INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

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XVII IUFRO World Congress

PROCEEDINGS—REFEREATE—EXPOSES

DIVISION 1

MANAGEMENT OF ALLEGHENY HARDWOODS FOR TIMBER AND WILDLIFE

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INTRODUCTION

Allegheny hardwood forests occur primarily on the plateaus of Pennsylvania and New York in the northeastern United States, at elevations between 150 and 600 m. The annual precipitation in these areas averages 100 cm.

These forests originated after commercial clearcutting during the rail-road-logging era, between 1890 and 1930. They are second-growth, replacing the original beech-hemlock-maple forests that were there when the area was first settled in the 1800's. Black cherry, sugar maple, red maple, and white ash are the primary components of the Allegheny hardwood type; birch, beech, hemlock, and yellow-poplar are common associates (Marquis 1975).

The Allegheny forest region is one of the few large blocks of contiguous forest land in the northeastern United States, but it is surrounded on all sides by the eastern megalopolis. Nearly one-third of the entire United States population lives within a day's drive of the region. As a result, there is a large and nearby market for forest products, and great demands are placed on the forest land for outdoor recreation as well.

Allegheny hardwood forests provide an important share of the Nation's ash and maple timber—ash for baseball bats and tool handles; maple for furniture, flooring, and specialty products. But the prime timber species is black cherry, an outstanding furniture wood that grows in commercial quantities primarily on the Allegheny Plateau. Deer hunting is another major use of Allegheny forests. Pennsylvania ranks first in the Nation in the sale of hunting licenses; well over a million are sold each year, and deer harvests exceed 200,000 animals annually (Holt 1980).

Although both timber and deer are major resources in Allegheny forests, their management has not been well coordinated in the past. Deer populations are regulated through hunting, which is under control of the State game agencies. Populations in Pennsylvania have been maintained at a very high level since the 1920's, when complete protection of does from hunting combined with abundant browse from extensive clearcutting to produce an irruption in the population (Leopold 1943, Bennett 1957). The high population has permitted large deer harvests and good hunter success, providing excellent outdoor recreation opportunities for a large number of people and supporting an extensive recreation industry built around hunting.

But the high deer populations in Pennsylvania have had detrimental affects on other resources. As the second-growth forests began to reach maturity and were harvested, regeneration failures due to deer browsing became common. Over half of the harvest cuttings made during the 1960's and early 1970’s failed to produce satisfactory natural regeneration. Estimates of the impact on future timber production suggest that deer browsing will reduce timber income by an average of $32 per hectare per year over the entire Allegheny Plateau, an overall loss of about 50 percent of total timber value (Marquis 1981).

Excessive browsing has also affected other resources. Food and cover for other species of wildlife such as rabbits, hares, and grouse have been drastically reduced, and the deer themselves show typical symptoms of undernourishment such as small size and poor antler development (Latham 1977).

The long-term solution to this problem will require coordination of management efforts between the agencies that regulate the dear population and the agencies or individuals who own and manage the land. Deer populations will have to be reduced for the habitat to recover and seedlings to become established, at least initially. Later, it may be possible to increase populations again as silvicultural practices are instituted to raise the carrying capacity of the habitat.

In the interim, much research effort has been directed toward the development of silvicultural techniques to secure adequate seedling regeneration in spite of the high deer population. These techniques have permitted continuation of timber harvesting without a complete loss of forest vegetation, and are now being integrated into a more intensive, coordinated scheme to maximize both timber and deer under multiple-use management.

The extremely high deer populations in Allegheny hardwoods, and the silvicultural practices developed to accommodate timber management to these conditions, provide excellent insight into techniques that may be used elsewhere to sustain high levels of output from both timber and deer resources.

TREE REGENERATION WITH HIGH DEER POPULATIONS

Direct protection

When it first became apparent that excessive deer browsing was resulting in complete failure of tree regeneration on many clearcut areas, fencing to exclude deer from the site was considered. Although a 2.5-m-high fence of standard woven mesh wire is effective, its cost, $400 to $600 per hectare, is prohibitive for general use (Marquis 1978a).

A search for other forms of direct protection included tests of plastic and nylon fence materials and various designs of electric fencing. Cost savings achieved through easier erection of plastic fence materials were more than offset by high prices for the plastic and increased maintenance
caused by falling limbs and similar damage. Electric fences appear more promising (Brenneman 1981), especially a new 5-wire design that utilizes high-tensile-strength wire that is not easily broken by falling limbs, a high-voltage, low-amperage energizer that is not shirted out by vegetation, and a solar-cell-powered battery charger that minimizes maintenance. Even so, costs of this fence average $175 to $225 per hectare.

Any fence that completely excludes deer from regeneration areas also eliminates their access to a major food source. If all regeneration cuts ware fenced, the amount of deer food produced might be reduced by 20 or 25 percent as shown below:

			Total deer food produced on 500 ha	
	Area within deer range	Food production	With regeneration areas unfenced	With regeneration areas fenced
	ha	kg/ha/yr	------------------kg/yr------------------	
Regeneration stands	50	450	22,500	0
Unthinned stands	300	100	30,000	30,000
Thinned stands	150	225	33,750	33,750
Total	500		86,250	63,750

The figures above are based on the assumptions that a) the area of management appropriate for such calculations is the home range of a deer, approximately 500 hectares (a radius of about 1.25 km); b) this area is under even-age management on a 100-year rotation and contains 10 percent regeneration, 60 percent unthinned poletimber, and 30 percent thinned sawtimber. Deer food production factors are based on average amounts of seedling regeneration and herbaceous ground cover in Allegheny hardwood stands plus equations relating seedling size or herbaceous coverage to dry weight of browsable twigs and foliage last than 1.5 m above ground. Similar assumptions will be used throughout this discussion in calculations of deer food production.

In addition to fencing, forms of direct protection that would permit seedling establishment without completely excluding deer from the area were also investigated. Chemical repellents of various types all proved ineffective where alternate foods were scarce. Individual seedling protectors of wire or plastic mesh were more effective, but required periodic maintenance and were more expensive than any of the other techniques tested if used in adequate numbers to provide full stocking over the entire area (Marquis 1977).

Fertilization

As an alternative to direct protection, we investigated fertilization to encourage seedlings to grow rapidly above the reach of deer. Nitrogen and phosphorus from ammonium nitrate and triple superphosphate, applied at element rates of 168 and 49 Kg per hectare, stimulated rapid height growth of species such as back cherry. Average height increases of more than 1 meter were obtained during the 2 years after fertilizers were applied, and some individual stems grew nearly 2.5 m in l year. Fertilization reduces the time seedlings are subject to browsing to a few years rather than the ~6 to 8 years typically required (Auchmoody 1978), greatly improving regeneration success where there are adequate numbers of seedlings.

Aerial fertilization is now a standard practice on the Allegheny National Forest, where it is used during the second or third year after harvest cutting to provide added insurance against regeneration failure where success is not certain. Current costs of about $250 per hectare have thus far prevented its use on other ownerships.

Fertilization has a significant short-term affect on deer food production. Total dry weight and crude protein content of woody and herbaceous food produced during the first few years after cutting are substantially increased. But accelerated growth hastens stand development and reduces the length of time that vegetation remains in the zone that deer can reach. The net effect is no significant change in food production over the first ~8 to 10 years, but a redistribution of the tine that food is available after cutting (Parrow et al. 1976). Thus, total deer food production is not affected by fertilization, but regeneration cuts met be scheduled at shorter intervals to insure a constant progression of new openings within the home range of deer.

Selection of regeneration areas

Direct protection and fertilization are sometimes the only way to insure perpetuation of forest trees on sites that are difficult to regenerate. But costs of $200 to $600 per hectare at the time of stand establishment are considered prohibitive in U.S. practice. Techniques that do not require large investments were needed to assure regeneration over the majority of Allegheny hardwood areas.

Early experiences with regeneration clearcuts on the Allegheny Plateau showed that nearly half the stands had failed to regenerate satisfactorily after cutting. The other half, however, regenerated satisfactorily in spite of deer browsing. Studies of the stand and site conditions before cutting revealed that nearly all stands that regenerated satisfactorily had an abundance of advance seedlings in the understory (Grisez and Peace 1973). Although very small (generally less than 15 cm tall) due to browsing and dense overstories, these advance seedlings provide the basis for a new stand after overstory removal. Where advance seedlings were absent, the few new seedlings that became established after cutting were consumed by deer.

Thus, the strategy for successful regeneration in the presence of a large deer herd emerged: provide such a dense regrowth of seedlings that deer cannot eat all of them before some grow out of reach.

Vary large numbers of advance seedlings are necessary to insure that this dense regrowth occurs immediately after overstory removal. A guide for the amounts of advance regeneration required has been developed. It requires a survey of advance reproduction before cutting; 70 percent of the 1.8-m-radius plots examined must contain at least 25 black cherry or 100 desirable seedlings total. This guide insures both adequate numbers and suitable distribution of advance seedlings over the area.

No Allegheny hardwood stands with less than 40,000 seedlings per hectare have qualified for harvest cutting under this guide, and stands that do qualify average more than 100,000 advance seedlings per hectare. Obviously, very large numbers of these small advance seedlings are required to provide regrowth dense enough to overwhelm the deer.

The high number of advance seedlings required is the result of the current high deer population: If deer populations are managed at lower levels in the future, fewer advance seedlings will be required.

Currently, we are conducting dear enclosure studies to define the relationship between deer population level and the numbers of advance seedlings that will produce successful regeneration after harvest cutting. Deer populations of 0, 10, 20, 40, and 80 deer per 260 hectares are being maintained in fenced enclosures of either 13 or 26 hectares where there are uncut, thinned, and clearcut stands in proportions typical of a managed even-aged forest. Data from this study will not only provide information on amounts of advance regeneration required at various deer levels, but will provide guidance on deer population levels appropriate to achieve a balance between timber and wildlife resources.

Site and amount of regeneration openings

Since the strategy for securing successful regeneration is to overwhelm the deer with more seedlings than they can consume, other factors that affect the availability of deer food need to be evaluated. The size of regeneration openings was initially thought to be of importance; the larger the opening, the more seedlings to overwhelm deer. Also, deer in other geographic areas have been found to use small openings (less than 2 hectares) more heavily than larger ones (McCaffery and Creed 1969), presumably because of the proximity of protective cover. But we have not found size of the individual opening to be important--in a study of 34 clearcuts that ranged from 2 to 50 ha, there was no significant relationship between regeneration success and opening size.

A more important factor is the total area in regeneration openings within the home range of deer. The larger the proportion of the total forest area in regeneration openings, the greater the deer food production, and the lower the browsing impact on seedling regeneration. Thus, four openings of 10 hectares produce about the same amount of deer food and have about the same impact on browsing pressure as one opening of 40 hectares.

The variation in total deer food production on a 500-ha area that might result from differences in both area in regeneration openings and regeneration potential of the openings is shown in Table 1.

Note that increasing the area in regeneration openings from 10 to 50 hectares increases total food production by only 5 percent when the regeneration potential is low. The reason is that food production in clearcuts that do not contain an abundance of seedlings is not much different from food production in other stands, so changing the proportion of openings has only a small effect. Production lost from the smaller area in openings is partially, offset by production from the larger area in thinned and uncut stands.

Thinned stands, because they have moderately high food production and considerably more area than regeneration openings, make an important contribution to total food production, especially when regeneration potential is low. For example, with 10 hectares in openings rather than 50, total food production will range from 70,250 kg if the 40 hectares not clearcut are left uncut to 75,250 kg if the 40 hectares not clearcut are all thinned. This compares to 76,250 if all 40 hectares were clearcut.

Table 1.—Total production of deer food on a 500-ha area as affected by proportion of regeneration openings and regeneration potential

Stand Class	Food production	2% of area in regeneration openings		10% of area in regeneration openings	
		Area	Food Production	Area	Food Production
	kg/ha/yr	ha	kg/yr	ha	kg/yr
	LOW REGENERATION POTENTIAL: 25,000 SEEDLINGS PER ha				
Regeneration	250	10	2,500	50	12,500
Uncut	100	320	32,000	300	30,000
Thinned	225	170	38,250	150	33,750
Total		500	72,750	500	76,250
	AVERAGE REGENERATION POTENTIAL: 75,000 SEEDLINGS PER ha				
Regeneration	450	10	4,500	50	22,500
Uncut	100	320	32,000	300	30,000
Thinned	225	170	38,250	150	33,750
Total		500	74,750	500	86,250
	HIGH REGENERATION POTENTIAL: 300,000 SEEDLINGS PER ha				
Regeneration	1,350	10	13,500	50	67,500
Uncut	100	320	32,000	300	30,000
Thinned	225	170	38,250	150	33,750
Total		500	83,750	500	131,250

Note also in Table 1 that the effect of area in clearcuts is quite different when the regeneration potential is high. In this case, increasing the area in regeneration openings from 10 to 50 hectares produces well over 50 percent increase in total deer food production from the 500-hectare deer.

The food production in openings that contain an abundance of vegetation is so much greater than in other stands that area in openings become a major factor affecting total food production.

To reduce browsing damage to seedlings, it is therefore important to a) insure that areas to be regenerated contain as many advance seedlings as possible, and b) schedule as much area as possible in cleat-cuts and thinnings. Both measures will increase the total food supply and reduce the damage. However, where regeneration potential is low, it is not possible to overwhelm the deer simply by scheduling more area in cuttings; raising the regeneration potential of areas to be harvested is more important.

Shelterwood cutting

Many stands do not naturally have large numbers of advance seedlings. In fact, only about 25 percent of the Allegheny hardwood stands that are ready to be harvested have enough advance seedlings to qualify for clear-cutting under the guidelines previously described. For stands with insufficient advance seedlings, other silvicultural techniques were needed to greatly increase the regeneration potential. Shelterwood cutting is widely used to improve the amount or size of advance regeneration, but little was known about the residual densities, numbers of cuttings, or intervals between cuttings that would produce best results.

A series of experiments was launched to investigate the silvical requirements of the various Allegheny hardwood species. These included detailed studies of sunlight requirements, using shade cloth tents of varying densities, and artificial control of other environmental factors, such as soil moisture and temperature. Similar experiments were conducted in forested areas where cutting to varying residual densities was used to vary sunlight exposure and other environmental factors. Auxiliary treatments, such at trenching, irrigation, supplemental lighting, soil heating cables, and fertilization, were used to separate canopy effects from soil effects. Seedlings grown in pots under various cutting regimes for various lengths of time were transferred to a clearcut to determine the ability of different sizes and ages of seedlings to survive complete overstory removal. And finally, large-scale cutting experiments were employed to test the effects of various shelterwood regimes over a wide range of site and stand conditions.

In brief, we learned that reducing canopy density to about 60 percent of full stocking produced small increases in the amounts of sunlight and soil moisture available for seedling establishment and altered light quality so as to increase seed germination of for-red-sensitive species such as red maple. The improved conditions provided good seed germination and greatly improved initial seedling survival so that the number of advance seedlings gradually increased over a 5- to 10-year period. For example, the number of advance seedlings increased by 121,000 stems per hectare over a 6-year period in one experiment, compared to the uncut control (Marquis 1978b).

Although it maximized the number of advance seedlings, the comparatively high density of the shelterwood overstory (60 percent) permitted only minor increases in seedling growth. Thus, advance seedlings remain small under this regime. But this is a distinct advantage under very high levels of deer population, far the small understory seedlings are browsed only lightly.

Once an adequate number of advance seedlings has become established, the overstory should be completely removed in a single operation. The small advance seedlings survive well if they have started under a 60 percent canopy, and the full sunlight insures that they will grow as rapidly as possible out of the reach of deer (Marquis 1979).

One difficulty experienced with this two-cut shelterwood sequence is that undesirable understory plants, such as beech root suckers, noncommercial striped maple seedlings, and herbaceous ferns and grasses, may be stimulated to the detriment of desired seedlings. High deer populations over many years have aggravated this problem, because heavy browsing on the more palatable tree seedlings has permitted expansion of these undesirable and less palatable plants to fill the void (Marquis and Grisez 1978). Once established, ferns and grasses are capable of interfering with subsequent seedling establishment through an allelopathic mechanism (Horsley 1977). In stands where these plants are present, herbicides must be used to remove the interfering plants before the seed cut of the shelterwood sequence. Although this also removes desired seedlings, it reduces interference and prepares the site for reestablishment of desirable seedlings, which is more rapid that reestablishment of the undesirable ones (Horsley 1978).

Rotation length strategies

A short-term technique to circumvent browsing damage is simply to delay regeneration harvest cuts until some future time when the deer population may be lower. Such a policy might at first appear unwise, since it could disrupt the even flow and total sustained yield of timber products, and could conceivably make regeneration even more difficult on those few areas still harvested, because deer pressure would be concentrated on a smaller area of regeneration opening.

But extended rotations have some advantages not immediately apparent. Allegheny hardwood forests are complicated mixtures of tolerant and intolerant species with widely different growth rates and timber values. They are very complex to manage for even timber alone, not always following patterns expected of even-aged stands of a single or similar species. Although the current practice is to clearcut the entire stand when the intolerants, such as black cherry, mature (80 to 100 years), the slower-growing tolerant sugar maple and beech are seldom mature at that time. Clearcutting tends to sacrifice many tolerant stems that are just reaching their period of maximum value growth.

To evaluate the trade-offs of various rotation-length strategies, we used computer stand-growth simulation to compare financial returns from timber production under a wide variety of cutting strategies. The effect of these strategies on total deer food production was also calculated.

In brief, it was found that stands containing 70 or more percent intolerant species were most profitably managed for timber if clearcut and regenerated as soon as the intolerants mature, as is the current practice. But stands with less than 70 percent intolerant species can sometimes be made to produce higher yields by harvesting only the intolerants when they mature and carrying the tolerant species for an additional 30 years or so until they, too, reach maturity. This requires maintaining a modest percentage of intolerants in the stands to serve as seed sources until the end of the rotation. And this strategy is profitable only where the tolerants are large enough to mature in an additional 30 to 40 years. If they take longer than that, it is possible to earn more by starting over with a new crop of fast-growing high-value intolerants.

Extending the rotation increases the proportion of sawtimber-size stands, and--since these are the stands suitable for commercial thinning—increases the proportion of the area thinned. As a result, total deer food production is maintained at about the same level under the extended rotation as under the more traditional one. The reduction in food production from regeneration stands is offset by an increase in production from the stands thinned, as shown in the tabulation below:

	Area ha	Production factor kg/ha/yr	Total production kg/yr
Single rotation			
Regeneration stands	50	450	22,500
Unthinned stands	300	100	30,000
Thinned stands	150	225	33,750
Total	500		86,250
Extended rotation	35	450	15,750
Regeneration stands	270	100	27,000
Unthinned stands	195	225	43,875
Thinned stands			
Total	500		86,625

MANAGEMENT GUIDES FOR TIMBER AND DEER

The silvicultural practices described briefly here provide ways to insure seedling regeneration in the presence of a large deer herd. Stand and site conditions differ greatly, and the best practice, combination of practices, differs accordingly. To insure proper application of the practices most appropriate to each stand, we have developed a series of management guidelines that bring together all pertinent information in a form that makes it simple for the practicing forester to evaluate stand condition and choose an appropriate prescription for stand treatment. This reduces the many complex decisions to their simplest form, removing much of the subjective judgment that has been required in the past.

There are three steps: stand examination, stand analysis, and prescription. The examination is a traditional wedge-prism cruise of the overstory, supplemented by measurement of specific site and understory factors that influence regeneration or deer food production. These data are summarized and analyzed in ways that reveal major aspects of the stand's potential for future growth, stage of maturity, need for thinning, ability to regenerate and provide deer food, etc. From this information, plus a series of guidelines in the form of flow charts, a stand prescription can be developed that includes a detailed description of treatments to be applied, and if cutting is involved, amounts to be cut in the various species groups and size classes to achieve the desired residual stand.

The flow charts show a series of decision points concerning stand or site conditions that have an impact on the final prescription. The path taken from each decision point is determined from some quantitative measure of stand or site condition, with critical levels determined from experience and incorporated into descriptive guides. Figure 1 is one of these flow charts.

Because the prescription process has been reduced to objective decisions, the entire process can actually be handled by computer. Data from the stand examination are fed into the computer and summarized, and a recommended prescription is produced.

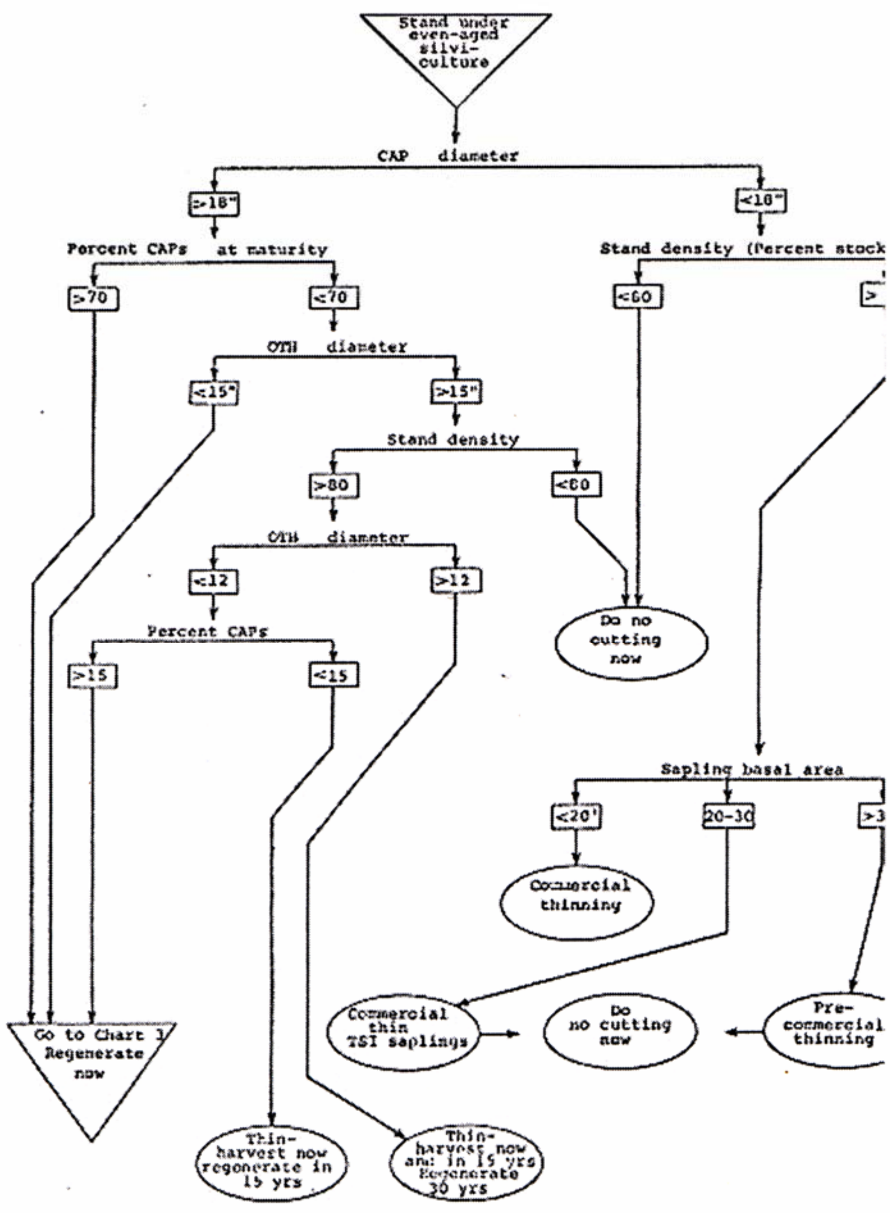
In our experience to date, the computer-generated prescriptions are generally silviculturally sound and practical, and extremely useful to the forester in managing his forest. Of course, no guides of this type can ever be complete for all of the many possible circumstances that might be encountered, so they must be used as a supplement to professional judgment, not as a substitute for it. If used in that way, they can be a powerful tool in the consistent application of practices currently considered optimal.

SUMMARY

The management practices and techniques described here were originally developed to insure adequate seedling regeneration in the presence of a large deer herd. The key is providing so much deer food within the home range of the local herd that the deer cannot consume all of it, and some seedlings will escape to form the next stand. This is accomplished by selecting areas with abundant advance regeneration, by stimulating advance regeneration through shelterwood cutting (using herbicides for site preparation where needed), maximizing the area in high deer-food producing condition (regeneration and thinned areas), and sometimes through special measures such as fertilization and direct protection. Control over the deer population is essential, but once it is achieved, those same techniques will become an integral part of a coordinated management system for Allegheny hardwoods that should allow sustained high yields of both timber and deer.

Keywords: Multiple use, Allegheny hardwoods, Natural regeneration, deer habitat

Figure 1 - Decision chart for intermediate culture of even-aged stands. This chart is one of five that comprise the Allegheny hardwood silviculture guidelines. These charts are used with additional written material providing detailed definitions of each decision point and prescription. CAPs = cherry, ash, poplar. OTH=all other species.



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