The Wood Pulp Industry.

By M. D. Renkenberger.

Wood pulp and the wood pulp industry have come to their present importance within the last twenty-five years. An increased use of paper, of which wood pulp forms a large per cent., appears not only in newspapers and all kinds of common papers but in the manufacture of many useful and ornamental articles. This increased use of wood pulp in the paper industry, together with the fact that the particular kinds of timber used for pulp exist in limited amounts, makes it not only wise but absolutely imperative that the matter of raising trees for pulp wood be considered. Unless, indeed, some substitute is found for wood pulp, this matter must be taken up seriously in the States, and that within a very few years.

The wood pulp industry first appeared as such in the census of 1870. Since then the growth has been rapid and steady, the increase in the value of raw material, for example, in 1900 being more than 59 per cent. over the value of material consumed in 1890. The growth of our export trade in paper and pulp stock has been steady and healthful, amounting in 1900 to a total of $6,674,296, an increase of nearly 500 per cent. during the decade. The grades exported are largely wood papers (especially news), while the usual imports are of the higher grades of book and fancy papers and specialties. The per capita production of paper has increased from 8.1 pounds in 1860 to 56.9 pounds in 1900, the per capita value of which is now over $1.66. One author claims that more wood is consumed in the form of pulp by the great paper making establishments than is used by the combined railway systems of our country.

The raw material for pulp comes chiefly from the spruce and poplar of northern United States and Canada. At the enormous rate at which this one industry is using up existing timber, to say nothing of the vast drain made upon the virgin forests for lumber, fuel, etc., there will soon come a time when either inferior grades will have to be used or a substitute be found. As yet few attempts have been made to raise trees for pulp wood and as the consumption of wood for this purpose is enormous,

and as the virgin supply is limited, the writer sees no reason, in view of the steadily raising price of pulp wood, why the growing of trees for pulp can not be made a profitable business in forest culture.

Historical.

From the earliest Egyptian papyrus to the paper of today the predominant characteristic is that it consists of the enduring portion of vegetable growth known as cellulose or pure fiber. All parts of plants have been used for this purpose and a list of raw material used for paper would include linen and cotton rags, jute, hemp, esparto grass, wood pulp, clay, straw, peat, cornstalks, and a half dozen others.

The discovery that wood could be converted into its component fibers and freed from lignin, gums, etc., became the basis of modern paper making and brought the wood pulp industry into prominence in a largely forested country. The German process for making "ground wood" was introduced into this country about the middle of the nineteenth century, the soda process from England a century earlier, and the sulphite process is an American invention of about 1867, and owing to its cheapness in producing a strong cellulose fibre from spruce, its use has increased more rapidly than that of the soda process. The first wood pulp made in this country sold at 8 cents per pound; today the price of "ground wood" pulp is about 1 cent per pound. The scarcity of rags and the cheapness and abundance of the pulp supply in the great forests of spruce and other woods caused the new material to be generally adopted. At first aspen and basswood were preferred for paper making, but as the supply of these woods was quite insufficient for the demand, coniferous wood was tried, and spruce soon came into the first rank for the purpose. This widespread demand, which has steadily increased, has been one of the chief causes of the destruction of large areas of forests—forests, too, in which no steps were taken toward reproduction either natural or artificial. In North America during the three years ending in 1894, 200,000 acres of forests had been denuded to satisfy the demands of 210 paper factories.

Uses of Wood-Pulp.

The principal use to which wood pulp has been put is in the manufacture of the coarser kinds of printing, writing, and wrapping papers. The use of the German process for making a ground wood fiber has steadily increased, to a great extent superseding the use of rags, entirely

so in the manufacture of news and wall papers, very largely so in the manufacture of book and wrapping papers and to a considerable proportion in writing and other grades. In fact fifty per cent. of our paper is manufactured from wood pulp.

Wood pulp is used for many other purposes besides paper making, sometimes usefully, at other times with doubtful advantage. Such are: the use of compressed pulp bricks for construction purposes; its use in textiles such as silk and cotton; in panelings and interior house decorations; in celluloid, surgical bandages, car wheels, pulleys, paper boxes, pails, barrels, etc.; for filters in breweries and sugar factories; for fuel, etc. As compared with paper making, however, these other uses of wood pulp are only of subordinate importance and perhaps hardly consume one per cent. of all the wood pulp thrown onto the market.

Raw Material and Preparation.

The raw material of wood pulp is spruce, poplar, and in smaller quantities various other woods such as balsam, hemlock, birch, according to the location of the industry, the process employed, and the kind of paper in which the material is to be used. The variety as to the kinds of trees that have been used with varying success at various times and places is extensive; such are soft pine (hard pine containing too much resin), fir, spruce, balsam, hemlock, birch, large-toothed aspen, cottonwood, Carolina poplar, buckeye, basswood, box elder, quaking asp, beech, bamboo, linn, willow, soft maple, catalpa and perhaps others—in fact any tree can be used, it is merely a question of relative value and relative expense. The kinds of timber most largely used in pulp manufacture are soft, easily worked, light both in weight and color, possessed of long fibers, not fading easily, and containing little resin or other infiltrations. It will be seen that spruce among conifers and poplar among broad-leaved trees possess the requisite qualities in a remarkable degree. In the United States spruce forms 76 per cent. of all wood for both mechanical pulp and chemical fiber. Poplar being softer (and used most for soda fiber) forms 12.9 per cent. of all woods consumed in making different kinds of pulp. Other unspecified woods for pulp or fiber make up the remaining 11.1 per cent.

In the preparation of pulp, the wood should be worked up green and the bark and defective parts must first be taken off. There are two principal methods of reducing wood to pulp—the mechanical and the

chemical. These two methods give different results as regards paper manufacture, the product of the mechanical method, termed "paper pulp" being more granular, whilst that of the chemical method, termed "cellulose," is more fibrous, and hence stronger. In making the mechanical pulp, the wood is cut into suitable lengths for grinding, the bark removed, and the blocks held by hydraulic pressure against the edge of a rapidly revolving sandstone and by attrition reduced to a mushy consistency. The fiber as thus ground is passed through filterers of various fineness. The fibrous mass is now brought to another machine, where the water is pressed out, and it is cut into slabs, baled, and shipped to regular paper mills without drying. The pulp so made is the basis of all lower grades of paper. As already noted, the pulp industry has become an integral part of the paper business, over half of the ground wood produced being made into paper on the spot.

By the chemical process, which is more recent and more costly, but which produces a much longer fiber, the finely ground wood fragments are placed in large boiling tanks or digestors, lined inside with lead or other acid-resisting material. Chemical pulp or "cellulose" is of two kinds, depending upon the use of caustic soda (alkali) or calcium sulphite (acid) to macerate the wood. It should be remembered that all chemical processes of wood pulp manufacture are based upon the underlying principle that the middle lamella and infiltrated material which surrounds and holds together the individual fibers of wood is soluble and produces a chemical reaction with certain aqueous solutions, notably that of the bisulphite of lime. The problem is to apply the macerating liquid under conditions which will completely and quickly eliminate the infiltrated substances without unnecessarily weakening the fiber, and for this purpose the solution must be applied at a high but carefully governed temperature and under a mechanical pressure that will force the chemical solution into every pore of the woody structure, thus permitting it to attack the non-cellulose matter in which the fiber is embedded and by which it is permeated. The matrix thus loosened and dissolved is removed by washing with water.

Where sulphite of lime is used, the wood fragments are boiled in sulphurous acid from 24 to 60 hours under a pressure of about three atmospheres. The soft, crumbling, reddish-yellow pieces are then pounded, washed, filtered, and pressed into sheets about the thickness of pasteboard.

When soda is used, the woods employed are usually softer, of mellower fiber, and without much strength. The process is similar to that of sulphite, except that in place of sulphurous acid a solution of caustic soda is used in the digestors. There are various other methods by which attempts have been made to separate the wood fibers, most interesting of which perhaps is Kellner's electrical process, in which the wood, boiling in a solution, commonly salt, is subjected to electrical discharges. The value of this process has not been ascertained, however. Of all the chemical methods in use the sulphite method is by far the cheapest and most satisfactory.

Characteristics and Advantages of Wood-Fibered Paper.

Ground wood with an admixture of from 10-25 per cent. of the chemical fiber is used for newspaper stock, wrapping paper, and for many of the lower grades of book, magazine and writing papers. For the very best grades of paper, whether for printing or writing, an admixture of sulphite with rag pulp is necessary. For permanent records the author is of the opinion that only rag pulp, and that of the best quality, should be used. It is true that in from 15 to 20 years the "wood pulp" books, papers, etc., will be greatly deteriorated and that for permanence some other substance must be used. A writer in a recent number of the "Outlook" suggests that publishing houses should print a special edition of each publication on a special quality of durable paper, suitably resistant both to chemical and mechanical wear and tear and thus preserve them for posterity. Whether or not the people of our country are careless in this matter, the fact remains that papers made from wood pulp and especially mechanical fiber, are perishable, and that within a very short time. Notwithstanding the great desirability for permanent copies of all our good publications, the larger majority of printed matter will continue to be discarded after the first reading—newspapers entirely so and magazines and even books to a large degree at least at the end of six months or a year. It is quite probable that the same prodigality would exist if our papers were made of the scarcer rag pulp, but wood pulp is not only cheaper than pulp made from rags, but it takes impressions better, wears out type less and decreases the possibility of spreading contagious diseases.

Future Needs and Possibilities of the Wood-Pulp Industry.

Having given a more or less incomplete account of the production, uses, supply, and present status of wood pulp let us now notice what this enormous industry means to our limited forested areas. Some idea of the rapid destruction of our spruce forests for pulp purposes can be got from the following: "A prominent New York newspaper uses 150 tons of paper daily. To produce this amount of paper 225 cords of spruce wood are consumed. It requires 1½ cords of wood to produce one ton of paper pulp. As the spruce ordinarily occurs in our northern mountains it averages about 5 cords to the acre." This means that every day, for this one newspaper alone, 45 acres of our mountain spruce are being consumed. Of course in the best spruce stands, such as those of Saxony and Bavaria, where large quantities of spruce are raised for pulp, it grows in dense, pure stands and yields many times as much as the average acre in this country, at the lowest about 20 cords. Even at that a single edition of a metropolitan Sunday paper would use up more than 10 acres of the very best spruce stand.

And again, from the Scientific American of November 14, 1903: "It has been estimated that nine novels had a total sale of 1,600,000 copies. This means 2,000,000 pounds of paper. The average spruce three yields a little less than half a cord of wood, which is equivalent to 500 pounds of paper. In other words, these nine novels swept away 4,000 trees. Is it any wonder that those interested in forestry look with anxiety upon the paper mill?"

Paradoxical as it may seem however, in those countries that are growing pulp timbers, the paper pulp manufacturer is the most powerful ally of the forester in that he uses the thinnings of the forest which begin while the forest is still young and continue throughout its whole existence.

The situation of the pulp manufacturer is well given by one of our most active foresters, John Gifford, who says: "The pulp manufacturer's plant represents the investment of perhaps a million dollars, while the plant of the lumberman is worth only about ten or twenty thousand dollars. The lumberman owns the land not for the land's sake, nor for the amount and quality of timber the land is capable of producing, but for the crop which covers it. He buys it, uses it, and then abandons it. He pays taxes on it only during the process of reduction. The pulp

man on the other hand, is tied to the soil. His heavy investment makes him fearful as to future supplies. For this reason, with commendable foresight, some of the pulp men are buying the land with the timber, and are beginning to work the woods in such a way that future supplies may be assured." It is foolish to suppose that our natural forests under present management and weak attempts at planting will furnish a supply of pulp wood for the future use of the people. Extensive correspondence with paper pulp manufacturers in several States, including Minnesota, Wisconsin, Michigan, New York, Ontario, Pennsylvania, and Indiana, reveals the fact that all agree that the supply of our best pulp timber must shortly give out, but few consider the matter seriously enough to suggest any definite plans or directions for the present. At this date, however, the author is informed that the United States Forest Service has begun the investigation of the wood pulp industry, but have not yet proceeded sufficiently far to warrant a report on the subject. Our own State, too, according to the statement of the secretary of the State Forestry Board, intends to demonstrate on the Forest Reservation in Clark County that growing timber for pulp industries would be a profitable thing on the cheap lands of the State. Indeed, land fitted for agricultural purposes could not profitably be used for any branch of forest culture. Such waste lands as could be profitably utilized in growing pulp wood exist in thousands of acres all over our country. There are the numerous burnt-over slash lands of our pine States; the arid wastes of many of our Southwestern States; the unused agricultural lands of the New England States, and the innumerable other tracts of unused, low-lying, light-soiled areas throughout the valleys of the Missouri, Ohio and Mississippi rivers. As nurse trees, in shelter belts, sand fixers, windbreaks, etc., trees which make good pulp might also be grown.

In view of the facts: (1) that the demand for pulp timber has increased wonderfully in the last few years, (2) that the price of raw material, according to a well known authority, has increased 150 per cent. within the last seven years, (3) that the native supply is limited and can not last many years, (4) that the importable supply is inadequate in those countries from which we could ship it profitably, and in countries such as Canada, blessed with a great abundance of pulp timber, the prohibitive tariff is so high (over $4.00 per cord) that we can not possibly afford to have it brought in, (5) there is only a small probability that an abundant and successful substitute can be found for the use of wood pulp in papers;

—in view of the above facts and of the abundance of unused land in our country, the author is encouraged to believe that the time will soon come when the growing of pulp timbers will be one of our recognized industries, and therefore has some hope of results from the application of the following suggestions.

Suggestions, Recommendations, Estimates, Etc.

Of the trees used for paper pulp, spruce, hemlock, and poplar are the most widely used and collectively furnish perhaps 90 per cent. of all wood used either for ground wood or chemical fiber. Spruce is used mostly for "ground wood" and sulphite pulp, forming as ground wood almost the entire substance in newspapers, and as sulphite fiber from 10 to 25 per cent. of the stock in the better grades of printing and writing papers. Spruce now brings from $9 to $11 per cord, and as it is rapidly becoming a substitute for pine, its value will rise. It is recommended that spruce be planted either in pure stands or mixed with poplar or hemlock on the numerous burnt-over, non-agricultural lands in our north-central States. According to a paper manufacturer of competent authority, the virgin spruce forests of northern New York which were cut over from 20 to 30 years ago are now affording spruce trees from 12 to 20 inches in diameter and are being used for paper pulp with good results.

Hemlock, and especially the western hemlock, makes a good sulphite pulp, and, as the spruce supply fails, is steadily taking its place not only as a lumber substitute, but, on account of its high cellulose content, in the wood pulp industry also. References to figures and statements in well known publications will substantiate the statement that the growing of spruce and hemlock for pulp wood on the available tracts would be a profitable industry.

In this country the poplars furnish 12.9 per cent. of all woods used for pulp of all kinds, being chiefly used for soda fiber mixed with from 10-20 per cent. of stronger pulp. Poplar pulp forms the chief material for such papers as the Ladies' Home Journal and Youth's Companion. Sulphite pulp alone would make too harsh a paper, while soda pulp alone would make too weak a paper. Mixed together in the proper proportions, however, a paper characterized first by strength, second by softness and delicacy is produced. The use of poplar for pulp is rapidly spreading in the east-central States, great quantities being shipped in from the Carolinas and adjoining States. A forester of one State has recently said:

"If I could replace the maples in the State forest by poplars today I would do it gladly. It would be worth thousands of dollars to the State." Considering the rapid growth and ease of propagation of the Populus family, there seems ample excuse for estimating its probable success on the cheap lands of our own State. In fact the author feels confident that such trees as aspen, cottonwood, and its subvariety, Carolina poplar, can not only be grown at a reasonable profit, but will make productive the capital locked up in our low-priced, non-agricultural lands. The practicability of planting depends upon the possibility of protecting the land and the return to be expected. The question of protection from insects, stock, fire, etc., must be answered with respect to the individual case. For the land which can be protected there remain to be considered the cost of planting, the rate of growth, and the probable returns.

Estimates of Cost and Returns per Acre for Cottonwood.

The estimate following is intended to cover the cost and returns for one acre of planted cottonwood on the cheap unused lands of Indiana. Other members of the Populus family, such as aspen, may be planted on waste areas with practically the same cost and yield. As cottonwood does not form sufficient shade to keep out weeds and grasses, the Federal Forest Service advises that the understory should consist of box elder, hackberry, white elm, osage orange, or such shrubs as wild plum, choke cherry, wild currants and gooseberries.

The cottonwood seedlings, preferably yearlings, or better, cuttings, can be obtained cheaply from nurserymen or may be collected by the planter from the sandbars along streams. The seedlings or cuttings should be planted where they are to remain permanently. Planting is a very simple operation. It may be advantageously performed by a man and a boy working together. The man, by driving a spade into the ground, makes a slit, into which the boy slips a tree behind the spade; the man then withdraws the spade, trampling the soil about the tree as he advances to plant the next one.

Cottonwood plantations should be protected for at least five years from grazing animals, and five or six plowed furrows free from weeds should be maintained around the grove to keep out fire. If the undergrowth recommended by the Forestry Service is not planted, cultivation for two or three years will be necessary.

For the sake of definiteness, it is assumed that at the end of 20 years the stand will be sold on the stump for pulp wood. Indiana waste land suitable for such purposes is classed as worth perhaps $12 per acre, although the author is informed that many tracts in Greene, Monroe, Brown, Lawrence, Owen and southern Putnam and Park counties can be bought for less than $12 per acre. For purposes of taxation, the forestry law of 1899 appraises such land at $1 per acre, making the taxes practically nil. It will require 680 seedlings to plant the acre at a distance of 8 by 8 feet. The cost of these is estimated at $2. After the land is cleared, at the end of 20 years, the value doubtless will be as great as at the beginning, but the value of the land is not taken into consideration. Should $12 be added to the $120 which it is estimated could be secured for the timber product, it would simply increase by that amount the profits of the transaction. The statement following shows the items and amount of the investment for one acre:

Expenses on 1 acre for 20 years—

Cost of seedlings	$2 04
Cost of transplanting at $4.50 per 1,000	3 06
Value of land	12 00
Taxes at $1.80 per $100	36
Cultivation for 2 years	2 40*
Total	$19 86

Amount at 3 per cent. compound interest, $35.87.

At the age of 20 years the average cottonwood is 14 inches in diameter with a height of 50 feet. Studies made by the Forestry Bureau on cottonwood as a planted forest have shown that the yield in average cases has been at least 30 cords per acre in 20 years. Other practical foresters would harvest the crop in 10 or 12 years, thus securing less cords per acre, but owing to the shorter period of investment a higher annual per cent. on money invested. Under the 20-year plan, the 30 cords would sell on the stump at not less than $4 per cord, bringing $120. Deducting from this sum the amount at 3 per cent. compound interest, $35.87, there remains $84.13 as a return on the investment over and above that received from a 3 per cent. compound interest loan. This is equivalent to a return of $4.20 per year from the time of planting to the time

* This expense may be eliminated if cover is planted as recommended above.

of cutting, a very satisfactory return considering the fact that it is secured from land which is practically useless for any other purpose, and which without a timber crop would be a source of constant expense for taxes. The pulp wood crop not only gives a fair margin over and above ordinary investments but it makes productive the capital locked up in the land.

In this estimate the cost is the record of actual facts; the assessed valuation, such as could be obtained under the present forestry law of Indiana; the rate of interest, the average per cent. that money returns to its owner above taxes; the rate of growth, the average of planted cottonwood in the Mississippi Valley and the price less than that which has already been received where fair access was had to market.

Since the estimate is based upon present conditions, it more nearly applies to a plantation established 20 years ago, and to be marketed now, than to one established now and to be marketed 20 years in the future. Wood prices, according to B. E. Fernow in the Forestry Quarterly, vol. III, No. 1, have steadily risen and are now rising much faster than in the period before 1890. This same authority says further that the rate of increase in wood prices in general will be at least at the rate of 2 to 3 per cent. per annum for the next 20 years. This means that the return on the investment would be proportionately greater.

Besides the financial advantages from raising pulp trees, the general advantageous influences incident to forested areas would be more largely secured and our State would be more diligently doing her share towards the proper reforestation of areas which should naturally be in forest. The progress is encouraging, investigations are being made and many others are being planned. Both pulp men and foresters are taking an increased interest in the matter, and in many other ways the indications are that the industry of growing pulp wood will eventually occupy a prominent place among the profitable employments in the States and Provinces bordering our Great Lakes.

At this point the author wishes to express his indebtedness to the botanical department of Wabash College for substantial aid in collecting statistics and in numerous other ways materially assisting in the preparation of this report.

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