SYNOPSIS OF PARAGRAPHS.

CHAPTER I.

Foundations of Sylviculture.

CHAPTER II.

The High Forest.

CHAPTER III.

The Coppice Forest.

CHAPTER IV.

The Coppice Under Standards Forest.

CHAPTER V.

Propagation of Forest Products Other Than Wood and Timber.

LECTURES ON SYLVICULTURE.

CHAPTER I.

FOUNDATIONS OF SYLVICULTURE.

Paragraph I. Introduction.

Sylviculture means the raising and tending of forest products (wood, bark, deer, stock and other by-products).

Sylviculture was practiced by the ancients only for park or orchard purposes. The first writings on Sylviculture proper appear in the so-called "House Father Literature."

Sylviculture as a discipline was developed by George L. Hartig, Henry Von Cotta and Christian Hundeshagen. European standard books on Sylviculture of more modern tenure are those of Charles Heyer adapted by Schlich) and by Charles Gayer.

European Sylviculture in word and work has, in the course of years, petrified into a set of recipes. It is high time for Sylviculture to be taught and practiced on the basis of Plant Ecology.

For America, European Sylviculture at the present moment is of no more use than Chinese Sylviculture, owing to the great economic differences separating the old from the new country. The ecological principles underlying Sylviculture are, obviously, identical for all countries.

The planting of trees on a large scale is, in this country, now out of the question, since the expense of planting an acre of land usually exceeds the value of an acre of forest. The modern owners of woodlands are not far sighted enough—possibly not credulous enough—to anticipate the arrival of European stumpage prices for a time at which plantations now started will have developed into mature trees.

If we can assume that stumpage in this country will be as valuable in 1980 as it is now in Germany, France and England, then forest planting must be, at least, as remunerative here as it is in the old country (small soil value in the United States).

Sylviculture as a discipline comprises the following themes:

A. Ecological principles, facts and definitions.

B. The genesis of the forest.

C. The pedagogy of the forest.

D. The sylvicultural forms.

In the discussion of themes B, C, and D, a distinction is made between the treatment of:

1. High forests.
2. Coppice forests.
3. Coppice under standards forests.

Paragraph II. Ecological factors and their influence on the sylva.

A. Definition.—Plant ecology is a branch of botany showing the dependence and adaptation of plant forms and plant life of and to the surrounding local factors (climate, soil, etc.).

B. Natural laws govern the organization of the species and regulate the communal life (symbiosis) and messmateship (commensalism) of individuals with their own kin, with relatives and with other plants belonging to the same household and feeding at the same table.

C. The most important ecological factors are:

I. Air. Oxygen, nitrogen and carbonic acid, the main components of air, are essential for plant life. The relative proportion of the two integral parts, 79% N., 21% O., varies very little with altitude, latitude and elevation. Salt particles in the air near ocean and sulphuric acid in the air near melting works are very injurious to plant life.

II. Light. Intensity depends on:

Season.
Latitude.
Altitude.

Direct insolation is said to be on the whole of less importance than diffused light (excepting polar regions).

Light is not required for germination of seeds. Without light, however, there is no assimilation, and hence no possibility of tree life. Assimilation increases with increasing intensity of insolation; excessive insolation is, however, destructive. For each species, and for each stage of its growth, there exists a certain optimum, minimum and maximum of insolation with reference to the possibilities of its success. The damaging influence of excessive insolation is prevented by the inner organization of the plant.

The duration (number of days) of insolation is as important as the intensity of insolation. Within the individual tree the lower branches are killed gradually, being overshadowed by new upper branches. Without light no bud; without bud no leafing branch; without new leaves annually formed no limb can live.

Within one and the same species a tree once acquiring superiority over its neighbors is apt to retain superiority until death. Since it enjoys more light, it assimilates better.

Within rival species, owing to greater sensitiveness of chlorophyll and thanks to more favorable inclination, form and position of leaves, some species exceed others in assimilation and vitality under the same influx of light. Shade bearing are such leaves as assimilate sufficiently (so as to bear buds at the axils) in spite of the fact that only little diffused light chances to strike them.

Many dicotyledonous trees form a so-called "leaf mosaic," the lower tiers of leaves fitting themselves into the interstices of light left in the upper tiers. Many leaves alter their inclination toward the sun according to the hourly degree of insolation (photo-metric movement). The epidermis of light demanding and sun-exposed leaves is heavy, leathery. The leaves of shade bearers are thin and wither quickly when picked. Light demanding leaves are often shining, reflecting and whitish, so especially in tropical countries, and the leaf stomata are deeply sunk into the surface. On the same tree leaves growing in the shade are darker than those growing in the light; old leaves darker than young ones.

The formation of spines and thorns indicates a sun plant; hair or down are usually found in light demanders more than in shade plants.

III. Heat.

For each plant and for each step of its development can be determined a minimum, optimum and maximum of heat required or allowed. Without heat growth is impossible, since cell division is impossible. The formation of chlorophyll, breathing, assimilation, germination, flowering, fruiting and transpiration depend on heat. The distribution of the genera is governed, pre-eminently, by heat.

For some polar plants, life is possible below 32 degrees Faht. As a rule, however, plant activity begins to be observable at 50 degrees Faht.

The maxima of heat compatible with plant life generally lie below 115 degrees Faht. Excess of temperature over maximum is more disastrous than deficiency of heat below minimum. Plants, however, temporarily fortify themselves against periodical extremes:

1. By non-freezing cell contents.

2. By reduced water contents (seed, rosin).

3. By lignification.

4. By dropping leaves during winter or during period of excessive drought.

5. By adequate covers (bark, hairs, bud scales, layers rich in air cells, reddish color, wrappings formed by last year's leaves). These covers, at least, allow the plant to escape rapid changes of temperature.

Short periods of vegetation and long periods of rest result from deficient heat. Hence no annual plants in polar regions. Short shoots, evergreen leaves, preparation of flowers in year preceding fruit are characteristic of a polar flora. In tropical countries there are no periods of rest unless determined by periods of drought.

IV. Moisture of air and precipitations.

Water is at hand

a. to increase the toughness of wood (imbibition water of cell walls);

b. to allow of solution of cell contents (cell sap);

c. to serve as plant food, through assimilation;

d. to allow of osmotic movement of sap;

e. to assist in photometric movement of leaves (through swelling and irritation);

f. to reduce rapidity of change of temperature by evaporation.

Only some lichens survive a process of absolute drying. Lack of moisture causes crippled growth, and frequently subterranean forests (mesquit).

After Henry Mayr, the minimum of moisture compatible with tree growth is two inches of rainfall and fifty per cent. of relative humidity during period of vegetation.

Phanerogamous plants are unable to absorb water directly through the epidermis, obtaining it instead through the spongiolae of the roots and, in gaseous form, through the stomata of the leaves. Mosses and lichens, however, absorb water directly through the epidermis. The hygroscopic power of a dead cover of mosses on the ground equals that of a live cover.

Wet climate creates evergreen woods (Pacific coast and Antarctic forests of South America).

A dry climate gives rise to annual species, to a distinct period of rest, to rapid flowering and fruiting.

Precipitations equally distributed over the twelve months of an entire year and precipitations falling during a few weeks result in

2

entirely different floras. Rain in summer stimulates growth much more than rain in winter. De Candolle divides our globe according to moisture and heat and on the basis of floral differences resulting therefrom, into five regions in the fourth of which we are living.

1. Hydromegathermal region (water great heat). Mean annual temperature over 68 degrees Faht. (Amazon river region, wet tropical zone).

2. Xerophilous (Dry loving) region. The region and borders of arid deserts, prairies, sunny slopes, etc., exhibiting a flora very modest in moisture requirements.

3. Mesothermal (medium heat) region, having mean temperature of 59 to 68 degrees Faht. (northern Florida, etc.).

4. Microthermal (little heat) region of 32 to 59 degrees Faht.

5. Hecistothermal (least heat) region of less than 32 degrees Faht.

The most important representative of a Xerophilous character is the Yellow Pine. The hecistothermal zone shows Spruces, Birches, Cottonwoods.

V. Wind.

Wind brings moisture and drought, heat and cold; it covers or uncovers vegetation with sand or snow drifts, tumbling, at prior geographical eras, whole mountains into the valleys (Loess formation). Severe wind dwarfs tree growth and forces branches to grow in leeward direction only. The influence of a slight obstruction, preventing the access of wind at high latitudes, is splendidly illustrated by the growth of Spruce and Fir on Pisgah Ridge. On high mountains tree growth is often entirely determined by wind (slope of Little Ball).

Species resisting wind best in Pisgah Forest are Red Oak, Chestnut, Locust.

Picea alba and dwarf pines like Pinus pungens and montana show great strength in resisting wind. In the west Tsuga mertensiana, Pinus albicaulis, Pinus monticola, further western Juniper rank first among the trees braving severe storms.

Wind is essential for the breathing and for the perspiration of leaves and bark; for driving pollen on stigma to fertilize the seed; for trimming the branches, thus forming clear boles; for distributing seed. The investigations conducted by Fliche (French Forester) have, however, yielded the astonishing result that winged seeds travel much slower than heavy seeds covetted by birds. Fliche gives the following number of years as required by trees traveling from Nancy to Paris, a distance of 160 miles:

Beech ....18640 years.
Chestnut ....12920 years.
Pine ....48680 years.
Sarvis ....1330 to 2000 years.

VI. Structure of soil.

Soil consists of natural rock; or of rock disintegrated under the influence of water, frost, heat, oxygen, carbonic acid, lichens, bacteria; or of washings deposited by water, wind or glaciers.

The components of soil are:

a. Soil skeleton, large grains, principally quartz and stones.

b. Soil flesh, minute semi-soluble particles,—the mud of the rivers.

c. Soil fat, the humose particles giving the soil a dark color.

d. Soil blood, the air and water, filling the pores of the soil. The size of the pores determines the capillary capacity.

According to the resistance which soil offers to spade or plow, we distinguish the following classes:

Light soil;
Loose soil;
Binding soil;
Heavy soil;
Stiff soil.

VII. Air in the soil.

Roots require oxygen for breathing. Like fish, they die from lack as well as from superabundance of oxygen. Subterranean air is rich in carbonic acid exhaled by roots, fungi, bacteria, animals. Swamp soil contains little air. Hence such species only find a living in swamps which have large inner air ducts (Cypress knees, Nyssa root, bamboo, cane breaks, sour grasses).

Prairial soil is naturally so compact that it contains little oxygen.

VIII. Water in the soil.

It occurs:

a. Chemically bound to minerals and salts.

b. Absorbed by the hygroscopicity of soil.

c. Raised by the capillary power of soil.

d. As ground water—lakes, swamps, brooks being merely areas of open ground water.

The size of the pores and the presence of humus govern the intensity and rapidity of water obtention and retention. Sand, for instance, allows water to enter its large pores quickly, but gives it up rapidly as well. Wet, moist, fresh, dry and arid soil are distinguished.

The degree of wetness of soil is of the utmost importance for tree growth. At its southern limit, a species grows only in swamps or along watercourses. The water in the soil dissolves the mineral salts so as to form sap and seems to be of great influence on the bacterial life in the soil.

IX. Heat in the soil.

It is derived from the earth's own temperature, from chemical processes in soil (notably fermentation) and from sun rays. In the latter case, the angle of insolation, the duration of insolation, the heat capacity of soil, the color of soil, the porosity of soil and its vegetable cover serve as influencing factors.

A cold root has no pumping power. Fine root fibres die from temperatures which fine branches easily withstand. The actual influence of the heat in the soil on tree growth is practically unknown. The opening of the buds in spring and the fall of leaves in autumn are probably connected with the thermic changes occurring in the various strata of the soil.

X. Depth of soil.

Flat rooted species easily obtain the superiority over taprooted species on shallow soil. Tree roots, however, are not apt to penetrate to a depth greater than six feet. Shallow soil increases danger from fire, drought, storm. A tap rooted species, planted on shallow soil, produces only a stunted form. Shallow soil is well adapted to the coppice system, in case of broad leaved tap rooted species.

XI. Food in the soil.

A tree, like a crystal, is composed of various chemical elements. The available amount of that necessary element which happens to occur in the relatively smallest degree determines in both crystal and plant, the rate of growth actually taking place (Liebig's law). The superabundance of one component, even of a necessary component, prevents, on the other hand, the local existence of many species.

The ten necessary elements found within a plant in solid, liquid or gaseous condition are O, H, C, P, Fe, K, Mg, Ca, N, S.

"Roots search food as if they had eyes,"—a rule easily proven in any nursery.

XII. Species of soil.

a. Rock. Most important rock formations are: Granite, gneiss, limestone, sandstone, slate and trap.

Vertical stratification facilitates decomposition and tree growth. The various species of rock differ in hardness, porosity, heat conduction, and above all in soluble mineral contents.

b. Quartz sand. Quartz sand is unfertile when pure, since silicic acid fails to be digested by the roots and fails to react with the acids usually found in the soil. Quartz sand is loose, has small hygroscopicity, small capillarity and small heat-retaining capacity. It is hot during the day and cold at night.

c. Lime. Lime when pure is a poor soil, although not quite as dry and hot as sand. Lime, however, mixed with loam and clay (so-called marl) forms an extremely productive soil.

d. Clay. Clay has great absorbing and hygroscopic power. It is wet and cold. Main components are aluminum-silicates.

e. Loam. Loam is a mixture of sand and clay—the usual soil in agriculture and forestry. It is usually colored by iron (red loam at Biltmore). We speak of a sandy loam or of a loamy sand according to the prevalence of one or the other component. Loam soil exhibits a happy medium of qualities favorable to tree growth.

f. Humus. Humus results from the decomposition of vegetable and animal matter under co-operation of bacteria, fungi, rain worms (Darwin), larvae. Humus forms a solvent of mineral plant food. A bad conductor of heat and cold, it prevents rapid changes of temperature in soil, has great hygroscopicity and great water-retaining power and is a preventive to evaporation of soil moisture.

Mild forest humus shows a basic reaction, whilst the sour humus of the swamps shows an acid reaction.

Unfavorable is the dust humus formed by many Ericaceae.

XIII. Physical versus chemical qualities of soil.

Agriculture withdraws food only from the top layer of soil. It deprives that top layer of its rarest and most valuable components, by the annual crop of grain excessively rich in nitrates, phosphates and potash. The porosity, and through it the water capacity and the heat capacity of soil, are readily controlled on the field by the plow. It is necessary in agriculture, in the long run, to return to the soil in the shape of fertilizer annually as many pounds of nitrates, phosphates and potash as have been removed in the shape of crops from a given acre of land.

The productiveness of agriculture depends, above all, on the chemical qualities of the soil tilled. A crop of trees, on the other hand, takes from the soil very little, since the tree consists mainly of C, O, H, or since wood is nothing but air solidified by sunshine. The phosphates, nitrates and potash absorbed by the tree are returned to the soil by the fall of branches, leaves, seeds, flowers, etc.

The traces of chemical fertility locally removed in the shape of logs are, in addition, counterbalanced by the decomposing influence on the rock exercised by roots and root-bacteria.

Hence it is not likely that a rotation of crops, as is required in fields, has any advantages in the case of forestry. In primeval woods, we know that Nature allows a species to succeed itself.

The physical qualities of the soil preeminently influence the tree species and the rate of its growth. The chemical qualities of the soil play the most potent role in the case of agricultural species.

Soil fit for agriculture is not necessarily good forest soil (prairies). Soil fit for forestry (strong north slopes) is often utterly unfit for farming.

XIV. Soil covers.

Soil covers are either dead or living. Dead soil covers are snow, debris of leaves and twigs. Living soil covers consist of mosses, grasses, etc.

Snow keeps the soil warm, prevents rapid changes of temperature, prevents young plants covered by it from perspiring, prevents lifting of plants by frost.

The debris on the ground feed millions of animals and fungi; they harbor, on the other hand, mice, larvae and other enemies of plant growth. Debris frequently prevent reproduction from self-sown seed and increase the severity of forest fires. Living as well as dead soil cover influences evaporation of moisture, porosity of soil and water drainage.

XV. Life in the soil (Compare Swiss L. F. F. 1904, May and June).

The soil lives like a plant or an animal, since it shows continuous changes of form and of composition. Very little, however, is known of the life and the interdependence of millions of live individuals found in the soil. Certain it seems that tree growth is bound on the presence of certain fungi and bacteria living on the roots (Mycorrhiza). Most important are the bacteria capable of digesting the nitrogen of the subterranean air. Leguminous plants (Clover, Black Locust) are beset with root knobs, containing bacteria busily engaged in the assimilation of nitrogen. The hyphae of a fungus called Frankia play a similar role on the root knobs of Alder and Sweet Fern. After P. C. Mueller, Spruce will grow on poor sand lacking nitrogen if Pine is mixed with it, furnishing nitrogen through its mycorrhiza.

The maximum number of bacteria is said to be found two feet below the surface of the ground, and none exist below six feet. The number of bacteria per pound of soil varies from one hundred million to two hundred and fifty million.

Important, too, in plant ecology is the life of the larger animals (worms, insects, centipeds) changing the vegetable matter of the soil into manure proper, mixing mineral soil and vegetable matter, increasing the porosity, drainage and aeration and neutralizing the acids of the soil. Shade, protection from wind and sufficient moisture are beneficial to animal life in the soil.

Paragraph III. Influence of the sylva on the ecological factors.

The influence exerted by the forest on local climate (heat, air, precipitations, etc.) is dwelt upon in the lectures on forest policy.

Whilst the ecological factors shown in the previous paragraph exhibit the important influence which the soil has on the tree, there exists at the same time, although to a lesser degree, an influence of the tree on the soil. This influence is invariably such as to facilitate life to the tree itself and to its progeny. The production of humus is the main source of that influence.

Governing factors are:

A. Leaf canopy overhead. Evergreen as well as deciduous woods annually return to the soil by the leaf fall a large amount of dead matter readily assimilable. Shade bearers furnish a better humus than light demanders, excluding, at the same time, intensive insolation, so that the decomposition of the leaf carpet and the evaporation of the soil moisture is favorably retarded.

A humus formed by Beech, Maple and Chestnut is considered especially good. Beech is justly called abroad the "Mother of the Forest," owing to its soil-improving qualities. The leaf canopy is particularly dense during the thicket and the pole-wood stage. Even light demanders, whilst young, improve the fertility of the soil. At a higher age, when the light demanders place themselves far apart one from another (say less than 100 trees per acre), the humus on the ground is destroyed, being replaced by a dense and impermeable matting of grasses or shrubs.

Amongst the conifers, Yellow and White Pine seem to furnish the best humus. Spruce humus is too waxy.

B. Rate of disintegration of leaves.

This rate depends on insolation, on heat capacity of soil (sand versus clay), on atmospheric humidity. Usually, decomposition of leaf fall takes place within two or three years. The thin leaves of the shade bearers decompose quicker than the heavy leaves of the light demanders. The high atmospheric moisture of high altitudes causes accumulation of large quantities of leaves. In the tropics there is little litter on the ground.

C. Root system.

It is the decaying root which allows the precipitations to trickle down to the lower strata of soil. Hence tap rooters seem more efficient than flat rooters in converting a rapid surface drainage into a slow underground drainage. Decomposing the rock by chemical action, the tap root forces it to yield its soluble salts.

D. Soil improvement through root-bacteria and fungi.

The upper layers of forest soil are densely peopled with the hyphae of basidiomycetes, living on humus. Leguminous trees (Locust, Kentucky Coffee tree, etc.) by their root-bulbs increase the fertility of the soil, and the Alders seem to act in a similar way. On abandoned fields in Pisgah forest the soil is improved by Sumac, Sassafras, Locust, etc. These species act as ushers for more exacting forest growth, improving the physical conditions of the soil.

Very little is known about the nature of the improvements.

Paragraph IV. The North American Sylva.

The northern limit of the forest coincides with the isothermal line, 30 degrees Faht., which lies on the west side of the continent at 70 degrees latitude in Alaska (under influence of the Japan current), and on the east side at 55 degrees latitude in Labrador and at the Hudson Bay.

The rainfall and, consequently, the existence of forest depends on the moist sea winds supplied by the Pacific, the Atlantic, the Gulf and the Great Lakes. A cross-section through North America at the latitude of Lake Michigan and Portland, Oregon, shows the inter-dependence between the lowest gaps in the mountain chains and the forest on the next mountain chain lying to leeward. For instance: lowest gap in Coast Range at 3,000 ft. above sea level; no forest in Cascades below 3,000 ft.; lowest gap in Cascades at 4,000 ft. above sea level; no forest in Blue Mountains below 4,000 ft.; lowest gap in Blue Mountains at 5,000 ft. above sea level; no forest in Rockies below 5,000 ft.

The east slope of the Coast Range, Cascades, Blue Mountains and Rockies shows little or no forest, and the lowlands to the east of the mountain chains are deserts and prairies.

Moist sea winds, after passing one chain allow the forest to grow on the next chain only above the altitude of the gaps in the first chain.

The following table shows the composition of the forest of the United States and of Canada, under the influence of the climate:

Percentage of forest area occupied by:

	In United States.	In Canada.
Tropical forest	½%	0%
Sub-tropical forest	15 %	0%
Forest of the moderately warm zone...........	75 %	10%
Forest of the moderately cold and alpine zone..	9½%	90%

The United States contain two big and one minor forest region, namely the

Atlantic forest region;

North Mexican forest region;

Pacific forest region.

The Atlantic and the Pacific forest join under the influence of the Hudson Bay winds at 52 degrees latitude, in Assiniboia. There are no prairies proper north of this latitude.

The tropical forest shows no seasons. Its species are evergreen. In the United States it is found only at the extreme southern point of Florida.

The sub-tropical forest is characterized by the evergreen broad-leaved trees, and is the zone of rice and oranges, extending in eastern North America to 35 degrees, in western North America to 40 degrees, latitude.

The moderately warm forest region is the zone of the broad-leaved deciduous trees, of corn, vine and wheat.

The moderately cold forest region is that of the evergreen conifers too cold for the production of corn.

In North Carolina a trip from the coast to the high Balsams leads the traveler from the northernmost limit of the sub-tropical through the moderately warm forest region into the southernmost limit of the moderately cold forest region which sets in at about 6,000 ft. elevation.

A. The Atlantic forest.

I. Eastern tropical forest. Mahogany occurs only as a small tree; Palms and other typically tropical orders (Sapotaceae, Ebonaceae, Euphorbiaceae, Verbenaceae) compose the forest. It must be remembered that Southern Florida exhibits only the extreme northern occurrence of the tropical forest.

II. Eastern sub-tropical forest. It shows evergreen Oaks, Magnolias, Persea, etc., besides the Pines, the soil being too poor for the formation of a large wintergreen broad-leafed forest. The winter temperature averages 53 degrees Faht.; precipitations are heavy; relative humidity is 75 degrees. Sabal palmetto is a characteristic weed. Bald Cypress and Cuban Pine are characteristic trees of the region. Among the other Pines, the Long Leaf Pine is the most important, associated in the north and west with Pinus clausa, echinata, taeda, serotina, glabra. Liquidambar, Nyssa and Fraxinus platycarpa occur in swamps at the edge of which southern White Cedar frequently appears.

III. Eastern winter bald forest of the moderately warm zone. It is fringed at the south, north and east by a broad belt of Pines, which belt connects this region at the south with the sub-tropical forest, at the north with the Fir and Spruce forest of the moderately cold zone. It is divided into a northern and a southern half by the 39th degree of latitude. Each half shows an Atlantic, a central and a prairial sub-region.

a. South Central sub-region. Traversed by the Mississippi, the sub-region is characterized by high temperatures, large precipitations and fine soil, which allow of the best development of broad-leaved woods found in the world. Twenty-three Oak species, eight Hickory species, two Walnuts, Buckeyes, Chestnut, Gums, Cottonwoods, Yellow Poplar, Sycamore, Beech, Maple, Elm, Red Cedar, etc., stand in a dense undergrowth formed by Dogwood, Kalmia, Rhododendron, Hazel, Cherries, Hawthorn, Buckthorn, Witch Hazel, etc.

In this sub-region the heavy seeded broad-leaved trees obtain the maximum of size, quality and number of species at altitudes running up to 3,000 ft. Higher up the number of species diminishes. At 5.000 ft. only Red Oak, Chestnut, Beech, Buckeye, Sugar Maple (resembling north central subdivision) are found, and at 6,000 ft. the Spruces and Firs (southernmost sentinels of moderately cold zone) set in.

b. South Atlantic Sub-region. It comprises the Eastern foothills of the Alleghanies (Piedmont Plateau) and part of the Coastal Plain. Temperature 3½ degrees Faht. less, soil poorer, precipitations less abundant than in the South Central Sub-region, hence much Pine (taeda, mitis, rigida, virginiana). Only ten Oak species; White Cedar swamps; broad-leaved flora otherwise as in South Central, but of rather inferior development.

c. South Prairial Sub-region. Extending from the 92nd to the 102nd degree of longitude, the forest appears poorer than the annual temperature and the annual rainfall seem to indicate; a discrepancy between cause and effect, possibly due to forest fires. West of the 95th degree of longitude, Oak, Ash and Walnut occur along rivers, especially on Eastern banks. Oak also appears scattered through the depressions.

d. North Central Sub-region. Precipitations very abundant from South as well as North. Average winter temperature 30 degrees Faht. Quick change of temperature. The light-seeded, broad-leaved species reach maximum in this section, also White Pine and Hemlock. Six Maples, five Birches, Elms and Lindens, further Ash, Butternut, Red and White Oak compose the forest.

e. North Atlantic Sub-region. Plenty of moisture, the mountains being close to the sea-shore, but not so much as in Lake states. Average winter temperature 34 degrees Faht. at seashore. Pinus rigida and mitis, Beech, Birch, Chestnut, Maples, often replaced by Poplar and Willow. Spruce sets in at altitude exceeding 1,000 ft., accompanied by Hemlock, White Cedar, Red Cedar, White Pine and Tamarack.

f. North Prairial Sub-region. Dry summers, blizzardy winters and more sandy soil. No Hemlock. Red Pine and Jack Pine intruding fom North. Scrub Oak openings. On best soil still good development of Linden, Maple, Elm and Birch. White Pine of poorer quality than in sub-region "d."

IV. Eastern Evergreen Forest of the moderately cold zone.

The majority of this zone lies in Canada, in northern Lake states, Maine. It occurs in North Carolina at 6,000 ft. elevation; in the Adirondacks at 2,000 feet; in Maine at sea level.

The region occupies a big belt stretched across the continent, so that western and eastern flora joins hands in it. A typical tree of this region, the White Spruce, often forms large pure forests. Other species of the zone are Red Spruce, Black Spruce, Balsam-fir, Cottonwoods, Cance Birch, Hemlock, White Cedar and Tamarack, the latter here ootaining its optimum.

B. The North Mexican forest.

The North Mexican Flora intrudes, coming from Mexico, Arizona and New Mexico. It is different from the Pacific flora, unimportant commercially, interesting only botanically. Forest possible only at altitudes exceeding 5,500 feet. Forest proper—dense forest—only at 8,000 feet.

I. North Mexican sub-tropical forest.

Characterized by Cactus, Yucca, Agave and Mesquite (Prosopis). Evergreen Oaks in moist valleys. Madrona (Arbutus), a beautiful tree, on sunny slopes often mixed with Manzanita (Acrostaphylos pungens).

II. North Mexican forest of the moderately warm zone.

This zone, very narrow, should contain winter-bald broad-leaved species. The dryness of the soil and of the air, however, allows of their occurrence only on moist ground along rivers. Western Walnut, Mexican Ash, Poplars and Willows. The Pines are the leading species of the zone, forming huge forests at altitudes exceeding 6,000 feet elevation. Some of these Pines are northern sentinels from Mexico, others outposts from the States. Most important is Pinus Chihuahuana, in Mexico largely used for timber, up to 80 feet high, three feet in diameter, three needles. Pinus Arizonica, a five-needled pine, occurs at 6,000 feet elevation. Pinus reflexa, locally known as White Pine, occupies moist dells at 8,000 feet elevation. Nut pines at lesser elevations as low brush, notably Pinus edulis, monophylla osteosperma.

C. The Pacific forest.

Typical difference from Atlantic forest lies in the relative lack of broad-leaved woods—not in species, but in area. Tropical forest is absent, possibly due to lack of moisture at low elevations in Southern California.

I. Pacific sub-tropical forest.

Occupying Southern California. This zone is devoid of dense forests, the northern edge excepted. Evergreen Oaks, or rather Winter Green Oaks (Quercus densiflora is leafless during dry summer) dot the ground in park-like groves. California Laurel (Umbellularia californica) is a characteristic tree of this region, growing up to 100 feet high. Impenetrable bush thickets cover hot aspects, formed by Leguminosae, Labiatae, Compositae, Rosaceae, etc. The rare and beautiful Montery Cypress along the seashore. Sequoia sempervirens is the biggest tree of the zone, found only at its edge in the Coast Range. Pinus insignis known as Montery Pine is valuable on sand dunes.

Pinus tuberculata (attenuata) occurs most frequently in even-aged woods. Pinus sabiniana, Nut or Digger Pine, valuable for the Indians, of Olive-like appearance, is mixed in the Oak parks and in the Chaparal thickets. Another Nut Pine is Pinus parryana, growing 30 feet high. Pseudotsuga macrocarpa on St. Bernardino range. Eucalyptus and Accacia were successfully introduced from Australia, Oranges and Figs from the Orient.

II. Pacific forest of the moderately warm zone.

This zone covers the major part of Oregon and Washington and the mountains of Northern California. It is characterized by very even annual temperature and high precipitations. Here the winter bald broad-leaved species should rule supreme. The winter bald Oaks are represented in Oregon by Quercus garryana (White Oak), in California by Quercus Kellogii (Black Oak), Fraxinus Oregona, Acer macrophyllum, Populus trichocarpa (Black Cottonwood, the biggest Cottonwood of the world) occupy the bottom land along the rivers; further Sorbus, Amelanchier, Crataegus, Prunus, Salix, Aesculus, Alnus, Acer, Platanus, Negundo, Betula. All of these latter species unimportant commercially.

In strict contrast with the Atlantic forest of the same zone, the conifers rule in importance, foremost among them the Douglas Fir (Pseudotsuga taxifolia) which stands temperature of 15 degrees Faht. easily. Best development on west slope of Coast Range. In the Rockies, it forms only summer shoots and short boles, owing to shorter growing season and lack of atmospheric moisture. In Colorado, Arizona, New Mexico occurs a gray variety. In the Sierras it appears only as a dependent species.

Pinus ponderosa (Yellow Pine, Bull Pine). Height and timber quality depend on proximity to Pacific Ocean. Optimum in Sierra Nevada, where trees 300 feet high are frequently found. Very heavy sap-wood. Name ponderosa undeserved. No tree of the United States occupies a larger territory or shows greater adaptability.

Chamaecyparis lawsoniana (Port Orford Cedar) occupies only a very small territory close to the Pacific Coast. Does not ascend mountains to over 1,500 feet. Heavy shade bearer, splendid reproduction.

Thuja plicata (Red Cedar of the West) up to 170 feet high. Rare in California. Best development in Oregon and Washington and Northern Idaho, where it occupies only the moister coves. Boles very tapering; shade bearing; thin bark.

Libocedrus decurrens (White Cedar, Bastard Cedar) on west slope of the Sierras at medium elevations, where the tree is mixed with Abies concolor, Yellow and Sugar Pine. Regeneration easy, often in places previously occupied by the Pines.

Pinus lambertiana (Sugar Pine), a White Pine since it has five needles in a sheath. Specific gravity even less than that of Eastern White Pine (Pinus strobus). The biggest Pine of the world. Very large cones. Optimum in Sierras at 5,000 feet elevation; occurs often with Sequoia, Libocedrus, Abies concolor, Yellow Pine, Pinus Jeffreyi. The latter, a very close relative to ponderosa and distinguished from it by bluish shoots and needles bent towards the shoots, occupies the lower Sugar Pine belt. It prefers moist ground and reaches only one-half the size of ponderosa.

Mayr groups the above trees as follows, according to their demands on moisture:

Demands on soil moisture:

1. Libocedrus decurrens,
2. Pinus jeffreyi,
3. Abies concolor,
4. Pinus lambertiana,
5. Pinus ponderosa.

Demands on air moisture:

1. Abies concolor,
2. Pinus lambertiana,
3. Pinus jeffreyi,
4. Libocedrus decurrens,
5. Pinus ponderosa.

Abies grandis (White Fir of Northern Pacific Coast). The only fir on Vancouver Island. Optimum at coast in Oregon where it grows up to 300 feet high, standing alongside gigantic Cottonwoods; extends eastward across the Northern Rockies, and is the first Pacific fir met by the traveller going west on the Northern Pacific. Requires moist soil.

Abies concolor (White Fir of Colorado and of the Sierras). Running south to the San Bernardino mountains, where it occupies elevations of up to 10,000 feet. Traversing Nevada, it occurs in Colorado (gardener's variety glauca). It accompanies Sugar Pine and Bigtree. After Muir, always mixed with Abies magnifica, occuring at altitudes ranging between 5,000 feet and 8,000 feet.

Abies bracteata (Santa Lucia fir of high mountains) occurs in Southern California in moist cool dells.

Tsuga heterophylla (Black Hemlock of low elevations). A fine tree, the progeny of which forms a dense undergrowth underneath Douglas fir. Heavy shade bearer, requiring plenty of moisture, occurring in Alaska, Coast range and Cascades.

Picea sitchensis (Tideland Spruce). Along coast on very moist soil in Washington, on dryer soil in Alaska, very shade bearing and branchy. Stinging needles. Up to 200 feet high.

Sequoia Washingtoniana (Bigtree). Occurring only in the Sierras in scattered groups at elevations ranging from 4,000 to 7,000 feet.

Enormous seeding capacity and sprouting capacity. Average diameter 20 feet, height 275 feet, age up to 4,000 years.

III. Pacific forest of moderately cold zone.

This zone is economically of no importance, although it is the forest zone proper, owing to the impossibility of agriculture within this zone. It is "The Canadian Forest Zone." It lies in the Sierras at 8,000 feet, in the Cascades at 4,000 feet, and in Alaska at seashore. The forests of the Northern Rocky mountains belong to it preferably.

Pinus murrayana (Lodgepole Pine). Shade bearing, in close stands, very branchy, very sappy, retaining cones, easily destroyed by fire. closely related to the Jack Pine of the east. Frequent on old burns, typical for Yellowstone Park, going south to Arizona.

Larix occidentalis (Western Tamarack). Splendid lumber tree, often in pure forests, optimum in Montana, natural regeneration easy, rapid height growth, little sap wood, timber equal to Long Leaf Pine.

Pinus flexilis (Limber White Pine). More branchy and much shorter than eastern White Pine; forms open forests on south slopes of Sierras and in Nevada at 7,000 feet elevation; from Montana it extends southward to Colorado.

Pinus monticola (Mountain White Pine). In Cascades, British Columbia, Idaho, Montana, in the latter state more on slopes draining westward.

Abies nobolis, amabilis, magnifica, the Red Firs of the west. Magnifica known in California as Larch. The two first named often associated with Abies grandis and more frequent in Washington and Oregon than in California. Amabilis extends into Alaska. Red Firs are lacking in the Rockies. Needles are dark.

Picea engelmanni (White Spruce). At home in middle and southern Rockies, on northern slopes at altitudes averaging 10,000 feet.

Picea parryana (Colorado Blue Spruce). Needles very pointed and stinging, of a bluish tint. Occupies moist ground.

IV. Pacific forest of the Alpine region.

Typical trees are:

Pinus albicaulis (Dwarf White Pine). Occurring in the Cascades and the Rockies (Utah).

Pinus balfouriana and aristata (Fox-Tail Pine). White Pine found in California at 8,000 feet to 12,000 feet elevation; twigs thin, retaining needles for many years.

Abies lasiocarpa (Balsam). At edge of tree growth only a shrub. In Colorado at lower, warmer situations a valuable tree. Occurs in all states of the west.

Larix lyallii (Larch of British Columbia). Occurs here and there in Washington, Idaho and Montana, at very high altitudes.

Tsuga mertensiana (Hemlock). A storm-battered hemlock, at high altitudes in Sierras, Cascades, Montana. A branchy tree up to 100 feet high, inaccessible and hence of no value.

Paragraph V. General definitions and explanations.

A. In Europe, under the term "Wood" is understood an aggregate of trees of such uniform character that it can be subjected to the same manner of treatment. In the American virgin forests, "woods" are rare. As a matter of fact the term "woods" as well as the term "forests" has no definite meaning in America. A forester should keep in mind, however, that a plantation or a natural regeneration, whatever its age and its condition, must be classed under the heading "forests."

A "group" of trees consists of even-aged specimens of the same species and is larger than a bunch, clump, or cluster. No recognized definitions of the term "group" and "clump" are at hand, unfortunately, based on the space or the acreage covered by them as units. Groups, as understood in the following pages, are distinct aggregates of trees covering $\frac{1}{10}$ to 4 acres.

B. Pure forests, pure woods, pure groups or bunches are such as contain one timber species only, 5 per cent. admixture being permissible. Species able to form pure forests are termed gregarious or ruling species, sub-divided into distinctly ruling species, which are usually found in pure stands, and conditionally ruling species, which are occasionally found in pure stands.

I. After Drude, the participation of a species as a mess-mate at the forest table is expressed by the following terminology:

a. Social species, denoting the main character, the striking feature (in numbers and volume) of the forest; the rank and file of the forest.

b. Gregarious species, occurring in clumps and groups, island like;

c. Copious species, interspersed with others, the degree of frequency being interpreted by exponents, f. i., copious^3, copious^2, copious^1;

d. Sparse species, occurring isolated and in single specimens;

e. Solitary species, very isolated and very rare.

II. It might be preferable to express the ratio of the participation in per cent.

Social, forming 60% and over of growing stock.

Gregarious, forming 40% and over of growing stock.

Copious, forming 20% and over of growing stock.

Sparse, forming 1% and over of growing stock.

Solitary, forming less than 1% of growing stock.

Intermediate stages might be indicated by a union of the given designations, f. i., "social-gregarious."

III. The configuration of the ground and the rapidity of its change vitally influence the possibilities of a species as a component of the forest.

IV. Species which are not, or which are locally not, "ruling" species are called "dependent" species.

A species might be ruling in North Carolina, while it is dependent in South Carolina. The distribution of the species is limited by its demands on soil and climate. Far away from the center of distribution a species is likely to be dependent.

V. The ruling species in the south are: Long Leaf Pine, Bald Cypress, Loblolly Pine, Short Leaf Pine, Sweet Gum, Post Oak, Cottonwoods, Chestnut.

The ruling species in the west are: Lodgepole Pine, Pinus ponderosa, Douglas Fir, White Fir (Abies grandis), Engelmann's Spruce, Western White Pine, Port Orford Cedar, Redwood, Sitka Spruce.

VI. Obviously the meek species are those that conquer the globe. With the inroads of civilization on the fertility of the soil, and especially on the water capacity of the soil, these meek species obtain additional chances to supersede the exacting species.

C. Weapons of the species in the struggle for existence are:

I. Shade-bearing qualities.

II. Modesty as regards the fertility of soil, the moisture and the heat during the period of vegetation.

III. Power of resistance to storm, sleet, snow, late and early frosts, droughts, fire, etc.

IV. Immunity from forest insects and forest fungi.

V. Longevity. Oak lives longer than Beech; Sequoia longest of all.

VI. Reproductive power, especially reproductive power from stumps, frequency and richness of seed years.

VII. Portability and sensitiveness of seeds; number of enemies of seeds; germinating percentage of seeds.

VIII. Rapidity of height growth in early youth.

D. Density of stand. Every ruling species shows a particular density of cover and a particular ramification during every stage of its life, when grown in pure forests.

I. Density of leaf cover overhead.

a. The form of the crown of the individual depends on sideshade, topshade, neighborly friction and quality of soil.

b. Natural regeneration causes a greater density of cover than artificial regeneration, certainly during the thicket and pole stage. Other influencing factors are: quality of the soil, age of the forest, inroads by snow break, wind fall, fire, deer, fungi, insects.

c. A dense canopy overhead produces clear boled timber and allows of a heavy layer of humus on the ground. The method of regeneration distinctly influences the value of the timber to be formed.

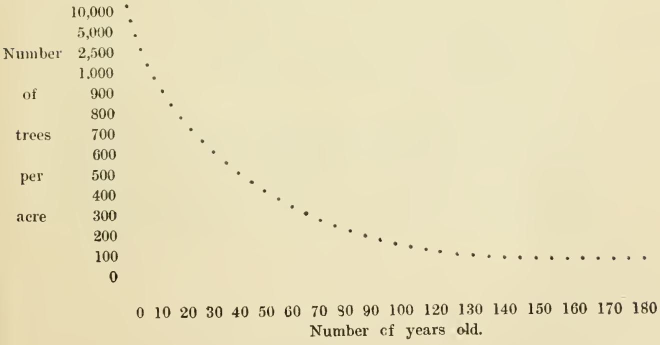
II. Number of trees per acre.

Under normal conditions an acre of pure forest contains the more specimens of equal height or diameter, the better the quality of the soil and the better the climate; and the more specimens of the same age, the poorer these factors are. For example—Yellow Pine Forests:

	Number of trees per acre.		
Soil.	Boles 75′ long.	Diameter 12.″	Age 60 yrs.
I quality...	320	240	380
II quality...	240	215	460
III quality...	190	190	540

During the pole stage and tree stage shade bearers exhibit per acre of ground about 50% more trees than light demanders.

The following curve illustrates the interdependence between age and number of trees per acre:



III. Growing space of a tree.

In their early youth all species stand or even desire a dense cover overhead. When the food supply stored in the seed shell is consumed, however, the seedling requires light to digest its food. With increasing age, the tree boles getting longer, the crowns rub and beat one another intensely, swaying pendulum fashion in the wind. As a consequence each crown is surrounded with an air space, the relative width of which depends largely on the length and the flexibility of the bole. It might be stated that the growing space of a tree is a function of the square of the gradually lengthening bole.

Trees differ in the ease with which warring neighbors lose their buds and shoots. Oak, for example, loses its May shoots easily, whilst Beech, struggling with Oak, loses a few leaves only along its flexile swaying twigs. In heavy storms Yellow Pine often loses whole branches. White Pine, on the other hand, does not easily lose its shoots. The top shoots of the taller individuals are immune from harm. Thus a tree, once in the lead of its competitors, has a good chance to retain the lead over them.

IV. Grades of density of cover are: Pressed cover, Close cover, Light cover and Open cover. No strict definition of these terms can be given. Obviously the number of stems under pressed conditions is very large.

Indications of a normal cover are:

a. Relation between length of crown and length of bole.

b. Normal diameter growth and height growth.

c. Proper participation of the various diameter classes in the volume of wood at hand. The normal participation in a pure, even-aged wood is for the

1st. Diameter class—40% of total volume.

2nd. Diameter class—24% of total volume.

3rd. Diameter class—17% of total volume.

4th. Diameter class—12% of total volume.

5th. Diameter class— 7% of total volume.

If cover overhead is too dense, the first class shows over 40% of volume and vice versa.

V. In nature, the same causes necessarily have the same result. The causes of timber production are soil and atmospheric food "falling" onto the soil in the shape of sunshine, moisture and air. Hence, whatever the species are, it seems as if the acre of ground, fully stocked, must produce on the annual average the same weight of timber—not the same volume of timber. Thus, ceteris paribus, species of light specific gravity are the best volume producers. Since, however, shade-bearing species are better digestors of atmospheric and terrestrial food, the largest growth per acre per annum is obtained from shade bearers of light weight (Hemlock, Spruce, Fir, White Pine).

In the virgin forest the annual production of wood fibre is exactly offset by the annual death and decay of wood fibre. The virgin forest is a forest seemingly in economic stagnation.

VI. The sectional area of a tree usually measured chest high ($4\frac{1}{2}$ feet above ground), inclusive of bark, is the area of the circle corresponding with the diameter measured chest high.

The sectional area of an acre of forest is the sum total of the sectional areas of the trees standing thereon. It rarely exceeds one-half per cent. of the acreage of the ground, or 218 square feet per acre.

E. Rotation.

Under rotation is understood the number of years which a seedling requires to reach maturity. For a second growth in America, rotations will vary in length from 60 years to 160 years, according to the species and local conditions. During a rotation a wood lot may pass through the cleaning stages, thinning stages, the stage of preparatory cutting, the seed-cutting stage and the stage of final removal.

F. Size classes and age classes.

I. Pinchot adopts the following seven age classes or size classes of trees in his "Primer:"

a. Seedlings, up to 3 feet high.

b. Small saplings, from 3 to 10 feet high.

c. Large saplings, 10 feet high to 4 inches diameter.

d. Small poles, from 4 inches to 8 inches diameter.

e. Large poles, from 8 inches to 12 inches diameter.

f. Standards, from 12 inches to 24 inches diameter.

g. Veterans, over 24 inches diameter.

II. During the sapling stage, the specimens form a thicket; during the pole stage, they form a polewood; and during the standard and veteran stage, a tree forest.

III. During the thinning stage (pole stages) of trees in an even-aged wood, the following classes of mess-mates might be distinguished:

a. After Schlich, "Dominant," "Dominated," "Suppressed, yet alive," and "Dead."

b. After Pinchot, "Dominant," "Retarded," and "Overtopped."

c. The usual classification, adopted by German foresters after Krafft is:

1. Predominating trees, having crown strikingly well developed.

2. Dominating trees, with well-developed crowns, forming the main cover overhead.

3. Condominating trees, with crowns of a fairly normal form, but of somewhat poor vigor, carrying, however, their crowns within the level of the main canopy.

4. Dominated trees with crowns more or less crippled or pressed from the sides, subdivided into two sub-classes, viz.:

a. Most of crown free from cover overhead.

b. Most of crown underneath cover overhead.

5. Trees absolutely suppressed, standing entirely under the cover of others.

G. Even aged woods:

Woods, the components of which differ in age by less than 25 years, are called "even-aged woods."

In America, even-aged woods and hence the advisability of thinning is mighty rare. The struggle for existence between even-aged comrades can readily be alleviated by the forester's interference.

In America, even-aged woods are formed, for instance:

I. By Long Leaf and by Cuban Pine.

II. By Jack Pine and Lodgepole Pine.

III. By Bald Cypress.

IV. By Douglas Fir.

V. By Pinus echinata, taeda, strobus, ponderosa, virginiana on abandoned fields.

H. Distribution of species.

The horizontal distribution of species depends on the latitude and the proximity of the ocean, or better on sea winds, and proceeds parallel with the vertical distribution. In the neighborhood of Biltmore, the following altitudes may be given:

Spruce and Fir—5,500 ft.

Beech—2,000 to 6,000 ft.

Hemlock—2,000 to 3,800 ft.

Chestnut—2,000 to 5,000 ft.

Chestnut Oak—2,000 to 4,000 ft.

Pignut Hickory—3,000 ft.

Bitter-nut Hickory—3,800 ft.

Black Cherry—3,500 to 5,000 ft.

Pinus virginiana—2,000 to 2,500 ft.

Pinus strobus—2,000 to 3,500 ft.

Yellow Poplar—2,000 to 4,000 ft.
Buckeye—3,000 to 6,000 ft.
Red Oak—2,000 to 5,500 ft.
White Oak—2,000 to 5,000 ft.
Spanish Oak—2,000 to 3,800 ft.
Post Oak—2,000 to 3,000 ft.
Black Oak—2,000 to 3,600 ft.
Echinata—2,000 to 2,600 ft.
Rigida—2,000 to 3,500 ft.
Pungens—4,500 ft.
Locust—2,000 to 5,500 ft.
Black Gum—2,000 to 4,000 ft.

Every species thrives best in certain centers, which are few in the case of the exacting and numerous in the case of modest species like yellow Pine, both east and west.

Aside from vertical and horizontal elevation, the influence on distribution exercised by storm, snow and sleet is very marked.

Paragraph VI. Light demanders and shade bearers.

A. A plant is termed the more shade bearing or tolerant of shade, the less light it requires for the functions of assimilation, breathing, perspiration, flowering and fruiting. Only parasites live without light, and hence without chlorophyl.

B. The following characteristics, in their aggregate and not singly, may lead the observer to classify a tree as a shade bearer:

I. Dense leaf canopy.

II. Leaves thin, dark, flat, more numerous, not glossy, not downy, not bunched at the ends of the branches, with blades spread horizontally, withering quickly after separation from the branch.

III. Thin bark.

IV. Thick sapwood.

V. Branches persistent, spread flat or pointing downward, comparatively thin and interlacing. Crowns long.

VI. Little live soil cover, and a heavy layer of dead humus underneath leaf canopy.

VII. Dense stand of trees.

C. Factors influencing the relative demand for light within one and the same species are:

I. Latitude and hence intensity of insolation.

II. Exposure.

III. Fertility of soil, and hence digestive power.

IV. Age of plants.

V. Distance between the crown levels of the shaded and of the shading trees.

Instances for I and III.

White Pine is, in the south, almost shade bearing; in the north it is almost light demanding.

Yellow Poplar on fertile soil stands heavy shading overhead.

D. Woody species in their relative order of resistance against heavy shading might be arranged as follows:

I. Relative order for the southern Appalachians:

Witch Hazel.
Dogwood.
Fir.
Hemlock.
Hard Maple.
Chinquapin.
Black Gum.
Spruce.
Soft Maple.
White Pine.
Pinus virginiana.
Linden.
Chestnut.
Red Oak.
White Oak.
Chestnut Oak.
Ash.
Spanish Oak.
Black Oak.
Finger Oak.
Post Oak.
Pinus rigida.
Black Locust.
Poplar.
Hickory.
Pinus echinata.
Sassafras.

Unfortunately, at Biltmore, shade bearers are usually weeds interfering with the valuable species

II. Pinchot gives the following schedule for the Adirondacks:

Hard Maple.
Beech.
Hemlock.

Spruce.
Balsam.
Soft Maple.
Birch.
White Pine (intermediate).
Black Cherry.
Black and White Ash.
Bird Cherry.
Cottonwood.
Tamarack.

The trees above White Pine Pinchot calls "tolerant" and those below White Pine "intolerant of shade."

III. The leading species of the United States, classed according to light or shade-demanding qualities are:

a. Eastern Conifers:

Long Leaf Pine—distinctly intolerant of shade.
Echinata—light demander.
Taeda—intermediate.
Virginiana—intermediate.
Rigida—not so much as virginiana.
Bald Cypress—light demander.
Chamaecyparis spheroidea—shade bearer.
Spruce—fair shade bearer.
Balsam—intense shade bearer.
Hemlock—intense shade bearer.
Tamarack—light demander.
Arbor vitae—shade bearer.
White Pine—intermediate.
Jack Pine—light demanding towards intermediate.
Norway Pine—light demander.

b. Eastern hardwoods:

Beech—shade bearer.
Hard Maple—shade bearer.
Silver Maple—shade bearer.
Red Maple—shade bearer.
Black Gum—shade bearer.
Sourwood—light demander.
Locust—light demander.
Yellow Poplar—light demander.
Chestnut—intermediate.
Oaks—light demanders (White and Red Oak stand lots of shade when young).

Elm—shade bearer.
Birch—light demander or intermediate.
Black walnut—intermediate.
Linden—shade bearer.
Umbrella tree—less light demanding than Yellow Poplar.
Cucumber—less light demanding than Yellow Poplar.
Sycamore—medium shade bearer.
Willows and Cottonwoods—light demanders.
Liquidambar—light demander.
Hickories—light demanders.

c. Western Conifers:

Douglas Fir—intermediate.
Ponderosa—light demander.
Nut Pines—intense light demanders.
Lodgepole Pine—intermediate.
Sugar Pine—intense light demander.
Lawson Cypress—intense shade bearer.
Tide-land Spruce—shade bearer.
Redwood—shade bearer.
Western Hemlock—intense shade bearer.
Western Firs—intense shade bearers.
Larch—intense light demander.
Engelmann's Spruce—shade bearer.
Colorado Blue Spruce—shade bearer.

Paragraph VII. Pure versus mixed woods.

A. Conditions inviting pure woods and mixed woods.

Conifers are more apt to grow in pure forests, owing to their greater modesty. Abroad, up to a very recent time, the desire of the forester was to raise mixed woods, but quite recently the "Danish propaganda" has turned the minds of some foresters back to pure woods.

Severe climatic conditions and poor soil conditions invariably give one species the preponderance, for example: Bald Cypress rules in the swamps of the South, Tamarack in those of the North; Nut Pines prevail in the semi-arid regions of the Southwest; Long Leaf Pine on poor sand in the South; Cuban Pine in half swamps of the South; Red Spruce on the "Black Slopes" of the Adirondacks; White Spruce in Northern Canada; Lodgepole Pines on old burns; Jack Pine on poor sand in the Lake States.

Pure forests are sometimes in the interest of the owner, for example: Pure Spruce near paper mills; Hickory near carriage works; Tan Bark Oak near tanneries.

A high rotation often leads to a pure forest, a short-lived admixture being gradually pressed out.

Abroad the forester is required to maintain the fertility and productiveness of the soil. Since light-demanding species allow the soil to be baked by the sun during the pole and tree stage of the forest when grown purely, admixture of shade bearers under such conditions is advisable, obtained, for instance, by underplanting Yellow Pine with Beech, when Pine is 50 years old.

B. Kinds of mixture.

A mixture may be temporary or permanent; a mixture may be even aged or uneven aged; the species may or may not differ in height growth; the mixture may be composed of single individuals; of strips, rows, bunches, groups; or it may show an irregular character.

In the course of time the original character of the mixture might be changed entirely by the forester or by nature.

C. Advantages of mixtures.

Mixed forests take advantage of differences of soil qualities; the moisture-demanding species gradually claiming the dells and more modest kinds obtaining preponderance on the dry plateaus or spurs.

A mixture may form a preventive against late frost.

A mixture is better protected against damages by fire, insects, fungi, storms, snow, etc.

A mixture produces a better quality of humus (Pine and Oak humus is better than pure Oak humus or pure Pine humus).

A mixture produces a larger quantity of timber for the above reasons in addition to the fact that a mixture allows its components to more fully utilize the productive factors of the air as well as those of the soil through

a. Difference of crown formation, crown levels, crown density.

b. Difference in root system (tap and flat-rooters mixed).

c. Difference in mineral and light requirements.

A mixture also tends to produce cleaner timber—certainly so for the benefit of light demanders when placed in mixture with shade bearers.

For all these reasons a mixed forest may be said to produce a larger and safer revenue than a pure forest.

Valuable species might be raised beyond the limits of their habitat in mixed forests.

D. Objections to mixed forest.

The administrative and the sylvicultural management of mixed woods is more difficult and hence more expensive than that of pure woods.

In America logging expenses are much increased where only one species can be utilized in mixed forests. Logging for Spruce on "Black Spruce Slopes" in the Adirondacks is relatively cheaper per thousand feet board measure than logging for Spruce where Spruce forms only one-third of the growing stock. This objection does not hold good, of course, where all species are marketable at the same time.

E. Rules governing the composition of a mixture and rules for treating mixed forests (holding good for artificial and semi-artificial forests):

I. Species selected for a mixture must improve one another.

II. Each species should occupy that section of ground on which it thrives best.

III. The mixture should at least maintain the productiveness of the soil.

IV. A light-demanding species mixed with a shade bearer must either be given an advance in age or else must naturally possess an advantage in rapidity of height growth; otherwise it soon disappears. This relative height growth is not a fixed quantity; it usually differs according to the soil and to the climate.

V. The denser the forest cover is, the earlier and the more intense must be the help given to the species likely to be suppressed (Sassafras and Locust in mixture with Chestnut).

After Henry Mayr: species which are botanically different from the most natural mixture (Oak and Pine at Biltmore; Birch and Spruce in Balsams; White Pine, Linden and Elm in Michigan). The exceptions to this rule are many (Norway and Jack Pine in Michigan; Red Firs and White Firs in the Pacific Coast States).

Paragraph VIII. Dr. Henry Mayr's (Munich) fundamental principles of Sylviculture.

A. Forest is possible only where the mean temperature of the four months of most active growth averages 50 degrees Faht. or over

B. A mean summer temperature (May to August) of 53 to 59 degrees Faht. produces the Fir and Spruce zone of Europe, Asia and America. A mean summer temperature of 59 to 64 degrees is productive of Beech, also of White Oak, Maple, Hemlock and Chamaecyparis. A knowledge of the summer mean is essential when introducing exotics. A knowledge of the possibilities of forest growth in a given country implies a knowledge of the mean summer temperature.

Some very modest trees are unreliable as indicators or thermometers (i. e. Pinus echinata, Pinus ponderosa).

C. A species may be grown far from its original habitation, provided that the local climate of the new region is analogous to that of the old. If the exotic comes from a warmer climate, it should be placed on south slopes with plenty of sun; if it comes from a colder climate it should be placed in moist soil and on cool aspects. There is no such thing as adaptation of trees to a different climate, or as acclimatization of trees. Walnut, Peach, and Black Locust have been grown in Germany for centuries, because the climate of naturalization was and is essentially identical with that of the natural habitat of the trees.

D. Tree specimens of a cold climate do not possess in themselves any special power of resistance to frost. It is useless to import seeds from colder climates in the hope of obtaining greater hardiness (Douglas Fir from Oregon and from Colorado differ, however, in hardiness).

E. Species of trees growing in hot localities or else in open stands place comparatively small claims on the fertility of the soil. All species bear shade better when brought to a warmer climate and require more light when brought to a colder one (White Pine).

F. In level countries, at not over 500 ft. elevation, the habitation of a species depends on latitude considerably modified by sea winds. In many countries, away from the ocean, that modification is so strong as to create a dependence of the habitation more on longitudes than on latitudes. In high mountain regions, altitude may produce effects similar to those of latitude: it is, therefore, a mistake to label one species as a mountain species and another as a plains' species. In Eastern North America Picea rubens, in Western North America Douglas Fir, also Abies grandis and amabilis, bear witness to this truism.

G. The climatic needs of a species are better characterized by the forest zone than by the latitude or the altitude at which or up to which it grows. Even a knowledge of altitude and latitude combined furnishes insufficient information relative to such climatic needs.

H. If, in a given climatic zone, there are found two neighboring species of the same genus, it is safe to assume that these two species were not mixed originally, but that each had its distinct habitation and that the mixture is due to the action of man.

I. In primitive forests the species which harmonize are those which differ botanically.

J. When two species are so alike as to be almost varieties but have, nevertheless, different climatic needs, then they are, in reality, true and distinct species (Douglas Fir in Colorado and Oregon).

K. Frost injury is always due to the death of the plasmodium killed by the direct action of the frost. The plasmodium is most sensitive during the time of cell formation and of active growth. The plasmodium in the inert stage, as in seeds, is actually insensitive.

L. All species become more hardy as they grow older. This is simply due to the trees rising above the cold layers of temperature near the ground and to the greater thickness and mass of the trunk, resisting rapid changes of temperature.

M. The degree of moisture in the air required for forest growth is 50% relative humidity during the growing season. The broad-leaved trees and the two and three needled Pines are the species best adapted to regions of extreme dryness or of sudden changes in atmospheric moisture.

N. The association of trees into a forest has the effect of increasing the relative humidity by not to exceed 10%. Hence the necessity of maintaining forest in regions where the tension of watery vapor is close to 50%. The partial destruction of a forest may entail the death of the remainder rendering reforestation impossible unless it is started from the nearest adjoining forest. Inside a forest the greater atmospheric humidity acts as beneficially as a moist ocean wind, lacking, however, the latter's violence.

O. It is in moist, cool localities (mountains and northern climate) that climatic variations are the least extreme during the growing season. It is here that the annual rings are equal, the grain fine and regular, and the timber of the greatest commercial utility.

P. The moister the climate, the easier becomes forest culture, and the forester is apt to make the least mistakes in thinnings, regeneration, fellings, etc. Air moisture seems to exercise a favorable influence on the straightness of the stems.

Q. It is known that a failure of rain for several days may be fatal to young plants. The faculty of persistence increases with age, and the grown trees can endure long periods of drought. If, however, the lack of rain is such as to bring the sum total of precipitations during the four months of the growing season below the two-inch mark, then the forest disappears, even if the humidity of the air remains above 50%. Exception—immediate neighborhood of lakes and rivers with their sub-soil percolation.

R. A fairly moist soil is the best for all species in their optimum climate. In hotter places the locality must be more damp, while in colder ones it may be dry without hindering growth (White Pine in the Pink Beds in swamps, in Canada on dry soil; Sitka Spruce in Washington in swamps; in Alaska on dry land).

S. Snow protects those parts of a plant which it covers; it increases the danger, however, for the parts just above the snow level. Snowy winters are, therefore, useful to low plants, but harmful to trees (except broad-leaved trees).

T. As regards the winds, the most dangerous are those which follow the direction of the barometric minima, which in Eastern America travel from east to west; in Europe from west to east; in East Asia from south to north. Next dangerous are the winds traveling in the opposite direction, whilst those from other points of the compass are more harmless. Every mountain, however, creates a deflection of the current and possibly a return in the opposite direction.

U. In their youth trees are almost indifferent to the quality of the soil; with increasing age their exigencies increase. Thus plantations on poor soil may thrive well for a number of years, only to be suddenly arrested at the beginning of the pole stage.

V. In their most suitable situation (natural optimum) a species succeeds on soil of any mineral description. In a less favorable climate the soil requirements of the species increase.

W. The light most favorable to activity of the chlorophyll is not the light of the blazing sun, nor is it the diffused light coming through rain or fog, but that light which is reflected by brilliant white clouds. Leaf cover overhead is favorable when it filters the rays of a burning sun and unfavorable when it excessively reduces the intensity of insolation. Under a continental climate, cloudless days are more numerous than near the coast. The influence of thinnings and removal cuttings on the remaining growth consequently depends on the continental position of a forest—not solely on species and soil.

X. The regeneration of forests approaching exploitable age is easiest in their optimum climate. If the climate is too warm, seed will be more abundant, and the young plants will endure cover better. The moisture of the air, however, is wanting, and the denser cover overhead may intercept too much of the needed rainfall.

If the climate is too cold, the moisture of the air indeed increases; but the production of seeds and the persistence under cover decrease.

V. In mixed forests artificial regeneration is more difficult than natural regeneration. A clean felling results in a capricious complication of natural laws and phenomena whose contrary actions are not easily understood. Natural regeneration, a mixture of species suitable to the locality, a crop resembling as closely as possible the primitive state, such are the conditions which the forester should seek to realize for the avoidance of dangers as well as for the greatest possible yield of the most valuable produce. No method of treatment harmonizes better with nature's laws than the so-called selection system, when each tree is placed in a condition most favorable to its development, and when no single tree is removed for a purpose other than that of regeneration or improvement of the crop.

CHAPTER II.

THE HIGH FOREST.

Paragraph IX. Genesis of the high forest and its methods.

Wood crops can be started either naturally (from stump shoots, root suckers and self-sown seed) or artificially (by planting seeds, seedlings or cuttings). Forests starting from stump shoots, root-suckers and cuttings are called "coppice forests." Forests starting from seeds or seedlings are termed "high forests."

A. Planting in Europe.

Up to 1830 seed planting only was practiced to start high forests artificially. Since then seedling planting has gradually conquered the European field, especially in the case of Yellow and White Pine, Spruce, Ash, Maple and Larch. Beech and Fir are invariably regenerated abroad from self-sown seed; also Oak in France, while in Germany acorns are usually planted.

B. Advisability of planting in America.

Excepting the case of the prairies and, possibly the case of fields abandoned by farmers in the Eastern States, the idea of artificial propagation of forest crops (by planting) seems preposterous in America. As long as an acre of virgin forest can be bought for a lesser sum of money than is required, in the same locality, for the successful re-forestation of an acre of ground, the chances for a remunerative outcome of planting seem very slim. However, the following points should not be lost sight of:

I. The stumpage prices apt to prevail in America in the year 1960 are likely to equal those now prevailing abroad. Hence the same practice which is now remunerative abroad must prove paying in this country; possibly more paying for the reason that the value of the soil on which the growing crop must yield an annual dividend is abroad about ten times as high as it is in the United States.

II. An expense for taxes and administration is incurred annually by the forest owner, whether the forest ground is kept fully or only partly stocked; hence it seems a remunerative venture to—at least—reinforce natural regeneration by artificial planting.

III. The growth of weeds naturally plentiful in primeval conditions cannot be overcome unless radical artificial remedies are adopted.

C. On the other hand, the following objections to planting must be considered:

I. As long as the American forest is much endangered by fire, it is unwise to invest any money in young growth for which the danger of destruction by fire is excessive.

II. Trees of a condition now considered " weeds " may gradually attain a stumpage value (as Chestnut at Biltmore).

III. Even European forestry is now reverting to a natural propagation of forests owing to the dangers usually inherent to artificial planting.

D. Definitions.

The word reforestation is used if the area to be planted has been previously occupied by tree growth.

The word afforestation is used if there was no tree growth on the plot for a number of years beforehand.

Paragraph X. The Seed.

The quality of seeds is shown by their size, weight, color, scent. A tree standing in an open position, not too young and not too old, produces the best seeds.

A. Seed years:

The atmospheric conditions of the year or years during which the seed is formed further influence the quality of the seed. Drought in summer and early frosts in fall cause the seeds to drop immature. Black Oaks and Pines require two years for the formation of seeds. Juniper three years. It seems as if all trees require a number of years for the preparation of seeds, inasmuch as the medullary rays before a seed year are found full of starch, and after a seed year devoid of starch. This phenomenon may explain the periodical occurrence of seed years in Bamboo and Canebrakes, in Chestnut, Oak, Beech, Pine, etc.

The length of the period elapsing between seed years depends on the local climate and the position of the trees, being short for trees standing in orchard-like positions on warm and sheltered ground where abundant heat allows of the rapid accumulation of starch.

B. Rest:

After dropping from the tree, all seeds undergo a period of rest in our climate. This rest is very short in the case of Cottonwood, Willow, Elm and Soft Maple. In the majority of cases, in Eastern North America, it lasts from November to April. In rare cases (German Ash, German Linden, Red Cedar, Hornbeam) the period of inactivity covers about seventeen months. Seeds which get too dry while stored, often show a prolonged period of rest. For White Oak seed the period of rest is only two months; for Red Oak five months. The assumption that frost is required during the resting period for the benefit of the seed is erroneous. The germinating percentage is greatest immediately at the conclusion of the period of rest.

C. Tests:

Germinating tests are made with from 50 to 200 grains.

I. Water test applicable to large seeds. Thrown in water the good seeds will sink, and the bad seeds will float.

II. Cutting tests, made with a knife, used for testing acorns, chestnuts, nuts of Nutpines, also seeds of Ash, Yellow Poplar, Beech, etc.

III. Hot-pan tests for conifers, which causes good seeds to jump and burst, poor seeds to burn and char.

IV. Pot tests made in the following manner: Fill the lower half of a flower pot with sawdust, the upper half with sand in which the seeds are embedded. Place the pot in a basin partially filled with water, in a warm room.

V. Flannel test: Place the seeds between two strips of flannel kept moist by running their ends into a bowl of water standing at a lower level.

VI. Test in the commercial-test apparatus, which consists of a bottom plate (glass or china), a bell-shaped top (same material) and a clay disk containing 100 small grooves, which fits into the bottom plate. All three parts are open in the center. The clay disk is burned in such a way as to retain good hygroscopic qualities, and is boiled for a number of hours (in water) before using, to kill adherent spores of fungi. Moist sand is kept between the disk and the bottom plate. The grains are inserted into the grooves.

Paragraph XI. Preparations for planting seed on open ground.

The germinating bed must offer the seed a proper, constant and equal supply of heat, oxygen and moisture. The actual amount of heat, oxygen and moisture required has not been ascertained scientifically. Observation in the woods is the best teacher of the conditions securing the largest possible germinating percentage for any given species.

The preparation for seed-planting may extend over the entire area to be planted; or only over certain strips which may be interrupted or continuous; or it may merely involve the grubbing of plots or spots. Where the ravages of game or mice are feared, irregular working is advisable.

A. Removing the soil covers, such as briars, Kalmia, Chinquapin, mosses, dead leaves, humus. A plow and grubber (cultivator) or a harrow can usually not be used for the purpose; the hoe (a strong make) is largely used abroad; weeds are removed with brush hooks or scythes or machetes or are, if possible, killed by deadening. In certain cases an iron rake might do. Often it is necessary to remove the cover by fire: fire, however, produces a heavy growth of weeds on fertile soil (as in Pisgah forest).

B. Loosening the soil. Just after logging, the soil has enough porosity to allow of the development of a second growth. On abandoned fields or in prairies thorough working with the plow, often continued for a number of years, may or must precede the act of planting.

Paragraph XII. Securing and preparing the seeds.

A. European tree seeds are usually bought from reliable dealers, who rival in furnishing the best seed at the lowest price, guaranteeing a certain percentage to germinate. In America, the forester must secure seeds himself, collecting them by contract, or preferably, by day work. Some European sylviculturists insist that seeds should be taken only from the best and strongest trees. Mayr considers special care superfluous.

B. Under "coning" is understood the method of obtaining seeds of coniferous species from their cones. Coning of Spruce, Pine, Fir and Larch on a commercial scale is practiced in Europe by Henry Keller, Appel & Co. and A. Lecoq, all of Darmstadt, Germany.

Certain Pine species (Nutpines) have wingless seeds. The wings of other Pine seeds hold the grain in a claw.

The seed of Spruce lies in the wing as in a spoon; the seed of Larch and Fir is attached to the wing and is not easily separated.

Among the broad-leaf cone bearers—Alders, Birches and Magnolias—the coning of Magnolias only offers some difficulties.

I. The methods of coning are as follows:

a. Coning by insolation, the oldest and safest method. Trays, the bottoms of which contain open lath work or wire netting, are placed in the sun and removed to a shed if rain threatens to fall. The cones are spread on the trays in layers not over two cones deep and are stirred with a rake. In place of trays, drums might be used to good advantage. In a cold climate the sun process allows of obtaining the seeds only at a time too late for seed planting. The germinating percentage of seeds obtained by the sun process is, otherwise, superior to that of seeds coned by other methods.

b. Coning by stove heat.

It is essential that the heat in the coning room should not reach 110 degrees. Thorough ventilation is required to prevent sweating and moulding of cones. The cones are spread in the coning-room in thin layers on shelves or screens, through the interstices of which the seeds drop. The cones are stirred three or four times a day.

It is unwise to have the stove in the coning-room. An American hot-air furnace in the basement is well adapted to furnish the heat.

Many of the large European forestry administrations have such or similar establishments for coning.

c. Commercial method.

In the commercial establishments, heat is supplied by steam pipes, controlled by automatic devices. The trays or drums are kept in a constant rocking motion by machinery. The seeds, after falling through the crevices of the trays, are at once conducted to a cool room.

II. Separating seeds from their wings.

In the case of Pine and Spruce seeds, flailing is sufficient. It is not advisable to wet the seeds before flailing. For Larch, rubber millstones are used, the distance between the stones being equal to the smallest diameter of the seed.

III. Cleaning the seed from dust, needles and wings. The seeds are freed from admixtures by fanning, shoveling, centrifuge or any grain-cleaning machine. The large commercial establishments drop the seeds on endless rolls of cloth, which are moving on an incline. The heavy seeds slide down, whilst dust and wings are carried uphill.

IV. Statistical notes.

a. Spruce in the Adirondacks (after Clifford R. Pettis).

1. Cost of picking cones 50c per bushel (green).

2. One bushel of green cones yields two bushels of dry cones, containing 1⅞ lbs. equal to 1½ qts. of Spruce seeds.

3. One bushel of cones weighs 60 lbs., one bushel of seeds 40 lbs.

4. One pound of seed contains 150,000 grains.

5. It costs 95c to collect, cone and clean one pound of seeds.

b. White Pine at Biltmore.

1. 100 bushels of cones will weigh 2,200 lbs. (a "long ton").

2. One bushel contains 600 to 700 cones, and yields, on an average, ½ lb. of absolutely clean, wingless seeds.

3. One pound of such seed contains 25,000 to 30,000 grains.

c. Yellow Pine (ponderosa) in New Mexico (after Wm. H. Mast).

1. One bushel of cones yields 1.55 lbs. of clean seed.

2. The expense of collecting, coning and cleaning averages 23c per pound.

d. Colorado Blue Spruce in New Mexico (after Wm. H. Mast).

1. One bushel of cones yields 1.2 lbs. of clean seeds.

2. The expense of coning, collecting and cleaning averages 23c per pound.

e. Shortleaf Pine at Biltmore (Pinus echinata).

One bushel of cones yields one pound of clean, wingless seeds at an expense of $1.00 per pound.

C. Seeds stored beyond the duration of their natural period of rest show a reduced percentage of germination. The percentage might be increased by the use of slightly acid solutions, lime water or hot water. Coniferous seeds are often placed in cold water for from three to seven days previous to planting; seeds thus treated, however, must be supplied with moisture artificially after planting if drought sets in.

D. The "malting" of seeds (placing the seeds in heaps, moistening them and stirring them in a warm room) is a rather dangerous procedure. After Weise, Douglas Fir and White Pine seeds should be mixed with moist and fertile soil and stable manure, to be then exposed to a hot-house temperature until the germs begin to show. S. B. Green recommends to pour boiling water on the seeds of Locust, Honey-Locust and Coffee-tree, and to allow the seeds to remain in the water until it is cold, planting immediately thereafter.

Paragraph XIII. Actual planting of seeds on open ground.

Seeds should not be planted on rainy days, especially not on clay soil. For broadcast planting, the area to be planted and the seed are divided into equal lots. The quantity of seed allotted to the unit of space is subdivided into halves. Each half is sown separately by going over the ground crosswise.

Broadcast planting is rare nowadays.

Rough nursery beds (either running full length of the area or interrupted beds), furrows or banks are frequently provided. Narrow trenches may be pressed into the beds or banks with the help of a board, a hoe handle or a wheel.

The seed is usually sown by hand, possibly with the help of a beer bottle, a so-called seed horn and, rarely, with a seed-planting machine. The machine should only be used on ground as well prepared as a wheat field (prairies or abandoned fields). On land newly cleared, roots and stumps prevent the use of a machine.

"Covering" purports to place or rather press the seeds into contact with the mineral soil on all sides; to prevent sudden changes of air temperature from striking the seed; to prevent the seeds from drying out under excessive exposure to the air. The cover must be such as to allow a young germ to push its cotyledons easily through the cover. The seeds keeping their cotyledons below ground (Oaks, Sassafras, Chestnut) allow of a heavy cover.

In the case of coniferous seeds, a proper cover is secured with the rake or with a brush drag; or by marching the planters, a band of sheep or a herd of cattle over the plantation. Heavy seeds are often strewn on the ground without any preparation and then covered with a shovelful of dirt. In America seed-planting in the open is an unadvisable measure as long as the prices of seeds maintain their present figure.

"Planting of cones" was the leading method used a hundred years ago by European foresters. The cones were strewn on the ground and stirred periodically by sheep, with good results.

Seeds more than one-quarter inch thick, especially nuts, are usually dibbled with dibbling hammer, wedge, knife, hoe, spade, etc. The hole made should place the seed at the best depth. The hole is closed by side pressure, by the foot or the hammer, or by allowing a lifted sod to drop back in place. The common planting spade often puts the seeds too deep.

A. The quantity of seeds used per acre depends on:

Price of seed.

Density of stand desired.

Tenderness, sensitiveness and rate of growth of species.

Local damage from late frost, drought, weeds, insects, mice, squirrels, rabbits, game, birds, etc.

Quality of both soil and seeds.

Fineness of prepared soil.

Method of planting by hand or machine, regular or irregular, broadcast or in patchwork. Planting seeds in bands or strips only requires two-thirds or three-fourths of broadcast amount; planting in patches one-half, in holes one-fourth of the same.

B. Figures adopted at Biltmore for broadcast planting are, per acre:

White Oak and Chestnut Oak, 12 bu.

Red Oak and Black Oak, 8 bu.

Ash, 40 lbs.

Beech, 130 lbs.

Maple, 40 lbs.

Elm, 24 lbs.
Birch, 32 lbs.
Firs, 45 lbs.
Spruce, 10 lbs.
Larch, 10 lbs.
Yellow Pine, 8 lbs.
White Pine, 12 lbs.

C. Small seeds: Number of seeds in one pound (approximately, all coniferous seeds without wings):

Ash	6,200
Elm	55,000
Silver Fir	9,000
Tamarack	70,000
White Pine	30,000
Maple	5,000
Birch	80,000
Spruce	56,000
Yellow Pine	70,000

D. Large seeds: Number of seeds in one bushel are: White Oak, 8,000; Red Oak, 3,000; Walnuts, 800.

Paragraph XIV. Season for seed planting on open ground.

For Cottonwoods, Elms (excepting Red or Slippery Elm), Soft Maple, Black Birch and Mulberry, the best time of planting is nature's time,—immediately after the fall of the seeds—in early summer. In the case of the species enumerated, the period of rest is very short and the seedlings starting rapidly have time to lignify before winter. In all other cases the forester can plant either in fall or in spring. Planting in winter is usually prevented by the condition of the soil.

A. Planting in fall invites:

I. Inroads of animals in winter.

II. Washing of seed when snow melts.

III. Damage from late frost, since planted seeds sprout early in spring.

B. Spring planting necessitates:

I. Expense for seed storage over winter.

II. Checks during storage, injurious to germinating percentage.

III. Higher expense for planting, planting taking place at a time when labor is scarce.

Spring planting forms the rule, except with Fir, Beech, Chestnut, White Oak.

In semi-tropical regions or places of periodical drought, the best planting time is the fortnight preceding the rainy period. On dry soil seeds are planted as early in spring as possible so as to profit from the moisture left by melting snow.

Seeds which naturally germinate 18 months after maturity (Red Cedar, Hornbeam, some Ashes, some Basswoods) require stratification: Place seeds, in dry soil, in a ditch ten inches deep and ten inches wide, to a depth of five inches. Cover seeds with straw and dry weeds, and finally with dirt. After the lapse of a year the seeds are ready for planting.

Paragraph XV. Auxiliaries to seed planting.

A. Means to protect species needing shade in earliest youth.

I. Plant seeds with oats, barley or summer rye, planting the grain seed in quantities not to exceed 75% of the normal. Cut grain crops high. This method was used regularly 100 years ago, for European Pine and White Oak, possibly with a view to early returns, possibly to distract ravages of field mice and birds.

II. Certain species, tender and shade demanding in early youth like Beech and Fir, cannot well be raised in the open, unless an usher growth 12 to 15 years older (of Yellow Pine, Sassafras, Black Locust, Birch) is previously started on the ground. The usher growth is gradually removed when the seedlings underneath want "skylight." In semi-arid parts such usher growth is perhaps doubly advisable; further in prairies, where Poplars and Willows, Box Elders and Soft Maple might serve as ushers (also Locust).

B. Means to protect the seed plantation from animals and weeds.

I. Against seed-eating animals. Planting in late spring offers some protection. Planting in sprouting condition protects heavy seeds from rodents; slight coating of red lead protects conifers from birds. A watchman might be kept on large plantations, to scare the birds away. By coating large seeds with tar, crows might be kept away.

II. Light cover of weeds is no disadvantage. Where weeds are heavy, seedlings should be planted, rather than seeds. Mowing (with scythe) weeds and ferns, crushing briars—preferably before weeds are seeding—is recommended. Where seeds are planted in rows or furrows on abandoned fields, cultivation checks weeds.

III. Pasture is not allowed in seed plantations before the thicket stage is past.

C. Reinforcing. Bare spots where seed planting has failed are usually reinforced by planted seedlings. The latter are taken from adjoining dense spots. In broad-leaved species, the blanks where planting has failed, had better be marked during the preceding summer.

Paragraph XVI. Planting seeds of the broad-leaved species.

A. Acorns.

The germinating acorn leaves the cotyledons below ground. If the first shoot is killed another forms at once. A shelter (or usher) growth to husband a plantation during its first years is hardly needed. Still plantations of Yellow Pine made to protect the Oaks planted between the Pines are often found abroad. Its long tap root prevents the Oak from being lifted by frost.

The soil cover given varies between one and three inches, according to the looseness and porosity of the soil. In case of spring sowing, germination requires from five to six weeks.

At Biltmore, White Oak and Chestnut Oak acorns planted in fall are often found sprouting before Christmas. The germ in such cases, however, does not appear above the ground. Red Oak and Black Oak seem to sprout only in spring. Acorns may be sown broadcast, especially on abandoned fields. Formerly acorns were planted often with oats and barley or summer rye. The cover is given with a harrow in case of broadcast planting.

More often acorns are planted in furrows from two to seven feet apart. It is better to plant acorns closely within furrows far apart, than sparingly in furrows near together. The cover is given either by a second furrow or by hoe or rake.

Cultivation between rows (during summer) is not practiced abroad. On abandoned fields at Biltmore it seems required for the purpose of checking mice, squirrels and rabbits.

Where acorns are planted for mixture merely with Beech, Pine and Chestnut, the planting in irregular patches or else "oversoiling" are often used. In the latter case a handful of acorns is roughly covered by a shovelful of dirt.

The usual method adopted abroad for raising Oak is dibbling.

The answer to the question whether spring or fall planting is better, depends on the number of enemies preying on the acorns in winter. Since the Black Oaks are not much molested, it might be as well to plant them in fall. Black Oaks suffer little in germinating percentage during winter storage. White Oak acorns, however, are much eaten by mice, squirrels, turkeys, hogs, etc., and would be planted in spring if winter storage did not invite a large loss of germinating percentage. For wintering White Oak acorns, it is best to place them (imitating nature) in slight layers under a cover of humus on fairly dry soil. After Charles Heyer: Large baskets are roughly made on dry soil, the bottom and walls lined with moss; within are placed alternate layers of moss or sand and acorns. The basket is roofed with straw.

After Von Alemann: Ditches 8 feet wide by 10 inches deep are made on dry soil. The acorns must not be too wet when put into the ditch. The cover consists of a layer of vegetable matter. A rough hut is made all over the ditch, out of slabs, bark, twigs, etc. The acorns are stirred up twice a week during winter. Heyer's method also requires a steep-walled ditch around the place of storage to keep mice out. Possibly it might be wise to keep sacked acorns submerged in running water.

B. Chestnuts.

Chestnuts require more fertile and hence better-prepared soil than acorns. The nut has still more enemies than the White Oak acorn. Its germinating power is much reduced by dry storage over winter. The devices for storing acorns might be used as well for chestnuts. Possibly storage in the husk is preferable. At Biltmore planting of Chestnut on abandoned fields is very unsuccessful, owing to enemies and poorness of soil. But abandoned fields in Pisgah Forest often show fair growth of chestnut—on better soil, especially on moister soil. No experience is at hand relative to nut-plantations on good land newly cut over. Chestnuts dibbled in at Biltmore to form a lower story beneath Yellow Pine are always eaten by squirrels.

C. Walnuts.

Walnuts, both Black and White, can be held over winter like potatoes, without loss. Yet fall planting is better where squirrels do not endanger the nuts.

Walnut has done well planted in furrows on abandoned fields at Biltmore where soil was good, without cultivation; on poor soil the weeds are choking it to death. The dibbling of walnut into woods just cut over has been badly handicapped in Biltmore and Pisgah Forest by squirrels. Otherwise dibbling is the best method in the woods. Possibly the attacks of squirrels might be prevented by late-spring dibbling of nuts in sprouting condition.

D. Birch.

Birch seeds are very small, two-winged. European price for Betula lenta, lutea and nigra, $2.50 per lb.; for Betula papyrifera, 62c per lb.; for European White Birch (Betula alba), 8c per lb. Germinating percentage is bad, especially if seeds are not kept in loose storage. The soil requires little preparation for seed planting. A heavy layer of humus must be removed. Seed can be planted any time from fall to spring. The old foresters used to plant the seed on the snow,—so as to have the seeds washed into the soil by melting snow.

The southern Birches, being solitary, might be planted in irregular patches or trenches, or in places where the mineral soil is exposed by the fall of trees whirled out of the ground with stumps and roots. European Birch is very modest, thriving well on dry soil.

The seedlings are very hardy. They suffer, however, from weeds, grass or leaves blown over them and depriving them of air and sunlight. Betula lenta, at Biltmore, is apt to "damp off."

E. Beech.

Nuts appear every three to seven years in the woods. The nuts ripening in October had better be planted at once after ripening, though much endangered in winter by mice. Storage over winter, possible as in White Oak acorns, requires still more care. If spring planting is resorted to, nuts germinate within five or six weeks. Beech seedlings must have a shelter growth, and cannot survive in the open (excepting moist mountain slopes). The preparation of soil is made with hoe or spade roughly, to a depth of three inches. Abroad, Beech is often used for an undergrowth in pole woods of Pine, Oak, Tamarack, Ash, etc., with a view to improving the humus and, indirectly, the boles of the trees forming the upper story. "Beech is the mother of the soil," because it furnishes the best humus. Beech is exacting; it requires strong and moist soil. Pure forests of Beech are found at Biltmore at 6,000 feet elevation; and extensively in Swain country at 4,000-4,500 feet, with Poplars as standards in an upper story. The price of German Beechnuts is two pounds for five cents.

F. Alders.

The western Alder, Alnus Oregona, and the European Alder are valuable, while the eastern Alder is only a shrub lining the creeks. European Alder is invaluable as a swamp tree and for plantations on very binding soil (clay pits). The seed of the European species is worth 10 cents per pound. Seeds ripen in October and are best kept over winter in the cones. The small seedling is not sensitive to heat and cold, but suffers under the heavy grass usually found in swamps. Since swamps are inaccessible in early spring,—planting of seedlings is preferable to planting of seeds.

G. Ash.

Seeds are abundant, showing about 70% germination. The seedling, in the first year, develops to a length of eight or ten inches, from seeds covered with three-eighths inches of dirt. Little preparation of soil is needed. During the first two years, on good soil, a heavy shelter overhead is easily borne. American White Ash may be grown in slightly swampy soil, or soil subject to long inundations. Prices of Ash seeds: European Ash, 4c per pound; White Ash, 25c per pound.

At Biltmore, White Ash seeds planted in rows six feet apart, on abandoned fields, have done well when soil cover was not too heavy.

H. Maple.

Hard Maple seeds ripen in September. Silver and Red Maple seeds in June. It is wise to plant the seeds just when ripe, especially American species. Price of seeds: Acer rubrum, $3.00 per pound; Silver Maple, $1.00 per pound; European species, 4c to 5c per pound; Sugar Maple, 80c per pound. The green germ of American Maples is said to die if the seeds are not at once planted. Soft Maples develop the seedling in the year of the seed. For seeds to be planted in woods, the soil is prepared with the rake, and the seeds covered with one-half inch of soil. Maple planted on abandoned fields on Northern slopes, well watered and well drained, is likely to be successful. The young seedlings are sensitive, and a cover overhead is advisable, where late frost prevails. On rocky soil in Northern coves, Maple seed is often strewn on the rocks, the rain being expected to wash the seeds into the crevices. At Biltmore, Hard Maple is found only at elevations exceeding 3,500 feet. Sugar Maple is more exacting (in soil) than Soft Maple. It does not grow as well in swampy soil as Soft or Red Maple. Acer negundo (Ash Leaf Maple) does very well in the northern prairies. Seeds ripen in fall.

I. Elms.

Seeds flat, roundish, winged, the wing surrounding the seeds. Seeds, ripening in June, must be planted at once, since they cannot be kept in dry storage (except Slippery Elm—pubescens). Germinating percentage is always small. Elms require such good soil that they can be raised only on strong, northern, moist soil of agricultural value. Never planted broadcast; in suitable localities, seed might be planted in patches on soil roughly prepared with rake. Very little cover must be given.

Seeds cost: Ulmus americana 22c per pound. Ulmus campestris 6c per pound

J. Buckeye.

The Asiatic species is valuable in deer parks, its fruit being eaten by deer and boar. The American species are poisonous (flava and glabra). Seeds ripen in October, winter well, but can as well be planted in fall. After Weise, the seeds should be planted with the navel down. First class soil (Ohio) is required, or at Biltmore strong North coves at higher altitudes, where Buckeye is sometimes found in small groves. Planted in furrows on abandoned fields (Biltmore), Buckeye has shown rapid progress during the first year, but has since made small shoots only. Seeds of the Asiatic species cost 2¼c per pound.

K. Black Locust.

The seeds ripen in fall and are easily kept over winter uninjured by mice, birds or insects. To prevent seeds from lying over, S. B. Green advises to pour boiling water over them just before planting, a treatment causing many seeds to sprout at once. The fleshy, oval cotyledons and the primordial leaves are not pinnate. The tree is an exception to the rule of optimum depth of covering (the depth of long diameter of seed) since it does best when covered 2 to 3 inches deep. The seedlings are sensitive to late frosts. The planting had better be delayed until the danger of frost is past. The price of seeds, 5-10c per pound, renders Locust seeds the cheapest seed obtainable since the germinating percentage is high. The seedlings grow until late fall, when they reach nearly two feet in height. At Biltmore, Black Locust is planted into Oak coppice on raked patches, with the rake, and on abandoned fields in furrows 5 to 6 feet apart. Five pounds per acre is enough. Plantations suffer from ground mice and, later on, from a moth. Locust thrives on exhausted agricultural soil and is used in Europe exclusively to reforest the Hungarian prairies; further along railroad cuts. Forest-grown Locust is much superior to field-grown Locust.

L. Hickories.

The nuts of the thin-shelled species (ovata and minima) cannot be held over winter and need fall planting. Seed plantations suffer from mice and squirrels, and especially from voles, which bite off the seedlings below ground, row after row. Bitternut seems exempt from such attacks. The seedling, in the first years, spends all its energy in developing a large tap root. The plantations at Biltmore made in furrows on abandoned fields might have been better, had they been cultivated continuously to check the mice and voles. Hickoria ovata, 13c per pound; Bitternut, Pignut or Mockernut, 15c per pound. Hickory needs fertile, fresh soil; the "Hickory flats" in virgin forest are convertible into superior farm land.

M.. Linden or Basswood.

Seeds falling in early fall are always poor. The ripe seed (in bunches, attached to wingbracts) falls in late fall or winter. Linden is very exacting and pure woods are very rare. Planted in the forest, it serves only as an admixture. Seeds are planted in spring on soil roughly prepared with rake or hoe. The cotyledon is typically five-pronged, hand shaped. The young plant is so sensitive that cover overhead is strongly advisable.

N. Cucumber tree.

Seeds ripening in cones late in fall are removed with great trouble by hand. Many seeds lie over. The seedling develops on good soil a very long and strong shaft. For forest planting, Cucumber is used only in patches, mixed with Chestnut and Yellow Poplar.

O. Yellow Poplar or Tulip Tree.

Seeds appear annually; of very low germinating percentage. Nature plants the seed between October and May, slowly dismembering the cone. Seeds may be planted in spring after loose storage. The cones are apt to heat and mould, if tightly packed. The cotyledons (size of a nickel) do not show the typical lack of the tip of the leaf blade. They drop off (in strong seedlings) before July 15th. Seedlings do not suffer from mice. Heavy rains, however, are apt to wash them out of the ground. The young seedling stands a good deal of shade. If deprived of light entirely, it is certain to be killed by the first frost. Seeds cost 15c per pound. Large quantities are required for planting, say 50 pounds per acre. Plantations at Biltmore were utter failures, probably owing to poor seed. The seedling grows very fast when young; at the age of two years the seedling is three feet high, on good soil. Where planted in the woods it is necessary to check the weeds, especially on north slopes.

P. Sassafras.

It might be planted on poor abandoned fields as usher growth. At Biltmore, seeds gathered in late summer have failed to sprout, whether planted in fall or spring. The fleshy cotyledon is kept below ground at a depth of say one and one-half inches. Possibly, the seed must pass through a bird before it can sprout, or the flesh must be peeled off by hand or by malting.

Q. Black Cherry.

Primeval trees are found only on fairly rich soil. The Cherry, however, can be easily raised on abandoned fields not better than those at Biltmore. During early youth, until pole stage, mice and rabbits peel the bark badly. The end of the annual shoot is almost always killed in winter. The small purple fruits ripening in early autumn are eagerly eaten by birds. The seeds, after passing through the bird, are scattered all over the woods. The seeds are easily kept in winter, but lie over if kept in a dry condition. A hot-water bath before planting might cause the seeds to germinate simultaneously. In woods, Cherry should be planted under one-half inch dirt cover, irregularly, with full enjoyment of light. Seed 50c per pound. The seeds might be planted in rows on abandoned fields more cheaply than the seedlings.

R. Black Gum.

Nyssa sylvatica has never been raised on a large scale, owing to the low value of its timber. As an undergrowth or admixture with Hickory, Ash, Oak, etc., it might prove, however, a valuable tree, owing to its dense leaf canopy and owing to its shade-bearing qualities. The seeds, cherry-like, dark blue in fall, of acid taste, seem to appear annually, and old trees are often surrounded by an abundance of seedlings; the latter, very light colored, are four inches high by July, showing two heavy oval entire cotyledons, whilst the primordial leaves show the proper form. Seedlings do not seem to suffer from frost, heat or animals. On abandoned fields, however, Black Gum seems to come up from sprouts and not from seeds. The seed is not on the market.

Paragraph XVII. Planting seeds of the coniferous species.

A. Firs.

Very intensive shade-bearers, the Firs cannot be raised without shelter overhead. The young seedling suffers much from frost and heat. Its six to ten cotyledons show two white stripes on the upper side. The young plant is apt to die from leaves smothering it. Its height growth, to the seventh year, is small whilst the seedling tries to establish a root system and to cover its growing space by long side branches. Fir is usually planted in irregular patches as an admixture, moss and mould being raked away. The seeds losing vitality quickly when winter-stored (unless stored in the cones) are usually planted in the fall, in spite of impending ravages of mice and birds. The covering is from one-fifth to one-third of an inch. Since the cones begin to dissolve in November, they must be gathered in early winter. Abies concolor, $3.00 per pound; Abies fraseri, $3.50 per pound; Abies amabilis, $4.50 per pound; Abies balsamea, $1.00 per pound; Abies grandis, $3.00 per pound; Abies magnifica, $5.00 per pound; Abies nobilis, $2.00 per pound; Abies pectinata, 5c per pound.

B. Spruce.

Seeds ripen in the year of the flower and are emitted from the cones, becoming pendulous, between November and April. The seeds are easily wintered either within or without the cones; after some authors, preferably in the cones. Seed years occur at intervals of about five years. The germinating percentage is high. The seeds are usually planted late in spring after bird migration, either broadcast on ground roughly raked, or more often on interrupted beds from one to two feet wide, prepared with hoe and slightly raised over the general ground level. It is said that a man can plant one acre of ground in eight hours, using the rake. Previous to planting it is wise to moisten the seeds in cold water for from three to five days, especially if the seeds are planted in late spring. The cover should be one-fifth inch. Germination takes place after four weeks with from six to eight cotyledons, serrate on the upper side. Young plants are sensitive to drought and readily raised by the frost. Spruce suffers from suppression by weeds and leaves. Its height growth is more rapid than that of Fir. Prices of seeds: Picea canadensis, $1.10; excelsa, 13c; engelmanni, $5.50; rubens, $4.25; pungens, $5.00; sitkaensis, $5.50 per pound.

C. Yellow Pines.

On dry sandy soil, it is wise to plant in early spring, so as to find a moister seed bed. The young seedlings do not suffer from late frosts and are not apt to be lifted by winter frost. The removal of stumps stops the attacks of stump breeding bark beetles and snout beetles (weavils). Intensive loosening of the soil invites the attacks of junebugs, wire worms, etc., and is not needed on sandy soil. Broadcast planting is advisable on soil slightly covered with grass; the cover should just be scratched with the harrow. The seed, unless planted with the rake, is embedded in the soil by driving sheep, cattle and hogs over it. Before planting it might be wise to fire the ground, notably so in the case of Jack Pine, Lodgepole Pine and Norway Pine. Yellow Pine is never planted in patches, since it comes up in larger groups only, of even age. Planted under shelter it would not obtain enough sunlight. The seeds are often planted on long strips two or three feet wide, separated by trenches, the weeds and dirt removed from the trenches being heaped on the strips. On the very driest soil, Jack and Red Pine will do in the north; in the south, Long Leaf Pine. The moisture demands of Pinus taeda exceed those of Pinus mitis. Wet ground is required by Cuban Pine. Pinus ponderosa may grow on any soil and aspect, north and south. European Pine should not be tried in places where snowfall is heavy. The sand dunes at San Francisco are planted in Monterey Pine. A method much used abroad some 80 years ago was the planting of Pine cones (eight bushels of cones per acre). The cones were moved from time to time by a brush drag. Another old method for raising Pine consisted in planting the seeds on top of oats, barley or summer rye. The cover given should be one-fifth of an inch. The seeds are mulched for three to seven days, before planting, in cold water. Old seeds are apt to lie over for a whole year. Germination occurs in from three to four weeks. The first leaves stand singly, and not in sheathed bunches. The primordial leaves are strongly serrate. The germinating percentage is high, say seventy to ninety per cent. The seedlings of Pinus rigida creep on the ground the first two years as if dwarfed. Prices: banksiana, $5.00; murrayana, $10.00; inops or virginiana, $1.10; jeffreyi, $4.00; mitis, $10.00; ponderosa, $2.50; pungens, $4.50; resinosa, $9.00; rigida, $2.50; European Scotch Pine, 50c; tuberculata, $4.50; taeda, $10.00; palustris, $4.50 per pound. In Jack Pine, Lodgepole Pine and Table Mountain Pine the seed is not emitted for a number of years from mature cones. At Biltmore, mitis drops the seed between November 1 and December 15; Palustris seeds seem to drop before December 15, since seedlings appear by middle of January.

D. White Pine.

White Pine seeds cannot be kept as easily over winter as Yellow Pine seeds. The seed matures at Biltmore about September 15, and then falls at once. The European recipe, to gather the seeds when drops of rosin appear on the cones, is misleading. After gathering, the cones should be fully matured by exposure to sunlight. Cones placed in heavy layers—over six inches—after gathering are apt to mould, when the seeds will be destroyed. White Pine emits seeds easily, placed in light layers on wire netting, when heat is applied, and when the cones are stirred several times a day. The rooms in which the coning takes place must be well ventilated. Seed years occur in the South every three years—in the North say every seven years. Mulching before planting is absolutely necessary. Germination after three to four weeks: seven to ten cotyledons, primordial leaves singly. Seedlings suffer still more from fungi (honey fungus) than Yellow Pines. Owing to the high price of seeds of White Pine, the seed is usually planted in nurseries only. An experiment at Biltmore, namely planting of seed without preceding preparation of soil in patches with the rake, under light cover, has proved a failure. White Pine does well on abandoned fields after fires—except on East and Southeast slopes where flat-rooted plants are apt to be lifted by frost. Germinating percentage only from forty to fifty per cent. Seeds cost about $1.50 per pound.

E. Hemlock.

Seeds mature toward the end of September, are very small and easily removable. Seedlings are very shade bearing and minute. Hemlock cannot be grown in the open. Price of seed being high and natural regeneration being easy, plantations will not be made on a large scale. Price of seeds: canadensis, $3.50; heterophylla, $8.00; mertensiana, $5.50 per pound.

F. Larch.

The cones are very tough and not easily opened by heat. It is hard to separate the wing from the seed. The germinating percentage is low. The seed is planted in spring on open ground, usually in patches, mixed with Pines, Spruces or Hardwoods. The planting of seed of Northern Tamarack in Northern swamps is out of the question. The height growth in early youth is rapid. Larch puts heavy demand on light. Cotyledons, five to seven in number, appear four weeks after planting. The seeds are mulched in cold water for at least a week before planting. The primordial leaves stand singly; brachyblasts are formed only from the third summer on. Young shoots never show brachyblasts, but needles only. Price of seeds: European Larch 50c per pound; Japanese Larch (leptolepis) $2.50 per pound.

G. Douglas Fir.

It had better be called Pseudoabies than Pseudotsuga. Cones are ripe in October; bracts are twice as long as scales; seeds fall immediately. Germinating percentage is 20 to 30 per cent.; seed received from dealers is apt to lie over. Thorough mulching or hothouse treatment (after Weise) increases the percentage and the rapidity of sprouting. Germination takes place after five to seven weeks. The five to seven cotyledons are pointed and show two white stripes and a raised midrib above.

Two varieties of Douglas Fir:

a. Pacific Coast Douglas Fir, growing rapidly, foliage bluish, large cones, two top shoots during summer, the second one usually from a side bud.

b. Rocky Mountain Douglas Fir, known as varietas glauca, owing to its grayish foliage, of very slow growth, greater hardiness, smaller cones, developing only one shoot annually. Price of seed: $3.75 per pound.

II. Lawson's Cypress.

Cones blue brown, globular, only six scales, small, three seeds under scale, seeds two winged. Wing one-twenty-fifth inch wide. Seeds mature in September and October, falling at once. 150,000 grains per pound. Sprouting with two cotyledons only, one-fifth to one-third inch long. Young seedlings stand shade. In the sapling stage, fungi seem to play havoc in the plantations, a fact which may explain the small range of the species. Seed 60c per pound.

I. Western Red Cedar (Thuja plicata).

Scales of cones oval and upright, covering pairs of seed. Seeds two-winged; wings one-quarter inch long, elliptical, drawn in at top. One pound contains 300,000 grains. Two cotyledons only. Seed cost $2.25 per pound. Seedlings stand heavy shade.

Paragraph XVIII. Actual planting of seedlings: Introductory remarks.

A. The forester uses seedlings one to ten years old or, better still, one to five years old. The planting expenses increase at a cubical ratio with the increasing weight of the plants.

B. Seedlings are planted either with or without "balls" of dirt. They are taken from the nursery or from the woods. Yellow Pines over three years must be planted as "ball plants." Ball planting is always safer, as it involves a small loss of root fibre. Under any circumstances, it is wise to leave as much dirt as possible attached to the roots, preventing the roots from drying and allowing them to quickly re-establish their sucking contact with the pores of the soil.

C. The small stemlet of young seedlings might be cut off before planting (stump plants). Advantages of planting stumps:

I. In case of Locust, etc., lack of thorns.

II. In case of tap rooters (Walnut, Hickory, Oaks where loss of root fibre is great), rapid re-establishment of the equilibrium previously existing between water-sucking power and evaporation.

III. Certainty of planting the seedlings neither deeper nor higher than they were in the nursery.

Conifers cannot be stump planted.

If stump plants of Ash or Maple are to be used, stumps one and one-half to two inches high should be left. In the case of Oak, the stemlet should be cut off just above the point of differentiation. Stumping seems practicable in the case of Chestnut as well, and is often applied to Catalpa, Locust and Honey-Locust. Stumping is objectionable on account of the rabbits eating the new shoots, or where weeds are rank.

D. Bunch planting is often practiced where very small seedlings, cheaply raised and not transplanted in the nursery, are thereafter exposed in the woods to atmospheric hardships or to damage by animals. From two to thirty such seedlings form a bunch planted into one hole. Bunch planting is applied to German Spruce and Beech, although losing favor with the foresters abroad.

E. Plants may be planted irregularly or else in triangles, squares, rectangles. The advantage of an exact regular arrangement, which may be obtained with the help of long planting strings, bearing blue and red marks, are:

I. Saving of time and expense. Each workman is kept busy by the work of his neighbor, and none can fall behind. Supervision by rangers is facilitated.

II. The number of plants needed is easily found and the probable expense is more accurately estimated.

III. Small seedlings can be found easily in high weeds or grass.

IV. A plantation may be opened to pasture at an earlier date.

V. A mixture of species, and, later, underplanting are more readily obtained.

VI. The cleaning, thinning and pruning of the plantation is facilitated.

VII. Possibility of cultivation between the rows in prairies and on abandoned fields.

The triangular form gives the largest number of plants per acre, distributes the growing space equally, and is therefore said to raise cleaner stems. The arrangement in squares allows for a given planting distance 15% less plants per acre than the triangular system.

The rectangular system, though scientifically objectionable, practically prevails over the others. The plantlets standing close within a row assist one another from early times on. Planting between the rows and the cultivation of slopes are facilitated within rectangles. It is said, however, that the saplings form large side branches and retain the same for a longer period of years. Rectangular plantations are known to suffer less from snowbreak.

F. Usually it is best to make the holes for the plants before planting—unless, on clay soil, the holes are apt to fill with water. The making of holes takes more time, in many a case, than the planting itself. It should not be done during the few spring days favorable to tree planting.

G. The rangers should make all needful preparations for planting several days or weeks before planting, securing the seedlings, " heeling them in " close to the plantation and getting the implements and tools in proper condition.

Planting distance.	No. of plants per acre in squares.	No. of plants per acre in triangles.
1 foot	43,560	50,650
2 foot	10,900	12,674
3 foot	4,850	5,640
4 foot	2,725	3,168
5 foot	1,750	2,034
6 foot	1,210	1,407

Paragraph XIX. Criteria of good seedlings.

A. The root system:

The root system should be as compact as possible and as rich in fine hair fibres as possible, qualities which are only obtained in a well-fertilized nursery. It must be remembered that the small hair fibres are the feeders of seedlings, and that the stronger roots act merely as bones or as the skeleton giving the plant a firm anchorage in the soil.

A short exposure to sunlight and to dry winds kills the root hairs. Roots cannot live in air any better than fish, though requiring oxygen like fish. Toumey claims that " many successful planters never set evergreens until the root tips show signs of growth." This experience is entirely at discord with the universal European experience. Conifers are very sensitive against loss of root fibres. Fresh tips, evidently, are most apt to be injured in handling or by drought.

The pruning of the root system is a necessary evil in the case of very long tap roots. Conifers do not allow of it. Badly damaged roots may be clipped with a sharp knife just above the damaged point.

B. The shaftlet: Crooks are not injurious, the plant healing them quickly. Slender plants are not desirable, partly because they sway badly in the wind, thus getting loose in the soil; partly because slender shafts are due to excessively close position in the nurseries. In the case of broad-leaved seedlings one or two years old the shaft of spindling specimens may be cut off without lasting injury (not in conifers).

C. The buds: The buds must have a healthy color, a large size and a goodly number. Small buds prove the plant to be weak; so that it has a poor chance to withstand the hardships of transplanting. In conifers, the condition of the buds is especially telling. Poor and few buds in hardwoods render it advisable to lop the stemlets.

Paragraph XX. Age, size and number of seedlings used.

A. Young plants are more easily transplanted than old plants, the loss of root system being smaller. Large saplings (10 ft. high to 4 inches in diameter) are transplanted only at great expense and great risk. They must be transplanted with big balls of dirt attached.

B. The number of plants used per acre in Europe varies between 1,000 and 40,000 specimens per acre in case of Pines, Spruces and Beeches. The advantage of a large number of small plants is:

I. Better chance for nature to select the fittest.

II. Less reinforcing required.

III. Even unexperienced planters can be used.

IV. Plant material is very cheap.

V. Larger returns from first thinning and clearer boles.

On the other hand, the advantage of planting stronger seedlings, especially transplants three to six years old, lies in the following points:

VI. On poor soil, strong plants have a better chance.

VII. Older plants have already overcome the "measles" of childhood—fungi, insect diseases—to a large extent.

VIII. Such plantations suffer less from snowbreak.

IX. The rotation is shortened by a number of years. In a White Pine plantation made with seedlings seven years old, instead of seedlings two years old, the rotation is reduced from fifty to forty five years; and the original cost of planting may be 27% higher, figuring at 5% interest; 22% higher, figuring at 4% interest; 13% higher, figuring at 3% interest.

C. Generally speaking, Oak, Hickory and Walnut should be planted one year old on account of the large size of the tap roots.

Spruce, Fir and Hemlock should be planted three to five years old, after previous transplanting in the nursery. Ash should be planted six years old when used in half swamps having luxurious growth of weeds. Yellow Pine must always be planted one or two years old, unless ball planting is resorted to.

After Toumey: For the prairies, yearlings are best in case of Cottonwoods, Box Elder, Soft Maple (Soft Maple sprouts in June and is very small in fall), Russian Mulberry, Catalpa, Walnut, Black Cherry, Locust and Honey-Locust. At Biltmore, Black Cherry transplants three years old do very well. Locusts two years old are clipped back. Maple and Ash are transplanted and used three to four years old; Yellow Pines are used one or two years old; White Pines two, three or four years old; Catalpa one year old, etc.

Paragraph XXI. Lifting seedlings from nursery beds.

It is not advisable to plow the seedlings out of the ground or to tear them out with tongs. In the case of species having small reproductive power (Conifers, Beech, Birch) additional care is needed. The spade should be used; and the plant should be lifted together with large clumps of dirt which, thrown on the ground, collapse and allow of safe extrication of the plants contained in the clumps.

It is wise, carriage charges permitting, to allow some dirt to stick to the roots. On more binding soil the hollow cylinder spade might be used for lifting small plants. Plants should be well covered with burlaps, wet moss, dirt, etc., at once after digging. Plants left for a number of days between the plantation and the nursery should be heeled in thoroughly, shinglelike, one row covering the other, in a shady place.

Paragraph XXII. Transportation of seedlings.

The roots are thoroughly protected. A voyage from Europe to Biltmore, though it may take six weeks time, will not injure the plants. Plants are loosely put together in bunches of one hundred to two hundred pieces, are placed in baskets or open crates, the roots in the center, the tips at the circumference. Layers of plants alternate with layers of damp moss. Seedlings packed tightly, especially in boxes, are apt to mould.

Plants merely taken to a nearby plantation on wagons should be well covered with branches, moss or sacks, and should be sprinkled during transportation. Ball plants do not need packing unless balls are very loose, when burlaps are necessary. One hundred Yellow Pine ball plants, after Rankin, with balls ten inches square, make up a two-horse load. Fifty thousand seedlings without balls and well watered, or eighty thousand seedlings slightly dampened, usually make a wagon load.

Paragraph XXIII. Common methods of planting seedlings in the open.

A. Planting in furrows.

The furrows should be made deeply with a subsoil plow. The plants are distributed, at proper distance, in the furrows. Then another furrow is at once given with a turning plow, throwing the needful dirt over the plants, which are thereafter adjusted and pressed into proper site, by hand.

This is a quick method of planting, but is practical only on prairies or on abandoned fields. It involves the danger of reckless spreading of roots and of loose imbedding of the plant in loose soil. The plants are also apt to be placed too deep and to be shaken badly by wind. The method, however, yields good results in case of

I. Stump planting (Oak, Locust, Catalpa).

II. Planting many one-year-old seedlings (so that a large percentage might be lost without great injury).

III. Plants not sensitive to deep planting (not for White Pine and Spruce). Plants placed too deep form a second root system close to the surface and develop a bushy bole, useless in forestry, pleasing in a garden.

At Biltmore, the furrow method was used by Pinchot at the Shiloh Crossing plantation. A modification of the furrow method was used at the Rice farm in 1903, where deep furrows were drawn, the plants inserted by hand, covered by hand and adjusted by hand. A planting machine (Dr. Fernow's), resembling a tobacco planting machine, is not used.

B. Planting in holes. The holes are either holes dug with the spade or clefts wedged into the soil. Most planters mulch the roots in loamy water so as to increase their weight and so as to reduce their spread before insertion into the hole. The root fibres suffer from this mulching, however, being braided unnaturally. The root tips should not be bent upward. The depth and width of the hole should correspond with the actual size of the root. Several plants might be placed in the same hole to save expense. Theoretically it is best to place each plant in the center of its hole. At Biltmore, however, planting in the lower edge of the hole is preferred because:

I. No root is hemispherically developed.

II. Planting at the edge is the best preventative against deep planting, the planter holding the plant with the left hand at the point of differentiation against the edge of the hole, when drawing with the right hand the dirt required to fill the hole.

III. Such plants are firmly imbedded and are less shaken by the wind. On forest soil it is wise to place the top dirt dug from the hole around the root tips, and the bottom dirt of the hole close to the surface. The workmen should be shown daily by the forester how to plant. It is of the utmost importance to pulverize and loosen the dirt first, and to then press and beat it tightly with fist, heel or mallet around the roots. Some planters give a trifle of forest humus into the hole; others carry fertile garden dirt in baskets to the plantations. The placing of stones on the hole (as refrigerators) is recommended. One man's work at hole digging per day is 300 to 3,000 according to root-size and conditions of soil.

C. The seedling must stand, after planting:

I. Firmly, the dirt being tightly packed around its roots, so that it cannot be shaken and so that the roots may establish their sucking contacts.

II. Naturally, the roots having the same manner of spreading and ramifying which they had in the nursery.

III. Erect and just as deep as it stood in the nursery (exception: barren sand).

Paragraph XXIV. Special methods and tools used for planting seedlings in the open.

A. Biermans spiral spade, costing $2.00, is pointed parabolically, the blade being 7½ inches long and 5 inches wide. When used boringly, this spade forms a parabolic hole and loosens the soil. With the left hand the seedling is pressed against the side of the hole, while the right hand places some sod ashes (See Par. XXIX, D. VI.) immediately over the fine root fibres. Then the best part of the soil is used to fill the near half of the hole, and the poorest for filling the far half. The instrument is adapted to hardened soil. On wet and binding soil, the dirt clogs in the curves of the spade. Capacity per hand in Germany 320 plants per day.

B. The Planting Dagger is used for Yellow Pine seedlings one or two years old, to be planted on sandy soil. The dagger is three inches longer than the longest root. It is made of wood, iron shod at the point. It makes a narrow, funnel-shaped hole, which is closed by pressure from another hole made a few inches from the first. On loose, sandy soil it is wise to plant Yellow Pine seedlings deeply—up to first needles—since Yellow Pine is not affected, in that soil, by deep planting. Daggering is the cheapest possible method for planting Long Leaf Pine, Jack Pine, Lodgepole Pine, etc. Capacity 800 to 900 per day and hand.

C. The Buttlar Iron, once much used for thrusting holes into the soil, is now in disfavor since it causes the seedlings to be inserted into holes having walls as impenetrable as those of a flower-pot. Only plants one or two years old can be thus planted ("cleft planted").

D. The Wartenberg Iron consists of a sword 18 inches long, attached to a heavy handle. Price $2.25. Similar irons were made at Biltmore out of three-inch wagon tire, at a small cost. A deep cleft is made by the iron in which tap-rooted seedlings are readily inserted. On binding soil, however, or in a broomsedge field, the use of this iron cannot be recommended.

E. The planting hammer is used to make small holes for small roots. The iron part of the hammer is about five inches long. The planting hatchet, a similar make, may be used to advantage for planting one-year-old plants. The holes are closed by beating the dirt round the holes with the back of the hammer or with the hatchet.

F. Von Alemann constructed a very heavy square spade which is pushed and drawn in a particular way, like the lever of a handcar on the railroads, so as to make the lower part of the hole wider than the middle part, the cross-section of the whole forming an X. If Oaks are planted, an extra hole is made at the bottom of that made with the spade, by means of a long dagger in which the tap root of the oak is to be imbedded. The hole is closed by pressure from the sides. It seems doubtful whether the soil will close entirely over the roots unless it be sandy. One man can plant 580 Oaks two years old or 1,270 Yellow Pines two years old with this instrument on plowed ground.

G. The Planting Beak, constructed by Barth, makes and empties a triangular hole, taking out the dirt filling the hole. Plants one or two years old are placed along the vertical side of the hole. Then the dirt kept in the beak is filled in. The instrument is 3½ feet long and weighs 15 pounds. It is said to be superior to all cleft planting tools, whilst it works just as cheaply on loose soil.

H. Planting under sod cover. (Von Alemann). Two sods are turned over, like the covers of books, and laid back, upside down, without loosening the "hinge" of the sods. The soil in the hole is deeply worked with a spade. In the middle of the hole the plant is placed, with the roots spread as much as possible within the entire hole. Then the two sods are turned back into their original position, so that the seedling stands between them. This is a good method on ground where frost is to be dreaded, and is used for Ash, Alder and Water Birch one to three years old.

I. Mound Planting (Manteuffel). Small mounds are made consisting of rich nursery soil to be carried in baskets to the plantations. The plant is placed into the mound, its roots touching the vegetable mould underneath. The mound is covered with sods to prevent erosion. The method works well on very dry and hard ground. About 100 plants are planted per day and per man after this method. Its advantages are:

I. The vegatable cover of the soil, by its disintegration, furnishes food for the rootlets.

II. The quality of the soil surrounding the roots is very good.

III. The soil in the mounds is kept moist with condensed atmospheric vapor, owing to its greater porosity.

IV. The planter is not likely to plant the seedling too deep.

The method is also applied on very wet soil. The mounds may be replaced by ridges. Experiments have shown that planting in mounds does better in years of drought than planting in holes.

Modifications of the Manteuffel method are in common use. Ordinary soil dug out at the planting site may be used to make the mound; or, where there are heavy sods, a sod is turned upside down and left to rot for a year. The mound thus made is rich in plant food resulting from the disintegration of root fibres and vegetable matter.

Disadvantages of mound planting are:

a. The mounds are easily washed away on slopes unless under cover of mother trees.

b. The best soil is washed out if the mound is not covered with sods, stones or brush.

c. Insects and mice find hiding and breeding places in the sod-covered mounds.

d. Mound planting is very expensive.

J. Ballplanting, with Charles Heyer's hollow cylinder spade.

The cylinder spade can be used to best advantage on binding soil. It lifts the plant (seedlings, notably conifers one or two years old) from the nursery without loss of roots and prepares for it a hole on the ground to be planted having the exact form of the ball of dirt adhering to the roots.

The method is particularly safe and seems particularly adapted for prairie planting since it protects the seedling before, during and after the act of planting; since it prevents the seedling from loosing its foothold in the soil under the influence of high winds; since it allows of planting at almost any season of the year.

On stony soil, the cylinder spade cannot be used. Edward Heyer's "cone spade" facilitates the transfer of larger seedlings with heavier balls of dirt from the nursery or from the woods to new plantations.

Paragraph XXV. Season for planting seedlings.

Factors influencing the season are:

Local climate.

Labor available.

Time available.

Species planted.

Theoretically seedlings should be planted during the period of inactivity of roots and buds, or in mid-winter. This theoretical demand, however, in a Northern climate, cannot be carried out, the ground being frozen at that time. Hence the choice only remains between planting in late fall and planting in early spring. After Engler, roots show two periods of active growth, viz.: a spring-and-summer period influenced by soil moisture, and a fall period influenced by soil heat. The growth of the roots during August and September, between the two periods mentioned, is very weak.

In spring, the growth of the roots starts in March and April and shows the highest activity in May, June and July.

A. Spring Planting.

The seedlings are planted before the opening of the buds. The moisture left in the soil by the melting snow is very favorable to their growth. Objections to spring planting are:

I. Scarcity of labor, unless forest planting begins at a time at which fields are too wet to be worked.

II. Larch, Maple, Cherry and Birch sprout so early in spring that it is impossible to adopt spring planting in their case.

III. Moist ground, hummocks and swamps are not accessible in spring.

IV. The soil is not packed as tightly around the roots on the arrival of spring as is the case in fall planting.

B. Fall Planting.

Fall planting is preferred on wet areas and in the case of early sprouting species. The disadvantages of fall planting otherwise outweigh the benefits combined therewith.

I. Seedlings planted in fall are apt to be heaved up by the winter's freeze.

II. The severe winds of the winter loosen the foothold of conifers planted in fall.

III. Fall-planted seedlings are more subject to late frost, opening their buds some ten days earlier than spring-planted seedlings.

IV. On weedy soil, fall-planting is handicapped by the presence of a rank growth of weeds which has rotted down at the arrival of spring.

In the Southern states, even at Biltmore, planting in January and February is very feasible, perhaps advisable in average years.

Ball plants can be planted at any season of the year.

In countries of periodical rainfall (California, India and Porto Rico) it is best to plant just before the beginning of the rainy season.

In swamps, summer planting or early fall planting is a necessity.

Paragraph XXVI. Cultivation of plantations.

A. Practice: The European forester never cultivates any plantations for the reason that his plantations are made immediately after lumbering, when the rootwork and the stumps on the ground render cultivation difficult. Under the incident conditions of soil (humus; porosity), cultivation is usually not required for the success of a plantation. Irregular plantations cannot be cultivated.

The forester afforesting sand dunes obviously objects to cultivation.

The forester afforesting swamps finds cultivation impracticable.

B. Advisability: Cultivation is advisable:

Where there is neither humus nor rootwork in the ground;

Where the soil, like prairie soil, is compact and hard, lacking in aeration, porosity, capilary power, hygroscopicity;

Where competing herbaceous weeds threaten to smother small seedlings;

Where mice or soil breeding insects prevail, which are disturbed, exposed or killed by continuous cultivation.

C. Frequency.

The forester may cultivate up to three times per annum, during one, two or more years—sometimes till the leaf canopy overhead secures for the soil a solid layer of humus by dense shading.

D. Tools.

A bull-tongue plow is used, on rough ground, for plant rows placed less than three feet apart.

Cultivators are used, as in agriculture, where the soil is loose, and where the rows are far enough apart and the ground is free from stumps or roots or bolders.

Hoes are used in exceptional cases only, where labor is cheap and where the soil does not allow of using teams and machinery.

Mules and horses are muzzled to protect broad-leaved seedlings from being browsed.

Paragraph XXVII. Prairie planting in particular.

A. The prairie exhibits as marked climatic differences as the State of Georgia compared to the District of Labrador.

"General prescriptions for prairie planting" are impossible, owing to these climatic diversities.

B. The species used must be adapted to the quality of the soil, the intensity of summer heat, the duration of the summer, the soil moisture, the air moisture. Native trees should be given the preference in case of doubt.

C. Prairie plantations are meant either for production of timber (ties, posts, etc.), or for shelter to stock, house, orchard and field.

D. Species recommended for prairie planting are:

I. For Canada:

White Spruce, Cottonwood, Balm of Gilead, Box-elder, Green Ash, Russian Poplar; further Yellow Pines.

II. For Minnesota and Dakota:

Cottonwoods, Soft Maples, Willows, Ashes, Box-elder, Tamarack in swamps, Bur Oak along rivers.

III. For Nebraska and Iowa:

The same species and Red Cedar, Russian Mulberry.

IV. For Kansas, Arkansas, Oklahoma and Missouri:

Osage Orange, Black Locust, Hardy Catalpa, Post Oak and White Oak.

E. Naturally we should expect Xerophytic species, like Yellow Pines, to do best in the prairies, and the old stumps found buried in the ground bear testimony to their possibilities. Being evergreen the Pines protect the farmers best from blizzards. Still, just Pines are most apt to meet with distress previous and after the act of planting. Ball planting should be tried. The European Pinus montana resists wind particularly well.

F. Preparation of soil: It is best to prepare the soil thoroughly by several years' field crops. Deep plowing is required (Toumey) in the fall previous to planting and in the spring of planting.

G. Preparation of plants: The seedlings arriving at the farm should be removed from the package; heeled in under shade, protected from winds and sprinkled if frost is not to be feared. Toumey wishes to puddle plants before heeling, and desires to plant the conifers invariably after the broad-leaved kinds.

H. Planting: The planter must patiently wait for proper weather. Thorough protection of the roots during every moment of the act of planting is essential. Each individual must be planted by itself—no dozen methods! The plants should be set closely within the rows; the soil must be packed tightly round the roots. Reversed sods or stones may be used to ballast the roots and to prevent the wind from shaking them loose.

I. Cultivation: Cultivation is necessary up to the time when the trees cover the ground fully, littering it with humus. Where barefrost is dreaded, cultivation should end in late summer.

Paragraph XXVIII. Methods of obtaining plants for planting.

A. Frequently, seedlings are obtained from the woods nearby, a method which seems to recommend itself as cheap and natural. It is a fact, however, that the roots and the buds of wild seedlings are badly adapted for the purpose of planting. The former are far-spreading; the buds are weak and few. In addition it is risky to take plants from the shelter of mother trees suddenly onto open ground. The use of wild seedlings over two years old is particularly unsuccessful. The failure of the timber culture act to prove efficient is largely due to the use of wild plants in prairie plantations.

At Biltmore, seedlings of Yellow Poplar, Yellow Pine, Ash and Maple are often picked up with a spade and taken to the nurseries with good results. Such seedlings are taken at a very young age, without loss of dirt, to nurseries placed under lath screens. They are never removed directly to open plantations, with the exception of ballplants of Yellow Pine.

B. Purchase of plants from commercial nurseries:

During the last 15 years, a number of financially strong commercial nurseries have arisen abroad which, buying seed cheaply, located on suitable ground at good shipping points, enjoying many years' close acquaintance with the needs of Sylviculture, have supplied the various German administrations with cheap plants of a superior grade. The Biltmore Estate has often obtained plants raised by Heins Sons, Halstenbeek, near Hamburg, notably White Pines, which have been very successful in spite of a six weeks voyage. On the other hand, American nurseries usually prepare plants only for ornamental purposes and not with a view of fostering the development of the tree bole.

Since the rangers and the helpers in forest planting should know the sylvicultural needs of the seedlings, it is surely wise to offer them object lessons at home through self-administered nurseries.

C. Nurseries proper, in charge of the forester.

Where mice are much feared the nurseries should be surrounded by a deep, straight walled ditch. Fences are made of wire, lath, rails, etc., differing in material, strength, height and fineness of mesh according to the enemies locally dreaded.

Proper nurseries yield the largest percentage of seedlings out of a given quantity of seeds. The seedlings raised therein have a better, more compact and more fibrous root system than wild plants. Expensive and exacting species should always be raised in "forest gardens."

There may be distinguished:

Nurseries under tree cover.

Shifting nurseries.

Permanent nurseries.

I. Nurseries under tree cover form the exception, being required only for the production of seedlings of tender species; notably of Hemlock, Hard Maple, Beech. The nursery is formed by a polewood heavily thinned and dug over with the spade. Here Beechnuts are planted broadcast or in furrows and the seedlings removed when two years old, without transplanting. Hard Maple and Hemlock should be raised as in open nurseries.

It is a noteworthy fact that broad-leaved kinds often thrive best under conifers (Oak and Beech under Pine) and conifers best under broad-leafed kinds (Spruce best under Beech, Maple, Birch). Only theoretical explanations can be given for this truism, the best explanation being the difference of enemies attacking such species.

Objections to nurseries under tree cover:

a. Soil preparation is costly and insufficient.

b. Plants raised cannot be planted in the open without loss.

c. Nurseries under tree cover suffer badly from mice and squirrels and obtain insufficient rainfall. On the other hand, weeds and grasses are kept down by the shelter overhead.

Nurseries under tree cover form the exception, not the rule.

II. Shifting versus stationary nurseries.

The advantages of stationary forest nurseries over shifting forest nurseries are:

a. Reduced cost of tilling.

b. Reduced cost of fencing.

c. Reduced cost of supervision.

On the other hand, stationary nurseries suffer from:

1. Excess of weeds.
2. Higher cost of transportation of seeds and seedlings.
3. Large needs of artificial fertilizing.
4. Danger from mice, insects and fungi for which such nurseries act as incubators.

For raising ball plants, the shifting nursery is undoubtedly best; otherwise the selection between shifting and permanent nurseries depends on local conditions; such as the price of manure and of fencing; charges for transportation, etc. Seed plantations made on open ground are often used as shifting nurseries—especially so in the case of Yellow Pines.

Paragraph XXIX. Permanent nurseries in particular.

A. The size of "forest gardens" (the German name for stationary nurseries) depends upon the quantity, the age and the size of the seedlings annually needed. Further, on the presence or absence of transplanting beds, fallow beds and paths between the beds. Regular forest management has forest gardens fitted with:

I. Transplanting beds, their total size being equal to transplanting space by number of plants yearly needed by number of years which the transplants are left in such beds.

II. Seed-beds, their total size being equal to one-fourth of size of transplanting beds for one age class by number of years which the seedlings are allowed to stand untransplanted.

III. Foot paths and roads equaling 30% of I and II.

IV. Fallow beds equaling 100% of I, II, and III, if seedlings and transplants are left for one year only in their beds; 50% of I, II and III, if left for two years; and 33%, if left for three years.

B. Form of beds. Beds are usually four to six feet wide, separated by paths one or two feet wide, the beds preferably elevated over the paths by from three to twelve inches, so as to check the migration of insects, mice and moles; and so as to allow of better aeration of the soil. Sometimes the beds are kept in board frames, an expensive though useful arrangement.

C. The following factors must be considered in selecting the site of a nursery:

I. Soil: A sandy loam or marl is best for seedlings. The correct degree of looseness is secured by mixing sawdust, spent tan, humus, ashes and weeds with the mineral soil. The soil should have no stones, in order to allow of proper seed planting and in order to facilitate the digging of the plants.

II. Exposure: The best exposure is a gentle northwest slope. The bottom of a valley is too frosty in spring. Southwest and southeast slopes are subject to rapid atmospheric changes. Eastern aspects invite damage by frost.

III. Proximity to water and possibility of irrigation.

IV. Accessibility and distance from ranger's house.

D. Fertilizing: Stationary forest gardens require continuous fertilizing. Crops of seedlings exhaust the soil like grain.

The following table exhibits, in pounds per acre, the amounts of fertilizing matter annually consumed by Pine seedlings, Pine poles and crops of rye.

Fertilizing matter.	Yellow pine one year old.	Yellow pine eighty years old.	Crop of rye.
Phosphoric acid	9.8 lbs.	1.7 lbs.	16.7 lbs.
Potash	20.7 lbs.	2.8 lbs.	24.2 lbs.
Calcium	17.2 lbs.	10.1 lbs.	9.7 lbs.
Magnesia	3.0 lbs.	2.0 lbs.	4.2 lbs.
Sulphuric acid	0.0 lbs.	0.3 lbs.	1.1 lbs.

The following fertilizers are used in forest gardens:

I. Animal manure, which is considered best. Cattle manure is preferred to horse manure; on clay soil, however, horse manure is better. Heavy weeds come up from stable manure which has not had time to fully decompose.

II. Commercial fertilizers: Experiments conducted with superphosphate, bone meal and so on have failed to yield conclusive results. The best kalium fertilizer seems to be kainit (kalium chloride); the best nitrogen fertilizer is saltpeter.

After Von Schroeder, the following quantities of phosphates, potash and nitrates are needed to raise 4,000,000 plants on an acre of nursery:

520 lbs. kainit.

60 lbs. superphosphate.

320 lbs. whale guano.

III. Humus, the natural forest manure, is the cheapest fertilizer obtainable in the woods. Humus of Pines mixed with that of broad-leaved species is best. Humus just one year old is said to be richest in bacilli favorable to tree growth, and to be devoid of filiform fungi disastrous to plants.

The weeds removed from nurseries furnish, through their decomposition, a valuable humus.

A mixture of humus with street sweepings, kitchen refuse, loam, burnt lime, etc., is often placed in huge heaps near the nurseries. The heaps are kept in a rotation so that the heap made in 1903 is used only in 1906. The heaps are stirred up repeatedly so as to be acted upon by the air.

IV. Vegetable matter other than humus. Such fertilizer may be obtained by raising, on the fallow beds, during the fallow year, cowpeas, clover, lupine (the latter on sandy soil) and other leguminous plants, all to be plowed under in fall.

Leguminous plants increase the nitrogen in the soil.

V. Wood ashes: Excessive use of wood ashes is disastrous to sprouting plants, especially on sandy soil. Besides kalium, wood ashes contain from 5% to 20% of phosphoric salts. Wood ashes should be used, however, moderately in Yellow Pine nurseries.

VI. Sod ashes are recommended where other fertilizers are too costly. Sods of grass, of weeds or of huckleberries are dried, the majority of the dirt removed and used to build a chimney and a kiln resembling a charcoal kiln, wherein layers of sod alternate with layers of brushwood, waste thinnings, etc. The kiln is covered with sods and wet dirt. Kilns burn, according to size, for from two days to two weeks. The sod ashes contain all mineral fertilizers needed; have great hygroscopicity and are free from insects, fungi and other bearers of plant diseases.

Sod ashes should be exposed to the atmosphere for a year before use, and should then be well mixed with the top layer of nursery dirt.

Paragraph XXX. Seed planting in seed beds.

Seedbeds: Prescription for preparation: Plough and cross-plough to a depth of one foot; mix manure well with soil; heap the dirt taken from the paths on top of the beds; remove stones.

Seeds are planted either broadcast or in drills to a depth generally equaling their longest dimensions.

A. Broadcast planting is always used in commercial nurseries while the sylviculturists use it only for seeds of small germinating percentage (Birch, Elm, Beech, Alder and Yellow Poplar) or in case of very light grained species which do not allow of any covering.

Broadcast planting is permissible if seedlings are kept in the bed one year only. Economy in size of nursery and less weeding are the advantages of broadcast planting.

With the help of a roller or, better still, of a heavy plank, the surface of the seed bed is pressed down until an even surface is obtained. Then the seeds are planted, dirt or fertilizer or sod ashes sifted on top, and the surface of the bed again pressed down as before. To prevent the formation of a crust, a cover of moss or leaves is often given, to be removed before the time at which the cotyledons are expected to appear. Better than moss or leaves are coverings consisting of Pine branches (exception: on Pine seeds).

B. Planting in rills. The rills are from one-fourth to three inches wide; made with a "rill board," a plank well seasoned to which mouldings are nailed. These mouldings may either be square or triangular in their cross sections.

The rills are from five to ten inches apart. Double rills are preferred, lately, in Germany. In order to economize in the use of fertilizer and in order to obtain a compact root system, trenches are sometimes made and filled with particularly fertile soil, at a distance apart equaling that of the rills. These trenches are made with a special "trench hoe," triangular in shape. The seed is put in the rill with the hand, with the help of a reduplicated playing card, a bottle of seed or, better, a stick 2″x4″ groved on one side and as long as the width of the bed, or, best of all, a hinged gutter into which the seeds are filled by "thimblefuls" or "spoonfuls," evenly distributed in the base of the gutter. The gutter is placed over the rill and opened by pressing the two sides together, when the seeds drop through the "slot." To insure even distribution of the seed in the gutter, small niches may be provided at short, equal intervals at the base of the gutter, the aggregate size of the cavities corresponding with the quantity of seeds to be planted in each rill.

Advantages of rill planting:

I. Economy in seed.

II. Stronger plants of more compact form grown at proper intervals apart.

III. Economy in manure.

IV. Seeds put at proper depth.

V. The foot of plantlet can be easily covered with moss or leaves.

VI. Weeding is made easy.

Unless very experienced help can be had, rill-planting is certainly preferable. Undoubtedly, however, insects, mice and moles following the rills do greater damage than in broadcast planting.

The quantity of seed per square foot of seed bed depends on the number of seeds in a pound; the germinating percentage; the quality of soil; the number of years which the seedling is meant to stay in the beds; rapidity of growth. Oak 2% of a quart; Beech and Chestnut, 4% of a quart; Locust, Ash, Maple, Elm, Birch, 30 grains; Alders, 45 grains; Fir, 150 grains; Yellow Pine, 15 grains; Spruce, 20 grains; Tamarack, 30 grains; avoirdupois—all per square foot.

The figures given are illustrations, not prescriptions.

Heavy seeds (nuts) are usually dibbled in, with a "dibbling board."

Paragraph XXXI. Transplanting in transplanting beds.

Transplanting is expensive. It must be done at a time when forestal labor is anyhow fully occupied. Transplanting is, therefore, resorted to only

A. In case of very expensive seeds or seedlings.

B. In case of very slow growing seedlings.

C. In case of plants exposed in the open to severe dangers (drought, frost, game, mice, insects, weeds).

To avoid transplanting, the following alternatives are used:

I. The offspring of very cheap seeds (German Spruce) is "singled out," weaklings or individuals standing crowdedly being pulled out by hand, or being cut out by scissors.

II. "Root pruning" is adopted which inforces a compact root system by cutting off, with a sharp spade, far-spreading roots, or long tap roots.

The transplanting distance is, at least, three by six inches and is governed by rapidity of growth expected and by the number of years which the transplant is to be left in the transplanting bed.

Transplants are set in clefts in the transplanting bed made with the help of a transplanting dagger, or are placed into trenches made with a hoe or spade.

Planting boards may be used, along which the seedlings, whilst pressed into equidistant slight grooves, are held in proper position by a string tightly spanned.

Transplants are often left for one year only in the transplanting bed, although the act of transplanting weakens the plant temporarily, thus checking the first year's growth in the transplanting bed. Conifers should not be transplanted more than once. Hardwoods are rarely transplanted more than once, excepting the Ash, saplings of which are used for planting hummocks.

Paragraph XXXII. Protection of nurseries.

A. Protection of nursery plants against drought: Lath covers, cloth covers, branches, cornstalks, top covering of slabs, laths, etc.;

cultivating rows of plants; watering which must be continued if once begun.

B. Protection of nursery plants against frost: Same measures as in "A" inclusive of watering; smoking fires; pressing seedlings lifted by frost back into the bed; no weeding from September on.

C. Protection against excessive rain (which washes the plants out, or splashes them with mud-pants, or incrusts the surface): Top dressing of leaves, moss or Pine branches; "combing" mud-pants off the seedlings; lath or brush covers.

Paragraph XXXIII. Nursing in nurseries.

A. Weeding: Weeding is facilitated in nurseries by a regular arrangement of the plants and by narrow beds. Tools are: knife, fork, hoe or special weeding wheels. Weeding should be stopped a month before frost comes in. The purpose of weeding is not only the removal of competitors; it is also aeration of the soil.

Weeding can be dispensed with in dense, broadcast seed beds; in thinly stocked beds planted broadcast it is most necessary and most difficult.

B. Cultivation: Cultivation in the transplanting beds of commercial nurseries (Beadle at Biltmore) is done by cultivators drawn by a horse. Cultivation in forest nurseries proper purports to break the crust forming under the influence of heavy rain fall. Usually the act of weeding cultivates the soil as well. Cultivation is most easily effected by drawing some strong nails driven into a stick along each rill. This cultivation, at the same time, disturbs and scares away mice, voles and insects.

C. Carpeting the intervals between rills or rows:

Reversed moss, spent tan, sawdust, straw, hay, twigs (always of another species), poles (never fresh cut pine poles, which are incubators to snout beetles) are often laid between the rills or rows so as to preserve moisture, to prevent mud-pants from forming on the stemlets and to check weeds. These carpets, however, harbor mice and insects. Large leaves in the carpet threaten to smother young seedlings if blown upon them.

D. Trimming. The top shoot when killed by early frost or drought might be cut off. In no other case must it be touched. The side branches of broad-leafed species and of winterbald conifers might be clipped before or after planting and transplanting so as to reestablish the previous equilibrium existing between water sucking power of the roots now checked by transplanting and water evaporation from the crownlets left unchecked by planting. Species having a heavy central pith column should not be trimmed too close to the stemlet (Ash, Catalpa, Maple). Ash and Catalpa are apt to form forks which may be prevented by timely trimming.

Large broad-leaved plants planted in furrows often die, when shaken loose by winds. They may be saved if cut to the ground previous to June 15th.

Paragraph XXXIV. Special nursery methods proclaimed by renowned sylviculturists.

A. Biermans' method.

Peel the soil cover of an area four times the size of the seed bed and burn the sods thus gotten into sod ashes. Leave them over winter. In spring, mix one-half of the sod ashes with the stirred up top dirt of the intended seed bed. Spread the other one-half pure on top of the bed. Smooth the surface of the bed and press it with a board. Spread seeds broadcast as close together as possible, so that the soil is hardly visible between the grains. Cover seeds with sod ashes sifted on top, and press the cover down with a board. Transplant the young germs in June. Shorten the taproot of Oaks by cutting with a sharp knife. Oak nurseries should be underlaid with impenetrable soil. Yellow Pine and Larch should be used in the open when one year old; all other species two to three years old.

This method yields very well rooted seedlings. The use of sod ashes is, perhaps not an essential feature of the method; fertilizer or manure might be taken instead. The striking point is the transplanting of germs in June.

B. Von Buttlar method: Von Buttlar wants to raise long roots, not compact roots, for use in sandy soil. The nursery is worked to a depth of three feet, the bottom soil being brought to the surface. Larch, Fir and Elm seed are planted broadcast; all other species in rills. No transplanting. All species are used one or two years old.

C. Manteuffel method. The plants required by Manteuffel must have short, flat roots. Consequently, the best soil in the nursery should be the top soil, and the ground underneath should not be worked to any depth.

Remove by peeling the top layer of the soil, and beat the dirt out of the peeled sods onto the seed beds. Mix it with the dirt of the underground in fall. In spring, burn the sods and other vegetable matter at hand on the beds, mixing the wood ashes thus obtained with the top soil. Spruce shall not be transplanted and is to be used when two years old. Fir and all broad-leafed species must be transplanted.

Paragraph XXXV. Raising and planting hardwood seedlings on open ground.

Beech: Usual age of plants fit for use, two to five years. Transplants rarely used. Ball plants very successful. Bunch planting best, especially for underplanting. Do not cut stemlet to the ground and avoid pruning. Planting in open hardly successful. Beech best for underplanting. Almost light demander on poor soil. Beech is exacting (good soil and moisture). Instruments used are hoe, spiral spade, cleft irons.

Black Locust: Seeds should be planted two to two and one-half inches deep, an exception from the rule considering the small size of the seed. Drills eight inches apart. Germinating percentage of seeds very high. Seedlings are fit for planting when one year old. Usually, however, they are left in the seed bed for two years, and are then planted directly in the open. The planting of stumps and fall planting are strongly recommended. Plantations handicapped by twigboring moth (Ecdytolopha species) and by voles. Locust grown in the open is inferior to forest grown Locust.

Linden: Is usually planted in the open as a transplant three to four years old, or as a ball plant two to three years old. Spring planting. Good soil required. Pruning of branches a necessity. Plantations in Biltmore made in '98 on splendid soil, but without cover overhead, were slow to develop.

Oaks: The nursery treatment differs greatly according to local likes and forestry authorities relied upon. The treatment of the tap root is a continuous point of dispute. Manteuffel cuts the tap root one and one-half inches below ground (just as the voles did in Biltmore nurseries). Buttlar ties a knot into the root. Alemann forbids any crippling of the tap root, making an extra cleft in the planting hole to receive the tap root. Levret prevents the development of a tap root by placing the acorns on small macadam, covering them with one inch of dirt. The ground underneath the macadam must be hard.

Large areas of Oak planted in Northern Germany with the tap root cut off prove the success of Manteuffel's method. The hollow borer cannot be used. Trimming of branches is all right. Roots should be pruned, after Fürst, with a sharp spade at six inches below ground in the second spring. Spring planting is best. Some planters remove the first germ of the acorn ("offgerming") with a view to stopping the development of the tap root—very costly. Stump plants do very well, especially in the coppice woods. Usually seedlings one and two years old are planted. The use of saplings, transplanted repeatedly, is not advisable. Cleft planting of seedlings on broomsedge fields at Biltmore proves unsuccessful; the weeds choking and the rabbits eating the seedlings. Cleft planting in cutover woodlands, however, on fairly loose soil is a method to be strongly endorsed. In France the clefts are made inclined, not vertical; saplings 20 years old do not show any crooks due to the method. Planting of seedlings or of young transplants in spade holes, in furrows or in clefts made between the lid and the pit formed by reversed sods prove successful at Biltmore. Young plants are not subject to lifting by frost nor do they suffer from drought. The nursery should not be worked deeper than one foot while the success of the final plantation largely depends on looseness of ground at a greater depth. Generally Red Oak is more vigorous in early youth than White Oak. At Biltmore, Chestnut Oak is the best species for abandoned fields.

Chestnut: Soil well worked to a depth of sixteen inches, kalium a necessity, lime disastrous. Seedling planting (plants one or two years old) forms the rule; planting of stumps is also good.

Since Chestnut is very sensitive under changed conditions of growth, ball planting is probably the best method. Seeds are kept in the burrs over winter, or in layers alternating with layers of dry sand. Immediate fall planting, however, is best. Nuts are planted in drills two inches deep two inches apart, the drills six to twelve inches apart. At Biltmore planting of seedlings has met with continuous failure. Planting under cover or under an usher growth is probably advisable. Chestnut is exacting, needing atmospheric as well as soil moisture.

Tree Alder: It is usually planted as a transplant three to five years old. Yearlings are too small; seedlings two years old can be ball planted. Trimming allowed. Seeds planted broadcast on the beds, one-fourth inch of dirt on top. Sprinkling necessary. No protection against atmosphere needed. On swampy ground, fall planting of transplants is best.

Birch: Seeds very poor; those of Black Birch mature in summer. Seeds must be covered very slightly or, better perhaps, must be beaten with a shovel into the nursery soil after broadcasting. Formation of crust over seeds is best prevented by a cover of Pine branches. Under lath screens, stems are apt to damp off in June. Seedlings are planted either as two year olds, with or without balls, or as transplanted stumps three to five years old.

Birch is sensitive to deep planting; is not affected by heat, frost or drought.

Ash: The easiest species among hardwoods to raise, plant and transplant. Planted as a seedling one year old or transplanted up to three times. Plants as old as eight years can be planted successfully without balls. Seed is placed in rills seven to twelve inches apart. Where soil is very weedy, large and strong transplants must be used. Planting in holes, on mounds or in furrows. The cleft spade is also permissible in planting yearlings. Trimming is not advisable, except to prevent formation of forks. Transplanting of germs, in June, is quite successful

Elm: Seeds to be planted in summer (excepting Slippery Elms), just after ripening, in rich nurseries, and to receive very light cover of sand. Seed beds must be sprinkled, and the formation of a crust must be prevented. Seedlings cannot penetrate a layer of one-half an inch of dirt. Usually, transplants three to five years old are used. Fall planting is preferred. Elms stand trimming easily.

Maple: Drills three-fourth inches deep, one inch wide, twelve inches apart. Transplanting takes place when seedlings are one or two years old. Seedlings grow rapidly. Fall planting is preferable. Planting in large holes is best, since Maple cannot form a compact root system. Sugar Maple planted at Biltmore on abandoned fields four years old did very well on North Slopes, in pure stands as well as mixed with White Pine. Maple is easily transplanted, and even yearlings or two year olds might be planted in the open on good soil. In swamps, Red and Soft Maple are preferable. Sugar Maple requires well drained soil.

Yellow Poplar: Very poor seeds, hence broadcast planting. Covering with spent sawdust, instead of dirt, seems advisable. Seedlings transplanted either as germs in first summer or when one year old. Very rapid growth in first and second year. Easily transplanted in holes on suitable soil. Seedlings can be taken in June and July from wood roads to the nurseries, with balls of dirt. Abandoned fields at Biltmore, planted with four year olds did poorly except in northern depressions. Strong soil needed. Compact soil not unfavorable.

Catalpa: The favorite Kansas prairie tree. Very high germinating percentage. Very fast growth in first year. Rills one inch by one inch by twelve inches. Seedling plants one year old are strong enough for planting. Stump plants are preferable. At

Biltmore the top shoot is often killed by frost; it should certainly be cut off after planting. Catalpa requires wheat soil in order to form proper bole, and does not answer in a cold climate. Spring planting in holes or furrows.

Walnuts: The planting of seedlings is only permissible where mice, squirrels and hogs are sure to get the nuts. Very long taps make planting difficult. Best soil needed. Small seedlings are choked out by weeds. Plants one to three years old to be used. Avoid pure plantations! Cover in the nurseries three inches—distance apart four to ten inches.

Hickory: To be treated like Walnut; during the first years, the stems remain very minute while a large tap-root forms. Voles follow along the rows of plants and cut off the roots at a point about one inch below ground. Loose, porous soil is needed.

Cherry: Planted in rills one-half inch deep and eight inches apart. Transplants two or three years old, transplanted when one year old are best for use in the open. Protection from rabbits peeling the stumps is required. Rapid growth in nurseries. Twig tips are usually killed by the first frost since the twigs grow during the whole summer and fall. Pruning required. Black Cherry does well on abandoned fields mixed with White Pine, Pine, Ash, Maple.

Sassafras: Planting of seed in nurseries at Biltmore has been an entire failure. The seeds lived through the first summer but did not begin to sprout. Deep cover required, since cotyledons are kept underground. The removal of the flesh enwrapping the seed (by malting, etc.), seems required before planting.

Paragraph XXXVI. Raising and planting softwood seedlings on open ground.

Yellow Pines: Seeds are covered two-fifths to three-fifths inches deep. Nursery soil to be pressed thoroughly before and after seed planting. Planting of yearlings (from 5,000 to 40,000 per acre) forms the rule. The roots of such yearlings are ten inches long. On sandy soil, cleft planting is universal (with planting dagger). On binding soil, ball plants one or two years old are best.

Recently some foresters began to use transplants two years old which more readily overcome the infantile diseases. No mound nor bunch planting. On very sandy soil Yellow Pines are planted deeper (up to first needles) than they stood in the nursery. A plantation ten years old should densly cover the ground.

Jack Pine (Pinus divaricata) does very well on the poorest sand. It is, however, handicapped by deer; very rapid growth. Pinus rigida crawls on the ground during the first and second year, putting up a strong stem thereafter. Pinus sylvestris (Scotch Pine) is the cheapest that can be planted and the most successful species at Axton. At Biltmore it does exceedingly well on dry south slopes.

White Pine: Quite different from Yellow Pine is the case with which it is transplanted. Seedlings one year old are very small and apt to suffer from leaves smothering them. Seedlings two years old have been planted at Biltmore on abandoned fields (in holes) very successfully. Transplants three and four years old are usually used. Owing to its greater shade bearing qualities White Pine may be used also for temporary underplanting. Seedlings suffer badly from fungi. White Pine is subject to damage from too-deep planting. At Axton, the best and strongest individuals form a second summer shoot, the buds of which are killed by early frost, so that no top shoot grows in the ensuing year. At Biltmore, the second shoot seems to be safe from frost.

Relative to other White Pines (flexilis, monticola, albicaulis, lambertiana, aristata) no information is available.

Spruce: Nursery rills one inch wide, five inches apart. Transplanting distance usually four by six inches. Slow growth at first. Smallest size that may be used are seedlings two years old. Ball planting best, bunch planting frequent in mountains. Transplants three to five years old are preferable. Plant in holes, never in clefts. Very sensitive to deep planting. Spring planting forms the rule except in high mountains. High atmospheric moisture is a prerequisite for Spruce. Do not trim. Number of plants per acre from 1,500 transplants to 10,000 seedlings. Picea excelsa might replace P. rubens (the former being cheaper), if the resistance to snow-breaks shown by rubens were equalled by excelsa. Plantations twelve years old should fully cover the ground.

Firs: Seed should be planted in fall. Rills close, say four inches; cover, one-half inch. Early growth very slow; lath screens very essential, owing to sensitiveness of youngsters to heat and cold. Transplants five years old are best. Planting on open ground is dangerous; underplanting is very advisable. Species most planted are Abies pectinata, balsamea, concolor.

Larch or Tamarack: The Western, European and Japanese Larch are scattering species, doing badly in pure stands. Growth in early youth is rapid. Seedlings two years old and transplants three years old are preferred for forest planting. The distance of the rills, and the transplanting distance must be comparatively wide.

Seedlings might be cleft planted; but hole planting forms the rule. Fall planting necessary. Larch permits of heavy trimming. Mulch seeds for one week before planting. European Larch does well at Biltmore and in the Adirondacks.

Hemlock: Grows very slowly in youth. Seedbeds require heavy sheltering (under cloth screens). Transplant the two year olds, and plant the five year olds under cover in the woods.

Douglas Fir: Seeds are still expensive; hence transplants four years old are usual, though seedlings two years old are certain of success. Hot-house treatment of seeds secures early and simultaneous sprouting. Plant seedlings in open ground, not under cover. Plantations made near London, England, lose the long top shoots by sea winds; at Axton, they suffer from frost; at Biltmore, the growth is strikingly poor, possibly due to the deficiency in atmospheric humidity. Plants 14 years old are hardly chest high; plants 11 years old, only knee high. In all cases the Washington variety is used. Varietas glauca, of Colorado, forms one summer shoot only, grows slowly, and is said to be more hardy.

Red Cedar: Juniperus virginiana: Seeds lie always dormant for one summer. Seedlings two years old are ready for planting. High lath screens in nurseries advisable (Green). Very slow growth. Shade bearing.

Lawson's Cypress: Stands intense shade, resists frosts, suffers from fungi; is well adapted to underplanting.

Paragraph XXXVII. Results of planting experiments with American hardwoods.

For many years, the governmental forestry bureaus of the German Empire have been examining into the merits of some leading American tree species.

Locust and White Pine have been planted so extensively that they are considered to be "naturalized forest citizens."

In a number of instances, the European views fail to tally with the results of American investigations made with reference to the sylvics of our leading species.

A. Fraxinus americana: requirements as in excelsa; stands inundation better—even long ones!

Germination in first spring; no overlying.

Plant seeds in fall, or else in early spring after three days soaking. One year old, one foot high.

Use transplants two or three years old.

Root is a tap-root with many side roots.

Mayr does not advocate its propagation anywhere in Germany.

B. Catalpa speciosa: suffers badly from short summers, often freezing down to ground. Hence frequently spreading growth.

Seeds of high germinating percentage.

Use either seedlings or transplants two years old.

Light demanding, but fond of side shade.

Mice peel at point of differentiation; all game aie fond of Catalpa.

C. Juglans nigra: mild, fresh soil required, and long warm summers.

When one year old, strong tap-roots over one foot long; root fibres at end of tap-root tip.

When two years old, the tap-root is over two and one-quarter feet long.

Height growth: 5 years old, 5 feet.
10 years old, 13 feet.
20 years old, 35 feet.

Decidely light demanding; fond of side shade in early youth.

Yellow Pine shelter wood is very good: More shade prevents lignification. In close stands, it is free from branches.

Nuts sprouting late (being dried out) cause shoots to be killed by early frost: Hence pregermination advisable.

Frost hard in sapling stage.

No game or mice enemies.

Plant nuts or yearlings on well-plowed ground, and cultivate. Plant close together, so as to avoid branchiness. Prune lignified branches only, owing to heavy pith column.

D. Prunus serotina: Modest, provided soil is moist.

Light demanding, but does well under slight Pine cover.

Roots many tapped, strong.

Height growth better than that of any European hardwood, save Ash.

5 years old, 6 feet high.
10 years old, 13 feet high.
15 years old, 22 feet high.

Proof against all effects of frost!!!

Rabbits cut and peel (also mice) young plants.

Seed-beds: plant in fall, to avoid lying over, or else soak in water for three days previous to planting in spring.

Use transplants three years old; plant close, to avoid side branches.

E. Acer saccharum: Fresh, sandy loam, or fresh sand; forming stool-shoots on dry soil, and no stem.

Growth quick; light demanding; strong root system.

Forms forks frequently 15 feet above ground.

Height 35 feet, when 20 years old.

Most frost hard of any Maple species. Game and rabbits despise it.

Seeds mature in June, and can be planted at once, but are just as well preserved and planted in spring.

Use seedlings two years old, or transplants, four years old.

F. Acer negundo: Requires strong soil; does not do on dry soil. Growth very quick to start with—up to 6 feet in 2 years, in 20 years 50 feet.

Development of low, branchy crown.

Light demanding, frost proof.

Use seedlings one year old.

Damaged by game and rabbits.

G. Acer saccharinum: Requires strong soil; not clay.

Growth slower than in other Maples, up to fifth year, 20 years old 35 feet high.

Apt to form forks.

Sensitive against frost and drought; requires shade; does best when used for underplanting.

Use transplanted small saplings.

Never plant on open ground!!!

Mayr recommends it only for sugar orchards—not for timber production.

H. Betula lenta: Avoids wet frost dells and poor dry soil; forms tap-root on sand and flat-root on clay.

Height in 5 years 5 feet; in 20 years 36 feet.

Growth bushy to start with, but soon straight, erect and free from branches.

Decidedly light demanding, but fond of side shade.

No more frost-proof than Beech. Late and early frost damages it, especially on wet clay.

Game, rabbits and mice are very dangerous.

Seed-bed should not be dug over.—Peel off the top cover of grass and weeds on humose sand; hoe the soil and then use roller. Plant broadcast, one pound for two square poles; cover by sifting one-twenty-fifth inch of sand on the seeds and roll again with roller; keep Pine branches on the seed-bed until after germination.

Use tall transplants for planting in the open, owing to animal dangers.

Red Birch is said to do well planted with Pine on abandoned fields, further united with natural regeneration of Beech.

I. Hicoria ovata: All Hickories require strong, deep, fresh soil. Not on clay.

Pignut is satisfied with more sand.

Mockernut is satisfied with more clay.

Butternut requires water, more than the others, and stands inundation.

All Hickories require hot summers but stand severe winters; hence continental climate is preferable to sea climate.

Tap-root of yearling one foot long; of two year old plant one and three-quarter feet; hence transplanting after two years very difficult.

Height growth begins to set in from sixth year, and is good then.

Age 5 years, average height 2.4 feet.
Age 10 years, average height 7 feet.
Age 15 years, average height 13 feet.
Age 20 years, average height 20 feet.

Buds open late but shoot is quickly made.

Nuts germinate slowly; hence malting or better repeated sprinkling with liquid manure advisable; many nuts lie over, even for two years. Nuts thoroughly dried lose germinating power.

Malting or "pregermination" advisable.

In the case of Hickory and Walnut, the following recipe for pregermination is given:

"Make a ditch three feet deep and wide; put nuts in the ditch to a depth of one foot; fill ditch with water up to top of nuts; then add a slight cover of straw; then dirt; then horse manure.

"In this ditch the nuts are kept until planting time, when the nuts will germinate a few weeks after planting (in May)."

Plant seedlings one or two years old, or else nuts, on plowed ground. Cultivating advisable.

Late frost is avoided by the late formation of shoots. Early frosts are bad, if seedlings did not have time to lignify owing to late germination.

Avoid planting on open ground; shade is born readily for a number of years!! Straggling plantations often develop after natural or artificial reinforcing with other species.

Young plants suffer from mice. Damaged seedlings should be coppiced down.

J. Hicoria minima: Height growth quicker to begin with than in Shagbark.

At 20 years, however, Shagbark catches up.

Wood much poorer than in Shagbark (more brittle).

K. Hicoria glabra: Like Shagbark; more modest as to soil; more sensitive as to frost (?).

L. Hicoria alba: More sensitive than Shagbark; same rate of growth; does well in the Westerwald, badly in river valleys.

Paragraph XXXVIII. Results of planting experiments with American softwoods.

A. Pinus divaricata: Very modest: Stands frost and drought and does not shed needles.

Root system tap-rooted, many fibred.

Height growth very rapid, several shoots per summer. Better than Scotch Pine.

2 years old, 8 inches high.

5 years old, 5 feet high.

8 years old, 10 feet high.

Game and hares handicap it, still there is strong reproductive power.

Seed one-half pound per square pole; seed has 60% germination; cones fertile from sixth year on.

Use yearlings or transplants two to three years old for the very poorest soil.

B. Pinus ponderosa: Fails absolutely in Germany, probably owing to insufficient summer heat.

C. Pinus rigida: Very modest; does well in salty swamps; suffers badly from snow-pressure.

When 5 years old, 7 feet high.

When 20 years old, 32 feet high.

Growth is very rapid, but from 12 years on P. sylvestris catches up and then keeps ahead.

Diameter growth better than in sylvestris, too.

Strong reproductive power after insects, game, fire.

Very light demanding.

Cones seed-bearing from twelfth year on.

More proof against late frost, more sensitive for early frost than sylvestris.

Less shedding of needles; more danger from game.

Use yearlings, or transplants two years old.

D. Picea engelmanni: likes strong but not wet soil—it is winter frost hard; but suffers slightly from late frosts.

Root system deep, many fibred; not flat.

Dislikes top shade.

Yearling only one to two inches high; two years old four inches high; five years old one foot high.

Height growth always slow, hence easily outgrown, and pure stands required.

Use transplants, five years old.

E. Picea parrayana: Very frost proof, more so than any other Spruce!

Stands wet soil: not exacting.

No top shade.

Root system compact, fine fibred.

Slow early growth, as in Engelmann's Spruce.

Plantations 10 years old average one and three-quarter feet only in height.

Animal proof.

F. Picea sitchensis: Requires moist soil and moist air.

Heat requirements as in P. excelsa.

Soil requirements less than in P. excelsa, growing both on sand and on clay. Not in stagnating moisture, but stands inundation well.

Does well on seashore and on higher altitudes.

Height growth at first very slow; from fifth year on better than in excelsa.

Short branches, slowly dropped; close stand required, fond of forking.

No head shade! Side shade welcome but not required.

Frost and drought only dangerous during first and second year.

Game does not bother it.

Seed-beds of mild, rich soil to strengthen weak seedlings.

Use strong transplants, five years old.

G. Abies amabilis: Plants five years old are still very sensitive against direct insolation and subject to late frosts.

Rate of growth as in A. pectinata.

H. Abies concolor: Spring shoots formed late; resists frost and any other climatic attacks well!

Not exacting as to soil, doing well on Scotch Pine soil of second quality, provided that it be fresh.

Tap-root formed in second year.

Height growth in early youth better than in any other Fir: plants eight years old have average height of three feet.

On good soil even Spruce is outgrown by it.

Wood light (spec. grav. 0.35)!!

Seedlings two years old are fit for planting.

Sensitive against being planted too deep.

Seed-bed treatment as in A. pectinata.

I. Abies grandis: Treatment as in pectinata, which it exceeds in height growth. Soil requirements are the same.

J. Abies nobilis: Frost firm in winter, even unprotected. Late spring shoots help it to escape late frosts.

Stands dry soil; from fifth year on, more light demanding. Forms strong tap-root, and sometimes several branch whirls per annum. Plantation seven years old is three and one-half feet high.

Plant seedlings two years old, or transplants four years old.

K. Pseudotsuga taxifolia: Suitable to any climate, frost proof.

Soil should not be poorer than third-class Pine soil; no dunes; no swamps.

Root tap-root on loose soil, flat on shallow soil or binding soil, showing great adaptibility.

Height growth marvelous!

Age 5 years height 1.7 feet.

Age 10 years height 12 feet.

Age 15 years height 29 feet.

Age 20 years height 45 feet.

Age 23 years height 53 feet.

Diameter, 23 years old, from three inches to ten inches, average seven inches; number of trees per acre 350.

Close stand required to clear from branches.

Light and heat demands as in Picea excelsa.

Snow and sleet throw it over, or break top shoot, the latter loss being quickly replaced by side shoot taking lead.

Game is a very bad enemy.

Use transplants three to four years old.

L. Chamaecyparis lawsoniana: Does splendidly in Germany especially in the Eifel Mountains at 1,500 feet elevation.

Frost-proof; but sensitive in drought.

Exacting like Beech, fond of limestone.

Flat-rooted; suffers from snow.

Shade bearing in early youth; fond of half shade later on; always fond of side shade.

Slow in clearing itself from side branches; forms very close stands.

Very slow growth to start with; one year one inch high; two years four inches high; ten years eight inches high.

Plant seed-beds broadcast. Cover completely. Use transplants four to five years old. Sensitive for too deep planting.

Game are very bad; wood mice peel the stump, or cut the roots.

Less sensitive in late frost because late sprouting; more so in winter frost.

M. Juniperus virginiana: Avoid poor or wet soil.

Seeds lie over, always; seedlings one to two years old are very small and tender. Side shade always liked. Suffering from weeds and grass. Red deer and Roe deer bite and beat it.

Seeds kept in ditches over summer are planted in fall.

Use yearlings and hole planting.

N. Thuja plicata: Desires good, fresh soil.

No swampiness! No dryness!

Top shade or side shade is well liked; do not plant in open ground.

Deep root system.

Height growth slow to begin with, rapid from seventh year on:

Age 1 year; height 1 inch.

Age 5 years; height 4½ feet.

Age 10 years; height 8 feet.

Age 15 years; height 15 feet.

Age 20 years; height 23 feet.

Slow cleaning of bole; very dense thickets required.

Seed bearing from fifteenth year on.

Sensitive for frosts and drought during first years.

Game does not attack it; mice destroy young seedlings.

Seeds are planted broadcast; slightly covered with dirt; sheltered by lath screens.

Strong seedlings three years old (not transplants) are used since the root system is comparatively small, whilst the stem system is comparatively large.

O. Tsuga heterophylla: Requires strong soil; demands side shade, but hates top shade. Cannot stand open situations.

Root is a strong tap-root.

Height growth good from third year on.

Top-shoot-tips are frequently killed by first frost, without any apparent permanent damage!

Use seedlings three years old, raised by broadcast sowing.

Shelter seed-beds well! Sensitive against deep planting.

Mayr prefers heterophylla to canadensis for planting in Germany.

Paragraph XXXIX. Difficulties of natural seed regeneration.

American foresters frequently make the statement that the axe is the best sylvicultural tool inasmuch as its proper use secures a good regeneration free of charge. This statement is misleading. It is true that the density of the stand of the second growth obtainable from natural regeneration is frequently better than that obtained from artificial planting. On the other hand, such a stand can only be obtained under favorable conditions and at a great increase of logging expenses. While the cash expense of natural reseeding might be slight, the actual expense consisting in lessened receipts frequently exceeds the expense of artificial planting. In the primeval woods additional difficulties of seed regeneration lie in the following points:

A. Overaged trees have poor seeds.

B. Interference with the leaf canopy overhead at once invites danger from fire, increased by the debris on the ground, and by the impossibility of battling against fires in the underbrush.

C. In the primeval forest, the age classes are usually mixed in an irregular manner; hence uniform measures for reproduction are out of the question. The forester cannot generalize; he must individualize—a very expensive procedure in the face of low stumpage values.

D. The virgin forest usually contains a mixture of species; the best ones only are removable; the weeds and worthless species are left on the ground; and from this fact arise additional difficulties to propagate the most valuable kinds. To this must be added the difficulty of properly gauging light and shade according to the individualities of the species mixed.

E. In America the lack of a permanent system of transportation necessitates the operations to extend at one stroke over large areas, whilst natural seed regeneration requires the gradual removal of mother trees, in imitation of nature's own way of proceeding, on small and restricted areas only.

As a matter of fact, the lack of permanent means of transportation in primeval woods is the most serious obstacle to regeneration from self-sown seed conscious of its aim and its effect.

F. Natural seed regeneration requires cutting, according to the occurence of seed years and according to the development and requirements of young growth. Hence the axe must be independent from the fluctuations of market or mill requirements, an impossibility in the United States at the present time.

The term "natural seed regeneration" does not preclude artificial help to increase the chances of regeneration. The term merely implies "seeding," or scattering of seed, in the main unaided by man. Man, however, may carefully prepare the seed-bed, by plowing or hoeing or digging, or may carefully press the seeds naturally fallen into contact with the soil; and may protect the seed and the seedlings, at great pains, against external dangers.

Little help is given, where soil and stumpage are, and promise to remain, of small value.

Under the reversed conditions, the expense incurred for natural regeneration often exceeds that required for artificial regeneration.

In innumerable cases, natural and artificial regeneration are locally and irregularly combined.

It might be asserted, that the forest has secured its own regeneration through many millenia, and that it will continue to do so unaided by human activity. Why then, it might be asked, is it necessary or advisable to now offer costly assistance in order to secure natural reseeding of and in a lumbered tract of woodland?

There cannot be any doubt that nature, barring bad conflagrations or heavy pasturage, will start and develop after lumbering some kind of a second growth of forest. As a matter of fact, it is usually at hand, previous to lumbering, in an embryonic or incomplete state waiting for the chance to shoot ahead after the removal of the older trees. This ready nucleus, however, consists as a rule of inferior or worthless species; of specimens crippled by fire, by the fall (accidental or otherwise) of nearby trees, by the logger's axe or foot, by teams and loads passing by, etc. In addition, many members of that nucleus will die when suddenly bereaved of the shelter (against drought, cold, hail, etc.), previously exercised by the old trees now removed.

It must be remembered that a crop of weeds usually follows in the field after the harvest of valuable wheat; in the forest after the harvest of valuable timber.

Such "weeds" are unable to secure for the owner of the land a sufficient rate of interest on the value of the soil and an adequate reimbursement of the taxes due on the soil.

Another moment worthy of attention lies in the poor chances which a grain of seed stands, in nature's economy, to develop into a seedling, sapling, pole and tree. The probability is that only one grain of seed—out of millions of grains—produced by an individual tree during its lifetime succeeds in reaching tree size, replacing it progenitor on the forest floor. The ecologic incidents bringing about this result are far from being clearly understood. Still, it must be the sylviculturist's aim to provide for these incidents, if he desires to replace the old crop, removed at an unnatural rate of rapidity, at an equally fast rate by an offspring resulting from self-sown seed.

If the forester were satisfied to merely remove nature's moribunds, then he might get along with a purely natural regeneration, entirely unaided by human skill.

As soon, however, as his axe creates in the forest an unnatural death rate, the forester is compelled to also secure, by intelligent means, a supernatural rate of birth.

Human aid to natural regeneration should be denied where:

a. The danger from forest fire is such as to render investments in second growth very unsafe.

b. An outlay incurred for protection from fire is not apt to be refunded with interest by the value of the second growth.

That much aid and that much money should be, in all other cases, spent for the purpose of regeneration as promises, in the owner's mind and according to the forester's forecast, the highest relative revenue on the investments made.

At Biltmore, 10% of the annual gross receipts are annually reinvested, to be applied to natural regeneration of the forest.

Sylviculture and finance are continuously at loggerheads. From the business standpoint, however, that Sylviculture is certainly best which proves lastingly most remunerative.

Where and as long as the prospective value of seedlings is small, only a small expense can be reasonably incurred on behalf of their propogation.

Again, seedlings are more endangered by fire than trees. Where, and as long as the danger from fire prevails in the forests of the United States, investments made for raising seedlings are so risky as to be inadvisable.

Paragraph XL. Age of trees fit for natural seed regeneration (Enesar).

The age of perfect puberty depends on species, density of stand, quality of soil and climatic conditions. Generally speaking, it lies about the eightieth year of the trees.

Birch, Alder, Larch and Yellow Pines may be seed-regenerated from their twenty-fifth to thirtieth year on; Oaks, Beeches and Firs from their sixtieth to eightieth year on. Trees of very old age, say over 200 years old, have poor seeds and often defy natural regeneration if occurring in pure, even-aged stands.

Paragraph XLI. Methods of natural seed regeneration (Enesar).

A fixed method is applicable in the arts only where a fixed type of conditions exists. Fixed types rarely exist in primeval woods. Hence the impossibility, from a sylvicultural standpoint, to adopt any fixed European method of seed regeneration for direct application in American practice. A second growth, obviously, presents a more fixed set of conditions (it certainly lacks everywhere the hypermature age classes) than a primeval growth; and, consequently, it allows of a more methodical treatment. In Biltmore Forest methodical treatment is, therefore, permissible; in Pisgah Forest it is not or not yet indicated.

The types of seed regeneration might be considered:

A. According to the relative position of old and new growth:

I. The young growth develops underneath the old growth:

a. Whilst the old growth is left intact (natural seed regeneration by advance growth), or

b. Whilst the old growth is gradually reduced (natural seed regeneration under shelter woods).

II. The young growth develops at the side of the old growth (natural seed regeneration from adjoining timber).

B. According to the size of the units of regeneration, which may be:

I. Compartments, i. e., a cove, a slope, a top or a coherent part thereof, comprising from ten to one hundred acres.

II. Strips, i. e., figures of a more or less rectangular form, in which the length is a multiple of the breadth, the latter not exceeding 500 feet.

III. Groups, i. e., aggregates of growth of a more or less circular form, covering 0.1 to 3 acres.

IV. Patches, i. e., areas covered by the crown of an individual tree, about one one-hundreths of an acre in extent.

The figures given are meant to illustrate, and are not meant to define (in this paragraph as well as in the following fifteen paragraphs).

C. According to the degree in which the soil and the youngest seedlings are directly exposed to the sky:

I. Regeneration without exposure—by advance growth.

II. Regeneration with short, slight, partial exposure—under shelterwood.

III. Regeneration with entire, heavy exposure—from adjoining timber.

D. According to the timing of lumbering and of reseeding:

I. Lumbering precedes reseeding—natural seed regeneration on clearings, namely:

a. On uniformly cleared compartments (cleared compartment type);

b. On cleared strips (cleared strip type);

c. On cleared groups (cleared group type);

d. On cleared selected patches (cleared selection type).

II. Lumbering coincides with reseeding—natural seed regeneration under shelterwood, namely:

a. On uniformly sheltered compartments (shelterwood compartment type);

b. On sheltered strips (shelterwood strip type);

c. On sheltered groups (sheltered group type);

d. On sheltered selected patches (shelterwood selection type).

III. Lumbering follows reseeding—natural seed regeneration by advance growth, namely:

a. With uniform advance growth all over a compartment (advance growth compartment type);

b. With advance growth in strips (advance growth strip type);

c. With advance growth in groups (advance growth group type);

d. With advance growth in selected patches (advance growth selection type).

E. According to the participation of ligneous weeds (bushes, seedlings, saplings, poles and trees of a negative value) in the regeneration:

Totally successful seed regeneration;

Groupwise successful seed regeneration;

Patchwise successful seed regeneration;

Individually successful seed regeneration;

Unsuccessful seed regeneration.

In America, it will be frequently advisable for the forester to merely work toward a "groupwise" or "patchwise" successful seed regeneration.

F. According to the number and according to the distribution of standards left in the regeneration "area": Natural seed regeneration

a. With standards systematically left all over the compartments;

b. With standards left in strips;

c. With standards left in groups;

d. With isolated scattering standards.

The "compartment' types had better be called "uniform" types; the "selection" types had better be termed "patch" types.

Still the terms "shelterwood compartment system" and "shelterwood selection system" having become standard terms of forestal terminology, it seems unwise to throw them aside.

A number of "pure types" may be, and usually are, combined into "bastard forms." Of course, only types more closely related allow of bastardizing.

Bastard forms frequently found in the old country are:

"Advance growth selection" and "shelterwood group" type;

"Advance growth group" and "shelterwood compartment" type;

"Shelterwood group" and "shelterwood strip" type;

"Cleared strip" and "advance growth strip" type;

"Cleared group" and "shelterwood group" type;

"Cleared selection" and "shelterwood group" type.

Modern forestry abroad begins to despise methodical rules, gradually returning to nature with her irregularities. Pure, abstract types of seed regeneration are more and more discarded.

The selection of a method or a combination of methods depends entirely upon the composition of the growing stock found; on local dangers; on local means of transportation; on value of stumpage and prospective value of seedlings.

Where all age classes are mixed irregularly, individual selection is, ceteris paribus, indicated.

Where the age classes or the species appear in groups, the group method is or may be advisable.

In woods simultaneously maturing, the uniform type may recommend itself.

The following paragraphs are arranged to conform with the view point given under "D."

Paragraph XLII. Types in which lumbering precedes N. S. R.

Where lumbering precedes regeneration, the area lumbered must be reseeded from the borders of adjoining woods. With increasing size of the area cleared of timber, the rapidity, the certainty and the quality of regeneration rapidly decrease. The fact that such regeneration is possible on a large scale, is readily proven by object lessons in the primeval woods (Long Leaf Pine; Bald Cypress; Lodgepole Pine; Douglass Fir) as well as in second-growth forests (White Pine in Lake States; Yellow Pine in the south; Spruce in the Karpathian Mountains).

The chances for success depend on:

A. The species, which must have light or winged seeds readily carried about by the wind (many Pines, Spruces, Larches, Cottonwoods, Birches, Yellow Poplar), and which must not require, during their earliest stages of development, the presence of a shelterwood overhead.

B. The coincidence of the compass direction in which the clearing lies from the adjoining woods, with the direction of the wind preferably opening the cones and carrying the seed.

C. The local danger from storm which might tear down, gradually at least, the adjoining seed trees.

D. The condition of the cleared soil and its quality as a ready seed-bed, influenced by the presence of weeds; by the decomposition of the humus; by the degree in which the mineral soil has been laid bare in the course of logging operations; by the grade of the slope.

E. Fires favorable or unfavorable; pasture favorable or unfavorable to regeneration, as the case may be.

F. The frequency of seed years, and the possibility of lumbering during a seed year.

G. The size, the form and the environments of the area cut over.

H. The possibility of preventing undesirable species (Gums, Black Jack Oak) and undesirable specimens, like low-branched weed trees and spreading "wolves," from occupying the area to be regenerated, and the possibility of regenerating all, a few, or only one species.

According to the size of the clearing, we distinguish between:

The cleared compartment type (large areas cleared);

The cleared strip type (narrow belts cleared);

The cleared group type (fair sized groups cleared away);

The cleared selection type (small bunches of trees or merely single trees cut).

Paragraph XLIII. The cleared compartment type.

A. The area bared at one stroke by lumbering comprises between, say, ten and one hundred acres. If the width of the clearing is less than 500 feet, the "cleared strip" type is reached. If the acreage cleared is much in excess of 100 acres, the development of a second growth is very slow, very poor, very doubtful, so that the character of a sylvicultural type is lost. A number (say five) of seed years are required to restock the ground. The bordering woods, from which reseeding is expected, must not offer an unprotected front to the prevailing storm direction.

The regeneration obtained is, naturally, very heterogeneous and contains a great deal of misshapen advance growth as well as of weed growth.

Weeds trees left on the ground might be girdled if belonging to an undesirable species (Beech in Galizia).

A few seed trees might be left scatteringly (if wind firm) in groups or in strips, preferably close to the roads, often consisting of doty specimens without any value.

An usher growth of Cottonwoods, Birches, Sumac, Locust, Sassafras, etc., frequently precedes the second growth desired on the ground.

Fires preceding the seeding, and immediately in the wake of logging, greatly enhance the success of Yellow Pines, Douglas Fir, etc. Yellow Poplar, on the other hand, is checked by the heavy growth of weeds following fires. Stock pasture is of advantage, where it presses the seeds into the soil, and where it checks the weeds.

The clearing should comprise, if possible, only one side of a cove at a time or the lower part of a slope or the bottom of a cove, so as to allow of greater ease in reseeding.

B. Actual application: This type has been adopted,—not confessedly but actually—by the Austrian Government in dealing with the primeval woods of Galizia, consisting of Beech, Fir and Spruce.

The Bureau of Forestry has tried to adopt it, in modified form, for the Minnesota National Forest Reserve and for the majority of its business-working plans (Sawyer and Austin; Weyerhäuser).

Thousands of acres of abandoned farm land all over the Eastern States have been reforested in this manner, frequently against the owner's will.

C. Advantages: The cleared compartment type shows the following advantages:

I. Greatest ease in lumbering.

II. Concentrated operations and concentrated supervision.

III. Few permanent main links of transportation required.

IV. Smallest deviation from the old-time manner of destructive lumbering.

V. Possibility of temporary use of the clearing for the production of field crops benefited by the fertilizing effect of the humus.

VI. Ease of artificial reinforcing and possibility of soil preparation by plowing and by firing; of covering the seeds by pasturage.

D. Disadvantages:

I. Applicability to few species only.

II. Danger of partial or complete failure, especially in clearings covering 100 or more acres, or in case of border trees unfavorably situated.

III. Danger from heavy fires where the soil and the humus is baked by the action of the sun, with heaps of debris left on the ground after wholesale logging.

IV. Second growth consists largely of wolves, and of spreading advance growth and of poles undesirably ramified. Expensive girdling or cutting of seed-bearing weed trees, belonging to a worthless species.

V. The running expenses for protection from fire and for taxes are, to a degree, independent from the quality of the young growth. They are relatively high, and hence absurdly unbearable, if that growth is poor, straggling and very slow to develop, all of which is apt to be the case in this type of seed regeneration.

Thirty years after clearing, the average age of the young growth is not apt to exceed ten years.

VI. Groups of advance growth are almost sure to be destroyed or to be crippled by logging and by sudden change of environments.

Paragraph XLIV. The cleared strip type.

A. The width of the cleared strip is from two to five times the length of the mother tree. When one belt is seeded successfully, another strip is cut into the timber alongside the first belt, and so on.

Soil work is not required, provided the strip is cleared in a seed year. Usually the soil is torn up sufficiently by the removal of a large number of logs snaked or rolled or shot along the strip and over the strip to the nearest road.

One seed year is rarely enough to secure full regeneration of a strip. In the Alps, Pine regeneration takes from twelve to thirty years. On hardwood soil, the weeds are to be dreaded, preeminently so on fertile ground after fires.

It is wise to leave a few wind-firm mother trees scattered over the strip, notably immature specimens of the most desirable species. Less desirable species on the nearby border might be girdled or removed by extending the removal of that species into the bordering forest. In addition, valuable hypermature trees might be withdrawn from the nearby forest.

The cleared strip type does not require a permanent system of transportation of great intricacy, the strips themselves forming the main lines of transportation. The narrow edge of the strip merely is touched, on the valley side, by a road. According to the grade of the strip, sleighs, cables, chutes, donkey engines, etc., might be used to deliver the logs to the road.

At the beginning of operations, the first strip should be made in sheltered localities so as to allow the forest adjoining leewards to remain unharmed by storm.

The strips proceed windwards gradually, the next being cleared when regeneration in the preceding strip is fully secured.

The danger from insects and fungi is small. The danger from fire, to begin with, is great, although not as great as in large clearings to which the wind and sun are freely admitted. Later on the even-aged character of the strip will help to check fires.

Nothing prevents the owner from reinforcing the strip artificially if he thinks fit. Healthy groups of advance growth, formed by desirable species in the belt at the time of logging, might be carefully husbanded. Natural regeneration will set in as well at the side of the belt underneath the bordering mother trees. "Regeneration runs into the old woods." This is a very desirable state of affairs allowing, in the next belts, regeneration to start in advance of cutting. (Bastardizing the cleared strip type with the advance growth strip type.)

B. Actual application: This type of regeneration is locally used in the Tyrolian and Austrian Alps, for Spruce, Larch, Pine. The form of the strips need not be rectangular. It depends on maturity of growth, configuration of soil, danger from storm. The type seems well adapted to present American conditions, requiring, of course, local modifications or bastardations, governed by species and market. Its applicability, however, rests on the existence of some permanent chief arteries of transportation.

At Biltmore, the type is applied, in modified form, for the reproduction of Yellow Poplar and Yellow Pine.

C. Advantages of the cleared strip type:

I. Applicability to many species, to many conditions and to many localities.

II. Concentration of logging operations and of sylvicultural help possible. Cheap logging by donkey engines, chutes, snaking, etc.

III. Many points of attack, at which the season's cut might be obtained, are at the disposal of the forester, if he so desires. Hence great freedom of action.

IV. Comparative safety of the old woods from storm; of the young growth from fire, drought, frost, insects, etc.

D. Disadvantages of the cleared strip type:

I. If the seeding of the strip is not effected soon after clearing, the soil is baked by the sun, weeds are started and the ecological conditions are affected in a manner barring the success of seed regeneration and necessitating artificial help.

II. Border trees are exposed to sun scald.

III. Deer frequent the strips and spoil the young growth.

IV. The soil of the strip—especially of the first strip in a series—is rarely "in heat," certainly not over the entire strip, so that the seeds falling upon it have a poor chance of success. This is the case, preeminently, in the humid mountains where a heavy layer of raw humus covers the ground. A large number of years will often elapse, before the next adjoining strip can be taken in hand.

V. The strips should be cut where the timber is most mature at the time,—and not in a succession merely dependent on the condition of the young growth and on the necessity of proceeding against the prevailing storm direction.

Paragraph XLV. The cleared group type.

A. The groups cut comprise from 0.1 acre to three acres. The form is roundish, oval, square, etc., as the case may be, usually coinciding with a geological feature, f. i., a dell, a spur, a spring-head.

The incentive for group-cutting lies either in the simultaneous maturity of the trees stocking on it, or in the desire to obtain conditions particularly favorable to the reproduction of one of the species appearing in the old timber; or the group, previously stocked with an undesirable species, is to be seeded by a better kind.

B. Actual application: This type has never played an important role in connection with natural seed regeneration. Sylviculturally it seems well adapted to Yellow Poplar, Long Leaf Pine, Lodgepole Pine, White Pine, also to Hickory and Oak.

Where the groups run in the shape of long tongues, parallel at regular intervals, they are termed "coulisses." The coulisses are usually meant for the regeneration of more light-demanding species; the "benches" separating the coulisses for the regeneration of more shade-bearing species.

In Germany, the space formerly occupied by a cleared group is termed a "hole." Where the groups, after reseeding, are gradually enlarged, the cleared group-type is bastardized with the shelterwood group type.

C. Advantages: The soil of the group, thanks to a sufficient amount of side shade, retains its freshness and porosity. It is sheltered from severe winds and severe heat. Species too sensitive for reproduction in larger clearings or strips can be raised in groups. Where the age classes appear in bunches, each bunch can be harvested at its proper age of maturity. No harm or little harm is done to young growth during the logging season.

D. Disadvantages:

I. Operations are scattering.

II. Intricate system of permanent roads required.

III. Groups surrounded by tall timber frequently act as "frost-holes" where young growth suffers badly from early frosts and late frosts in clear nights.

IV. Thin barked trees surrounding the group suffer from sun scald; flat-rooted trees suffer from storm.

Paragraph XLVI. The cleared selection type.

A. In this type, individual trees considered mature are selected for removal, either absolutely singly, or in very small patches formed by neighboring trees.

The clearings made are so small that only shade-bearing species will regenerate thereon, unless the soil be particularly strong.

The cut is so scattering, that the soil is not sufficiently "plowed" by the loggers. Hence it will not act as a ready seed-bed.

In mixed woods composed of many species, only the most valuable kind is usually withdrawn, and the small gaps made are occupied by shade-bearing and often less valuable species.

Beneath hypermature trees, the soil has frequently hardened and defies any attempt of seedlings to establish themselves after logging.

The cleared selection type is almost invariably bastardized with the shelterwood selection type and with the advance growth selection type.

B. Actual application:

In the tropics, Teak, Mahogany, Ebony, etc., are cut by selection, frequently regardless of the effect which logging will have on regeneration.

In Europe, the type is found in the Fir forests owned by farmers; in parks; in protective forests at the headwaters of rivers; on very steep slopes dotted with Larch, in the Tyrol.

In America, Yellow Poplar, Walnut, Cherry, White Oak, etc., are cut by way of individual selection,—but with no regard to reproduction. Also White Pine in the Spruce and Fir woods of the Adirondacks where it never succeeds, withdrawn alone, to reproduce its kind.

C. Advantages:

I. The water-storing power of the soil is generally well preserved under this type.

II. The second growth is never endangered by snow or drought or frost or sleet; the old trees remaining do not suffer from storm or sun scald.

III. Small wood lots may yield a steady annual supply of timber or wood under this type.

IV. The type is well adapted to deer parks.

D. Disadvantages:

I. The operations are very scattering. Indeed, they cover continuously the entire forest or a large percentage thereof. Difficulty of supervision.

II. An intricate system of permanent roads is required, since the axe returns every few years to the same compartment. If the intervals of years are long—say from ten to twenty years—the type is bastardized with the cleared group type or with the shelterwood group type.

III. The type as a means of regeneration, in its purity, is possible only where

a. The compartments contain a mixture of all age classes, with the hypermature classes not too badly prevailing;

b. The species to be regenerated is an intense shade-bearer;

c. The soil is strong enough to allow light-demanding seedlings a chance at surviving a long period of partial suppression.

IV. The species removed—presumably the most valuable species—has reduced prospects of propagating itself, struggling against competing species, the number of its seed trees being relatively decreased.

V. Small chance for reinforcing.

VI. Impossibility of protection against fires under headway.

Paragraph XLVII. Types in which lumbering coincides with N. S. R.

In these types of natural seed regeneration—so-called shelterwood types—lumbering and reseeding go hand in hand, both progressing seriatim, slowly, cautiously. In the pure types, no tree is removed, unless the removal has a distinct bearing—or is expected to have it—on the production of a progeny or on its further development. Seedlings less than five years old usually stand within a few yards of their mothers. This distance is gradually increased—in the course of up to fifty years—until the youngsters do not require any more, or rather despise, the benefit of the parents' presence.

Lumbering operations are carried on—in one and the same limited lot—during a number of years.

Where the mother trees are very rapidly removed, after reseeding, from the proximity of the youngsters, the pure shelterwood types approach the types of cleared compartments, cleared strips, etc.

Where the mother trees are very slowly removed, after reseeding, from the proximity of the youngsters, the pure shelterwood types approach, or bastardize with, the advance growth types.

The chances for success depend on:

A. Sylvicultural talents of the forester in charge and of his staff, also on the size of the ranges.

B. Frequency of seed years and time allowed for the entire operations.

C. Shade-bearing character of youngsters and firmness of parents.

D. Existence of a permanent system of transportation.

E. Configuration.

F. Danger from storm, sleet, fire, animals, etc., locally existing.

G. Size of timber, value of timber, percentage of debris and waste.

H. Marketability of all species or of a few, even of one species only.

According to the manner in which the forester selects the nuclei for reseeding, we distinguish the following types:

I. Uniform type, or pure shelterwood compartment type, where the nuclei are geometrically and regularly distributed over the entirety of a large area (say over twenty to two hundred acres), the nuclei of the entire area being kept, during the entire progress of regeneration, in or about in the same uniform stage of development.

II. Shelterwood strip type, where the nuclei proceed, like advancing skirmishers, in regular military order from the leeward side to the windward side of a compartment (cove, slope, etc.). The nuclei to the leeward are kept in a more advanced stage of growth than those to the windward.

III. Shelterwood group type, where the nuclei are carefully selected, irrespective of geometrical arrangements, merely on the basis of the fitness of the individual spot to act as a seed-bed. The groups are gradually enlarged, increasing in circumference like waves caused by stones thrown in the water.

IV. Shelterwood selection type, where the most mature individuals are everywhere and continuously selected for removal, individually or in small patches, with a view to simultaneous reproduction of the species removed by seeds left on such patches. The patch does not form a nucleus to be enlarged; it is to be retained for a long time in its original size.

Paragraph XLVIII. The shelterwood compartment type of natural seed regeneration.

A. This type is characterized by the uniform manner, in which lumbering and regeneration proceed over large areas.

This uniformity is possible only in somewhat even-aged tracts. Great difficulties are experienced in mixed forests, owing to the difference of light requirements.

The fixed conditions inviting the forester to adopt this type are of a rather rare character, almost absent from primeval woods. The educational value of this type, however, is unparalleled.

B. Actual application: Shade bearers are better adapted to this type than light demanders. Beech is usually treated under this type; Maple and Ash frequently so; Oak largely in France, rarely in Germany; Fir and Spruce in parts of the Black Forest; Pine in the old country only rarely owing to its demands on light.

This "military" type was created by George L. Hartig, toward the end of the eighteenth century. It was considered the ideal type of regeneration up to about 1875. It is now far from being abandoned, maintaining its role as the most commonly used type of seed regeneration, although usually bastardized, in modern times, with the strip and the group type.

C. Advantages:

I. Thorough protection of the soil, of its productive capacity and its porosity.

II. Small risk of utter failure.

III. Large tracts taken in hand at one and the same time.

IV. Methodical, military manner of proceeding which facilitates instruction of the staff of rangers and proper execution of orders by the staff.

V. Mother trees, standing above the young growth in isolated position, yield an extra-increment of high value ("light increment").

VI. Young growth is well protected against climatic adversities.

D. Disadvantages:

I. Difficulty of obtaining a desired mixture of species in the young growth.

II. Necessity for the entire number of old trees to reach maturity at or about at the same time.

III. Even-aged forests are formed by this type which are badly endangered by insects, fungi, storm, snow, etc.

IV. The young growth is badly damaged during the latter stages of logging operations, especially where heavy logs (not wood) are obtained and where the road system is deficient; further on steep slopes.

E. The uniform system, being particularly instructive, deserves a most detailed consideration.

To the mother trees is allotted a three-fold task, viz.:

To seed the "regeneration area."

To protect the young growth from atmospheric hardships and weeds.

To prevent deterioration of the soil during the early stages of the second growth.

Three distinct stages of regeneration must be distinguished, viz.:

I. The "preparatory stage," initiated by a preparatory cutting.

II. The "seeding stage," initiated by a seeding cutting.

III. The "final stage," during which the final fellings take place.

I. The preparatory stage:

a. Purpose: The preparatory cutting intends:

1. To prepare the soil underneath the mother trees for a seed-bed, by increasing the rate of disintegration of vegetable matter. The soil is best prepared at a time when no weeds, but a few shoots of sweet grasses appear here and there. The humus decomposes at the quickest rate on limestone; at the slowest rate on sand and sandstone.

2. To prepare the mother trees for regeneration by allowing them a larger crown space, thus inviting the development of seed buds; further by increasing their stability, so that they may resist the storms when placed in a more isolated position;

3. To remove undesirable species, thus preventing them from propagating their kind.

4. To reduce the volume of the growing stock so as to facilitate the maintenance of a normal growing stock and so as to have less material to remove when the young growth appears on the regeneration area.

b. Duration: The duration of the preparatory stage depends upon the species and the soil. Shade-bearing species found in dense stands need a longer period of preparation than the light-demanding species. On soil rich with lime and in the lowlands, the preparatory stage is much shorter than on sandstone and in the highlands.

c. Area: The area (in per cent. of the entire forest area) to be prepared depends upon the necessities of the market and of the mill (equal annual yield), on the prospects of a seed year, on the frequency of seed years, and on the urgency of other fellings.

d. Trees: The preparatory cutting should remove all sickly trees and all undesirable species. Further, those which have the crowns low down to the ground, which will shade the young growth later on and which now lessen the rate of disintegration of vegetable matter. No dominant trees should be taken out. Near the edge of the compartment it is wise to keep the leaf canopy as close as possible, so as to prevent the influence of drying winds.

e. Marking: The forester himself should mark every tree to be taken out during the preparatory stage. When the wood cutters are not reliable, it is necessary to mark the stumps of the trees as well.

f. Lumbering: Where it pays to dig out the tree by the roots, it is well to do so, because a better seed-bed is the result. Care should be taken that only trees marked are felled, and that those left are not damaged. There is no need to move the firewood and timber out to the roads, if the regeneration area otherwise allows of snaking, wagoning, etc.

g. Pasture: Cattle should not be admitted any more for pasturage during the preparatory stage. Pannage of hogs will be of good advantage. Mice and insects are eaten by them. Hogs break up the net work of roots, leaves and moss forming the soil cover and hindering germinating seeds from catching root.

II. The seeding stage.

a. Time: The best time for "seeding cutting" is a seed year. The forester should be able to tell from the looks of the buds whether a seed year is at hand. The frequency of seed years depends on the species and on the locality.

If there is no prospect for seeds, the seeding cutting should be postponed, and if a sustained yield is desired, it should be made up by preparatory cuttings, final cuttings and thinnings.

b. The area over which the seeding cutting should extend depends on the area prepared for regeneration, on the length of the period of regeneration, on the periodical occurrence of seed years, on the requirements for a sustained yield and on the available market.

The scarcer the seed years, the larger is the area placed in the seeding stage when a mast year arrives.

The longer the period during which the seedlings require shelter, the larger is the area to be taken in hand at a seeding cutting.

c. Trees: It is wise to take the biggest trees first, as their removal at a later date will result in great damage to the young growth.

If the forester is sure to be able to remove some more trees after the lapse of one or two years, a light seeding cutting is usually best.

During the first two years of their lives the young seedlings stand a great deal of shade, even those of light-demanding species, on fair soil.

The degree of light which should fall on the ground after a seeding cutting, depends on species, height of trees, form of trees and locality.

In the case of tender and slow-growing species, the cover should be close. In the case of tall trees, slight interruptions of the leaf canopy is sufficient.

On good soil, where weeds are to be dreaded, the cover should be denser tnan under the reversed conditions. On a southern exposure, the cover should be dense. Fir, Beech and Spruce require a close stand of the mother trees on strong soil and at high elevations.

Oak and Pine on alluvial sand of average quality should be tapped heavily.

d. The proportion of trees ıeft and trees cut might be gauged by:

1. The distance or space between the crowns. It is very difficult to give any data as to the best distance of the crowns. The form of the crowns is so irregular that it is impossible to ascertain the best average distance.

2. The number of stems which gives a good idea of the cover overhead where yield tables are at hand, if the age and the locality are known.

3. The sectional area of the stems cut and of the stems remaining.

4. The volume cut and the volume remaining.

e. Preparation of soil: Shade-bearing species maintaining the porosity of the soil better than light-demanding species often allow the forester to get along without any preparation of the soil. Under light-demanding species, on the other hand, the hardening of the soil at the time of seed cutting often necessitates the preparation of the ground so that it may serve as a seed-bed. This preparation may consist of:

1. Removal of leaves, weeds or moss.

2. Working the ground by pasturing hogs.

3. Wounding the soil in open spaces, with a hoe.

4. Breaking the soil with a strong plow.

f. Lumbering. All cutting should be done as soon as possible after the seeds have dropped so as to bring them into contact with the ground at once. The wood or timber cut should be dragged to the roads previous to the germination of the seeds. The heavier the seed cutting is, the larger will be the percentage of seeds finding germination. Most of the seeds are imbedded by the steps of the woodsmen.

Advance growth should be removed wherever it appears singly. Care must be taken that remaining mother trees are not damaged by lumbering.

g. Covering the seeds: The covering of the seeds is invariably left to nature or to hazard. It might be advisable, however, to secure a covering artificially with the help of a rake, or by plowing, after the seeds have dropped, or by pressing heavy seeds (nuts, acorns) into the ground with a blunt stick.

h. Fire: After the seeds have dropped, the utmost care must be taken to prevent fire from running through the forest. A fire previous to the dropping of the seed may be advantageous, especially in the case of Yellow Pines. After the seeding, however, it should be prevented.

III. The Final stage.

The removal of the seed trees left takes place during the final stage.

a. Purpose: By the gradual removal of the mother trees, the young forest is gradually lead into a life under changed conditions, until it is ready to enjoy the full influence of sunshine, air and rain.

b. Number of cuttings: The more gradual the removal, the less damage results for the young growth from the logging operations and from changed environments. On the other hand, it is cheapest and best, from the logger's standpoint, to remove the seed trees at one stroke.

c. Beginning: The beginning of the final fellings depends on the development of the young growth. In the case of poor soil, or light-demanding species and of northern climate, fellings should start in the fall following the seeding.

In the case of shade-bearing species, strong soil and southern climate the second or third fall should be waited for. The drier the locality, the quicker must be the removal of the mother trees.

d. Duration: The duration of the final stage depends on species, on quality of soil, on success of seeding cutting, on occurrence of subsequent seed years and on climate. A tender, slow-growing and shade-bearing species allows of a protracted period of removal.

A few trees left in isolated positions are apt to damage the young growth by the reflection of the sun's rays from the bark; this is the case especially in species having a whitish bark (Beech, Maple, Birch, Silver Fir).

e. Marking for final removal: Broad-leaved trees should be marked in summer whilst the trees and the young growth are in leaf.

By the first final felling only small trees shall be removed, after Hess. From the second fall (after the seed cutting) on, the seedlings being stronger at that time, it is wise to take the largest trees.

f. Season: The cutting of the mother trees should take place when snow covers the ground, so as to do the least possible damage to the young growth. Fellings must be discontinued during hard frost. Broad-leafed species should not be cut before leaves are dropped as they will do more damage to their progeny when felled in leaf.

Hess is in favor of cutting in fall, claiming that tbe young growtn at that time is particularly tough and elastic. He does not attribute much weight to the presence of snow unless it covers the young growth entirely.

g. Stumps and roots: If the trees are dug out by the roots, the force with which they hit the ground is considerably lessened.

In coniferous forests, many parasistic insects breed in stumps, and in that case it may be necessary to dig them out of the ground, or to poison them.

Where the tree is entirely surrounded by young growth, digging should be prohibited.

h. How to fell a tree: The tree to be cut should be thrown onto that place where it is likely to do the least damage—especially onto "blanks." It is wise to throw the crowns of several trees onto the same spot so as to centralize the damage. On the other hand, many sylviculturists prefer to throw the crowns of the trees into the very thickest young growth, claiming that the damage thereby done is considerably less, and that many youngsters will be left undamaged.

i. Standards: In many cases, a few trees are left standing for a second rotation. Such trees are called "standards." Standards of Oak, Pine and Ash are frequently found. They should not be left unless they stand close to a road, or unless they are certain to outlast a second rotation.

j. Pruning of mother trees: Low branches which overshadow the young growth heavily should be cut.

k. Transportation of wood: All wood and timber should be moved to the nearest roads as soon as possible after the trees are cut. Speedy removal is especially necessary in coniferous forests, the young growth having little reproductive power. A snow cover might be used to remove the wood on sleds; high-wheeled trucks will answer splendidly on level ground. The method of "roping" used in the Black Forest also saves the young growth. All wood and timber must be removed from the regeneration area previous to the opening of the buds.

l. Pasturage: There is no need to say that the young growth should be protected against pasture.

m. Reinforcing: Blanks should be filled only when the mother trees have been entirely removed. The plants may be taken from dense places where the natural regeneration is complete or, better, from nurseries.

Paragraph XLIX. The shelterwood strip type of natural seed regeneration.

A. This type bears the same ratio to the shelterwood compartment type of regeneration which the cleared strip type bears to the cleared compartment type.

In the shelterwood strip type, as in the cleared strip type, fellings and regeneration begin at the leeward side of a compartment (cove, slope) and proceed gradually against the direction of the prevailing storms.

Heavy-seeded species as well as light-seeded species allow of the strip type. Distinct light demanders, however, defy it on the poorer grades of soil.

The nuclei are laid out geometrically in the shape of strips crossing the prevailing wind-direction at right angles. The most leeward strip is in the final stage; the most windward strip is in the preparatory stage; the middle strip is in the seeding stage, provided that the conditions are normal.

The breadth of a strip depends on species, frequency of seed years, configuration of ground and so on. At a breadth of over 500 feet, the strip type bastardizes with the compartment type.

More frequently, the shelterwood strip type is bastardized with the shelterwood group type.

Regeneration of a cove, slope, tract, etc., under the pure strip type, is exceedingly slow, unless there are at hand a number of "series of strips," all triplets, consisting of a preparatory, a seeding and a final strip.

The first strips are usually made, as in the cleared strip type, in well-sheltered ravines or gullies; or at the windward edge of lakes, fields, young growth; or at the windward edge of storm-firm trees (Oaks), where there is a mixture of storm-firm species with species endangered by storm.

The form of the strips need not be exactly rectangular. In the mountains, the strips usually run up and down the slopes—not horizontal—so as to facilitate the transportation of timber and wood removed from the strip.

B. Actual application: This type is frequently seen in the coniferous woods of the Eureopean moderately cold zone; also in Beech woods and Oak woods.

Like the uniform type, the strip type is not exactly natural. For that reason, the primeval woods do not exhibit any illustrations of the strip type.

C. Advantages: The advantages of the shelterwood strip type are identical with those of the shelterwood compartment type—excepting advantage III. It is especially adapted to small pieces of property, which could not yield steady returns under the uniform type. Greater security from storm is characteristic for the strip type.

D. Disadvantages:

I. Difficulty of obtaining a desired mixture of species in the young growth.

II. Trees at the extreme windward edge of a cutting series obtain an extravagantly high age, whilst regeneration proceeds slowly and gradually against them.

III. Tardiness of a complete regeneration of a whole compartment, slope or cove, where there are only a few points of first attack.

IV. Operations are more scattering than in the shelterwood compartment type.

Paragraph L. The shelterwood group type of natural seed regeneration.

A. Characteristic features.

I. Species: All species can be dealt with in a group system; those endangered by windfall, however, require a modification of the system, or small rotation, or a regular progress of the groups toward the storm danger.

II. Beginning: In the shelterwood system, the nuclei for groups are formed at a time, at which the soil begins to be, here and there, a ready recipient for seed. In the nucleus, two or three trees are cut, to begin with, and a few seedlings soon enter an appearance.

III. Continuation: The young growth gradually spreads out, more or less peripherically, from the nucleus, appearing at the feet of the nearest trees. These trees, in turn, are gradually removed, whilst the groups of seedlings continue to enlarge. Finally one group will flow into the other, and the regeneration will present a waving leaf canopy. The irregularity of the canopy depends on the rapidity with which the groups could be enlarged.

IV. Means of transportation: The type obviously requires a finely meshed, permanent network of transportation. The axe returns to the group under formation periodically, say every three to ten years, during a period of regeneration comprising from fifteen to fifty years.

V. Soil protection: The soil is continuously protected from intensive insolation, and is hence kept in continuous productiveness and water-storing capacity.

VI. Dangers: Protection from fire is very difficult; protection from storm difficult, although easier than in the shelterwood compartment type. Insects, fungi, and snowbreak are not to be dreaded much more than under the selection system.

VII. Lumbering: Mother trees are always felled in a manner forcing them away from the group. Hypermature trees close to the group are extracted at the same time. Lumbering operations are necessarily scattered. Hence the logging expenses and the cost of supervision range very high. The removal (snaking) of the trees cut takes place through the benches of trees left between the groups so that the soil is stirred up continuously within the benches.

The groups should be started, if possible, at the upper end of a slope so that the logs need not be snaked through young growth.

VIII. Artificial help: To start regeneration of a nucleus, and to accelerate the enlargement of a group, mosses, weeds and litter on the ground may be removed previous to a seed year (bastardizing with advance growth group type).

The so-called "hair-dressing" of groups, by which misshapen and branchy growth is cut back, and the wave-form of groups is maintained, may be seen in the Black Forest.

B. Actual application: The shelterwood group type appears to be a type of regeneration sometimes adopted by primeval nature in Beech, Maple, Fir and Pine woods.

As a sylvicultural type, the shelterwood group system has been fathrered by Charles Gayer.

It is the most modern type of German n. s. r., applied especially in the natural seed regeneration of Spruce and Beech.

C. Advantages:

I. The type grants the forester the utmost liberty of action, by offering him a large number of points at which to start and at which to continue his logging operations.

II. In mixed forests, the system allows of fostering the most valuable species and of checking the less desirable species or the weed species.

III. The type does not take any sylvicultural chances.

IV. The young growth is well protected against the usual atmospheric dangers.

V. The good qualities of the soil are carefully husbanded.

D. Disadvantages:

I. The type makes unusual demands on the personal and local attention of the manager as well as of the staff, necessitating small ranges and high administrative expenses.

II. Mother trees at the leeward side of an enlarged group are subject to dangers from storm; on the northeast side of a group subject to dangers from sun scald.

III. A large outlay is incurred for logging the trees owing to the scattering character of the operations and owing to the care required in felling and transportation, for the benefit of both young and old growth.

IV. In the case of very large trees, covering by their crowns as much as 500 to 1,000 square feet, the removal of an individual tears too big a hole into the forest and enlarges the group too rapidly at a stroke.

V. The type does not allow of the removal of hypermature trees with proper expedition. They are removed only when the waves of the group begin to touch their feet.

VI. The soil in the proximity of white barked trees bordering a group is scorched by reflected sun rays.

Paragraph LI. The shelterwood selection type of natural seed regeneration.

This type scarcely exists in a pure form. Where it exists, it is invariably bastardized with the cleared selection or the advance growth selection type of natural seed regeneration.

The pure type would imply the immediate development (or rather the simultaneous development) of a seeding growth in the very year (a seed year) in which the individual trees—very irregularly, very scatteringly, on the basis of their relative maturity—are selected for removal.

Where the removal leaves a blank, we meet the cleared selection type.

Where the removal allows an advance growth already at hand to fill the gap, there we meet the advance growth selection type.

The premises for the shelterwood selection type are identical with those for the cleared selection type and for the advance growth selection type.

Paragraph LII. Types in which lumbering follows after n. s. r.

In these types of natural seed regeneration—so-called advance growth types—no tree is removed unless its foot be already surrounded by a young progeny of desirable character which has previously developed beneath the parent's or step-parent's leaf canopy.

The case of exceedingly fertile soil and the case of step-parents having a light leaf canopy excepted, absolute shade bearers only can be propagated by this type. So f. i., Hemlock, Fir, Beech, Maple, Lawson's Cypress, Western Red Cedar.

In the Lake States, White Pine is found as a regeneration formed in advance beneath mature Norway Pines acting as step-parents (advance growth group type).

In the Adirondacks, Spruce regenerates similarly underneath mature Cottonwoods acting as step-parents or, on very fertile soil, selectionwise beneath Beech, Maple and Birch.

Striking it is that species not absolutely shade enduring are, in many a case, loth to be regenerated, as an advance growth, at the feet of their actual parents, whilst willing to be suppressed beneath step-parents of apparently similar density of foilage (Yellow Poplar at Biltmore underneath Oak or Short-leaf Pine; Spruce underneath Cottonwoods).

Species regenerating under their own kin resemble altricial (nidicole) birds; species avoiding parental superstructure might be likened to precocial (nidifugal) birds.

The chances for successful regeneration in these types seem excellent. Still, the following points must not be lost sight of:

I. Advance growth badly suppressed for a long time is frequently so badly crippled that it fails to recover within a reasonable number of years.

II. The advance growth is badly smashed by and during the felling operations, unless the mother trees are pruned and lopped before felling, and unless the timber obtained is carried out either by hand, or on high wheel trucks, or on a heavy cover of snow protecting the advance growth. Under any circumstances, fellings during the perioa of vegetation must be avoided.

III. Advance growth suddenly exposed to the full influence of sun, rain, snow, sleet, etc., is apt to suffer in case of sensitive species.

IV. A minute system of permanent roads is required, the advance growth usually appearing in groups or patches.

V. If the pure types of advance growth n. s. r. were strictly adhered to, a regulation of the annual cut according to the conditions of the market would be difficult to obtain. Hypermature trees would have to be left everywhere—merely because young growth if often slow to form on their feet.

In such cases, artificial preparation of a seed-bed (f. i., by uncovering the mineral soil) seems absolutely required, so as to expedite the formation of advance growth.

If the leaf canopy overhead is opened at the same time by felling operations, the types bastardize with the shelterwood types of n. s. r.

Accordıng to the extent of the area covered by an advance growth of suitable character we distinguish between:

a. Advance growth compartment type of n. s. r., the areas uniformly covered by advance growth measuring from twenty to one hundred acres (rare).

b. Advance growth strip type of n. s. r., the areas uniformly covered by advance growth appearing as strips measuring up to 500 feet in breadth (very rare).

c. Advance growth group type of n. s. r., the groups covered by advance growth having an extent of from one-tenth to three acres (frequent).

d. Advance growth selection type of n. s. r., the young seedlings and saplings appearing in scattered and small patches (very common).

Under "advance growth" is understood an aggregate (small or large) of seedlings or saplings belonging to a desirable species and formed without any human intention or attention, solely by nature, beneath a totally or partially untouched leaf canopy overhead.

Spreading advance growth appearing in bunches or groups can be doctored up with axe and brushhook and machetes, by an application of "hairdressing."

Where the advance growth is not freed, by one single operation, from the superstructure of parents and step-parents overhead, the advance growth types are further bastardized with shelterwood types.

Paragraph LIII. The advance growth compartment type of natural seed regeneration.

A. The type is applicable only where large areas exhibit on strong soil a uniform advance growth, consisting of seedlings, of saplings and possibly of small poles.

Previous to lumbering, the leaf canopy consists of two tiers: an upper tier formed by the parents (or step-parents) and a lower tier formed by the advance growth. Lumbering removes the upper tier entirely and leaves the lower tier intact—if possible.

In the safety of the lower tier lies the great difficulty of the system, especially on rough ground, in handling heavy logs of the superstructure, in dealing with cheap stumpage, in cutting soft woods characterized by small healing power and in the absence of an intricate system of transportation.

Where the upper story of trees consists of say 10,000 feet b. m. per acre, or of more, the ground is literally littered with logs or boles during the logging operations, and the advance growth has but a slight chance to survive the death of its progenitors.

B. Actual application: The type is found, in rare cases, abroad under the misnomer of a modified "selection system," where and when the logger returns for a wholesale removal of mature trees, at intervals of about twenty years, to the same compartments.

The type is also practical where prolific seed years produce, in mild sites and on strong soil, a uniform advance growth in even-aged Beech or Firwoods, without any previous human interference with the leaf canopy overhead (so-called regeneration from a complete-growing stock).

In the United States, compact advance growth is rarely found—possibly so in the case of Tsuga heterophylla. The destruction of the superstructure, however, usually followed by fires, tends to annihilate every vestige of advance growth.

C. Advantages:

Where the system can be carried through, it offers the following advantages:

I. Concentrated logging.

II. Well-preserved productiveness of the soil.

III. Soil never idling, but producing without any delay.

D. Disadvantages:

I. The type is applicable only to intense shade bearers; and these shade bearers are very apt to suffer from sudden changes of environments.

II. The logging expenses are very badly increased in the attempt to save the advance growth from destruction.

III. Under any circumstances, the rapid removal of mother trees inflicts scars upon the young growth apt to serve as entrance gates for fungi and insects.

Paragraph LIV. The advance growth strip type of natural seed regeneration.

A. Advance growth, being a chance product, is rarely found in symmetrical, long-drawn strips. Where the cleared strip-type is introduced, however, a strip of advance growth is often and easily started underneath the border trees joining the cleared strip to the windward. In that case, the advance growth strip-type is bastardized with the cleared strip type.

B. Actual application:

The type is found only in the bastard form just mentioned.

C. Advantages:

I. No expense required for regeneration (unless weeds, leaves or moss are removed).

II. Advance growth is readily saved, where the logs are removed through the adjoining woods.

III. A road system touching the lower edge of the strips is sufficient.

IV. Soil is never laid bare.

V. Little damage from rainfall.

D. Disadvantages:

I. Scattering operations.

II. Type is not applicable to light demanders.

III. Hypermature trees must be left in the woods until the strips, after many years, may approach them.

IV. Points of attack from which cutting may proceed are apt to be lacking, unless the forester is able to maintain a very large number of narrow cutting series, helped by the configuration of the ground.

Paragraph LV. The advance growth group type of natural seed regeneration.

A. In nature, advance growth usually appears in small bunches or in groups, for the reason that there is always a chance for many seedlings to sprout and develop on a spot where light, humidity and soil allow a single individual to make a start alone. In the primeval woods, groups of advance growth formed by shade-bearing species are almost invariably at hand. Even light demanders may form small groups of advance growth in spite of a superstructure overhead, provided that the soil is strong enough to support them.

Such groups, freed from the trees superstructing them, will develop one or a number of saplings which in turn and in course of time may yield one or a few poles promising to grow into trees of a loggable size.

Very frequently the groups are formed not under the leaf canopy of the parent species, but underneath another species acting as a step-parent.

Indeed, step-parents of a rather selfish kind, inimical to the children, are frequently encountered in tree life, handicapping and killing the young progeny thirsting at their feet for light and rain.

The endurance of advance growth living under adverse conditions is at times remarkably great. Fir, Spruce, Beech and Maple may be met grown only six feet high when 60 years old, retarded by parental superstructure.

The pure advance growth group type is frequently bastardized, in Europe, with the shelterwood group type when the forester uses existing groups of advance growth as nuclei to be gradually enlarged, instead of using spots as nuclei for group regeneration on which the soil chances to be in a conceptious condition. Further, when a shelterwood group is forming, advance growth groups are frequently started, under the influence of side light on seedlings and humus, at a goodly distance from the shelterwood group, underneath an apparently heavy superstructure of mother trees.

The advance growth group type pure and simple, however, merely implies the freeing of chance growth from a superstructure. It has nothing to do with the gradual enlargement of a group by ringwise cutting around the group.

The "hairdressing" or groups of advance growth is sometimes commendable.

B. Actual Application: Systematically, this type is nowhere applied in its purity. Accidentally, however, the lumbermen of America happen to employ it in woods composed of Fir, Hemlock, Maple, Beech, etc.

Primeval nature employs this type quite largely (f. i., in Chestnut-oak woods at Biltmore).

C. Advantages: The advantages of the type are identical with those given under C, I, II and IV, in paragraph LIV. In addition, this type may often allow the forester to favor a desirable species of shade-bearing character.

Under sylvicultural care, it renders regeneration an absolute certainty. The trees forming the superstructure frequently happen to be of a marketable size. The type does not require much sylvicultural understanding.

D. Disadvantages:

I. Border trees to the leeward of advance growth are subject to windfall and sun scald.

II. Advance growth groups continue to be badly suppressed, along the edge of the group, by border trees.

III. The logging operations are scattering, and an intricate system of permanent roads is required.

IV. Only intense shade bearers can be properly managed under this type; light demanders found in mixture with shade bearers must gradually disappear from the mixture. The shade bearers will readily form groups of advance growth underneath light demanders; but not vice versa.

Paragraph LVI. The advance growth selection type of natural seed regeneration.

A. This type is usually bastardized with the cleared and with the shelterwood selection type.

The selection by the forester of trees to be cut might be either by single trees or by very small bunches of trees underlaid with a carpet of advance growth covering about one one-hundredth acre of ground.

The logging operations, as in all selection types, are exceedingly scattering; indeed, they ought to continuously extend, as a matter of theoretical principle, over the entire forest.

Only shade bearers, notably Fir, Hemlock and Spruce, are well adapted to the type of advance growth selection.

The type, like the cleared and the shelterwood selection type, renders the construction of an intricate network of roads necessary. Every tree, so to speak—not every strip or every compartment—must be continuously accessible.

It might be necessary to prepare the soil, in scattered patches, where the layer of humus is too deep, and where the soil is so hardened or so covered with weeds as to prevent any chance of n. s. r.

Since the cuttings are comparatively light, the removal of the logs prepares the ground insufficiently for the conception of seed.

Seedlings and saplings in advance growth stand under very heavy shade for many a year, usually in small bunches of a few dozen specimens. Misshapen seedlings and saplings, also those badly damaged during logging operations, should be cut, or coppiced in the case of hardwoods.

B. Actual application:

Wherever the selection type is applied in Europe, it is pre-eminently applied in the shape of advance growth selection type; especially so in parks, in small farm wood lots and in protective forests.

Usually, every compartment (cove, slope) contains a wild mixture of age classes of trees. The axe returns to a compartment in intervals of from one to ten years.

The Beech, although an intense shade bearer, develops very branchy stems under such conditions (Beech forests in Buckinghamshire, England).

In primeval nature, all or practically all scattering and sparse species are subjected to seed regeneration of the advance growth selection type. The accidental death of trees in the superstructure allows a patch of advance growth found underneath to develop.

Instances: White Oak and Scarlet Oak at Biltmore; also Spruce on hardwood slopes in the Adirondacks.

It is surprising to find that scattering species are regenerated by primeval nature in a type which is considered by the sylviculturist only applicable to intense shade bearers. The explanation lies in nature's long-lasting patience and in her failure to be disheartened when failing in innumerable attempts.

C. Advantages:

I. The type protects the soil, and hence the waters, best of all.

II. It protects the young growth from frost, drought, high winds, insects, sleet and snow.

III. It is particularly pleasing, from the æsthetic standpoint by the unusually large variety of the pictures proffered.

IV. Since every acre of ground continuously retains its leaf canopy, no sunshine, air and rain go to waste in young growth insufficiently covering areas laid bare. At the same time, continuous retention of moisture in the soil allows of greater fertility; hence the quantity of wood fibre annually produced is greater in the selection system than in any other.

V. Small danger from windfall amongst parent trees.

VI. Small danger from fire, since the humus is kept moist continuously. On the other hand, a fire once broken out is extremely hard to stop.

D. Disadvantages:

I. Logging operations are very scattering, and hence expensive. The fall of individual, large trees amongst the multitude of their companions is very apt to inflict wounds upon them, through which fungi and insects enter readily. (Cancerous Firs of the Black Forest.)

II. A minute network of permanent roads is required.

III. The primeval woods, wherever they represent the selection type, show a preponderance of mature and hypermature age classes. Since the type does not allow of the removal of groups of trees at all, and of the removal of individuals only where they are underlaid by an advance growth, the owner of primeval woods adopting this type is forced to bring heavy sacrifices.

IV. It is very difficult to regenerate light demanders by this type, where they stand mixed with shade bearers.

Paragraph LVII. Regeneration of valuable species from self-sown seed (n. s. r.) with, amongst and into companions of a weedy character.

It is a well-known fact that only a few of the hundreds of seedlings raised (artificially or naturally) by the forester have a chance to develop into poles, standards and veterans.

Dense thickets, consisting of many saplings, are merely required to maintain the fertility of the soil and to prevent, by natural pruning, the young boles from growing into brushy and branchy specimens ("orchard trees").

For the purpose at stake it is immaterial, in a sense, whether the thickets consist of a "mob" of shrubby weeds mixed with a few "aristocrats" hailing from valuable species, or whether the entire thicket consists of "aristocrats." More than that; unless the aristocrat has a value already as a sapling or as a small pole, the "mob" frequently is more conducive to proper soil protection and to proper development of the "aristocracy" into large poles and standards than a purely aristocratic crowd.

The danger, of course, prevails continuously lest the aristocrats might be overtopped and killed by the mob.

A. Wherever the mob consists of even-aged seedlings (not of stoolshoots) of shrubs, that danger is small, shrubs usually exhibiting a slow rate of height growth (Alder; Dogwood; Hazel; Witch-hazel; Rhododendron, etc.).

Stoolshoots of shrubs, on the other hand, frequently grow so fast, so dense and so rank that they are sure to overpower an aristocracy of seedlings of even age.

If the mob promises to easily obtain the upper hand, then it is usually wise to delay regeneration until the shrubbage shows, at a much later year, signs of a declining growth (Calmia); or else to wait until the shrubs allow a deadening (Dogwood); or to fire the shrubbage in heavy seed years of the aristocratic parentage (Blackjack); or to lumber heavily if the shrubs are sensitive and if the aristocrats are hardy (Striped Maple).

Certain weedy shrubs, f. i., Bamboo species, offer periodically a chance for subdual, viz., when death overtakes them gregariously during their own seed years.

Other shrubs are eagerly eaten (or peeled) by sheep, goats or cattle, and might be brought to submission, in the winter following the fruiting of the aristocrats, by heavy pasturage (Mohrodendron for the benefit of Yellow Poplar).

The purpose at stake, in American Sylviculture, for years to come cannot consist in homogeneous regeneration of aristocrats evenly covering the regeneration area; it can only consist in that form, quality and density of regeneration—usually a partially successful regeneration—which the forester considers financially most desirable (compare paragraph XLI E).

The extirpation of shrubs by pickaxe and plow is usually impossible, unless it can be combined with "taungya."

It is often sufficient for increased aristocratic regeneration to break or reduce the humus formed underneath the shrubbage.

B. The battle against weed trees trying to propagate their kind in the forest is usually more difficult to win than that against shrubs since the progeny of weed trees does not stop to compete with aristocrats after the thicket stage. The forester must carefully gauge the chances for a final victory—usually a partial victory—of the aristocrats, footing on a knowledge of their relative height growth and their relative shade endurance.

Weed trees might be prevented from successful seeding by:

I. Deadening or stump peeling.

II. Actual removal (unless resulting in rank stoolshoots).

III. Sudden exposure of young progeny to draught or frost.

IV. Maintenance of a dense humus, or of a dense leaf canopy.

V. Pasturage.

VI. Stopping all logging operations during seed years of the weed-tree species.

VII. Fire.

Any of these remedies will answer on a regeneration area provided that it inflicts greater damage on the weed trees than on the aristocrats, and that the success is fully commensurate to the expense.

A careful choice of the type of regeneration (cleared, shelterwood, and advance growth types in compartments, strips, groups or patches) is, however, the best weapon in the hands of the forester against mobbish usurpation.

The time may come when the forester will avail himself of plagues of fungi, vertebrates and insects in the struggle against weed trees.

Obviously, where the logger, followed by fires, removes every vestige of the aristocracy and every chance for its reproduction on deteriorated soil, there the sylvan battle is lost for the forester before it is begun.

Frequently in nature's economy and ecology a crop of weed trees (Birches, Cottonwoods) intervenes between two generations of aristocrats. This "rotation of crops" resembles that of agriculture, and is hard to explain. Attempted explanations are: Exhaustion of soil in mineral matter required by the previous species. Presence of baccilli, bacteria, fungi, insects, etc., inimical to the previous species.

Paragraph LVIII. Pedagogy of the high forest.

Forest pedagogy or forest tendance, the second part of the sylviculturists' activity, is of little importance in America at the present time since there are no wood crops at hand which might be profitably tended. Forest protection, usually considered a branch of forestry, is merely a branch of forest tendance.

The following operations are here treated under the heading forest tendance:

A. Cleaning
B. Weeding } Indirectly remunerative acts or investments.

C. Improvement cuttings
D. Thinning } Directly remunerative acts yielding a surplus revenue.

F. Underplanting
E. Pruning } Indirectly remunerative acts or investments.

The definitions of the terms "cleaning," "weeding," "improvement cutting" and "thinning" are so indistinct that it is often difficult to differentiate them. Definitions might be based either on the age of the wood crop tended, or on the purpose aimed at, or on the financial side of the tending.

Cleaning and weeding are applied for the benefit of very young growth and usually require an investment.

Pruning, thinning and improvement cutting are applied for the benefit of polewoods or thickets.

Improvement cuttings and thinnings usually furnish a surplus revenue whilst pruning succeeds only in rare cases to be directly remunerative.

Paragraph LIX. Cleaning in high forest.

Cleaning may occur during the seedling stage and the small sapling stage. It implies the removal of saplings forming a shrubby advance growth (wolves); or the removal of undesirable stoolshoots; or the removal of seedlings and saplings belonging to a less-desirable species competing for space in a young forest. In natural seed regenerations, cleaning is particularly desirable. Instances: Removing poor coppice shoots which oppress by faster growth the valuable seedlings of Yellow Poplar. Removing Birch, Fire Cherry, Thorns and Briars in young plantations of White Pine, Yellow Pine and Spruce. Where a regeneration area of strong soil has been burned previous to planting, the competition of volunteer growth is frequently such as to make cleaning necessary. The forester should take care, however, not to extirpate species now of little value, but possibly of a fair future value.

In mixed regeneration, cleaning offers a good means to regulate the proportion of species admixed. The expense incurred for cleaning must be commensurate to the financial effect of the operation. Instruments used are axe and brush hook; also long-handled cleaning shears.

Paragraph LX. Weeding in high forest.

A plant, either herbaceous or ligneous, which has a negative value is a "weed." It might be a cripple of an otherwise very valuable species (fire crippled Chestnut in Pisgah Forest), or it might belong to a species having no commercial value (Rhododendron, Witch-hazel, Black Gum, Halesia, Chinquapin).

Weeding implies the removal of large saplings, poles and trees having the character of weeds. Weeding may take place before regeneration, or after regeneration has been started. It may act incidentally as a preparatory cutting, a seeding cutting or a final removal. It pays only as an investment since the stuff removed has a negative value.

The purpose of weeding might be the extirpation of suppressors of young growth; or an exchange of unhealthy crooked, fire-scalded, flat-headed poles for new, vigorous stump sprouts (Spanish and White Oak at Biltmore).

The term "weeding" is not found in books on Sylviculture; it forms, however, under present conditions often one of the most important and most remunerative sylvicultural acts.

Weeds are either girdled (deadened) or cut.

In the case of weeds having a diameter of over 6 inches, girdling is often preferable, because cheaper than cutting. Moreover, the cutting of broad leaf weeds often tends to merely replace the weed by weed sprouts.

To prevent this, in the case of sapling weeds, crushing shears might be used.

Some cottonwoods cannot be extirpated by deadening. In that case, the peeling of a strip of bark three feet long at a point two feet above ground is advisable. Cutting of weeds in August reduces the chances of their recovery. In the Adirondacks, the weeding of Beech overshadowing Spruce might be advisable, because remunerative.

Paragraph LXI. Improvement cutting in high forest.

The term improvement cutting was introduced into Indian practice by Sir Dietrich Brandis. Improvement cuttings are cuttings for revenue and for partial regeneration, combined with weeding.

An improvement cutting extracts from irregular woods:

A. Hypermature or dead trees still of value.

B. Misshapen immature trees.

C. Species of minor value.

D. Weeds of pole size and tree size.

Essential it is for the character of an improvement cutting, that it is intended to result, on the aggregate, in a surplus revenue. Cuttings, on the other hand, which leave the premises in a materially decreased financial value, can, of course, not be considered as improvement cuttings. Again, cuttings made at a sacrifice, with a view to an increased prospective value of the forest, are "weedings" or "cleanings" which must be considered as investments, like the expenses spent for regeneration.

I. The purpose of improvement cuttings is or may be:

a. A surplus revenue.

b. Improved financial prospects of the remaining crop carried about by:

1. Removal of trees and poles acting as suppressors;

2. Removal of inferior trees and poles acting as competitors;

3. Partial removal of a superstructure on a regeneration area;

4. Removal of less desirable individuals acting as seed-trees.

c. The effect of a preparatory cutting, a seed cutting or a final cutting in thin, irregular woods, without removing well-grown mother trees of desirable species.

d. Reduced danger from fire, fungi and insects.

II. Kinds of improvement cuttings are:

a. Improvement cuttings in primeval woods.

b. Improvement cuttings in culled woods.

c. Improvement cuttings in woods maltreated by fire and pasturage.

III. Marking: Trees and poles to be removed in an improvement cutting must be individually marked by the sylviculturist.

Generalizing rules for marking cannot be given; each tree or pole must be dealt with according to its individual merits and demerits.

The marking by the forester of improvement cuttings is, consequently, a timetaking affair.

IV. Localities: Irregular, thin woods composed of a multitude of species deserve improvement cuttings.

The local market must allow of the—at least partial—utilization of suppressing, competing, superstructing and less desirable individuals.

Paragraph LXII. Thinnings in high forest.

Thinnings proper are practicable only in dense and fairly evenaged groups or woods, always under the proviso that a permanent road system and a nearby market allow of a remunerative outcome of the act. In Pisgah Forest thinnings are out of the question as the woods are thin enough. At Biltmore, thinnings are made where polewoods of Yellow Pine occupy abandoned fields. Up north, from the merely sylvicultural standpoint, thinnings are possible in the Jack Pine woods, in Balsam thickets, on Black Spruce slopes, in Lodgepole Pine thickets, etc.

For many a year to come the American forester will have little opportunity to make any thinnings.

A. Purposes of thinnings:

I. To develop the log diameter of large saplings and poles at a time at which the log axis has been obtained.

II. To increase the volume increment per acre.

III. To increase the quality increment of favorably predestined mess-mates.

IV. To reduce the danger from forest fires (dead and dying trees), insect pests and fungi plagues.

V. To remove cripples and wolves.

VI. Early financial returns.

VII. Reduction of investment.

VIII. Shortening of the rotation by feeding a lesser number of mess-mates on a relatively larger amount of food (viz. moisture, heat, light, mineral matter, etc.).

IX. Regulation of the relative proportion of species in mixed pole woods.

B. The season for thinning depends upon local climate, seasonable prices of labor, advisability of peeling and intensity of thinning. The season usually selected for thinning in Europe is the late winter when the main cuttings are completed.

C. The time for thinning. Thinnings should begin in the late thicket stage and should be repeated, to begin with, in five-year intervals, say from the year thirty to sixty. Thereafter the intervals are increased up to the year eighty or ninety. A preparatory cutting, although conducted like a thinning, is no thinning, since its purpose is regeneration. Thinnings stop at the end of the pole stage. Where poles are non-salable, for instance, in European mountain districts and almost everywhere in America (excepting Biltmore Estate), thinnings cannot be made.

D. The material supplied by thinning may consist of firewood, pulp wood, mine props, fence posts, telephone poles, hop poles, hoop poles, tool handles, bolts for spokes, locust pins, tannin wood, etc.

In European practice the number of cubic feet obtained by thinnings during the course of a rotation per acre equals one-quarter or one-half of the number of cubic feet obtained by the final cut. Heavy thinnings, as practiced in Denmark, are said to yield as many cubic feet in the aggregate of a rotation as the final cut.

The tool used for thinning is invariably the axe.

E. Kinds of thinnings: The old doctrine was: "Thin early, frequently, moderately!"

This rule has been gradually abandoned during the past twenty years. The method of thinning naturally differs according to the purpose of it. William Schlich distinguished between quality thinnings, made to improve the timber quality of the trees left; and quantity thinnings meant to result in the maximum production of wood fibre per acre per annum.

If left alone, a dense thicket grows slowly only, the food being subdivided among a large number of messmates. Toward the beginning of forestry, sylviculturists were satisfied with thinnings burying the dead and moribund trees. Later on, thinnings were extended into the suppressed classes. The European experiment stations are now deeply engaged in working out the "best" method of thinning. Obviously, no method can be best for all sorts of species and for all sorts of local conditions.

1. The experiment stations distinguish between:

Grade 1. Light thinnings, removing the dead or dying.

Grade 2. Moderate thinnings, removing the dead, dying and suppressed.

Grade 3. Heavy thinnings, removing also the condominating trees, or such of them which are not absolutely essential for the maintenance of the main leaf canopy overhead.

Grade 4. Very strong thinnings, placing a limited number of dominating and predominating trees in a free position.

Results so far published allot the maximum volume production (exclusive of branches) per acre to Grade 3. All these four grades might be characterized as "thinnings from below" (Eclaircies par le bas).

French silviculturists are advocating, on the other hand, "thinnings from above" (Eclaircies par le haut).

The Frenchmen, as a matter of principle, leave alone the suppressed lower stems, protecting by them the quality of the soil as well as the clearness of boles within the predestined class. In addition, they relieve the tension, friction and struggle for food amongst the dominators by culling out the worst developed dominators, or a percentage of those dominators which stand too close together, and which have, consequently, one-sided crowns.

The objection to the French method lies in the following points:

a. Material without increment is left on the ground.

b. Weaklings and dying trees left increase the dangers threatening the forest.

c. Greater difficulty in marking trees to be removed.

However, where quality increment is at stake, the French method seems highly advisable.

III. Radically different from the systems of thinnings heretofore prevailing are the revolutionary views proffered by Borggreve, the "Bryan" amongst European sylviculturists.

Borggreve thinnings interfere or remove only the predominators and dominators—the biggest poles—closest to the best log size. Such thinnings begin only at the year sixty of a woodlot; they withdraw every ten years the largest one-seventh of the stems containing about one-quarter of the total volume.

Of course, high and early revenue is secured by such practice. On the other hand, the trees removed are those growing at the best rate of interest. (From the sixtieth year on 90% of annual secretion in a woodlot is supplied by the 40% (in number) of the largest trees).

The advisability of a Borggreve thinning largely depends on the reproductive power of a wood thus "maltreated." In the case of Yellow Pine and on poor soil, the reproductive power of a wood seems too small to allow of speedy repletion of the growing stock and of its leaf canopy. Much "food" goes to waste after Borggreve thinnings. In the case of White Pine and Spruce, the danger from storm and sleet after Borggreve thinnings must be badly dreaded.

IV. Wagener, at the year twenty-five of a forest, makes a thinning called "crown-free-cutting," surrounding the crown of each predestined tree with an air space two and one-half feet wide. Dominating trees left should stand seven yards apart after the Wagener thinning. Suppressed trees are not interfered with. Such cuttings are much heavier than Borggreve's. At the year twenty-five the bole of the dominators is not fully developed. Underplanting takes places at the same time. The dominators left stand in an orchard-like position and show a very rapid diameter growth. Only one log or so is expected to be obtained from the bole; it is obtained, however, within an extremely short rotation.

Obviously, for coniferous woods exposed to storm and of poor quality if wide ringed, the Wagener system is out of the question. The Wagener thinnings, unless they result in a heavy growth of adventitious branches, might be used to advantage for Black Walnut, Black Cherry and Oaks.

V. In mixed forests such species as reach maturity during the pole stage might be removed by way of thinnings; f. i., Locust and Sassafras from a pole wood of Yellow Poplar; Hickory when reaching spoke-bolt size from a mixture with Oaks; Chestnut when reaching telephone pole size from a mixture with Oaks, Black Gum and Yellow Poplar.

Paragraph LXIII. Pruning in high forest.

A. The object at stake might be:

I. Production of logs free from knots,—especially free from dead knots. Live or sound knots measuring one and one-quarter inches in diameter affect the lumber price only slightly. The prevention of dead knots is, therefore, most important. No topshoot is formed without side shoots, and no section of a tree bole is free from branches and free from branch knots. Hence the advisability of pruning the boles of such species which develop branches of large diameter and of great persistence when dead. Branches (excepting adventitious branches) invariably start from the central core.

II. Increased height growth.

III. The production of cylindrical boles of high form figure (Pressler's law of bole formation). Obviously, "II" and "III" are obtained only by removing live branches.

IV. The reduction of the shade falling on a young, promising undergrowth.

V. The reduction of danger from fire in coniferous woods close to public roads.

B. Species: Hardwoods suffer less from the removal of green branches than softwoods. Green branches of over five inches in diameter should not be removed at all, except in case "IV," owing to the certainty of subsequent disease.

Oak heals the wound inflicted by pruning best; Ash is likely to split; Maple is slow in closing a wound; Birch soon shows disease; Yellow Pine covers the wound quickly with rosin.

C. Actual European practice:

The practice restricts pruning to the case "I" and within case "I" to:

I. Dead branches.

II. Polewoods forty years to sixty years old.

III. Limited numbers of poles (say 100) per acre, namely, to the specimens presumably predestined to reach the end of the rotation.

Pruning extends to a height reaching up to forty feet, is done by help of ladders, of a climbing apparatus (not climbing irons) or of saws attached to very long poles. The best saw is the "Alers" construction.

In France, sharp, curved blades are preferred to saws, since they produce a smoother cut.

The branch is cut off as close to the bole as possible. Large branches are cut off in sections to prevent the bole from being scarred. In the case of broad-leafed species and in the case of live branches, large wounds are always tarred. Tarring in spring is impossible.

Expense at Biltmore for pruning Yellow Pine to a height of 16 feet is two cents per tree.

The best months for pruning are the months at which the sap is down.

The advisability of pruning depends largely on the prospective price—difference between clear lumber and knotty lumber.

Pruning at a late date, say 20 years before cutting, is of no use. Theoretically it is best to remove dead branches in the year of their death.

Where pruning is practiced, natural pruning produced by dense planting and hence dense planting itself might be spared, a proposition which cannot be generally indorsed.

Literature: Translation of DeCourval by Massachusetts Forestry Association.

Paragraph LXIV. Underplanting in high forest.

An upper story of high forest might be underplanted during the pole stage either artificially or by natural seed regeneration. In the latter case, weed species may answer the purpose. Underplanting may improve the timber quality of the upper growth. It usually does improve the productiveness of the soil.

Frequently the purpose at stake in underplanting is that of fully utilizing the productive capacity of the soil and of the atmosphere which is not entirely used by the upper story of growth. In that case, underplanting cannot be considered as a method of forest pedagogy.

A. The species to be underplanted are, notably, light demanders; for instance, Yellow Pines; Oaks; Hickories; Larches; Yellow Poplar, etc. In the primeval woods, Long-leaf Pine, Yellow Pine, Yellow Poplar, etc., show a natural undergrowth.

In practice, the wood to be underplanted is 40 to 60 years old. Heavy "thinnings from below" precede underplanting.

B. The species used for artificial underplanting are shade bearers and, if possible, soil improvers, notably Beech, Hard Maple, Fir, Lawson's Cypress, White Pine, Chestnut, Hemlock, etc.

Spruce is now disliked for underplanting, since it unfavorably affects the growth of the upper story. Seedlings one or two years old are commonly used for underplanting. Dogwood, Black Gum, Witch Hazel, Chinquapin, Witch Hopple, possibly Kalmia and Rhododendron might be used for underplanting where mere soil protection is desired.

The primeval hardwoods of the Alleghanies are frequently and densely underplanted with a low jungle formed by Ericaceae.

Paragraph LXV. Key to the Forms of High Forest.

That general condition of a forest is termed its "sylvicultural form" which is brought about by its type or types of past regeneration, hence by its display of age classes and by the arrangement of the species exhibited.

The treatment alloted to the "form" by the forester, provided that it is a systematic treatment, is termed its "sylvicultural system."

The multitude of forms found in primeval nature is innumerable, since the "molds" from which the forms are cast, vary indefinitely with every wrinkle of the topography and every variation of the climate.

Man's interference has tended—at least temporarily—to further increase the multitude of forms.

It is a hard task to differentiate amongst this huge collection of forms and to arrange the collection into "orders," "families," "genera" and "species" composing it.

A priori, two great groups of forms might be singled out, namely "*primeval forms*" the product of unbiased nature and "*second growth forms*," the product of nature influenced by man's interference. This human interference might have been of a character utterly disregarding sylvicultural ends ("culled forms"); or human art might have tried, successfully or unsuccessfully, to lend a helping hand ("cultured forms").

The manner in which the various age classes of the forest are mixed within the "orders of forms" is of paramount interest. From this manner of mixing depend:

I. The manner and the possibility of remunerative lumbering.

II. The type method and the expense of regeneration and pedagogy.

III. The dangers from insects, fungi, fire, storm, etc., threatening the forest.

The functions of the mixture are so all-important in forestry, that the synthesis of the age-classes must serve as a main criterion in the construction of a key to the sylvicultural forms.

It must not be forgotten, however, that age differences of, say, 20 years are very conspicuous during the seedling, sapling and pole stage of the forest; whilst the keenest eye cannot detect these same differences in an old tree forest.

In mixed forests exhibiting a large variety of species the analysis of the form presents particular difficulties. Such is the case by far more frequently in primeval than in culled or cultured high forest. Sometimes a distinct form of a minor, scattering species appears to be "grafted" upon a distinct form of one or several major, gregarious species ("grafted forms"). Where two distinct forms in mixture occupy more equal shares (not minor and major shares) in the aggregate display, we may speak of "wedded forms." "Husband and wife, though distinct individuals, unite for a life in a household of their own."

A. Primeval forms of high forest.

I. Characteristic for all primeval forms is a relative preponderance of the hypermature age-classes (veterans); a relative deficiency of the youngest age-classes (seedlings, saplings and poles); the presence of a large number of dead, decaying or unsound specimens only temporarily excelled in the "culled forms;" a large number of dead corpses of trees spread flat on the ground; irregular confines of the parts composing the aggregates; irregular composition of such parts by age-classes and species, many of which may be weeds; usually a heavy layer of humus on the ground; usually the presence of a few strikingly large and spotless trees overtowering their neighbors; absolute lack of permanent means of transportation.

II. Subdivision of primeval forms of high forest.

According to the relative share held by species of "weed trees" in the mixture of species composing them, the primeval forests might be subdivided into pauci, multi and omnivendible forests. Primeval woods, in which only 10% of the timber species command a value, might be called "paucivendible"; at 50%, the term "multivendible" and at approximately 100%, the term "omnivendible" might be applied.

The vendibility of the members composing the forest, whilst it controls the possibility and the manner of its sylvicultural management, does not influence, however, the actual display of the forest in the slightest degree.

It will be best, consequently, to subjoin the viewpoint of vendibility to the viewpoint of actual composition of the forest as displayed in the size of its composing parts—notably of its age-classes.

Thus we arrive at:

a. A selection form, where the age-classes raised are mixed by trees or small patches—a very uneven-aged form;

b. A group form, where the age-classes raised are segregated in groups occupying from one-tenth to four acres;

c. A compartment form, where the age-classes raised are segregated in large, coherent areas (coves, slopes) covering from twenty to one hundred acres—a very evenaged form of forest.

The epideta "paucivendible", "multivendible" and "omnivendible" added to the terms "selection form", "group form" and "compartment form" readily explain, in crude lines, the sylvicultural as well as the economic display of a primeval forest.

The groups or the compartments often show a sprinkling of huge trees known as "standards", having a much higher age and frequently belonging to a species different from that or those forming the main growing stock. Instances are:

Yellow Poplar standards in Beech compartments;

White Pine standards in Balsam compartments;

Yellow Pine standards in Oak groups;

Cuban Pine standards in Cuban Pine groups.

Long-leaf Pine standards in Cuban Pine groups.

Naturally, where the standards belong to several age-classes and do not form a distinct age-class by themselves, we merely meet a selection form.

Standards in primeval woods are frequent enough to call for the singling out of a fourth form, namely:

d. A standard form, which might be again subdivided into:

A form of standards over groups;

A form of standards over compartments.

A variety of the latter subform found in the Chaparal thickets of California and in the Calmia thickets of North Carolina might be termed "form of standards over paucivendible compartments."

The two-storied high forest is often formed by two or more distinct species appearing in distinct forms. It had better be considered as a combination of forms, one form being grafted upon another (f. i., multivendible compartments of Douglas Fir grafted upon the paucivendible selection form of Hemlock); or one form being wedded with another (f. i., multivendible group form of Longleaf Pine wedded with paucivendible compartments of Black Jack Oak).

The term "two-storied high forest" properly applies only to a permanent combination of two tiers of trees (representing one or more species), each tier emanating from regeneration of the compartment type of n. s. r. It is a compartment form wedded with a compartment form.

III. Treatment of primeval forests:

The only treatment required is of a protective, not of a sylvicultural character.

As long as the forest retains its primeval display, unhampered by human interference, the regeneration of the primeval selection form is of the cleared, shelterwood or advance growth selection type;

the regeneration of the primeval group form is of the cleared or advance growth group type; and the regeneration of the primeval compartment form is usually of the cleared compartment type.

Obviously, with the beginning of logging operations the "primeval forms" are gradually, piece by piece, changed into "culled forms," the display of which largely depends on vendibility and on fires.

Rarely only the primeval forest enters at once or directly into a cultured form (Pisgah Forest of the Biltmore Estate; Ne-ha-sa-ne park; government forests in Galizia) without passing through the stage of "culled form." In the large majority of cases, the primeval woods pass through "culled forms" into "cultured forms," in the course of generations of men and of trees.

B. Culled forms of high forest:

I. Characteristic for the culled forms of high forest is the absence of mature or maturing trees belonging to a desirable species; the preponderance of weeds, unsound trees, undesirable species and of trees and poles badly crippled by the logging operations. Only diseased trees or relatively small trees of the desirable species are left to seed the ground.

Advance growth is invariably spoiled where the trees are omnivendible or multivendible.

Characteristic for the culled forms is, further, the presence of large amounts of debris and of a parched humus.

As a rule, the culled forms show death and scars due to forest fires.

Frequently, the culled forest displays an entirely new assortment of the species composing it, the previously prevailing species having been removed by logging. It is more "mobbish" than the primeval forest.

II. Subdivisions of culled forms of high forest:

The culled forest is usually more uniform than the primeval forest from which it emanates, owing to the uniform character of the logging operations. Still, the compartment form, group form and selection form originally exhibited are usually retained.

In the compartment form and in the group form a few worthless trees or veterans left standing and continuing to live frequently remind on the "form of standards in high forest" or on the "form of underplanted high forest." (Compare C, II, b, of the same paragraph.)

III. Treatment of the culled high forest:

Where fires are kept out, the chances for seed regeneration are good—unusually good—owing to the condition of the seed-bed and to the unlimited food supply available for the seedlings.

In the case of Yellow Pines, light fires seem even helpful to n. s. r.

Since the valuable species form, however, the minority amongst the seed-trees, the worthless and less valuable kinds usually prevail in the young growth formed after culling. Cleaning and weeding are required to improve the prospects of the minority composed of noble species. Besides, improvement cuttings are indicated in the culled forms: "The culled form is *the* form requiring improvement cuttings."

The "aristocrats" frequently return only to the regeneration area after a score or two of years, the rash "mob" then acting as nurse-trees or as ushers.

Where heavy and extensive fires have swept the culled forest originally consisting of exacting species, patient waiting alone can secure conditions more favorable to aristocratic regeneration. Fires frequently convert a high forest of hardwoods into a coppice forest.

The younger age-classes suffer more from fire than the older age-classes. A fire-swept, culled forest is deficient, at least temporarily, in seedlings, saplings and small poles. A few years after a fire, the culled forest often displays the features of the underplanted form of high forest (Par. LXV. C. II. b.) or of the coppice-under-standard form (Par. LXXIII).

C. Cultured forms of high forest:

I. Characteristic for the cultured forms of high forest is great uniformity; lack of hypermature, unsound and misshapen aristocrats; lack of weed-trees; lack of coppice shoots; complete cover overhead; multi- or omni-vendibility; permanent means of transportation.

The cultured forest does not require weeding or improvement cuttings for the reason that cleanings and early thinnings have prevented the development of weed-trees and wolf-trees, whilst the hypermature veteran has been removed long ago.

If the culled form is "the form of improvement cuttings", the cultured form might be termed "the form of thinnings".

II. Subdivisions of cultured high forest:

a. Main cultured forms of high forest:

1. Even-aged cultured forms, when the age-classes mixed within a compartment differ by up to 25 years.

aa. Form emanating from the cleared compartment type of n. s. r.

bb. Form emanating from the short-time shelterwood compartment type of n. s. r., the periods of regeneration not exceeding 25 years.

cc. Form raised by planting seeds or seedlings over whole compartments.

dd. Form raised by underplanting seeds or seedlings over whole compartments, followed by (gradual) removal of the superstructing trees within less than 25 years.

2. Uneven-aged cultured forms, when the age-classes mixed within a compartment differ by over 25 years.

aa. Form emanating from the long-time-shelterwood compartment type of n. s. r.

bb. Form emanating from strip types, either restocked by n. s. r. or by planting.

cc. Form emanating from group types of n. s. r., or from planted groups.

dd. Form emanating from selection types of n. s. r.

b. Auxiliary cultured forms of high forest:

aa. Form of standards in high forest, when a limited number of trees are left to grow amongst and with the young growth for a longer or shorter number of years.

The standards might be left either in scattering groups or individually scattered over the second growth. In the latter case, only storm-firm species will answer. It is wise to leave the standards in the proximity of roads so as to allow their removal without inflicting damage on the young growth. Species well adapted for standards are: Yellow Pines, Larches, White Oaks, Yellow Poplar, Black Locust, Hickory, Walnut, Black Cherry. Shade-bearers and flat-rooted species will not answer the purpose.

It is unwise to leave standards unprepared by preceding cuttings for the life in the open. Standards set suddenly free will cover themselves rapidly with adventitious branches, will grow stagheaded, will suffer from storm and sleet, and will die without yielding the results for which they were left.

Where the standards shade the young growth too badly, it may be necessary to remove their lower live branches.

The number of standards left per acre does not usually exceed 25. Very good soil and short rotations allow of an increased number. Standards may be, but need not be, of the same species which forms the undergrowth.

Where the standards do not belong, approximately, to one and the same age-class, there the standard form bastardizes with the uneven-aged forms emanating from the group-type or from the selection type of n. s. r.

bb. Form of two-storied high forest, when an upper and a lower leaf canopy is maintained in distinctly separate tiers.

Species adapted to form the lower leaf canopy are: Beech, Hard Maple, Black Gum, Firs, Hemlocks. The species in the upper story had better have a light-demanding character. The form is created by raising a polewood (even-aged) of Yellow Pine, Oak, Hickory, Larch, etc.; by early and heavy thinnings from below; by very heavy thinnings after the completion of the principal height growth (year forty to sixty); and by planting at the same time either seeds or preferably seedlings of shade-bearing species. Should the undergrowth catch up with the upper growth, either the one or the other must be removed. The undergrowth preserves the fertility of the soil by thorough shading, by the formation of a mixed humus and by increased leaf-fall. It improves the bole-quality of the upper growth, the crowns of the lower growth holding the boles of the upper in close embrace. In addition, it prevents any part of the timber-producing factors of the locality (atmosphere, light, moisture, soil) from lying unutilized. Usually the undergrowth produces firewood, the upper growth timber.

The so-called "Seebach's modified high forest" has Beech in the upper as well as in the lower story. The lower story is obtained from self-sown seed of the upper story after very heavy thinning. Under and upper growth are finally utilized in the same year or in the same period of years.

III. Treatment of cultured high forest.

Regeneration in the cultured form of high forest takes place in any of the types of n. s. r., or by planting seeds and seedlings. As a rule, natural regeneration is now combined with partial planting. Cleaning and thinning are usually indicated, whilst, as stated, weeding and improvement cutting are not required.

Paragraph LXVI. Critical remarks on the forms of high forest.

A. Attitude of the investor:

It is almost amusing to observe the difference of attitudes which the statesman, the lumberman and the forester show with respect to the terms "primeval", "culled" and "cultured" forests.

Still, all of these forests are justifiable, at least temporarily, and usually justified by the economic conditions evolving them.

I. The primeval forest seems to be the "forest in economic stagnation." Still, fortunes have been carved by many investors, buying and retaining primeval forests for their own benefit and incidentally for the benefit of later generations of men. With every parcel of primeval forest destroyed, the value of the balance left increases in estimation and in actual usefulness.

Sylviculturally. no forest requires a more minute and more painstaking treatment than the primeval forest, when its conversion into cultured forest is at stake. Still, the small price obtainable for its products defies any attempt at a remunerative outcome of heavy sylvicultural outlays. What is the use of safeguarding or producing a second growth, by sylvicultural acts, which is devoid of any prospective value, or which is of a value inferior to the expense required to safeguard it or to produce it?

Thus, sylviculturally as well as financially it seems very frequently best to leave the primeval wood unattended, unregenerated, unconverted, for the time being.

II. The culled forest usually exists in localities where timber has a higher value than in the primeval backwoods.

Indeed, where the culling of the forest has made great progress in a state or in a county, there the culled forest is getting rapidly ripe for sylvicultural treatment.

Heavy culling merely proves a high range of stumpage prices, fostered by a near-by market and by good means of transportation.

Where the forest has been culled only of decidedly mature trees, there the chances for good results are bright, financially as well as sylviculturally.

The attitude which the owner of culled forests adopts towards sylvicultural investments, necessarily depends on a diagnosis of the future of the lumber industry appealing to him.

III. The cultured forest is still a rarity in the United States, and will continue to be a rarity during our lifetime.

Imagine for a moment, that the famous Black forest of Germany were suddenly transferred, with its fine Spruce woods, its splendid roads and its skilled laborers, into the heart of the Adirondacks! Would it be wise, financially, to continue its sylvicultural treatment as inaugurated in Germany?

It certainly would; the logs salable in the Black Forest are also salable in the Adirondacks at a good profit. And a network of splendid roads would tend to cheapen transportation by exactly that many cents per standard, which the stumpage itself would gain per standard.

On the other hand, that same Black Forest transferred to the Pacific coast—say into the Olympic mountains—would certainly prove a financial and therefore a sylvicultural failure.

The better it pays to cull the forest, the closer at hand is the time of the cultured forest.

It must be kept in mind, however, that the change from the culled to the cultured forest requires, aside from a market for the products obtained and from the willingness of the owner to embark in sylvicultural investments,

a. Investments in permanent means of transportation;

b. Relative safety from forest fires;

c. Time.

Wherever the woods emerge in a decrepit condition from the primeval stage after reckless lumbering, heavy fires, unlimited pasturage. there the adoption of a system will be found necessary after scores of years breaking entirely with the past and raising, after thorough destruction of the past growth, by artificial means a new crop of valuable species.

Large, continuous clearings badly resist reforestation like the prairies, although on a smaller scale. Extensive, even-aged woods form "incubators" for disastrous diseases; suffer from snow, storm, drought, and frost. On the other hand, their management is greatly facilitated, so that reinforcing, cleaning, thinning, regeneration and utilization are much cheapened.

B. Selection of form by the forester.

I. The primeval forms of high forest found by the forester usually appear unretainable. Whatever the case be, the first stroke of the axe is sure to remove the mature and hypermature trees, the preponderance of which belongs to the character of any primeval form.

However, when transforming primeval woods into cultured woods, the forester should endeavor to retain as much as possible the form originally sanctioned by nature. Such retention is the safest way to sylvicultural success. Still, it usually necessitates heavy investments for permanent means of transportation, and where the owner is unwilling to make them, cuttings by compartments or by strips are required, which in turn lead to the adoption of the advance growth type, shelterwood type, or cleared type of n. s. r.

The strip form, as mentioned elsewhere, seems to be particularly well adapted to meet American needs.

II. The culled forms of high forest must be retained by the forester in the compartment, group or selection form first encountered, unless the culling has been particularly light. Improvement cuttings are not apt to change the form of the forest. Where artificial reinforcing is resorted to, the forest will gradually develop even-aged forms. When after heavy culling the average growing stock per acre is badly reduced, then forms allowing of short rotations are indicated, so especially selection forms and standard forms. Frequently in such cases, the high forest is abandoned, and the coppice forest is resorted to.

III. In the cultured forms, the trend of the times favors uneven-aged forms, notably mixed group forms and narrow strip forms, on account of greater safety.

Heavy "thinnings from above" are in vogue, frequently in connection with underplanting (or underseeding by n. s. r.)

Regeneration is effected either by planting compartments, strips and groups, with or without a shelterwood overhead, or by the various types of n. s. r.

Where the deficiency of the growing stock leads to the adoption of short rotations, standard forms, two-storied forms, underplanted forms or coppice-under-standard forms must be resorted to. In the latter case, of course, the high forest form is thrown overboard.

Paragraph LXVII. High Forest by Species.

A. Oaks: The Oaks rarely appear in pure stands.

1. Primeval woods. The primeval high forest exhibits the Oak:

a. As the lower story planted in groups or compartments underneath an upper story of Long-leaf Pine, Loblolly Pine, Short-leaf Pine;

b. In small pure groups sprinkled amongst the Bald Cypress and Red Gum of the southern hummocks;

c. In the selection form grafted upon compartments of high forest of other hardwoods, notably of Chestnut, Hickory, Gum (Ten.); or grafted on compartments of Kalmia, Rhododendron, Chinquapin (N. C.).

d. In pure even-aged groups (prairie borders).

e. In selection forests mixed with many other hardwoods also in selection form.

II. Culled high forests: The culled forest of oak is usually axe-culled as well as fire-culled, thus partly losing its character as a high forest.

The n. s. r. of White Oak, Chestnut Oak and Scarlet Oak at Biltmore proceeds selectionwise or in compartments, notably so on Indian fields in the Pink-beds; underneath Chestnut, Maples, and Oaks on Poplar hill; mixed with Hickory on the lower west slope of Averys creek and so on.

The Oaks endure shade well for a long number of years, trailing on the ground until freed from superstructure. Coccinea three years old is only five inches high, being clipped back continuously by insufficient lignification of its top-shoots.

Even-aged polewoods of Oak are found all over the Blue Ridge and the Piedmont Plateau. Examination will usually prove them to be fire-culled coppice formed by the fire-killed, younger age classes of primeval woods (seedlings, saplings and small poles).

III. Cultured high forests.

The cultured high forest at Biltmore is still *in statu nascendi*, in the plantations on abandoned fields as well as in the n. s. r.'s of comp. 102 (compartment type), the slopes of Ducker Mountain, etc. The growth of the Oaks during early youth is very slow. The soil is usually so badly hardened as to require artificial help to n. s. r. Oak seedlings and saplings are rare in Pisgah Forest (excepting 3-year-old Scarlet Oaks).

The Oaks mingle with the Short-leaf Pine everywhere as an undergrowth started by n. s. r., or as a companion-growth in Pine pole-woods. Here too, however, the fires have usually converted seedlings and saplings into stoolshoots.

In the S. E., regeneration under shelterwood or in advance of logging (by the group type or by the compartment type) seems advisable. In the mixture with the Oaks should be encouraged: Maples, Black Gums, Pines (White Pine grows and retains its branches for a long time in the mixture), Chestnut, Hickory, Walnut.

Record of seed years at Biltmore:

White Oak: good in 1899.

Post Oak: in 1900 the only mast-bearing oak.

Black Oak: splendid, full mast year in 1901 in all situations.

Spanish Oak: splendid, full mast year in 1901.

Chestnut Oak: promises well in 1904.

B. Chestnuts:

1. Primeval forests:

Actually primeval forests of Chestnut seem very rare. The Chestnut woods of the Appalachians have been ransacked by fires for many decades of years. The n. s. r. seems to have been of the selection type. Chestnut seems to avoid limestone-soil and ceases to occur where limestone appears (Ky; Ten.).

II. Culled high forests:

The fire-culled forest shows an absolute lack of seedlings, saplings and poles.

The axe-culled forest consists merely of coppice.

Trees beset with dead branches are invariably wormy (Lymexylon).

Seed years seem to be getting scarce, possibly under the influence of fires, to judge from the reports of mountaineers. The old trees are frequently stagheaded and fail to successfully regenerate their kind.

Seedlings one year old are about eight inches high, when found in the woods. They appear individually scattering and not in groups.

III. Cultured high forests:

The cultured forest usually has the form of coppice or coppice-under-standards. Plantations in the United States are made more for fruit-growing than for timber-growing. The abandoned fields at Biltmore seem too dry for successful development. Chestnuts planted as an undergrowth below Oak and Pine have done poorly, owing to the ravages of squirrels.

The poles and trees seem to badly resent any sudden interference with the leaf canopy and with the humus.

Thinnings and cuttings in the shelterwood system should be light.

The competition of stoolshoots invariably formed after cuttings reduces the prospects of seedlings simultaneously obtained. Stoolshoots cannot be entirely prevented by deadening previous to cutting.

Chestnut produces a splendid humus and is an excellent companion for Oaks, Hickories, Walnut, Black Cherry, Ash and Yellow Poplar; also for White Pine and Hemlock. It regenerates in mixture with Yellow Poplar on small abandoned fields of Pisgah Forest to a limited degree.

Seed years: Fairly good mast in 1898.

On the mountain tops, where Chestnut stands in an orchard-like position, seed occurs annually.

C. Hickories:

I. Primeval forest: The Hickories appear regenerated in the selection type and in the group type.

II. Culled high forest: The Hickories suffer badly from fires. Fires do not kill the poles, but cause the butts to burst subjecting them to decay. Weeding and heavy improvement cuttings are beneficial.

III. Cultured high forest:

From the early pole stage on, the crowns should be placed in a free position so as to cause the formation of wide rings.

At Biltmore, the boles are apt to be very branchy, the tough limbs being very persistent.

In the mountains, on stronger soil, the boles clear themselves readily.

The Hickories regenerate by n. s. r. in abandoned fields in mixture with Black Gum, Sassafras, Yellow Poplar, Locust, Oaks, etc.

In the plantations on abandoned fields at Biltmore, Bitternut alone promises to be successful. The other species are badly handicapped by rodents and seem to be of very slow growth.

The Hickories seem to be immune from damage by frost in their native country; not so in Germany

Seed years are not of record.

D. Walnuts:

I. Primeval forests:

The Walnuts appear in the primeval woods invariably in mixture with other species, on strong soil, seemingly regenerated by the selection type.

II. Culled high forests:

The Walnuts seem remarkably fireproof from the early pole stage on. Seed regeneration is rare in the woods, but more frequent on old deadenings close to habitations, where the squirrels were held in check.

III. Cultured high forests:

Without artificial help, n. s. r. seems very problematic. Under any circumstances, the rodents must be kept off.

Plantations are frequently found and do very well in early youth, unless the soil is badly hardened and impoverished. The stands should be dense, whether pure or mixed with Oaks etc., so as to produce clean boles. Plantations seem to fail in the close proximity of old trees.

The plantations at Biltmore have failed invariably in the woods, owing to the ravages of squirrels; toungya on leased farms shows poor success, owing to the unreliability of the lessees; plantations of seedlings three years old failed badly; plantations of yearlings freeze to the ground annually on all slopes; plantations of nuts on small fields have done very well, where the ground was good; and the change from good to-bad, brought about by the undulations of the soil, is very marked. Failures on poor soil are now doctored up by a nursegrowth of Yellow Pines,—a remedy promising some success.

E. Beech:

I. The primeval forest exhibits the compartment, group and selection type of n. s. r. The humus is usually very heavy and so moist that fires have a poor chance to spread. In the South, at lower altitudes, Beech merely fringes the river banks.

II. The culled high forest shows many stump sprouts, stumps three feet high forming the sprouts on the top of the stump.

In the Blue Grass Region, huge park trees are frequently found in a dense undergrowth of seedlings and saplings. Here the more valuable species have been culled out many years ago, and the Beech is left in exclusive possession of the soil.

III. The cultured high forests of Beech are easily regenerated in the shelterwood-compartment type. The selection type yields branchy boles. Beech is the best companion imaginable for faster-growing species; is splendidly qualified for an underwood planted beneath aristocratic species; is exacting and sensitive.

Plantations on abandoned fields are out of the question, except at high altitudes.

No seed years are of record at Biltmore. The trees on the river banks fruit annually.

F. Basswood:

I. Primeval forests:

In the Lake States and in the Alleghanies, Basswood exhibits the form emanating from the selection type of n. s. r., grafted on the compartment type of White Pine or of Hard Maple, or else mixed with Hard Maple, Elm, Chestnut, Red Oak, Yellow Poplar.

II. Culled high forests:

The regeneration follows the selection type; fires clip the seedlings and saplings; larger poles and trees seem to withstand well.

III. Cultured high forests:

Young seedlings develop very slowly; they are less sensitive than their shade-endurance would indicate. Pure forests are found only in Russia.

Seedlings planted at Biltmore on old fields, of strong qualities, have hesitated to develop for six years, growing bushy and crooked; in 1904, they promise good results.

Linden underplanted below Oaks and Chestnuts after moderate thinning on North slopes seems to answer admirably, forming long and straight, although overhanging topshoots.

Seedyears in Pisgah Forest occur annually. The majority of the seeds, however, seem to drop immature.

G. Yellow Poplar:

I. Primeval forests:

Yellow Poplar appears invariably in the selection type, or in the form of standards.

II. Culled high forests:

The species attempts unceasingly to propagate its kind by n. s. r. The heavier the destruction by the axe, the better are its chances for success. Fires, on the other hand, annihilate the seedlings and check the chances for regeneration thereafter, owing to a rank growth of weeds following the fires. In Pisgah Forest, seedlings and saplings were entirely lacking, until fires were stopped.

The regeneration on old fields, on the other hand, is prolific and easy. Cattle press the seeds into the ground and check the competing weeds. Sassafras, Locust and Pine frequently act as ushers. The old fields are usually protected from fire by the owners wishing to protect their fences.

No known species prunes itself as readily from branches as Yellow Poplar, the dead branches popping off without leaving any stumps.

III. Cultured high forests:

No species at Biltmore is as easily regenerated by n. s. r. as Yellow Poplar. In Biltmore Forest, the group type is readily carried through with the help of three or four mother-trees to the acre. The other companions of the mother-trees, notably Oaks and Chestnuts, are gradually cut away; spreading Dogwoods are deadened to prevent them from forming stoolshoots.

In Pisgah Forest, regeneration is helped by preceding pasturage (especially in early spring, before the seeds of Poplar germinate) and by weeding following in the wake of n. s. r.

The seeds will never sprout in the humus; seedlings born late in spring (June) and showing the cotyledons still in September are sure to be killed by frost; also seedlings growing in the shade of weeds. The logging roads and log yards are real "nurseries" for Poplar. On steep ground, the seedlings are washed out by the rain.

The growth is very fast.

Seed years are annual; hollow trees are likely to furnish very poor seeds.

Plantations of 3-year-olds at Biltmore on poor old fields did badly; on good soil, especially where a volunteer growth of Locust has joined the plants, the success is complete.

H. Maples:

I. Primeval forests:

Here the regeneration follows the compartment type (Adirondacks, Missouri valley), the group type and the selection type (Biltmore, Northern Minnesota). Maple usually appears in mixture with other hardwoods, with Spruce and White Pine. Soft Maple occurs in low, moist sites as well as on dry ridges. Hard Maple demands well-drained and strong soil, preferring Northern aspects.

II. Culled high forests:

After culling, the younger stages of Maple are usually left in possession and develop in dense thickets, preventing more valuable species from establishing themselves. In the Adirondacks, Soft Maple is frequently found on Spruceflats after windfalls (associated with Yellow Birch).

III. Cultured high forests:

Dr. Fernow at Axton succeeded in establishing, in places, a splendid regeneration obtained from advance growth n. s. r. of the compartment type, removing the parents at one stroke. In Europe, the shelterwood compartment type answers admirably.

Biltmore Forest is deficient in Maple. Still, Hard Maple planted on abandoned fields, pure or in mixture with White Pine, has done admirably, excepting dry S. W. slopes, dry spurs, and very moist river bottoms.

In Pisgah Forest, Red Maple usually appears as a weed overshadowing aristocratic seedlings.

I. Ashes:

I. Primeval forests: The Ashes usually regenerate and stand in patches or groups, occupying the moister sites.

II. Culled high forests:

Protected by moist ground, the Ashes stand a good chance to escape the fires. During early youth, the seedlings endure remarkably heavy shade. Weeding and improvement-cuttings produce splendid results.

III. Cultured high forests:

Regeneration in the group type is easy, if helped by cleaning (Ducker Mountain of Biltmore Estate) and gradual removal of the obstructing trees. On old fields, on moist slopes, White Ash is often accompanied by Yellow Poplar and Halesia.

Plantations of 3-year-old Green Ash have failed utterly at Biltmore on dry, hard soil.

Plantations of 3-year-old White Ash in half-swamps do very well; also seed plantations on good soil in the gaps of a ridge.

The early growth is very fast.

Seeds are profusely produced from the pole stage on.

J. Red Spruce:

I. Primeval forests: The primeval Spruce woods appear as more or less even-aged compartments in the swamps and sloughs of the Lake States and on the dry, shallow South slopes of New England; in the cleared group form and in the selection form in Western N. C. at altitudes exceeding 5,000 feet, mixed with Abies fraseri (selection); in the selection form, grafted upon compartments of Beech and Maple, on the hardwood slopes of the Adirondacks. In the latter case, Spruce never regenerates in the heavy layer of broad-leafed humus, but selects invariably the half-rotted corpse of a dead tree for a seed-bed.

II. Culled high forests: In slightly culled forests immune from fires, Red Spruce seems to reproduce with remarkable ease. On fired ground, Birches and Cottonwoods frequently act as ushers. Its persistence below an impenetrable leaf canopy of Beech or Maple is surprising. Freed from superstructure, after long years of suffering, it answers the chance for rapid growth almost immediately.

III. Cultured high forests: Spruce requires high atmospheric moisture; is satisfied with shallow soil; can be readily reproduced by n. s. r. as well as by planting.

Seed years: Prolific in North Carolina in fall 1901. The trees, top heavy with cones, were mowed down by storms.

K. White Pine:

I. Primeval forests: The White Pine of the primeval woods appears in compartments, almost even-aged, or in groups, either pure, or with an admixture of Hard Maple, Linden, Elm, Yellow Birch; or in the form of standards over Red Spruce and Balsam; or in the selection form, as in the Calmia thickets of the Pink-bed Swamps. It is flat-rooted, subject to windfalls, in the North not tolerant of shade.

II. Culled high forests: The gorgeous White Pine forests of the Lake States, after culling followed by fires, are invariably surrendered to a shrubbage of hardwoods. Second growth is found in beautiful groups underneath Norway Pine; individually sprinkled amongst Jack Pine, Basswood, Birch, etc.; also on old burns in extensive, even-aged compartments; along roads and at the edge of clearings; in New England on old fields.

In Western N. C., White Pine regenerates readily on broomsedge fields; in mixture with the Oaks on the uplands; in mixture with Red Maple and Red Birch in the river swamps, etc.

III. Cultured high forests: At Biltmore, the n. s. r. of White Pine started by a few seed trees succeeds easily in the group type. White Pines planted under dense shelter require freeing soon (compartment 45). Individual trees are very retentive of branches. Plantations on several hundred acres have done admirably. White Pine is the easiest Pine to plant on old fields or in groups in the woods after clearing.

Seed years are frequent at Biltmore, recurring at intervals of two or three years, f. i., fall of 1902 and 1904.

L. Yellow Pines:

I. Primeval forests: The pure group form (Black-hills) or the group form wedded with the compartment form of Oaks reaching a lesser height than the Pines seem to be typical. Pine standards are often left. The compartment form of P. taeda is also frequent. P. divaricata and murrayana invariably occur in even-aged compartments; P. palustris and P. heterophylla usually occur in groups.

II. Culled high forests:

The culled forest is usually visited by fires which gradually convert an undergrowth of hardwoods, where it exists, into coppice. Beneath Longleaf Pine, this undergrowth begins to sprout only when the mature Pine is removed.

P. rigida and P. echinata less than 6 inches in diameter are also coppiced (New Jersey Pines) to a limited extent.

Where the pure high forest continues, fire has usually improved the chances for n. s. r. by preparing a ready seed bed and by lessening the severity of future fires.

All Yellow Pines regenerate prolifically on abandoned fields, often in stands which artificial planting could not produce equally well.

III. Cultured high forests:

The n. s. r. of P. echinata in the Biltmore woods creates nuclei for small groups which are freed and gradually enlarged. Heavy thinnings from the early thicket stage on prevent crowding in the pole stage and hereby check the chances for successful attacks by the bark beetles. Pruning 100 decidedly predestined trees per acre seems remunerative (dead branches only) at Biltmore.

Standard form of P. echinata seems indicated at Biltmore.

All Yellow Pines are easily planted when one or two years old and get along without cultivation on old fields. Heavy growth of weeds, on good soil, however, is sure to smother them.

In pure and large natural regenerations, it is wise to leave some hardwood standards with a view to securing an admixture of hardwood seedlings in due course of time.

In mixture with White Pine, Yellow Pine is soon subdued on good soil, while it retains the lead on poor soil.

Seed years of Pinus echinata at Biltmore occur every seven years. The fall of 1902 was a prolific breeder of seeds even in polewoods 35 years old (Walker-nursery at Biltmore).

CHAPTER III.

THE COPPICE FOREST.

Paragraph LXVIII. Genesis of the coppice forest and its methods.

The coppice forest is either the result of stump-shoots or is obtained from rootsuckers, layers and cuttings.

A. Stumpshoots (or stoolshoots or coppice shoots).

I. Species: All hardwoods whilst young form stump shoots when cut just above the callus. Amongst the softwoods, the Sequoias exhibit enormous stump sprouts. Amongst the Yellow Pines, P. rigida and echinata, after F. E. Olmsted also P. taeda, are capable of developing sprouts from stumps measuring less than six inches in diameter. White Pines, Spruces, Firs, Larches, Hemlocks, etc., never form coppice shoots.

II. Diameter: The sprouting capacity rapidly decreases, usually, with increasing diameter of the stump. The diameter at which the principal height growth is completed usually denotes the limit permissible for coppice rotations. This rule is particularly well illustrated by the behavior of Yellow Pine, Birch, Maple, Yellow Poplar, Oaks, Hickories, etc. Chestnut and Sequoia do not seem to follow the rule.

III. Soil: Good soil allows big stumps otherwise unproductive of sprouts to form stool shoots.

Good soil produces stronger, but less sprouts than poor soil.

IV. Life of stumps: The life and hence the sprouting capacity of stumps repeatedly coppiced is closely connected with the resistance offered by the timber to decay. White Oak, Chestnut, Sequoia and Locust are perseverant sprouters, the scars on the stump being protected from rotting by the antiseptic qualities of the substances incrustating the heart wood.

The reproductive power of Birch, Beech, and Maple is not sustained for a long time. Ash and Basswood show greater perseverance.

It might be said that a long-lifed species is also a perseverant sprouter.

The sprouting capacity is especially good in species capable of forming a separate and detached root system for the sprout independent from the mother stump. This is the case in species forming sprouts from the base of the stump (at the root collar).

V. Optimum number of stumps per acre:

The optimum depends on the length of the rotation. It is considered to be: For German Oak coppice, rotation 20 years, 2,000 stumps per acre; for Osier culture, rotation one or two years, 80,000 stumps per acre.

VI. Manner of coppicing: The use of the axe is preferable to that of the saw. Stumps should be as low as possible, to begin with. In case of stumps—notably Beech and Birch—coppiced a number of times it is better to cut in the new wood. The scar should allow the water to run off, instead of collecting it like a saucer. The expense of the genesis of the coppice forest is practically nil.

VII. Season of coppicing:

If the wood must be peeled, the cut should be made in early spring. Late spring cutting subjects the new sprouts to early frosts. Coppicing in August is supposed—for similar reasons—to affect the vitality of the stumps. Where the shoots are not to be peeled, cutting in late winter is best. Winter cutting prevents the stumps from bleeding and allows to remove the product cut before the appearance of new shoots without injuring the stumps.

Cutting in fall subjects the stumps to frost-cracks and to bark-blistering; it causes the new fleshy shoots to appear early in spring, at the season of prevailing late frosts.

Accessibility of the locality at the proposed season of cutting and availability of local labor further determine the season of cutting.

VIII. Reinforcing: Where the number of stumps is or becomes deficient, there the owner may plant seedlings or stump-plants to replenish the growing stock.

B. Root suckers: Cottonwood, Willow, Locust, Alder, some Elms and Maples, after European experience even Liriodendron (?) form root suckers, especially on porous soil. The suckers are increased by locally uncovering the surface roots. They might be severed from the stem and planted when two or three years old; but this is expensive. Gardeners often use pieces of roots, say ten inches long and finger-thick, for propagating broad-leaf species in good soil. An observer in F. and T., May, 1904, claims to have found that Fir and Spruce in the Presidential Range of the White Mountains propagate their kind by the natural and unaided formation of suckers developing from long, horizontal roots.

C. Layers: A low, long branch of a standing tree is partly buried in a trench one-half foot deep, held in place by hooks, pins or stones, the end of the branch protruding above ground. The branch thus imbedded forms roots and shoots. The latter are severed from each other a year or two before planting in the open.

Layering is a gardener's method only locally used in parks. At very high altitudes, under the influence of very great atmospheric moisture, the low Spruce branches naturally form roots and shoots in a similar manner.

D. Cuttings: Willows and Poplars are usually propagated by "cuttings," viz.: pieces of branches one foot long and two years old, tipped with a piece one year old. The cuttings are inserted obliquely, the tips barely showing above ground. Planting dagger or turning plow are the tools used. Care must be taken to prevent the bark from peeling off. It is claimed that the constant use of cuttings causes a deterioration of growth. Cuttings of sapling size taken from strong and long branches are also planted in good nursery soil for a number of years and planted in the open ground after catching root. Willows and Poplars allow of heavy trimming. Among conifers, only Sequoia permits the use of cuttings. It is claimed that Sequoia-chips sprout successfully in the moist climate of the Coast Range.

Paragraph LXIX. Pedagogy of the coppice forest.

The coppice forest is tended by cleaning, weeding, and thinning; also by improvement cuttings and pruning.

A. Cleanings: To prevent undesirable shoots from developing, the stumps producing them must be removed. Stumps of undesirable species (Blackgum, Hazel, Alder) can be removed only by digging, or by heaping dirt upon them, or by firing heaps of debris placed on the stumps. Usually, it is preferable to deaden undesirable trees instead of trying to prevent their stumps from forming sprouts. In some species, stumps three feet high will form poor sprouts, a quality which might be taken advantage of.

B. Weeding: Misshapen trees or poles of a desirable hardwood species, cut level with the ground, will at once produce shoots of good quality. Poles badly damaged by fires should be cut for an increase of vitality. Trees left because worthless should be deadened, unless they belong to the aristocracy, or unless they improve the good sprouts as well as the soil in the role of subordinate companions.

C. Thinnings: Thinnings in European coppice woods are rare; in tanbark coppice they usually purport to improve the quality of the bark. Where made, the thinnings usually remove the weaker shoots of a stump for the benefit of the better and stronger shoots. The rotations of European coppice being short, heavy thinnings tend to deteriorate the quality (branchiness and shape) of the shoots as well as of the soil; and light thinnings are rarely remunerative.

In America, coppice of Catalpa, of Chestnut, of Locust and Hickory may invite heavy thinnings where fence posts, telephone posts, railroad ties, wagonstock, etc., find a ready market.

In case of Hickory, thinnings periodically removing the best trees (à la Borggreve) might seem indicated.

D. Improvement cuttings: Improvement cuttings are necessary in culled coppice forest emerging directly from primeval hardwood forest heavily cut or heavily fired. Such forest is invariably encumbered with bushy and worthless standards (if the standards have a value, the forest belongs to the form of coppice under standards described in Par. LXXIII-Par. LXXVIII) interfering with the development of the shoots; or with undesirable species left by the logger. The mob frequently prevails over the aristocrats.

The first final cut at the end of the first coppice rotation usually answers the purpose of an improvement cutting.

E. Pruning: Pruning is required to prevent coppice of Catalpa, Locust and Ash from forming forks or heavy branches. Naturally, pruning is expensive and dangerous at the same time since live branches are removed. The danger is particularly great where the rotations are long, the pruned stump shoots being left for decades of years after pruning.

In the pollarding form, pruning or rather lopping obviously comprises the harvest of the crop.

Paragraph LXX. Key to the forms of coppice forest.

Although coppicing is called a type of natural regeneration, it is an absolutely unnatural measure never adopted by primeval nature. Primeval forms of coppice forest proper do not exist.

Species propagating their kind, at least partially, by rootsuckers frequently form rootsucker forests closely resembling coppice forests proper.

Chestnuts, Locusts and many other hardwoods broken down by storm may form natural sprouts as well from the stumps. Still, these cases are probably so scattering as not to deserve the name of "form of primeval coppice forest."

Thus there remain only two large groups of coppice forests, namely "Culled Coppice Forests" and "Cultured Coppice Forests." In both cases we have to deal only with the large-area form or compartment form of coppice.

Woods seemingly consisting of uneven-aged coppice shoots, mixed in groups or individually, are dealt with as "Forms of coppice-under-standards" (Par. LXXIII-Par. LXXVIII), unless the standards are worthless and promise to remain worthless.

A. Culled forms of coppice:

These forms emerge either directly from omnivendible primeval forms, or else have passed through the intermediate stage of "culled coppice under standards."

I. Characteristic for culled coppice is:

An even display of growth.

A surprising density of stand.

The presence of some weathered and worthless snags and stumps protruding from the even sea of coppice.

II. Subdivisions of culled coppice:

Uniformity being characteristic for culled coppice, sub-forms can scarcely be singled out, unless the means of coppicing—fire or axe—serve as a criterion. Hence there might be distinguished

a. The form of fire—culled coppice, and

b. The form of axe—culled coppice.

This distinction is not made on the basis of different display; but on the basis of difference in treatment required by the two forms.

III. Treatment of culled coppice:

The culled coppice is regenerated by being coppiced anew. In the case of fire-culled coppice, it is wise to delay the second cut as little as possible.

Coppicing in patches or small groups is not advisable, the young shoots requiring all the light available for rapid lignification.

An insufficient number of stumps may call for artificial reinforcing.

Improvement cuttings convert poor coppice shoots interfering with their neighbors from above into healthy coppice shoots pressing their neighbors helpfully from below.

B. Cultured forms of coppice:

No form of cultured forest can be obtained more easily and more cheaply than the form of cultured coppice.

In the European hardwood forests, the cultured coppice of the past has often served as the forerunner of the cultured high forest of the present sylvan era.

I. Characteristic for cultured coppice is an even stand, a dense stand, freedom from undesirable competitors and tree weeds.

II. Subdivisions of cultured coppice forms are:

a. The simple form of cultured coppice, where all shoots have the same age.

b. The two-storied form of cultured coppice, where the growing stock displays two tiers of leaf canopy, viz.: an upper and a lower tier, the age of the tiers differing by the length of a rotation.

In addition, a form of "high stumps" is usually distinguished, where trees are cut some six to ten feet above ground and where the shoots forming on that high stump are cut at short intervals. This form, adapted particularly for the production of fascines at levees, is known as:

c. The pollarding form of cultured coppice.

In this form, rotations of one to five years are usually adopted, and the "lopping" takes place in the "new wood."

III. Treatment of cultured coppice forms:

Regeneration in the cultured forms of coppice is, of course, by coppicing, helped by planting stumps, cuttings, suckers and layering. Regeneration may proceed against the direction of the wind which brings the heavy frosts of spring and fall (blizzard-direction). Cleaning and thinning are often indicated.

Paragraph LXXI. Critical remarks on coppice forests.

The coppice forest generally furnishes small-sized timber, notably firewood and farm supplies, but no or little saw timber. Its production is not so many-sided as that of the high forest, and for that reason not equally safe.

On the other hand, allowing of shorter rotations, the timber investment is much smaller than in high forest, and the returns from "final yields" are more frequent.

A comparatively small area may produce, under a coppice form, a regularly sustained yield.

The soil of the forest is frequently exposed, and shows a thin layer of humus. Shallow soil is, however, sufficient for the welfare of a coppice forest.

The water-retaining capacity of the coppice forest is small.

Coppice forest is less exposed to storm, fire, snow, and insects (being broad-leafed usually), and more exposed to late and early frosts than high forest. As a stock pasture, it is much more productive than high forest; but also much more damaged by pasture.

The expense of regeneration and of pedagogy is slight. The species forming shoots from below the ground and those forming root-suckers usually allow of long rotations.

Paragraph LXXII. Coppice forests by species.

A. Oaks:

I. Culled Oak coppice:

Culled Oak coppice is usually fire-culled. The stumps do not tire of emitting shoots after each fire. Still, the shoots become weak, stunted and bushy-crowned and refuse to grow in diameter as well as in height.

It is remarkable to find that these worthless shoots may be replaced by strong shoots after coppicing with the axe.

The poorer the fire-culled Oak coppice, the greater is the improvement obtainable by axe-coppicing.

II. Cultured Oak Coppice:

In Europe, Oak coppice is the form in which Oak bark is raised for tanning purposes, under a rotation of fifteen to twenty-five years.

In America, coppiced Oak is used only for charcoal and firewood—rarely for railroad ties. Rotations yielding ties will not allow of ready reproduction under the coppice form, unless the soil is very strong.

At Biltmore, Post Oak three inches through, White Oak ten inches through, Black Oak and Scarlet Oak twelve inches through are unlikely to sprout.

A rotation of not to exceed forty years seems indicated. Such a rotation might also yield hoop poles, poles for splitwood fabrics and minor wagonstock.

B. Beech:

Beech coppice yields firewood only, charcoal and so-called retort-wood for dry distillation.

The sprouting capacity of the Beech invites short rotations. Strong soil is required.

C. Hickory:

Hickory coppice promises good financial results on strong soil only. Fires must be strictly kept in check, owing to the heavy scars which they inflict on Hickory. Rotations of about twenty years, low stumps and winter cutting seem required.

On Biltmore soil, stumps over six inches in diameter usually refuse to sprout.

D. Locust:

Locust coppice densely planted on old fields seems to be a good investment, although the poles thus produced consist of sappy wood undesirable for fence posts. The young shoots suffer from a pith-boring moth (Ecdytolopha species).

The sprouting capacity is very good, helped by the ready formation of rootsuckers.

In Germany, wagon stock is obtained in rotations of twenty years.

E. Chestnut:

Chestnut is the American species best adapted for the coppice forest. Stumps of any diameter emit sprouts. A rotation of twenty to forty years will yield vineyard stakes, hop poles, telephone poles, posts, rails, ties and wood for the extraction of tannic acid; a rotation of five years is said to be used for the production of hoop poles for barrel hoops.

The European complaint does not seem warranted in America that rotations exceeding twenty years invite a disease known as "heart-rot."

In Alsace-Lorraine, thinnings take place in the tenth year; the cut is made in early winter, and the stumps are sometimes protected from the influence of frost by heaps of brush. In the Appalachians, such precautions are not called for. It is unnecessary, if not unwise, to reduce the number of sprouts starting from one stump artificially. Spring cutting and high stumps are objectionable.

On dry and impoverished soil, or under the regime of fires, Chestnut coppice is hopelessly lost.

F. Cottonwood:

Coppice forest of Cottonwood produces match stock and pulpwood. The stumps have little vitality and will not endure more than four rotations of twenty years each. Very low stumps are required to insure healthy sprouts and to encourage the production of root-suckers. The growth is very fast in the first years.

G. Willows (Osier-culture):

Osier culture is considered a money maker in Germany where labor is cheap. It is now in vogue in New York and in New Jersey. The best species are Salix viminalis, Salix amygdalina, Salix purpurea, Salix acutifolia (caspica). The rotation comprises one or two years. With the exception of Salix caspica, a moist soil is required (meadow land in river bottoms) by the willows.

The stumps do not yield a return for more than twelve to sixteen years.

For the formation of an Osier grove, shoots two feet long are used of which about 80,000 are put in per acre. It is stated that the more shoots there are per acre, the better is the quality of the Willow, as branchy stuff cannot be used for basket making.

Cultivation between the rows is said to be very advisable or even necessary, especially in the first years. There are many insects feeding on the leaves and many fungi besetting the leaves of the Willows.

A one-year rotation is best. After three or four years, however, a two-years' rotation frequently intervenes, so as to allow the root to develop unhampered. The shoots two years old are used for the framework of heavy baskets. The cutting takes place in July and August. Krahe, however, advises cutting in November.

The first cost of an Osier plantation is very high. After Krahe, the net yield amounts to $32 per acre per annum.

CHAPTER IV.

THE COPPICE-UNDER-STANDARDS FOREST.

Paragraph LXXIII. Genesis of coppice-under-standards forests and its methods.

"Coppice under standards" consists of an underwood and of an overwood.

The underwood is nothing but simple, even-aged coppice.

The overwood exhibits the selection, sometimes the group form of high forest, and is supposed to recruit itself from seedlings.

A. The underwood:

I. Species: The species forming the underwood must combine natural sprouting capacity with shade endurance. On good soil, a smaller amount of both qualities is required. Excellent species for underwood are Basswood; Chestnut; Gum; Hornbeam; Calmia and

Rhododendron; on strong soil, Ash and Hickory; underneath a light overwood also Oak.

II. Purpose: The underwood supplies or may supply

a. Companions for the younger age-classes of the overwood, causing them to form clear boles;

b. Protection of the soil, enriching it by its humus;

c. Firewood and small timber; also tanning material.

The underwood yields a direct revenue only in case "c." Obviously, where there is no market for firewood or small timber, the underwood is only indirectly useful.

III. Formation: For diameter, vitality and number of stumps, also for manner and season of cutting, the remarks of Par. LXVIII. A. (about coppicing) hold good.

B. The overwood:

I. Species: The species forming the overwood should be stormfirm and small crowned. Light demanders are usually preferred.

Yellow Pines produce wide-ringed timber on strong soil and suffer from sleet. Good species are: White Oaks, Red Oak, Hickory, Walnut, Yellow Poplar, Black Cherry, Locust, Larch, etc.; on poorer soil Yellow Pines and Long-leaf Pine (over Black Jack).

II. Age-classes: The number of age-classes in a normal overwood equals the fraction $\frac{R}{r}$ wherein

R represents the length of the rotation in the overwood, and
r represents the length of the rotation in the underwood.

The normal difference of age between consecutive classes is "r" years.

III. Normal formation: The overwood is composed of "standards" regenerated, at the year of coppiced underwood, from self-sown seed falling from the overwood or, in the cultured forest, from planted seedlings. The seedlings of the overwood grow up immerged and often badly endangered in the new underwood. When this is coppiced at the age of r years, an improvement cutting takes place simultaneously removing misshapen or damaged standards of the various older classes as well as the weaklings in the youngest class. By this improvement cutting the leaf canopy of the standards, which has had ample chance of enlargement during the past r years, is cut back to a normal limit.

The older an age-class is, the smaller is the number of its constituents.

C. Abnormal formation of overwood and underwood:

A normally proportioned and normally formed overwood is never found. Deficiencies lie

1. In a lack of one or the other age-class;

2. In an abnormal number of constituents per class;

3. In the fact, that the overwood is partially recruited from stoolshoots and not from seedlings.

Abnormal coppice over-standards is the usual consequence of the culling of primeval hardwoods or of primeval pineries forming a superstructure over Oaks, Hickories, Gums, etc.

The burned slopes and outskirts of the Alleghanies usually belong to the coppice-under-standard form. The fire-coppiced underwood here consists of Soft Maple, Calmia, Rhododendron, Chestnut, Oaks, Hickories, Black Gum, Sourwood, Halesia, etc., etc., all of which are usually devoid of value.

Culled and fired forest of Pinus echinata, taeda and palustris frequently belong to the same form, with Oaks in the underwood and the Pines in the overwood.

Paragraph LXXIV. Pedagogy of coppice-under-standards forest.

Coppice under standards is or may be tended by cleaning, weeding, improvement cuttings, pruning and thinning.

Thinnings are applied to the underwood only; whilst the overwood alone is the object of pruning.

A. Cleaning purports to eliminate undesirable shoots in young coppice, or removes desirable shoots liable to interfere with the development of overwood seedlings imbedded in the coppice.

B. Weeding removes weed trees, usually tending to form new sprouts from the stumps of the weed trees removed. Weeding is a necessity where a culled forest is to be converted into a cultured forest, the culled forest containing a large number of weed trees.

At Biltmore, the weed trees removed are Black Gum overshadowing the coppice and the Pine seedlings standing therein; fire-scalded Oaks or Hickories, bent and low crowned; wolfs of Yellow Pine; pretentious Dogwoods or Halesias and so on.

C. Improvement cuttings improve the prospects of the overwood, remove undesirable members of the overwood and regulate the number of the constituents forming an age-class of the overwood. "The normal cuttings in the overwood are improvement cuttings."

In semi-normal woods, the oldest class of the overwood is entirely removed. Class II is reduced to the former membership of Class I; Class III is reduced to the former membership of Class II, etc. It stands to reason, that the least desirable members of a class should be thus removed. In semi-normal woods, the improvement cuttings take place at the time at which the underwood is ripe for coppicing.

The improvement cutting yields timber of all sorts and of all sizes obtained from the various age-classes.

The improvement cutting does not regularly intend to help regeneration. Frequently, of course, the stumps of trees removed by the improvement cutting form sprouts partaking in the coppice-tier.

D. Pruning: Dead branches of the overwood trees might be removed to develop timber clear of dead knots.

Live branches of overwood trees formed low on the bole are removed to lessen the intensity of the shade to which the underwood and the seedlings imbedded therein are locally subjected.

The members of the overwood, owing to their free position, are apt to form and to retain heavy branches. The act of pruning in coppice under-standards corresponds with that described in section sixty-three for high forest.

The coppice is pruned only in rare instances, f. i., for the improvement of oak tanbark.

E. Thinnings are sometimes indicated in dense coppice in order to increase the food and light supply of the youngest age-class of overwood imbedded in the coppice; or in order to increase gradually the air space surrounding the members of that class, so as not to subject them to the shock of sudden exposure at the time of coppicing; or to obtain the ends of Par. LXII. A., especially where the overwood classes appear in groups; or to improve the quality and the quantity of the bark in tanbark coppice.

In all cases, the thinning must yield a surplus revenue.

Paragraph LXXV. Key to the forms of coppice-under-standards forests.

The primeval woods do not contain any form of coppice under standards. In culled hardwood forests, on the other hand, these forms are almost regularly met with.

A. Culled forms of coppice under standards.

I. Characteristics: Primeval hardwood forests are usually paucivendible only. After lumbering the merchantable species and sizes, a rank growth of coppice shoots frequently enters an appearance under the assistance of fires, overshadowed by poles and trees of all age-classes devoid of present value. Many individuals of the overwood are badly burned; or are hollow, fungus decayed, worm riddled, etc.

Thus whilst the underwood consists of fire coppice or shoots sprouting from the stumps of merchantable trees, the overwood consists of undesirable species and of immature trees usually crippled by firing and felling. In addition, there are plenty of weed trees left on the ground. The younger age-classes of the overwood are usually absent.

In forests originally composed of a Pine overwood and of a hardwood underwood—a form once frequently found all over the Southeast—the lumberman usually removes merely the taller Pines scaling over ten inches in diameter. The smaller Pines, if fireproof, henceforth join with the hardwood trees and hardwood poles in the formation of an overwood. The underwood consisting of miserable fire sprouts is continuously clipped by forest fires. The butts of these "snags" are flattened on the ground, as if liquid wood had hardened on it. The shoots, weakly inserted on the callus, can be torn off easily.

If these snags are cut, fresh shoots will form, of much greater vigor and of greater strength at the point of insertion.

II. Subdivisions of culled coppice under standards:

The number of forms of coppice under standards is particularly great, owing to the variations occurring in the tiers of forest, viz.: the overwood and the underwood.

a. The overwood is omni, multi, or pauci vendible, as the case may be. It is arranged either in groups or in patches (individuals) imbedded in the coppice. Thus we obtain:

1. The form of culled coppice under standards raised in the group type, and

2. The form of culled coppice under standards raised in the selection type.

b. The leaf canopy of the standards covers a certain percentage of the ground. This percentage, where high, forces the underwood into a minor role; where small, it allots to the underwood the major part.

The Longleaf Pine woods of the South, after heavy culling, illustrate the latter form; the Shortleaf Pine woods of the Biltmore Plateau exhibit the former form. These forms might be designated as:

1. The form of prevailing coppice under standards;

2. The form of coppice under prevailing standards.

c. According to the means of coppicing, there should be distinguished

1. The form of fire-culled coppice under standards;

2. The form of axe-culled coppice under standards.

III. Treatment of culled forms of coppice under standards.

Improvement cuttings and, where improvement cuttings cannot be made, weeding are usually required.

Fire coppice should be cut down, wherever the growth is stagnant.

An undue preponderance of standards may be checked by the use of the axe.

Planting of seedlings can usually be dispensed with. Where it is advisable to plant seedlings, the coppice must be cut clean to begin with.

B. Cultured forms of coppice under standards:

1. Characteristic for the cultured forms of coppice under standards is the lack of weed trees and of unhealthy standards; further the geometric regularity of the figures considered as compartments and sub-compartments.

The overwood is composed only of storm-firm and light-demanding species.

II. Subdivisions of cultured forms of coppice under standards.

As in the culled forest, there should be distinguished:

a. The form of cultured coppice under standards raised in the group type with

1. Prevailing coppice, or with
2. Prevailing standards.

b. The form of cultured coppice under standards raised in the selection type with

1. Prevailing coppice, or with
2. Prevailing standards.

The standards might be planted in regular rows (Charles Heyer's idea) or in regular groups or—irregularly—in suitable places; or they might be recruited from self-sown seed under the selection type.

III. Treatment of cultured forms of coppice under standards.

The regeneration of the overwood as well as its pedagogy is difficult, unless the group type is carried through. Individual seedlings are very apt to be suffocated in the mass of faster-growing coppice and require continuous, careful attention. Thinnings are required to prepare the youngest class of standards immerged in the coppice for its future task.

The overwood is sometimes pruned—in this case of dead as well as of live branches.

Paragraph LXXVI. Critical remarks on coppice-under-standards forest.

The coppice-under-standards forest combines the good qualities of the high forest with those of the coppice forest. It furnishes timber of all sizes in the largest possible variety. It requires a moderate investment sunk into the growing stock and allows the overwood to grow into log size at a very fast rate. It is a good form for the owners of small woodlands desiring steady returns. It protects the fertility of the soil better than the coppice form.

The logs furnished by the overwood raised selectionwise are necessarily branchy and wide ringed, with the incident bad and good qualities of such logs. The trees usually do not yield more than two saw logs.

Where the underwood is unsalable or low priced, stress must be laid on a prevalence of the overwood. Where it is valuable as a tanning material or as wagon stock, the underwood is favored.

The danger from fire—since hardwoods are usually at stake—is not very great. The density of the brushy underwood, however, aggravates the difficulties confronting the fire fighter.

In Europe, "coppice-under-standards" is more and more abandoned and restricted to the inundation districts along the rivers. Here, on strong soil, the undergrowth endures an enormous amount of shade, and the overwood develops fairly long boles in spite of a free position.

The coppice-under-standards form in Europe requires careful, minute and honest management: careful, because the leaf canopy of the overwood rapidly increases during the rotation of the underwood; minute, because individual trees or groups of trees must be continuously watched; honest, because an unscrupulous forester or a thoughtless owner may easily and heavily reduce the capital of the forest whilst claiming to merely withdraw revenue produced by it.

In America, in the hardwood forests of the Alleghanies and in the pineries of the South, the form is destined to play a most important role. The form exists and will have to be retained for decades of years to come, owing to its tempting financial merits; the ease and cheapness of regeneration; the short period of waiting between remunerative cuts; the variety of produce; the fast rate of growth; the small amount of growing stock required for "sustained" yields and so on.

In the course of time, curtailing the cut of standards or allowing the coppice to grow into larger sizes, the forester may gradually convert the coppice-under-standards forest into a high forest. The average growing stock, per acre, in the high forest contains about twice as many cords of wood as the average growing stock in the coppice under-standards forest.

On the other hand, by removing all standards, the form of simple coppice is readily obtained.

In the Oak-coppice-under-Pine-standard forest of Biltmore it has been observed that the Pine poles suffer less from bark beetles than they do in the denser polewoods of the high forest of Pine.

Paragraph LXXVII. Coppice-under-standards by species.

By culling and firing, every primeval forest of hardwoods existing in the United States is converted into coppice under standards. Again, many, nay, almost all two-storied high forests in the South having Pine in the overwood and hardwood in the underwood present the form of coppice-under-standards in a modified manner.

The number of constellations of species for a place in the overwood and in the underwood is endless.

A few remarks on characteristic forms must suffice.

A. Chestnut-coppice under standards of Yellow Poplar, White, Chestnut and Red Oak, Hickory, Ash, Locust,—the Pisgah Forest form.

Certain age-classes of the standards—the sapling stage and the pole stage, are invariably absent, owing to the fires of the last decades. The number of Chestnut stumps is deficient. The weed species of the forest (Halesia, Soft Maple, Dogwood, Calmia, etc.) readily replenish the coppice-stratum. The standards regenerate their kind readily where the weeds are not too rank. No means are known by which to extirpate the tree and bush weeds preventing n. s. r. of the standards in a sufficiently promising way. Heavy pasturage in early spring practiced before the Chestnut stumps had time to sprout and before the seeds of the standards (excepting Chestnut Oak and White Oak) had time for germination may solve the problem. Such pasturage, whilst it checks the weeds, presses the seeds of the standards at the same time into the mineral soil. Other remedies are: Deadening; cutting with high stumps left; bark peeling; removing side branches with a brush axe, etc. However, entire extirpation of the ligneous weeds does not seem financially advisable at the present time. Frequently it might be best to leave the weeds untouched for the time being, postponing the battle until the undergrowth of seedlings and coppice shoots requires increased influx of light. Then, too, the cutting of the weeds will force them to be satisfied with a subsistence below the level of the underwood.

Chestnut standards should not be left, since the shock of a sudden change of surroundings causes them to sicken. The adjoining woods will tend to reinforce the regeneration area by n. s. r. of Chestnut, where the compartments simultaneously coppiced are small or narrow. Artificial reinforcing seems unnecessary although the planting of Walnuts in suitable places may prove remunerative.

B. Oak coppice mixed with Hickory coppice under Pine standards.

This form prevails on the Biltmore Plateau and over vast areas in Arkansas, Mississippi, Alabama, North Carolina, South Carolina, etc.

Silvicultural treatment is possible only where the Oak can be removed to a nearby fuel-market.

Rotations of thirty to forty years for the coppice seem best.

Shorter rotations are required where the coppice is badly damaged by fires.

In seed years of Yellow Pine, the coppiced area should be as large as compatible with the market. It might be wise to cut early in fall and to burn the coppice before the Pine seeds begin to fall. Seed years of Pine at Biltmore occur at intervals of seven years. Improvement cuttings should make up the sustained yield, as far as possible, in years of deficient seeding; or such compartments should be taken in hand, in which the coppice growth is richly beset with Pine poles and Pine saplings.

In the course of the improvement cuttings, the nuclei of n. s. r. of Pine require careful attention. Weeds like Chinquapin and Black gum are checked wherever they obstruct the underwood; where they form part of the underwood, especially under groups of Pine, they should be thankfully accepted as shade-bearing improvers of the soil.

White Pine is not adapted to the formation of standards. During the earlier stages, it retains its branches badly where isolated in Oak coppice. During the later pole stage, it is apt to suffer from windfall. Groups of White Pine standards will answer better than standards individually scattered.

CHAPTER V.

PROPAGATION OF FOREST PRODUCTS OTHER THAN WOOD AND TIMBER.

Paragraph LXXVIII. Raising of forest by-products.

In many cases better revenue is obtained from the by-products raised in the forest, than from the wood and timber. In backwood sections, closed to traffic, forest pasture often yields the only means of obtaining revenue. In densely wooded districts, the combination of agriculture with tree growth is often advisable. The main products thus obtained and the industries connected with their production are:

A. Tanbark and raising of tanbark:

The thickness of the bark used for tanning purposes and obtained either under a high forest or under a coppice forest system is increased by proper thinnings. In Oak bark coppice abroad the number of stumps per acre is about 2,000, reinforced by stump planting at each cutting. The healthier the growth of the shoots, the better are the tanning contents of the product.

In America, at the present time, no difference is made in the price of old, corky bark and of young, fleshy bark obtained from shoots only five inches in diameter.

B. Cork industry:

The cork industry is conducted in Southern France, Spain, Portugal and Northern Africa. For America, its introduction seems highly remunerative.

Experiments made in Georgia and in the Carolinas with plantations of Cork Oak have produced very healthy trees; for reasons unknown, however, the cork production was deficient. Possibly the wrong species or the wrong variety was selected, or else mistakes were made in choosing soil, exposure and silvicultural treatment.

Mayr recommends experiments with Quercus variabilis for the section of Germany productive of Castanea vesca.

C. Forest pasture:

Up to 1880, forest pasture in Long-leaf Pine woods of the South (Cane-brakes) and in the hardwood forests of the Alleghanies has occupied the rank of the most important forest industry. Nowadays, pasture is indicated on many a windswept ridge where the growth of timber is stunted, whilst the atmospheric moisture allows of a luxurious production of grass. Under nut-bearing trees, hog pasture is highly remunerative. In "strong" coves, the growth of weeds offers splendid forage for cattle.

The more inaccessible the forest, the less is the value of the tree growth. Here an industry is advisable which converts vegetable fibre into animal matter. At the same time, the advantage gained by pasturage during and previous to regeneration frequently reduces the expense of regeneration.

Whether the fencing of forest pastures is advisable depends on circumstances. A two-string barbed wire fence costs $40 per mile.

Goats, as extirpators of woody weeds (Corylus, Azalea) are frequently useful on mountain pastures.

Woody weeds damaging the pastures are kept in check by continuous mowing, especially if mowed in August. A limited use of fire, too, improves the pasture. Forest pastures are invaluable as fire lanes.

Pasturage of cattle extends in Pisgah Forest from May 1st to October 15th. Sheep and hogs require feeding only in February.

The revenue made per month amounts to: per head of cattle, fifty cents; horses, seventy-five cents; sheep, ten cents.

Where the growth of trees on a permanent pasture is too dense, deadening or coppicing is required. Where it is too little or where erosion sets in, the pasture must be abandoned for a number of years. Dead trees placed horizontally on pastured slopes safeguard the pasture.

In European and in Indian forests, pasture still plays a most important role, frequently as a prescriptive right encumbering forests owned by the Crown or by the aristocracy.

Relative to forest pasture in the Cascade Reserve of Oregon *see* "Forest Policy."

Forest pasture in the Pine woods of the South and of the Southwest is of utmost economic importance.

Forest pasturage requires regulation in the following points: Number of animals per acre; species of stock and of trees; season of pasturage; remuneration; closed years; firing; responsibility; supervision; salting; improvements; access.

D. Forest fruit raising:

I. Pecan.

Large investments are being made in Pecan plantations in the South. Usually seedlings three years old are planted fifty to sixty feet apart. Payable crops are expected fifteen years after planting. Cultivation and fertilization of Pecan orchards are required just as in apple orchards.

II. Apple-trees planted on freshly cutover woodlands (Northwest slopes) are said to be particularly promising.

III. Chestnuts. Chestnuts are either obtained from the woods where Chestnut trees are grown for timber, or from orchards. In Pisgah Forest seed years are said to occur every seven years. The nuts sell at fifty cents to one dollar per bushel. The mountaineers burn the woods to more readily uncover the nuts.

Orcharding combined with grafting of French Chestnuts (Castanea vesca) on the American species has been tried in Pennsylvania with little success owing to forest fires.

In Southern France a large revenue is obtained from the nuts ($5 to $6 annually from a good tree).

IV. Acorns. The acorns of the White Oaks are ground as a substitute for coffee (Postum Cereal 80%). In addition, acorns are of high value for pannage and in game preserves.

V. Berries. The crop of berries growing in the forest is locally leased to the highest bidder. The huckleberry crop is improved by periodical burning.

E. Maple sugar:

The production of sugar depends on the size and on the development of the individual trees, influenced by careful thinning. An underwood and a heavy layer of humus is helpful. Planted sugar orchards are rare and suffer from sun scald and from hardening soil.

F. Naval stores:

No means are known tending to increase the production of naval stores. The best yield is obtained from healthy, large trees.

G. Rubber and guttapercha.

H. Truffles and champignons.

I. Ginseng (Aralia quinquefolia):

Ginseng grows in the Alleghanies in well-sheltered north and northwest coves of greatest fertility. The young roots are easily transplanted into nursery beds. The cultivation of ginseng in the woods, however, is not practicable.

J. Sumach leaves:

The leaves, used for tanning on a large scale, are gathered on abandoned fields in Virginia. No care seems to be devoted to the reproduction.

K. Pharmaceutical weeds:

A large number of forest weeds have a pharmaceutical value and might be locally propagated and fostered.

L. Peat bogs:

Peat bogs reproduce themselves where the top layers only are taken off periodically. Small benches are left between the pits utilized.

M. Fish and game:

In the Prussian State forests, twelve per cent of the annual revenue is obtained from hunting and fishing leases. Private owners in the Adirondacks and in the South draw a large revenue from leasing the exclusive privilege of hunting and fishing. For particulars regarding the raising and nursing of Fish and Game *see* lectures on "Fish and Game Keeping."

Paragraph LXXIX. Combination of sylviculture and agriculture.

As the woodlot belongs to the farm, so does the farm embraced by woodland belong to the forest.

Strange as it sounds: The forester abroad is sometimes charged with the administration of more farmland than of woodland.

A fair practical knowledge of agriculture is indispensable for the administrator of forests. Truly agricultural land within the forest should be cleared in due course, in pursuance of the maxim that every acre of ground must be placed under the (permanently) most remunerative industry.

The forest farm produces victuals for the lumber camp and forage for the teams and yokes; it yields the best possible fire lanes.

Under these circumstances it is not to be wondered at that a local, permanent or temporary combination of sylviculture and agriculture is frequently indicated, in coppice forests as well as in high forests, in cultured forests as well as in culled forests.

A. Reasons prompting the forester to adopt "agriculture" may lie in the following moments:

I. Frequently it does not pay to eradicate the "weeds" in the forest previous to artificial or natural regeneration by n. s. r. In such cases, the forester may take advantage of the fertility stored up in the humus, using it for a nuuber of years for the production of field crops and freeing the soil incidentally from competing weeds.

II. Similarly the forester is often at a loss to save his regenerations from the attacks of wild or tame animals. Allowing the plantations to pass their earliest youth in the midst of farm crops which pay for the expense of protection from animals by immediate returns, protection for the plantations is obtainable at a reduced charge.

III. The fertility stored away in the accumulated humus, although exhaustible within three or four years, frequently furnishes a snug revenue (especially where farmland is scarce, as in all mountain districts) defraying the outlay, or part of the outlay, required for successful reforestation.

IV. In the prairies, agriculture must precede the tree plantation, which will not thrive in soil devoid of porosity. The plantation of trees, on the other hand, will protect the farm from drought in summer and from high winds during winter; it will shelter the stock during severe blizzards, etc.

Henry von Cotta, as early as 1819, advocated plantations of trees in rows twelve feet to fifty feet apart, the intervening spaces to be used for agriculture. The trees and the rows were to be decimated gradually, and were again to be reinforced in compliance with the requirements of the farm.

Cotta's plan might be successful where drought is to be dreaded during summer, scorching the grass meadow and the grain field.

B. Modern application:

I. Field crops intervening between two generations of the forest.

All over the pineries of the South where abandoned fields produce splendid polewoods of Pine, the woods are cut at the thirtieth to sixtieth year of the trees; the soil is then used for the production of corn, cotton or small grain for a number of years and thereafter allowed to revert to Pine planted by n. s. r. from adjoining woods. The same system is followed by thousands of farmers in the old country.

II. Field crops temporarily raised amongst and together with forest crops.

a. In coppice forests:

In Germany, the owners of coppice woods, after coppicing, frequently burn the debris on the ground, ploughing the soil roughly thereafter and using it for growing small grain or potatoes as long as the fresh stool shoots do not overshadow the farm crops too severely.

This system allows the farmer to continuously (although intermittently) produce field crops on steep slopes liable to wash, with the help of fertility furnished by the humus and by the activity of the tree roots.

b. In high forests:

1. In the early stages of sylviculture, acorns and pine seeds were frequently planted (like red clover) with barley, oats or summer rye. Compare Par. XV for details.

2. Sir D. Brandis has established in Burmah a system named "toungya" by which seedlings of Teak, planted with rice by native lessees on government reserves, obtain protection from wild animals and fires as well as from the Bamboo threatening to suffocate the seedlings.

3. A similar system has been practiced since 1810 in the German Rhine valley where splendid polewoods of White Oak have thus been raised. Here in years past the returns from toungya used to more than cover the expense of forest planting and protecting. The field crops shade the Oak slightly and tend to protect it from the effect of late frosts as well as from the attacks of grub worms (Melolonthidae).

4. In Western N. C., the expense of clearing the forest for field crops amounts to ten dollars or twenty dollars, according to the density of the growing stock and according to the yield derivable from the sale of timber removed.

On good forest soil a few years of corn crops are apt to refund the outlay incurred for clearing.

Thereafter the Pines, the Oaks, the Yellow Poplars and the Ashes of the adjoining woods will quickly produce a superior plantation of trees.

Where the soil is stocked with tree weeds, and where no immature trees must be sacrificed, the system can be strongly endorsed.

SILVICULTURE.

ALPHABETIC INDEX

INDEX

INDEX

INDEX

U

V

W

Y