Problems and Progress in Artificial Hardwood Regeneration

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The demand for hardwoods has increased greatly over the past few decades for several reasons. Large volumes of hardwoods are now used in papermaking and associated industries. Increased demand by an expanding population has also added to the drain on present supplies. The area available for growing bottomland species such as cottonwood has decreased due to inundation of sites formerly supporting them. Foreign export of high quality, fine hardwoods has expanded in recent decades so much so that an export quota was established for a time for black walnut.

The trend in forestry is toward more intensive management practices to meet future demands for forest products which will have to be produced on fewer acres than are now available.

Volume growth of hardwoods exceeds the cut. However, most of this volume growth is on low grade or cull trees and is unsuitable for many uses. For quality hardwoods, cut already greatly exceeds growth and projected demands show a great increase.

The rationale for encouraging hardwood plantation establishment rests on five main assumptions:

1. Demand for quality hardwoods will increase over the years.
2. More intensive forestry practices will be economically feasible.
3. Timber production will have to compete with other uses for forest land.
4. Present forest stands in their poor condition can not fully meet future demands for quality hardwoods.
5. Plantation-grown hardwoods can be an important and significant source of quality hardwoods.

PAST PROBLEMS IN HARDWOOD PLANTATION ESTABLISHMENT

Hardwoods have been planted over a wide geographic area for various purposes but the results generally have been very disappointing. Some of the failures can be ascribed to off-site planting, vegetative competition, and damage from fire, disease, insects, and livestock. But too often the cause has been neglect. Undoubtedly many of these plantations, with proper protection and culture over a period of years, could have reached commercial size.

The objective in current hardwood plantation efforts is to grow high quality trees in the shortest time possible consistent with maintaining desired wood characteristics and within the limitations set by economic considerations.

The objective is therefore in two parts. One part is to learn how to optimize growth and quality from a purely biological and physical point of view. The second is to determine how much capital can be economically invested in practices which promote growth and quality.

At present, there is not much specific information on either the biological requirements of hardwood trees or the economics of plantation-grown hardwood timber. Until more specific biological information is available on how to maximize growth and quality, economic considerations must be very tentative.

SPECIFIC INFORMATION NEEDED

Considerable general information is available for planting hardwoods. Limstrom,[2] for example, gives overall directions for accomplishing the planting job. But, in spite of its general excellence, its recommendations rest almost solely on empirical information. To successfully establish hardwood plantations which will grow at maximum rates and yield high quality wood, more specific information than is given in planting guides is needed.

[1] The Station's field office in Ames is maintained in cooperation with Iowa State University.

[2] Limstrom, G. A. 1963. Forest planting practice in the Central States. U. S. Dept. Agr., Agri. Handbook 247, 69 pp.

The adaptation of species to site is of prime importance for hardwoods—perhaps even more important than for conifers since site quality requirements are generally assumed to be higher for hardwoods than for conifers.

Physical soil characteristics should be identified and quantitatively related to hardwood growth and quality. Although much work has been done in this area, further studies are needed, especially for the old field sites.

Soil-water-plant relationships need to be established and quantified.

The nutrient requirements of important hardwood species should be identified and correlated with soil nutrient levels and supplies. This information will be most useful in prescribing fertilizer treatments when the site quality and economics justify their application.

Many problems in connection with fertilizer other than the kind and quantity require further study. Some of these are methods of placement, time of application, residual effects, interactions between soils and fertilizer, and short- and long-term effects of fertilizer on soil microflora and microfauna.

Further work is required to determine the best means of controlling competing vegetation. Chemically, this problem involves kind, rate, and time of application; the effects on different species of hardwoods planted on different soils as well as the effects on weed species; and the interactions between fertilizers and chemicals used for weed control. In addition, information is needed on the effects on important hardwood species of combinations of chemical weed control substances applied for both quick kill and residual weed control. Comparisons are also needed on the relative effectiveness and costs of chemical and mechanical cultivation control.

There are not many serious nursery problems in producing satisfactory hardwood planting stock. However, modifications of certain characteristics of the general run of nursery stock might enhance the chances of obtaining satisfactory growth and development of a species planted on less-than-optimum sites. For example, a very fibrous root system might enable seedlings to become established on a site where a root system with a long taproot and few fibrous roots might fail.

Spacing of trees in a plantation is important in obtaining maximum utilization of the site consistent with the type of forest products desired. It is axiomatic that a tree should have enough space to develop without undue competition from its neighbors. Wide spacings, however, may entail an excessive amount of artificial pruning in order to produce clean wood. Some sacrifice in growth might be advisable so pruning costs would be acceptable. Therefore, we need to know the effect of different spacings on the amount of pruning necessary to produce the desired degree of freedom from knots.

Along with spacing studies, information should be obtained on how species grown in mixtures affect each other's growth and development rate, pruning ability, and so on.

Last but certainly not least is the matter of using available planting stock having the best genetic qualities for growth, quality, site adaptability, and resistance to disease, insects, and other damaging agents.

In the preceding section, some of the problems associated with maximizing the growth, development, and quality of plantation hardwoods have been mentioned briefly. While it is true that a great deal less is known about growing hardwoods than is needed to be most efficient, enough knowledge is available to assure a reasonably good chance of avoiding failure.

PROGRESS IN ARTIFICIAL HARDWOOD REGENERATION

The following recommendations for planting hardwoods are based on present knowledge. They stress some facts known for some time but many of these facts have not been generally accorded the attention they deserve.

Emphasis should be placed on using only the best planting stock. This should be fairly large stock having a stem diameter of at least 5/32 inch, a well developed fibrous root system, a shoot-to-root ratio of about 1.4, good form, freedom from disease, and the best genetic composition obtainable.

The site selected for planting should be on the deepest soils available. The soils should have good internal and external drainage, be free from mottling, and have a medium to medium-heavy texture. The medium-heavy textured soil should have well developed structure to provide adequate aeration.

Fertilization should be practiced when there is an indication of a nutrient deficiency. Leaf composition for good growth should be about 2.0 to 3.0% nitrogen, 0.25 to 0.40% phosphorus, 1.5 to 2.0% potassium, 0.4 to 1.0% calcium, and 0.6 to 0.8% magnesium. These percentages are general values, and a particular species may have somewhat different requirements. Within these values, however, good growth generally can be expected.

Control of competing vegetation is a must if the trees are to have full use of the available soil moisture and nutrients. This control will probably be required for 2 to 5 years, depending on the rate of crown closure. For example, simazine at the rate of 4 lb. per acre has given good control on medium-textured soils. Heavier soils require more (about 6 lb.), and lighter soils less (about 2 lb. per acre on sandy soils). Simazine adversely affects cottonwood and should not be used for this species. It has been used successfully with black walnut, green ash, red oak, and other species.

Ordinary planting methods have given good results in planting hardwoods. Machine and various hand methods are satisfactory. Deep planting of cottonwood in auger holes has given better survival and faster growth than the usual planting methods but results were poorer in both respects for black walnut.

Plantations must be protected from fire, disease, insects, and livestock. It may be necessary to use repellents to protect plantations from deer damage and to fence to exclude livestock.

Eighty percent of the tree value is in the butt log. Generally this log must be pruned several times in order to produce clear wood in trees grown at recommended spacings of 12 to 18 feet.

In some instances corn, soybeans, or other crops can be planted between the rows to help control weeds and to provide some income which will help defray the cost of establishing the plantation. This was done in a black walnut plantation at Amana, Iowa. The net return from the soybeans for less than 2 years was enough to pay for first-year plantation costs.

Follow-up inspection and care of the plantation is an absolute necessity. Any other course is hazardous and may lead to failure.

The main points to remember for successful hardwood plantation regeneration are:

1. Plant only on the best available sites. If the site is not suitable, do not plant.
2. Control competing vegetation until the crowns close or the vegetation becomes sparse. This can be done chemically, mechanically, or both.
3. Estimate fertility of the site and fertilize if there is a significant nutrient deficiency.
4. Plant only the best stock and be sure it is genetically adapted to the location. If no information is available on the genetic make-up of the stock, plant stock from seed of local origin.
5. Protect the plantation from fire, disease, insects, wild animals, and livestock.
6. Prune to produce the highest quality butt log of crop trees.
7. Plant at not less than 12x12 feet and up to 18x18 feet.
8. Plant interrow crops when possible and profitable.
9. Make periodic inspections of the plantation and be sure that all follow-up cultural practices are carried out.

DISCUSSION

Audience comment: Something which bothers me is that we speak of planting the hardwoods on the best sites. It doesn't seem to me that our best sites are our problem sites. Something less that the best site is the place where we must be able to grow timber.

Finn: I disagree 100 percent with that. If you are going to invest money, you are going to put your money where you can get the greatest return. Now, best can be a relative term. I'm not saying "best" in a sense that the site, for instance, needs no fertilization or ground preparation or that it needs no organic matter to be added to it. But if it has a tight subsoil, for instance, it would be unwise to plant it.

The old philosophy, as most of us know, was that every acre had to be in productive forest. So, if there was a group of old post oaks growing on top of the hill that would only produce half a log, that bothered the forester tremendously. The natural instinct was to clean it off and plant Virginia pine, shortleaf, or something else yielding three-fourths of a log, without a much higher value than the previous stand. This is the kind of philosophy I mean. I'm not saying that our efforts have to be confined solely to the best sites. With respect to fertility, you may have a site that has the physical characteristics necessary for good growth but which may, through past cropping practices, lack one or more elements that can be properly applied.

Perhaps, for example, drainage would be the thing required. But I still insist that you put your money where you get the maximum return. In our research in the Forest Service, of course, we are trying to explore this whole problem in depth.

Comment: You mentioned the need to use large planting stock. What bothers me is the requirement in tap-rooted species that they be root-pruned.

Finn: This is a problem, there's no question about it.

Question: I wonder if there should be more research on the use of smaller stock that could be planted under more normal growing conditions. On many of our planting projects, we have recommended—I think with a good deal of justification—avoiding large planting stock unless the site is very good.

Finn: Well, I think our major premise is that these practices we are talking about are going to be economically feasible. Now, it may well be that growing this kind of stock, shipping it, or handling it in the field will present difficulties. However, I think that this is the type of thing that an economist must decide. The bigger the stock you can plant and give all necessary care and attention, the better the chance of success you'll have. Also, the premise is that we are going to plant very much less on a given area than we are normally accustomed to, as in the case of a 6x6 planting.

Funk: We are going to assume 95% survival instead of 65%.

Finn: That's right.

Comment: What I don't see is why we can't use the same quality of trees, and with site preparations get the same survival, but grow the stock to a small size to avoid this problem of cutting the roots and damaging them, and to get a little more normal placement of them.

Finn: I think you have a very valid point and this brings up another question. When these roots are severed, you provide avenues for all kinds of root rots, which are definitely a problem in this region. So this is the other side of the coin. But I still think that in general what I said will hold.

Wright. On the size of planting stock, do you think it is possible that the planting of 5- or even 10-foot yellow poplar might ultimately prove to be most profitable?

Finn: Yes, certainly it is possible, although I don't know. I can't answer you on that point.

Comment: You run into problems here. I'm not speaking from the nurseryman's standpoint. We are doing some work with some spoil bank people and they have to carry this stock long distances. They want small stock—

Finn: If I may interrupt, I'm not including land of this nature in my remarks. In such cases, the high content of stone or similar material that we are up against presents a different situation.

Question: Have you done any work with vegetatively reproduced stock?

Finn: Yes, but only a very limited amount with cottonwood. I think our conclusions would be that cottonwood seedlings have done better so far than any of the hybrid cuttings of cottonwood that we have used.

Schreiner: When the Northeastern Station was moved from New Haven in 1942, I was left with about 150,000 trees ready for outplanting in the genetics nursery at Williamstown, Mass. We moved a small proportion of these to a nursery near Beltsville, Md., and finally made the outplantings 3 years later with stock which was 6 to 8 feet tall. I'm not advocating the use of stock of that size but we had 98% survival of soft maples and birches and still have 95% today. The trees are planted 8x8 and we used a disk harrow both ways through these plantations once during each of the first 2 years. While I am on this subject, I might say that in 1940 and in 1945, I published reports on site preparation for establishment of poplar. (That was published so long ago that probably no one here has read it.) In the experiment reported in 1945, we had various sizes of scalps and furrows and three treatments of the soil. In one treatment, merely the sod was removed; in another we carried the sod off but dug up the soil to a depth of 8 inches to loosen it; in the third we turned the sod under comparable to plowing. The most remarkable result was that we had no success except with the sod turned under.

I am interested in poplars on upland sites; they can be grown with little difficulty on suitable bottomland. On the basis of our results on upland sites, I believe the sod should be turned under. So I don't like the idea of using weed killers first. Plow in the organic matter first and then use weed killers if necessary.

Finn: In all of our studies we plowed and disked, then applied the chemical fertilizer. If there was a mechanical treatment it was carried on for 1, 2, or 3 years, but the initial destruction of the sod structure was a turning over. And I'd like to make one other observation on the turning over of sod. We had an experiment in the Zanesville area in the early 1950's. This was a planting methods study, using white pine and yellow poplar. The important thing is that where we threw a double-furrow and turned the sod over so that we had a sandwich of organic matter there, yellow-poplar after 5 years was 3-4 feet taller than it was on any of the other sites. This wasn't due to moisture differences because we had moisture measurements and could not attribute results to moisture differences.

Comment: They are doing the same thing with conifers by planting them in the furrows.

Finn: Leaf analysis showed that we had increased uptake of nitrogen and a few other elements by this treatment.