THE ROLE OF TREE IMPROVEMENT IN THE NORTHEAST
A SILVICULTURIST'S POINT OF VIEW

by David A. Marquis, principal research silviculturist,
USDA Forest Service, Northeastern Forest
Experiment Station, Warren, Pennsylvania 16365

ABSTRACT.--The role of tree improvement in the Northeast is likely to be quite different from that in other parts of the country, because artificial regeneration is not widely used on the commercial forest lands of this region. The best opportunities for traditional planting and improvement programs seem to be using coniferous species such as eastern white pine for the reforestation of open or poorly stocked lands, or for conversion from poor-quality hardwoods on appropriate sites. In the mixed hardwood stands that predominate throughout the Northeast, the widespread use of artificial regeneration and tree improvement will probably include mixtures of natural and artificial regeneration in the same stand. Imaginative and coordinated efforts by geneticists and silviculturists will be required to make such a culture feasible.

QUITE FRANKLY, I suspect that most silviculturists do not have a very clear picture of the role that tree improvement is likely to play in the Northeast. Many of us see the progress being made on tree improvement in other parts of the country and want to share in it, but we also see large differences in silvicultural practices that seem to preclude the same kind of gains here. Let me share some of these reservations with you, and then suggest some ways in which genetically improved material might be incorporated into the silvicultural practices of this region.

Tree improvement means artificial regeneration.--It seems self-evident that incorporating genetically improved material into the forest will require direct seeding or planting. However these silvicultural practices are not common in the Northeast.

Those who have worked in the South or the West suggest that it is only a matter of time until artificial regeneration becomes common here. They say that they, too, depended on natural regeneration, but that as silviculture became more intensive, natural regeneration proved to be undependable, or took too long to develop.

But to expect artificial regeneration to become common in the Northeast, one must ignore--or be unaware of--the large differences in silvical characteristics and ecological conditions between our northeastern forests and southern pines or coastal Douglas-fir.

The southern pines are early pioneer types; they have very rapid juvenile growth, and they grow naturally in pure, even-aged, single-canopied stands after drastic disturbance. Without fire or other periodic disturbance, southern pine would gradually be succeeded by more tolerant species. Silvicultural practices that destroy these competing undesirables are necessary on most sites, so it is logical to follow complete clearcutting with drastic site preparation and artificial regeneration. Genetically improved stock can easily be incorporated into such a culture.

In the West, natural regeneration of many species is uncertain, or at least very slow to develop. The quick green-up of clearcut areas that we are so accustomed to seeing in the East simply does not occur in many parts of the West. Planting is relatively easy and ensures quick reestablishment of the desired species without interference from undesirable plants. So planting is common after clearcutting to ensure prompt regeneration, even in areas where natural regeneration might eventually develop. Again, planting is used because it is a desirable silvicultural practice, with or without genetically improved stock.

I can think of few situations in the Northeast where seeding or planting is needed over large areas after the overstory crop is harvested. Natural regeneration is usually prompt and adequate.

Most of our valuable northeastern species are <u>not</u> true pioneers. They range from tolerants such as spruce, fir, sugar maple, beech, and hemlock to moderately intolerant species such as white ash, red maple, black cherry, and yellow birch. We have a few very intolerant species, for example, paper birch and yellow-poplar, but even these species generally grow with more tolerant species in mixed, multiple-canopied stands.

Although clearcutting is a very useful regeneration practice in most northeastern forests, it is not complete clearcutting in the sense of southern or western practices. The multi-storied stands of the East usually contain many small saplings, thousands of advance seedlings, and millions of viable seeds in the forest floor. When the larger trees are clearcut, the area almost immediately becomes a jungle of new growth. Some type of forest tree almost always revegetates the site, and in those few cases where trees don't regenerate, herbaceous plants quickly fill the void.

Direct seeding or planting in these situations is often futile. The seeded or planted material does not have the head start of the advance regeneration, and often requires a year or two to become established before it can grow rapidly. By that time it is nearly always overtopped by natural regeneration. Or, if there are no natural seedlings, the herbaceous vegetation interferes with the growth of planted seedlings so that they are vulnerable to deer browsing, rodent girdling, frost, and similar dangers.

These difficulties are especially important in the hardwood types, which represent about 75 percent of the commercial forest land in the Northeast. The futility of planting hardwoods on many clearcut sites has been brought home to me rather forcibly in a number of our experiments. We've had comparatively little problem with initial survival, but great difficulty with competing natural seedlings. When you end up with a multi-stemmed 3-foot-tall planted seedling surrounded by 15-foot-tall, single-stemmed, straight-boled natural seedlings that you cut back each of the past 5 years so that they did not overtop the planted stem, you have to ask yourself whether planting will ever make sense in areas where natural regeneration develops after cutting.

An alternative in the Northeast would be to use an extremely intensive culture, perhaps one that includes drastic site preparation and clean cultivation to eliminate natural competition. Other intensive measures such as fertilization and pruning might also be included.

But I wonder if this alternative makes much sense for hardwoods. We have far more hardwood fiber than we are now using, and projections to the year 2000 still show a considerable excess of growth over cut--though demand is expected to increase several fold.

However the outlook for sawlog-quality hardwoods is quite different--high-quality hardwoods suitable for furniture, veneer, and specialty products are already in short supply, bring very high prices, and will probably be in demand for years to come. Almost all hardwood silviculture in the Northeast is aimed at growing high-quality trees for these purposes.

In this situation, any intensive culture of hardwoods will certainly be aimed at producing quality sawlogs, with pulpwood and other fiber products as byproducts. Unlike conifers, which can be grown for sawtimber successfully in plantations, hardwoods tend to be short-boled, limby and crooked, and have extreme taper when grown at wide spacing.

Even with artificial pruning, it is not clear that we can grow hardwoods of a quality comparable to those from dense natural stands. And, of course, the costs of such an intensive culture would be high--very large increases in growth and value would be required to justify the expense.

So I see problems in getting seeded or planted hardwoods to survive in competition with fast-growing natural regeneration in clearcuts; I see a problem in growing quality hardwoods under intensive conditions at wide spacing; and I see an economic problem in using artificial regeneration for hardwoods or conifers on cutover sites where natural regeneration would be far less costly.

The high costs of artificial regeneration and associated techniques add a dimension to the economic analyses of tree improvement that is not a consideration in the South and West, where artificial regeneration is common. In deciding whether we can afford to invest in tree improvement in the Northeast, we must add the cost of planting, and the cost of competition control and similar measures to the cost of genetic improvement itself.

Although the cost of genetically improved seed or planting stock may be only a few dollars per acre, costs for artificial regeneration and competition control may be well over $50 per acre. With interest compounding over the entire rotation, such investments amount to several hundred--even several thousand-dollars per acre, which is more than the total value of some stands. So if the ability to use genetically improved stock is the only reason for switching to artificial regeneration, costs will be prohibitive for all but a few species that grow fast, have exceptionally high value, and pro duce large quantities of seed--examples include paper birch, black cherry, white ash, yellow-poplar, and eastern white pine.

Changing harvesting practices could alter the economic equation. For example, mechanized harvesting in the spruce-fir type apparently offers substantial savings, and solves some problems in obtaining adequate labor. And whole-tree harvesting on some hardwood areas increases yield appreciably, thus reducing unit costs. Both of these techniques tend to make natural regeneration more difficult, because they destroy considerable portions of the advance regeneration, and remove whatever shelter would have been provided by trees that are usually left after more traditional cuttings.

Artificial regeneration may prove necessary in some areas harvested by mechanical techniques. The savings from these methods will at least partially balance the cost of planting or seeding, and may provide one of the better opportunities to use genetically improved material in the Northeast.

However the benefits of these harvesting techniques will have to be weighed against factors such as increased costs that will be required for regeneration; nutrient losses from the more complete removals and longer site exposure; and restriction of silvicultural practices to even-age management with clearcutting, which may not be compatible with other land-use objectives on many areas. Efforts now underway to develop smaller harvesting equipment that would have the cost advantages of the large equipment without its disadvantages could also affect the future use of the larger equipment.

Considering the potential use of mechanical harvesters and whole-tree harvesting systems, and recognizing that natural regeneration will fail on a few areas even after conventional cuttings, I still see limited use of artificial regeneration in the Northeast in its traditional role--that of establishing pure stands composed solely of planted or seeded stems. And perhaps that is the key--perhaps we'll have to abandon some time-honored views of artificial regeneration if that practice is ever to prove clearly advantageous in the Northeast.

New concepts of artificial regeneration needed. -- If artificial regeneration has a place in our eastern mixed forests, I believe it will be as interplantings with natural regeneration, perhaps even before the final overstory removal. Such plantings would introduce into the mixture species or genetic material that is presently lacking, or that we have not successfully regenerated naturally; or would allow the use of silvicultural techniques that are presently impractical because of their complete dependence on natural regeneration.

For example, a major problem in silviculture of mixed stands is that the various species often mature at widely different times. In cherry-maple stands on the Allegheny Plateau, black cherry matures at about 80 years of age, but sugar maple requires nearly twice that time. If the stand is clearcut when the cherry matures, you sacrifice a lot of large pole and small sawtimber maple that is just beginning to earn money. But if you remove the cherry and try to carry the maple, you end up with no cherry seed source for regeneration when the maple is harvested,

There would probably be large economic benefits in carrying the maple to maturity if planting could be used successfully to reintroduce the intolerants at the end of the maple rotation.

As another example, white ash is an extremely valuable component of our northern hardwood type, but it is absent from many stands, and seldom represents more than 10 percent of the stand where it does occur. Natural regeneration is often uncertain, even where seed sources are present. So it would make good sense to underplant white ash after the seed cut of a shelterwood sequence, or after the final thinning, to ensure its representation in the next stand after final removal.

One could think of many other examples where the planting of scarce or difficult-to-regenerate species in mixture with natural regeneration would be a very useful silvicultural tool.

For this method to be successful, the planted stems would have to have a good chance of competing with the natural regeneration that develops. Underplanting, perhaps after the seed cut of a shelterwood or the last thinning, would provide partial shade for good early survival, but avoid intense competition until the planted seedlings were well established and ready to grow rapidly. Competition from herbaceous vegetation, girdling by mice, and similar threats to hardwood planting would be minimized; and natural seedlings that develop should help maintain high quality of the interplanted stems. There has been relatively little work on underplanting, but trials that have been conducted suggest that this technique could be quite successful.

So I see artificial regeneration and tree improvement on the vast majority of commercial forest lands, particularly in the hardwood types, used in close conjunction with natural regeneration, and not at all in the framework of the clearcut-burn-and-plant-pure-stands philosophy of other areas.

New research emphasis needed.--Major research is needed before hardwood plantings of any kind, especially interplantings, can be widely used. We know that it is useless to try to establish hardwoods without controlling competing vegetation. More recently, studies have shown that herbaceous plants not only compete but actually interfere with hardwood seedling growth by releasing toxic biochemicals. If we knew more about this phenomenon, perhaps we could develop more effective and less costly ways to reduce this interference.

Even when competing plants are controlled, seeded and planted hardwoods often require several years to become established before rapid growth begins. We need to find ways to reduce this lag and provide rapid growth immediately.

Studies of seedling nutrition may provide many answers. We need to know a lot more about the role of mycorrhizae in planted seedlings, and how important they are for early establishment and growth. Techniques of fertilization that provide needed nutrients over the 2 or 3 years after planting could also provide the extra growth needed to help artificially regenerated seedlings reach a dominant position relative to natural seedlings.

Of course, additional research also would be needed to develop practical seeding or planting procedures if artificial regeneration is to be interspersed with natural regeneration. And criteria for genetic selection should certainly be geared to such conditions. Since much of the difficulty in using artificial regeneration with hardwoods is getting successful establishment in competition with natural seedlings, it may be desirable to place greater emphasis on rapid juvenile growth. Perhaps a useful first step would be a simple screening of a large number of parent trees for offspring that exhibit early rapid growth. And perhaps screening for response to fertilization would produce genetic material that could be fertilized at planting time and given a shot of growth to get them above natural seedlings.

For example, recent studies have shown that there are tremendous genetic differences in response to fertilization within a species like black cherry. And if planting or seeding is likely to be done under a partial canopy, progeny testing may be important in partial shade as well as in full sunlight.

I'm sure that much of what I am suggesting is already being studied in one way or another, but I believe geneticists and silviculturists need to work very closely to ensure that we end up with genetic material and cultural techniques that are fully compatible, and that offer enough advantages over naturally regenerated stands to ensure their acceptance and use.

<u>Opportunities with conifers</u>.--Although the acreage is somewhat limited, agricultural lands, poorly stocked forest areas, and low-quality hardwood stands provide good opportunities for more traditional planting and tree-improvement programs. I believe one of the major contributions that geneticists might make in the Northeast would be to improve a few valuable timber species that are adapted to establishment and rapid growth on such sites.

At present, the decision of which species to use is often a choice between two evils; should I risk planting high-value hardwoods, though the chances of successful establishment are small? Or should I plant a species that I know will survive, for example, white pine, red pine, or larch, but that likely will never be very profitable because of lack of markets, or because of insects such as the white pine weevil, or diseases such as Fomes annosus root rot?

In view of the well-established herbaceous cover, the frequency of animal damage, the often poor or depleted soils, and other adverse factors associated with such sites, conifers are almost always the right choice for these areas. We have a few conifers, like white pine, whose potential timber value would be great if we could develop varieties resistant to the white pine weevil. White pine was the mainstay of the early lumber industry in this country, and this tree still possesses the same qualities that made it so valuable then. We know that white pine is adapted to a variety of sites throughout the Northeast, that it can be grown rapidly and yield large volumes per acre; and that the demand for soft pine lumber is not likely to be filled from forests in other parts of the country. Insects and disease are the major stumbling blocks to widespread culture of this species. So I see a major silvicultural role for an insect- and disease-resistant white pine that could be planted on old fields and on low-quality hardwood sites.

Other opportunities.--There are other situations in the Northeast where seeding and planting are essential, and where traditional tree-improvement practices should play important roles. There is much disturbed land in need of reforestation, including spoil banks of various mining operations, and drastically disturbed areas near major construction projects such as highways. The interest here is primarily in returning these lands to some sort of protective cover; timber production and other commodity objectives are less important.

Another quite different yet increasingly important type of land in need of planting is urban land, where trees may serve as visual barriers, or be used to absorb noise, dust, or pollutants or modify the climate. In urban areas, trees also would be sources of scenic beauty on lawns, around parking lots, and along city streets.

Of course, to be effective on drastically disturbed lands or urban areas, the criteria for species and for genetic selection should probably be quite different from those used for improvement of forest trees for timber production.

Rapid early growth would still be important, but other criteria, such as ability to wall off wounds or withstand pollution, could be of major importance in urban areas. I believe considerable progress is already being made in this area.

CONCLUSION

Traditional opportunities for tree improvement and artificial regeneration as used in the South and West seem more limited in the Northeast. The best opportunities seem to be using the few conifer species that have high timber values for the reforestation of open or poorly stocked forest lands or for conversion from low-quality hardwoods. There are additional opportunities to use a variety of other species in disturbed areas and on urban sites.

On the majority of commercial forest lands, and particularly in the hardwood areas, I do not foresee natural regeneration abandoned in favor of pure stands of artifically regenerated trees. I <u>do</u> see artificial regeneration and tree improvement increasing in importance, but being used in combination with natural regeneration rather than as the sole source of new stems. This is a whole new ball game, and we have a great deal to learn about cutting, planting, and other cultural techniques that might make this technique both feasible and economically desirable.