerated, in order that the seeds may have the best chance for germination—air, moisture, and heat to some degree being necessary—and that the seedlings may have a proper enjoyment of light for their best development and yet not be exposed too much to the hot rays of the sun, which, by producing too rapid evaporation and drying up the needful soil moisture, would endanger the tender seedlings. This cutting requires the nicest adjustment, according to the state of the soil, climatic conditions, and the requirements of seedlings of different kinds.

While the beech requires the darkest shade, the pine tribe and the oaks demand more light, and should, by the successive cuttings, be early freed from the shade of the mother trees. Beech seedlings are more tender, and only by the gradual removal (often protracted through many years) of the shelter of the parent trees can they be accustomed to shift for themselves without liability of being killed by frost. The final cutting of the former generation of trees leaves many thousand little seedlings closely covering the soil with a dense shade.

That the method of management must differ according to species and local conditions is evident; and in a mixed forest especially are the best skill and judgment of the forester required to insure favorable conditions for each kind to be reproduced. It is to be expected that such seedlings are rarely satisfactory over the whole area, and that bare places of too large extent must be artificially sown or planted.

Another method is the "management in echelons" (Coulissen, Saumschlag), which consists in making the clearings in strips, and awaiting the seeding of the clearing from the neighboring growth. It is applicable to species with light seeds, which the wind can carry over the area to be seeded, such as larches, firs, spruces, most pines, etc.

The cuttings are made as much as possible in an oblong shape, with the longest side at right angles to the direction of the prevailing winds. The breadth of the clearing, on which occasional reserves of not too spreading crowns may be left, depends of course on the distance to which the wind can easily carry the seed which is to cover the cleared area. Observation and experience will determine the distance. In Germany, for spruce and pine, this has been found to be twice the height of the tree; for larch, five or six times the height; for fir, not more than one shaft's length. From 200 to 360 feet is perhaps the range over which seeding may be thus expected. One year rarely suffices to cover the cleared area with young growth, and it takes longer in proportion to the breadth of the cutting. This method is very much less certain in its forestal results than the next named, and more often requires the helping hand of the planter to fill out bare places left uncovered by the natural seeding. But it is the one that seems to interfere least with our present habits of lumbering, and with it eventually the first elements of forestry may be introduced into lumbering operations.

To be sure, it requires from three to eight times the area usually brought under operation, but instead of going over the whole area every year it may be operated in a number of small camps systematically placed

along a central road connecting the different camps or cuttings with the mill. An ideal arrangement of such management may be sketched thus:

Suppose we have to supply a mill with 2,000,000 feet from pine lands, cutting 8,000 feet an acre, trees which bear seed every two years, and let the period in which full reforestation can be expected be six years. Then a tract of 2,500 acres, or an area of about 3 miles long and 1¼ miles broad, must be taken together in operation.

Dividing the tract by a central road on which the mill is situated and making the cuttings 300 feet wide by 1½ miles long, each cutting will contain 54 acres, and about five such cuttings will furnish one year's supply, with an average haulage of less than one mile to mill—twenty-six cuttings will be located on each side of the road.

IMPROVEMENT CUTTINGS AND THINNINGS.

When the area thus treated is covered with the new growing crop, there are in such a growth, of course, more individuals to the acre than can be expected to develop. A struggle for existence soon begins, and a constant natural thinning out is the result, requiring the judicious aid of the forester to produce a desirable termination of the struggle. In this the one point never to be lost sight of is to keep the soil well shaded. In fact, with this one general rule in view, a practical man will usually make but few mistakes in the removal of trees when necessity for it appears, which does not occur until the stems have reached the size of hop poles. Before that time the clearings are mainly to afford protection to the slower-growing and more valuable species by removing or cutting back the quicker-growing and inferior kinds. By no means, however, should the small shrub vegetation ever be disturbed unless spreading over valuable timber growth. So far from injuring the future trees of the forest this undergrowth is a decided benefit, keeping the soil shaded and sheltered against winds and therefore moist, and adding to its richness by the decay of its leaf mold. On the other hand, if of two or more valuable kinds one threatens to overtop the other and to shade it out, the ax may properly do its work in preserving the deserving weaker one. The question, whether a more vigorous clearing out in the earlier stages of development does not favor better development of the remaining growth without injury to soil conditions, is still an open one, though experiments for its solution have been instituted.

Up to a certain point the effect of the struggle between the trees of an even-grown thicket must be considered distinctly useful, by forcing height growth and showing more clearly which are the individuals of weak constitution and therefore not destined to become the dominant growth of the forest. Among this class, which we may call the overshaded, proceeds mainly the work of interlucation, i. e., the periodical thinnings which are made for the purpose of stimulating increased development in the dominant or "forward" trees, by securing to these increased enjoyment of light and room.

How this struggle for life and supremacy, by exclusion from the neighbor of the necessary factor of existence—light—proceeds in a naturally grown forest, is shown in the following interesting table, which was obtained by counting the trees of a naturally grown dense Norway spruce forest at different ages:

Age.	Number of trees per acre.	Over-grown.	Number of dominant growth.	Standing room per tree.
		Per cent.		*Square feet.*
20 years	9,377	49	4,783	4·64
40 years	1,265	42	733	34·43
60 years	604	32	410	72·11
80 years	393	21	310	110·70
100 years	285	11	253	156
120 years	241	4	231	180·75

Such a table is instructive in many ways. It shows that the struggle for dominance is severest in the period from the twentieth to the fortieth year, gradually decreasing with advancing age. From this we may infer that interlucations are most effective in the earlier period. It shows us that those trees which are now dominant, seemingly in full vigor, may yet be overshadowed and at last subdued by their neighbors. Thus we may group the trees of the naturally grown forest into the following classes:

TREE CLASSES: CLASSIFICATION ACCORDING TO CROWN DEVELOPMENT.

AFTER KRAFT.

[Used in determining the degree of thinnings and removals for reproduction.]

Dominant or superior growth.
- *Class 1.*—Predominant trees with highly developed crowns.
- *Class 2.*—Codominant trees with tolerably well developed crowns.
- *Class 3.*—Subdominant trees with normal crowns, but poorly developed and crowded above.

Dominated or inferior growth.
- *Class 4.*—Dominated trees with crowns poorly developed and crowded laterally.
  - (*a*) crowns wedged in laterally, yet not overtopped.
  - (*b*) crowns compressed, partly overtopped.
- *Class 5.*—Suppressed trees, entirely overtopped.
  - (*a*) crowns still having vitality (shade enduring species).
  - (*b*) crowns dying or dead.

An illustration of the appearance of these tree classes will be found on page 364 of this Report.

DEGREES OF THINNING.

The degrees of thinning usually resorted to are the following:
(1) Slight thinning takes out trees of class 5.
(2) Moderate thinning takes out trees of class 5 and 4*b*.
(3) Severe thinning takes out trees of class 5, 4, and sometimes 3.

KIND OF THINNINGS.

Thinnings are usually made for the following purposes:
(1) Improvement cuttings, to improve the composition of the forest and give advantage to the better kinds.
(2) Interlucations, to improve the form and hasten development of young timber.
(3) Regeneration cuttings, to produce favorable conditions for seed formation and reproduction of the forest.
(4) Accretion cuttings, to improve rate of diameter growth in older timber.

Thinnings are to open the crown-cover, giving access to light and air,

their object being to accelerate decomposition of the litter and turn it into available plant food; to improve the form and hasten the development of the remaining growth. The degree of thinning depends on soil, species, and age and is best determined as a proportion between the present growth and that which is to remain with reference either to crown-cover, mass, or diameter.

By thinnings or interlucations we imitate, assist, anticipate nature in this process of elimination, and, according to the degree of our thinning, we speak of a light or, as the Germans call it, "dark" interlucation, which removes only the suppressed, dead, and dying stems; a moderate one, which takes all the overgrown; and a severe one, which attacks also the lowest grades of the forward-grown, and even interrupts somewhat the upper crown cover. The degree of interlucation to be practiced depends greatly on the soil and the exposure; a "dark" interlucation is in most cases sufficient.

The necessity of a severer interlucation presents itself in a growth with an unusually large number of trees of uniform caliber, where sometimes the struggle for supremacy is unduly prolonged and the lessening of overstock is needed to secure the development of larger dimensions. Predominant trees ought to be taken only exceptionally, when a more valuable kind, which we want to favor—as, for instance, white oak—is in danger of being overwhelmed by a less valuable overgrowing neighbor, or when, on account of some peculiarities of a foregrown species of tree, detrimental consequences must be anticipated.

A deep, rich soil, with abundant moisture, on northern and northwestern exposures, will endure a severe interlucation with least injury, because the vigorous growth due to its favorable conditions will soonest close any gaps. On the other hand, it will almost always be well to leave even suppressed trees on thin and dry soils and those exposed places where by their removal entrance would be given to drying winds and sun.

The degree of thinning depends also a great deal on the species forming the forest. In another place we have pointed out the importance of the classification of the different species with reference to their relation to light and shade, as shade-enduring and light-needing. This classification has some bearing on the degree of interlucation. Those kinds which require for their development a larger amount of light would naturally show in a dense growth a greater proportion of suppressed trees, and consequently a severer interlucation would be indicated. On the other hand, these very species are the least capable of preserving favorable soil-conditions, because their naturally thin foliage not only does little toward the increase of the layer of humus, but does not efficiently exclude the rays of the sun, especially as they have the tendency with increasing age to thin out still more in their leafage. They are, therefore, the most difficult to manage, and the continuity of their crowns must be most carefully preserved.

The time when the first thinning should take place is generally determined by the possibility of marketing the extracted material at a price which will cover at least the expense of the operation. This is, however, not always possible, and the consideration of the increase in value of the remaining growth, or rather of the detriment to the same by omission of timely thinning, may then be conclusive.

On good soil and on mild exposures interlucation may take place earliest, because here the growth is rankest and a difference in the development of the different stems is soonest noticeable. Light-needing and quicker-growing kinds show similar conditions to those grown on

good soil, and here, therefore, early thinnings are desirable. In these cases the thinnings have also to be repeated oftenest, especially during the period of prevalent height accretion. Absolute rules as to the time for interlucations and their periodical repetition evidently can not be given. The peculiar conditions of each individual case alone can determine this. The golden rule, however, is, early, often, moderately. The right time for the beginning of these regular and periodical interlucations is generally considered to have arrived when the natural thinning out before mentioned commences and shows the need of the operation. This occurs generally when the crop has attained the size of hop poles. At this stage the well-marked difference in size of the suppressed trees will point them out as having to fall, and there will not be much risk of making any gross mistakes. Until the trees have attained their full height the thinning should remain moderate. From this time forward it will prove expedient to open out the stock more freely, without ever going so far as to thin severely. Within the last few years new and revolutionary ideas regarding principles and methods to prevail in thinnings are gaining ground, which we have not space here to discuss.

UNDER-PLANTING.

All these manipulations experience modifications according to circumstances, different species and soil conditions requiring different treatment. One of the most interesting modifications, the results of which in a given district were fully exhibited, is the v. Seebach management in beech forests. Such a management, which contemplates the production of heavier timber in the shortest time, tries to take advantage of the increase in accretion due to an increase of light which is secured by severe thinning; and in order to prevent the drying out of the soil by such severe thinning a cover of some shady kind is established by sowing or planting. This cover gradually dies off under the shade of the old timber, the crowns closing again after a number of years. The rate of growth in a stand of 70 to 80 years was thereby increased from 51 cubic feet per acre and year to 77 cubic feet per acre and year, while a neighboring stand, otherwise the same, but not so treated, increased by only 60 cubic feet, distributed over a larger number of trees.

The same method is applied to the production of heavy oak timber. In this case the oak growth is thinned out when about 60 years old and "underplanted" with beech. It may also be applied to older growths with advantage, as appears from the following results:

A stand of oaks 150 to 160 years old in 1846 was thinned to 96 trees per acre, averaging 37 cubic feet of wood per tree, the cleared space being "underplanted" with beech and spruce. In 1887 the oaks, now 190 to 200 years old, of which 59 trees only were left, contained 56 cubic feet in the average, thus growing during the last forty years more than one-half as much as during the one hundred and fifty to one hundred and sixty years previous to the operation, i. e. doubling the rate of growth. In this case, under the light-foliaged oaks, some of the beech and spruce developed sufficiently to furnish marketable material.

With Scotch pine it has been found in one case that while the average accretion of a stand 120 years old under ordinary condition was about 59 cubic feet per acre and year—the yield by thinning included—a stand underplanted with beech showed an accretion of 160 cubic feet per acre and year, besides much better log sizes and earlier supply of saw timber.

Translated into money an example from Bavaria may be cited as follows:

On one acre of pine 80 years old, underplanted at a cost of $2.85 per acre with beech now 40 years old, there were found—

	Yield of wood.	Average annual accretion per acre.
	Cubic ft.	*Cubic ft.*
105 pines	322	40
2,300 beech	156	39
Total	478	79

Supposing this stand to be left forty years longer, it may be figured that the pine would bring $650 and the beech $120; total per acre, $770, of which $49 was yielded in thinnings. White pine without undergrowing is expected to produce only $520 per acre when 120 years old.

As a basis for the management of thinnings and the highest effect of the same upon the increase in the mass of trees and the material product, intimate studies have been made into the influences of various conditions upon the accretion of trees and forests, results of which were shown in charts and sections.

Simply to indicate the necessity for the forester to study the anatomy and quality of the wood material, a study collection of thin sections for examination with the magnifying glass, prepared by the father of timber physics, Dr. H. Nördlinger, was also shown.

FORESTRY EDUCATION AND FORESTRY LITERATURE.

To be sure, the highly elaborate system of forest administration and forest management here outlined could not be developed or maintained without a special high-grade education of those who direct the work. This education is provided for in the most ample manner, and consists not only in theoretical studies at schools, academies, and universities, but also in practical studies in the forest itself under the guidance of competent and experienced forest managers.

The course which applicants for positions in the higher administrative forestry service are expected to follow, with more or less modification in the different states, may be briefly outlined here:

After promotion from college the student goes into the woods for a short period (one-half to one year) to acquaint himself, under the guidance of a district manager, with the general features of the business he proposes to engage in, and thereby tests his probable fitness for it. He then visits for two and one-half or three years a forestry school (called academy when by itself, when at a university it is connected with the "faculty" for national economy), where theoretical studies with demonstrations in the forest are pursued.

After examination and promotion the applicant is bound at his own expense to occupy himself for two years at least in studying the practice in various districts, changing from place to place. If occupation can be found for him he is employed at small daily wages on some scientific or administrative work, always keeping an official diary of his doings and observations, certified to by the district manager with whom he stays, and which forms part of his final examination. For nine months during this time he must continuously perform all the duties of a lower official—a ranger—for a whole or part of a range, and some

times also for a given time certain functions of a district manager. Then, after two years of law studies at a university, he enters into a close and difficult examination for a position as district manager, lasting eight to ten days. By passing this he is placed on the list of eligibles, and has thereby secured a right, enforcible in the courts if need be, to a position when a vacancy arises and his name is reached in the order of the list. This, in Prussia, may now be within eight or ten years after listing. During the interval he may be, and mostly is, employed on daily wages in various sorts of scientific and administrative work, such as revising and making new valuations, laying out roads, acting as tutor at the academies, or as assistant to district managers, or else taking the place of a manager temporarily, etc.

The higher administrative offices are filled by selections from the managers, length of service counting only when special fitness for the kind of work required accompanies it; so that, as in the army, the highest officer has been through all the grades below and is conversant with every detail of the service. The pay is small, graded in each kind of position according to length of service and somewhat according to cost of living in different places. The honor of the position, to which usually other honors are added, its permanency, and the assurance of a pension, graded according to length of service, in case of disability or age, make up for small salaries. The salaries, subject to change from time to time, without adding the value of perquisites like houses, farm lands, etc., range about as follows in Prussia:

1 director (Oberlandforstmeister)		$3,600
4 forest councilors (Landforstmeister)	$1,800 to	2,400
33 chief inspectors (Oberforstmeister), (with additions for house and traveling up to $1,100)	1,050	1,500
89 inspectors (Forstmeister) (with additions for house and traveling up to $1,100)	900	1,500
679 district managers (Oberfoerster), (with additions up to $825 and house and field)	500	900
3,390 rangers (Foerster) (with house and addition up to $110)	260	360
349 guards (Waldwaerter)	100	200

The rangers (Foerster) follow different courses of instruction, part of which they receive in subordinate positions under district managers; while serving in the army in special battalions (chasseurs) they receive also theoretical instruction, which is supplemented in special schools. When finally promoted to the responsible position of rangers, in which much discretion and latitude are given them, their pay amounts to from $260 to $360, with a house and field, with the assurance of pension on withdrawal.

It was the privilege of the writer to visit nearly every higher forestry school in Germany, as well as that at Zürich, Switzerland, and to secure some material which should aid in completing the exhibit and bring the existence and work of the institution to the attention of our public.

In addition to materials contributed, which have been mentioned before, the following served more specially the latter purpose:

Eberswalde: Water-color painting commemorating the 50-year jubilee of the institution in 1880; portrait of the director, Dr. Dankelman; photographs of the academy building, old and new; samples of work of students in manuscript (4 volumes); catalogues, plans of instruction, etc.; literature of professors.

Münden: Photographs of building and surroundings; map of city forest; guide and map to surrounding forests, used for instruction.

Tharandt: Photographs of buildings and surroundings; portrait of the director, Dr. Fr. Judeich; plan of instruction; map of surrounding forests, used for instruction.

Eisenach: Photographs of surroundings; photographs of professors; map of Thuringian Mountains; three German eagles, pair of mountain cocks (Auerhahn and Birkhahn).

Tübingen: Map and guide to the surrounding forests, used for instruction; literature of professors.

Giessen: Guide to experimental garden.

Munich: Literature by professors.

Zürich: A comprehensive collection of various materials specially prepared by Dr. Anton Bühler, the competent occupant of the chair of Foresty, and director of the Forest Experiment Station, especially charts illustrating experiments in thinning and forest meteorological observations; description of methods of reforesting denuded mountain slopes; plans of forest-garden experiments, etc. There were also exhibited by various plans and photographs methods and results of the model forest administration of the city forest of Zürich under the competent manager, Forstmeister Meister.

This opportunity was also used to form an opinion as to which of the 8 institutions visited would serve best the purpose of giving American students of forestry that knowledge which they can acquire only in a country where forestry has been practiced and object lessons are to be had, and where the principles underlying forest-crop production or forest culture have been fully developed.

While every one of the institutions has some special points to recommend it, be it due to its location or to the personnel of its faculty or to its methods of organization, I have come to the conclusion that all points of advantage in the institutions considered, together with the objects and nature of students from the United States, the choice should be between Munich and Zürich, or part of the time at each, with a short visit to either Eisenach, Tharandt, Münden, or Eberswalde.

The following table gives information regarding these forestry schools:

Higher forestry schools in Germany for the education of forest managers.

[Austria and Switzerland included.]

Name of place.	State.	When founded.	Length of course (years).	Instructors of forestry branches proper.	Total number of instructors.	Average attendance of forestry students.
At universities:						
Giessen	Hesse	1825	3	3	(*)	40–50
Tübingen	Wurtemberg	1818	(†)	3	(*)	50–60
Munich	Bavaria	1878	(†)	8	*18	90–100
At polytechnicum:						
Karlsruhe	Baden	1832	3	2	19	15–30
Zürich	Switzerland	1855	3	3	*20	15–30
Vienna	Austria	1875	3	6	43	130–140
Separate academies:						
Aschaffenburg	Bavaria	1807	2	2	9	90–100
Tharandt	Saxony	1811	2½	3	10	100–135
Eisenach	Saxe Weimar	1820	2	3	8	65–75
Eberswalde	Prussia	1831	2½	6	14	140–150
Münden	do	1868	2½	5	13	40–60

*The entire corps of professors of the university. In Munich 18 professors are engaged in lecturing on subjects which concern forestry students; in Zürich, 20 professors. In Munich all studies can be followed in any year, as the students may select. The attendance varies, of course, widely in different years, having been as high as 216 in Eberswalde and 120 in Münden. The above figures are for 1885–'86.

†Not prescribed.

The following table will serve to give an idea of what instruction is to be had at these institutions:

Plan of studies at Forest Academy Eberswalde.

Subjects of instruction.	Whole number of hours.	Subjects of instruction.	Whole number of hours.
FUNDAMENTAL SCIENCES.		PRINCIPAL SCIENCES.	
Natural sciences.		Cultivation of forests	80
		Forest implements	20
General and theoretic chemistry	32	Geographical forest botany	48
Special inorganic and organic chemistry applied	80	Protection of forests	32
Physics and meteorology	80	Forest usufruct and technology	80
Mineralogy and geognosy	60	Forest surveying	20
Definition of minerals and rocks	20	Appraising forests	80
Reviews for organic natural sciences	16	Calculation of the value of forests and forest statistics	32
Botany in general and forest botany in particular	64	Administration of forest and hunting	48
Anatomy of plants, vegetable physiology and pathology	60	Redemption of rights of usage	32
Microscopy	20	Forest history	40
Botanical reviews	20	Forest statistics	20
Botanical excursions, each 2½ hours	80	Review of various forest matters	56
General zoology	16	Examinations	40
Vertebrates	80	Forest excursions, each 4 hours	352
Invertebrates, with special reference to forest insects	80	Total	980
Zoölogical preparations	16	SECONDARY SCIENCES.	
Zoölogical reviews	20	*Jurisprudence.*	
Zoölogical excursions, each 3 hours	96	Civil law	72
Total natural sciences	840	Criminal law	32
Mathematics.		Civil and criminal law suits and constitutional rights	40
Geodesy	72	Jurisprudence	36
Interest and rent account	20	Total	180
Wood-measuring	20	Construction of roads	32
Mathematical reviews and exercises	56	Hunting	32
Surveying and leveling exercises, each 4 hours	192	Shooting exercises, 2 hours each	96
Plan-drawing exercises, 2½ hours	80	Total sum of hours for secondary sciences	340
Total mathematics	440	Grand total	2,648
Economic sciences.			
Public economy and finances	48		
Total sum of hours for fundamental sciences	1,328		

	Per cent.
Fundamental sciences	50
Principal sciences	37
Secondary sciences	13

Average per instruction week (21 weeks in winter, 17 during summer; 2 winter courses, 3 summer courses):

$$\frac{2648}{93} = 28{\cdot}5 \text{ hours, or per day, } 4{\cdot}9 \text{ hours.}$$

LITERATURE.

In addition to the live teachings, which an able corps of professors impart at these institutions and that which competent managers are ready to impart to the young students in the forest itself, a large number of weekly, monthly, quarterly, and annual journals and publications are keeping the foresters and forestry students *au courant* with the progress of forestry science and forestry technique. Adding the publications of this nature which appear in Austria and Switzerland in the German language, and which have their constituency in Germany as well, we can make the following respectable list, not counting the journals of the lumber trade and other related publications. Those

marked with an asterisk (*) are to be found in the library of the Division of Forestry; those marked (†) are considered the best or are most comprehensive; those marked (?) have been discontinued.

German forestry periodicals.

Name of publication.	Published at—	Issued—	Established.
Allgemeine Forst-u. Jagdzeitung *†	Frankfurt-on-the-Main	Monthly	1824
Aus dem Walde	Hanover	Irregularly	1865
Aus dem Walde	Frankfurt on-the-Main	Weekly	(?)
Deutsche Forst-u. Jagdzeitung	do	Semi monthly	(?)
Forstliche Blaetter	Berlin	Monthly	1863
Forstlich-naturwissenschaftliche Zeitschrift *†	Munich	do	1892
Forstwissenschaftliches Centralblatt *†	Berlin	do	1856
Jahresbericht des schlesischen Forstvereins	Breslau	Annually	1841
Jahresbericht der preussischen F. u. J. Gesetzgebung.	Berlin	do	1868
Land-u. Forst-wirthschaftliche Zeitschrift	Vienna	Quarterly	1886
Muendener forstliche Hefte *	Berlin	Irregularly	1892
Oesterreichische Forst zeitung *	Vienna	Weekly	1882
Der praktische Forstwirt fuer die Schweiz	Davos	(?)	(?)
Schweizer Zeitschrift fuer Forstwesen	Zürich	Quarterly	(?)
Tharandter forstliches Jahrbuch*	Dresden	Annually	1850
Verhandlungen der Forstvereine	Various	do	
Bericht ueber die Versammlung deutscher Forstmaenner.	do	do	
Zeitschrift fuer Forst-u. Jagdwesen *†	Berlin	Monthly	1869
Zentralblatt fuer das gesammte Forstwesen *†	Vienna	do	1875
Zeitschrift der deutschen Forstbeamten	(?)	(?)	(?)

Should the reader wish to collect a library of the most modern thought on all or any subject pertaining to forestry in Germany the list of books found at the Exposition should satisfy him, for although the books exhibited do not by any means include even all the best or most comprehensive or needful literature, they leave no subject untouched.

Publications of Professors at the University of Munich and of other authors.

[Faculty of Political Economy and Forestry.]

Author.	No.	Subject.
Prof. Dr. Karl Gayer	1	Sylviculture.
	2	Forest Utilization.
	3	The Mixed Forest.
Prof. Dr. F. V. Baur	4	Wood Measuring.
	5	Geodesy.
	6	Investigations into Actual Mass and Weight of Cordwood and Bark.
	7	The Spruce; Its yield, Accretion and Shape.
	8	The Beech; Its Yield, Accretion and Shape.
	9	Yield-tables of Spruce.
	10	Forest Valuation.
	11	Damage Awards to be Given in Forest Cessions.
	12	Academy or University?
	13	Forstliches Centralblatt (Forestry Journal).
	14	Forest Experiment Stations.
Prof. Dr. R. Weber	15	Forest Regulation.
Prof. Dr. H. Mayr	16	The Forests of North America.
	17	From the Forests of Japan.
	18	Monograph on the Abietineæ of Japan.
Prof. Dr. R. Hartig	19	The Decay of Wood.
	20	Investigation into Growth and Yield of Beech, Spruce, Pine, Fir, etc.
	21	Profitableness of Management for Timber in Spruce, and of Management for Firewood in Beech.
	22	Important Diseases of Forest Trees.
	23	Diseases of Trees.
	24	Investigations from the Forest Botanical Institute.
	25	The Wood of Conifers.
	26	The Wood of Beech (Hartig and Weber).

Publications of Professors at the University of Munich—Continued.

Author.	No.	Subject.
Prof. Dr. R. Hartig	27	Anatomical Distinction of Woods.
	28	The True Rot (Merulio lacrimans).
	29	Anatomy and Physiology of Plants.
Dr. K. v. Tubeuf	30	Contributions toward Knowledge of Diseases of Trees.
	31	Seeds, Fruits, and Seedlings of Forest Trees.
	32	Forest Natural History Journal.
	33	Seedlings of Abietineæ.
	34	Cucubitaria Laburni.
	35	Formation of Heart in Trees.
	36	Annual Botanical Reports.
Dr. Aug. Pauly	37	Bark Beetle Studies.
Dr. E. Ebermayer	38	Hygienic Significance of Forests.
	39	Physics of the Soil.
	40	Composition and Value of Forest Litter.
	41	Physiological Chemistry of Plants.
	42	Physical Effects of Forests.
	43	Properties of Forest Air.
	44	Lightning and Hail in the State Forests of Bavaria.
Drs. J. Lehr and T. Lorey	45	Allgemeine Forst u. Jagdzeitung (Forestry Journal).
Dr. T. Lorey	46	Handbook of the Entire Knowledge of Forestry.
Dr. H. Fuerst	47	Forestry Dictionary.
Dr. F. Judeich	48	Tharandter Forestry Annual (Journal).

FORESTRY ASSOCIATIONS.

Forestry associations thrive better in Germany than in the United States and are of a different character; they are associations of foresters, who practice what they preach. There is no more need of a propaganda for forestry than there would be here for agriculture, and the discussions, therefore, are moving in technical, scientific, and economic directions. Besides some thirty or forty larger and smaller local associations there is held every year a forestry congress, at which the leading foresters discuss important questions of the day.

FOREST EXPERIMENT STATIONS.

In addition to all these means of education and of advancement of forestry science, there has been developed in the last twenty years a new and most important factor in the shape of forest experiment stations, which are mostly connected with the forestry schools. If forestry had a strong and well-supported constituency before, this additional force has imparted new impulses in every direction.

The first incentive for the establishment of these stations came from the recognition that the study of forest influences upon climate could be carried on only with the aid of long-continued observations at certain stations. Accordingly, during the years 1862 to 1867, forest meteorological stations were instituted in Bavaria, which, under the efficient direction of the well-known and eminent Dr. Ebermayer, for the first time attempted to solve these and other climatic questions on a scientific basis. The results of these and other observations have been fully discussed in Bulletin 7 of this division, published during this year.

We were privileged to exhibit some of the apparatus devised by Dr. Ebermayer, and some of his results, namely:

Set of soil thermometers.
Rain gauge combined with evaporimeter.
Two charts showing relation of rainfall and evaporation within and without forests.

While these stations were continued and others added in all parts of the country, an enlargement of the programme was soon discussed with great vigor, leading (between the years 1870–'76) to the institution of fully organized experiment stations in Prussia, Bavaria, Saxony, Thuringia, Wurtemberg, Baden; Switzerland and Austria following in the same direction; all of these finally combining into an "association of German forest experiment stations," similar to the association of agricultural experiment stations in our country. Thus the science of forestry, which hitherto had been developed empirically, has been placed upon the basis of exact scientific investigation, the fruit of which is just beginning to ripen in many branches.

We, in the United States, are fortunate in that we can learn from the experience and profit from the assiduous work of these careful investigators. While we may never adopt the admirable administrative methods that fit the economic, social, and political conditions of Germany, we shall ever follow them where the recognition and utilization of natural laws lead to the practical acknowledgment of general principles and to desired economic results in forest culture.

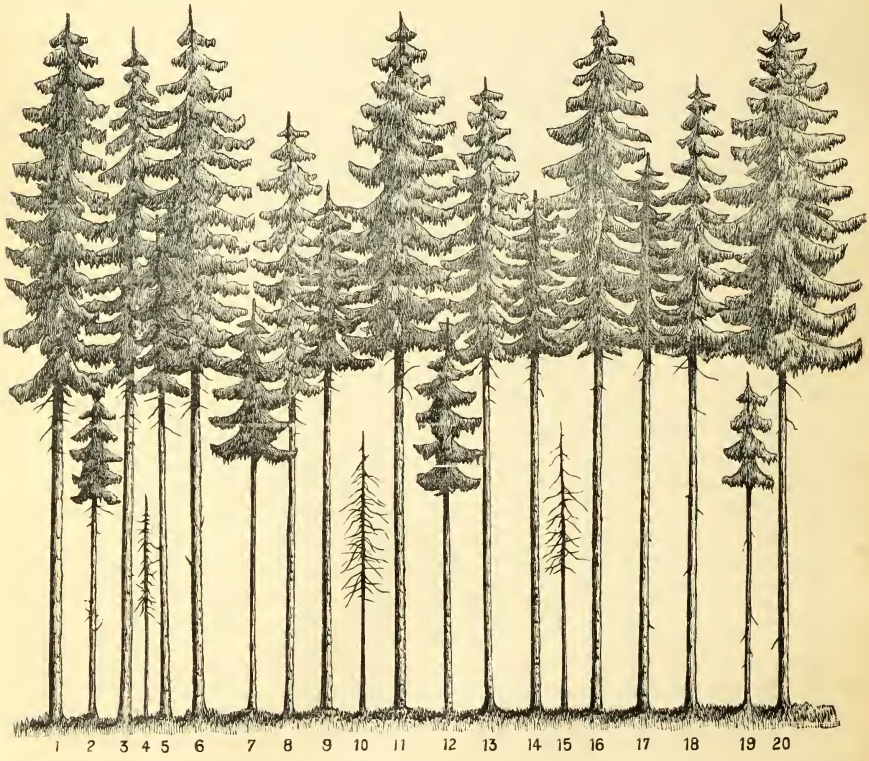

FIG. 4.—Tree classes: Classification according to crown development. Schematic (see p. 355). Class 1 (predominant): Nos. 1, 3, 6, 11, 16, 20; class 2 (codominant): Nos. 8, 13, 18; class 3 (subdominant): Nos. 9, 14, 17; class 4 (oppressed): Nos. 5, 7, 12; class 5 (suppressed, *a*): Nos. 2, 19; class 5 (suppressed, *b*): Nos. 4, 10, 15.