When Is Pin Cherry (*Prunus pensylvanica* L.) a Problem in Allegheny Hardwoods?

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ABSTRACT: *Pin cherry (*Prunus pensylvanica *L.) has important effects on early stand development when it occurs at high densities. We used data describing the first 15 years of stand development in eight clearcuts and used plots that had at least 25 black cherry or 100 desirable seedlings at age 3, as well as different levels of pin cherry stocking. Our findings identified seven pin cherry >5 ft tall at age 3 on 6-ft-radius plots as the threshold for negative effects on stocking of seedling-origin trees of desirable species at age 15. We incorporated these finding into the regeneration followup chart used as part of the Silviculture of Allegheny Hardwoods (SILVAH) decision support framework. Of eight stands used in this study, four had a pin cherry interference problem, and four did not. By age 15, there were one-third as many desirable seedling-origin stems, mostly black cherry (*Prunus serotina *Ehrh.), in stands with pin cherry above the critical threshold density. We suggest some silvicultural options for addressing the problem. North. J. Appl. For. 23(3): 204–210.*

Key Words: Pin cherry, *Prunus pensylvanica*, Silviculture of Allegheny Hardwoods (SILVAH), Allegheny hardwood, interference, regeneration.

Pin cherry (*Prunus pensylvanica* L.) is a short-lived (20–40 years), fast-growing, shade-intolerant species. It begins producing seed at an early age and continues to deposit it throughout its life. Viable seed can be found in the litter for up to 9 decades after a disturbance and will germinate following clearcutting and heavy overstory disturbance if present (Chittenden 1905, Marquis 1975, Auchmoody 1979, Graber and Thompson 1978, Peterson and Carson 1996, Thurston et al. 1992). Pin cherry occurs in many forest types across the northern United States and Canada (Wendel 1990). Reports by Jensen (1943) and Longwood (1951) suggested that it does not affect early development of northern hardwoods. Yet Marks (1974) hypothesized that pin cherry at high densities would interfere with establishment of desirable hardwood regeneration following complete overstory removal. He suggested that only the most shade-tolerant species, such as sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.), would survive under dense pin cherry.

Several researchers have tested Marks' hypothesis. Safford and Filip (1974) reported reduced paper birch (*Betula papyrifera* Marsh.) over time under pin cherry. Leak (1988) found fewer large seedlings of yellow birch (*Betula alleghaniensis* Britton) on 8-year-old regeneration plots where pin cherry was present, although neither sugar maple nor white ash (*Fraxinus americana* L.) was affected. Heitzman and Nyland (1994) found fewer black cherry (*Prunus serotina* Ehrh.) and sugar maple stems at age 20 when pin cherry >3 ft tall exceeded 3 stems per milacre at age 3. Ristau and Horsley (1999) found that when the number of pin cherry >5 ft tall on a milacre plot at age 3 had been greater than 1 stem, the plot lacked seedling-origin black cherry, red maple (*Acer rubrum* L.), or sugar maple at age 15. Sweet (*Betula lenta* L.) and yellow birch and stump sprout-origin stems were not affected. They also showed that the mean diameter of black cherry was significantly lower on high (12.0 in.) versus low (14.0 in.) pin cherry density plots after 70 years. Also, sawtimber volume was significantly lower on high (7,695 board feet [bd ft]/ac) than on low (13,149 bd ft/ac) pin cherry density plots after 70 years.

High densities of pin cherry usually do not occur in the forests of the Allegheny Plateau region because the species is browsed heavily by white-tailed deer (*Odocoileus virginianus virginianus* Boddaert) (Jordan 1967, Healy 1971), and

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the region has had high deer populations since the late 1920s (Redding 1995). Large numbers of pin cherry seeds are found in the forest floor seed bank (Marquis 1975). Therefore, where deer density is low and forage supply high, or where fences exclude deer, large numbers of pin cherry often become established.

The Silviculture of Allegheny Hardwoods (SILVAH) system (Marquis et al. 1992) organizes ecological, silvical, and silvicultural information into guidelines for natural resource managers to use in writing prescriptions to achieve sustainable forest management goals in Allegheny hardwood (cherry-maple) and northern hardwood forests of the Allegheny Plateau region. It includes a systematic approach to assessing early stand development (Marquis et al. 1992), identifying problems that threaten the development of desirable regeneration in young stands, and suggesting corrective measures. Six-ft-radius plots are evaluated as successfully stocked with regeneration or not. When more than 70% have desirable regeneration, the stand is considered stocked. The number of plots required is a function of total stand acreage.

We extended the results of Ristau and Horsley (1999) by developing pin cherry management guidelines for the SILVAH system. They had used regression analysis to determine pin cherry effects on individual species and developed thresholds for negative impacts. Decisions in SILVAH use the desirables category, which includes black cherry, sugar maple, red maple, white ash, yellow-poplar (*Liriodendron tulipifera* L.), cucumber-tree (*Magnolia acuminata* [L.] L.), and red oak (*Quercus rubra* L.) collectively (Marquis and Bjorkbom 1982, Marquis et al. 1992). We used a subset of the data reported in Ristau and Horsley (1999) to determine the threshold pin cherry density for effects on development of regeneration of all desirable species collectively, although the category was heavily influenced by black cherry at age 3. The SILVAH system contains a flow chart for regeneration followup. It allows managers to evaluate success following overstory removal operations (Marquis et al. 1992). We incorporated our results into that chart using the proposed criteria and evaluated differences between stands above and below that threshold level 15 years after clearcutting.

Methods

Study Areas

We used 6.4- or 3.2-ac even-aged stands at four different locations on the Allegheny Plateau where deer population densities (10 or 20 deer/mi^2) were controlled through the use of enclosures for 10 years (Tilghman 1989, de Calesta 1994, Ristau and Horsley 1999, Horsley et al. 2003). Total area maintained at 10 or 20 deer/mi^2 was 64 or 32 ac, with 10% of each enclosure receiving complete overstory removal, 30% receiving a thinning, and 60% left uncut. We used the eight 10- or 20-deer/mi^2 stands that received a complete overstory removal. Browsing did not prevent pin cherry from becoming the dominant (tallest) species where it became established early after the overstory removal (Ristau and Horsley 1999, Horsley et al. 2003). Table 1 details stand locations, sizes, and ages.

Vegetation Sampling

A fixed grid of 25 circular milacres centered on permanently marked stakes was sampled in each stand to enumerate the woody regeneration at 0 or 1, 3, 5, and 10 years after cutting. We counted stems by species and height class (0.2–1.0, 1.1–3.0, 3.1–5, and >5 ft) and recorded height of the tallest stem by species for black cherry, red maple, sugar maple, white ash, American beech, and sweet and yellow birch. Fifteen years after cutting, we resampled the stands using the same grid but increased the plot area to 1/40-ac. All stems greater than 1 in. dbh were measured by species and stem origin (seedling or stump sprout) using 1-in.-diameter classes. Because of proximity to fences (1/40-ac plots would not fit within the fenced area), 25 of the sample points across the study were eliminated, leaving 175 out of 200 original sample points as the pool of data.

Plot Selection

Data from these milacres were evaluated for stocking at age 3 using the SILVAH criteria (Marquis et al. 1992). We selected milacre plots with at least 25 black cherry stems at age 3. We excluded plots with at least 30% cover of grass or ferns to reduce confounding with known barriers to regeneration (Horsley 1993, Horsley and Marquis 1983), thus providing better pin cherry assessment. Altogether, 83 plots met our criteria. Ristau and Horsley (1999) determined that pin cherry >5 ft tall at age 3 interfered with other species, so we focused on that size class. To make the data compatible with components of SILVAH, we extrapolated the numbers from the milacres to represent those that would be on a 6-ft-radius plot.

Among the 83 plots, there were 29 levels of pin cherry density for trees >5 ft tall at age 3 (PCG5A3) ranging from 0 to 164 stems per 6-ft-radius plot. Twenty of the densities were represented by only a single plot, whereas the other

Table 1. Study areas used to determine the effects of pin cherry density early in stand development on species composition at a later time. Stands at 10 deer/mi^2 were 6.5 ac, and stands at 20 deer/mi^2 were 3.2 ac.

Stand name	Deer/mi^2	Ownership, location	Age
Fools Creek	10	Allegheny National Forest, Warren Co., PA	16
Fools Creek	20	Allegheny National Forest, Warren Co., PA	16
Deadman Corners	10	Allegheny National Forest, Forest Co., PA	16
Deadman Corners	20	Allegheny National Forest, Forest Co., PA	16
Gameland 30	10	Pennsylvania Game Commission, McKean Co., PA	15
Gameland 30	20	Pennsylvania Game Commission, McKean Co., PA	15
Wildwood Tower	10	Pennsylvania Bureau of Forestry/National Fuel Gas, Elk Co., PA	15
Wildwood Tower	20	Pennsylvania Bureau of Forestry/National Fuel Gas, Elk Co., PA	15

nine densities had from 2 to 30 plots. Pin cherry densities occurring at multiple plots were mostly low. To account for differences in sample sizes, averages were calculated for plots of each density (e.g., the average number of desirable stems for all plots with 0 pin cherry). We chose to average densities represented by multiple plots to avoid overweighting their influence in the regression model. Since the plots came from several stands, these averages have variability around them, likely due to differences related to unaccounted-for factors such as site quality.

Ristau and Horsley (1999) reported a logarithmic relationship between pin cherry density at age 3 (x) and species abundance at age 15. We fitted a natural log line to the data using SigmaPlot 2001 (SPSS 2001) after increasing the pin cherry density by 1 to accommodate the 0 pin cherry density in the model. A regression analysis based on the 29 pin cherry densities established a relationship between 3-year pin cherry stocking and the density of desirable regeneration at age 15. For that age, we used 18 desirable stems >5 ft tall on a 1/40-ac plot as the threshold for acceptable stocking at age 15, based on the recommendation of Marquis (1987). Stands with at least 70% of plots at this level of stocking should have 300–500 dominant or codominant stems per acre at age 60 (Marquis 1987). Use of different sample sizes around a central point at the different stages of development assumes that uniform conditions exist and that the pin cherry density on the smaller plot was representative of the larger plot size used at age 15. We determined the critical number of pin cherry on a 6-ft-radius plot at age 3 required to negatively affect desirable stocking at age 15 by setting $y = 17$ desirable stems (one less than full stocking) and solved the regression equation for pin cherry density at age 3 (x).

Using this critical level, we classified plots in the study stands as either above or below the critical level for stocking at age 3. When more than 30% of the plots in a stand had pin cherry greater than the threshold level, the whole stand was considered to have a problem. The 30% level for plots with pin cherry above the critical level is not an absolute. One stand had 32% of plots with pin cherry above the critical density. On observation of the data, stand level numbers at age 15 were more like the successful stands. Therefore, it was included with them, providing an equal number of stands with and without a pin cherry problem.

We used the SYSTAT 7.0 statistical package (Wilkinson 1997) to calculate mean values for density of key species,

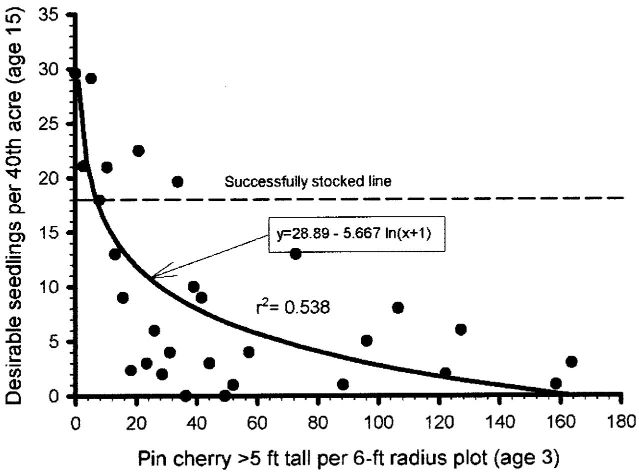

Figure 1. Regression results for determining threshold where pin cherry density negatively affects desirable seedling-origin regeneration at age 15 on circular 1/40-ac plots. Year 3 data are reported for 6-ft-radius circular plots. Points on the graph are from 29 pin cherry densities represented in the study. Both sample periods used the same plot center.

and we compared these means using a t-test of two groups with pooled variance. An α value of 0.05 was used to determine significance.

Results

Establishing the Threshold Density

We regressed 29 pin cherry densities at age 3 against abundance of desirable regeneration at age 15, as shown in Figure 1. The equation for the best fit line is $y = 28.89 - 5.667 \cdot \ln(x + 1)$. Solving that equation for x, with y set at 17, identifies the critical number of PCG5A3 as 7. Fifty-four percent ($R^2 = 0.538$) of the variation in number of desirables at age 15 is accounted for by the regression line. The standard error of the estimate was 6.2, so the regression equation was solved for 17 ± 6.2 to establish a range around the mean of 2–23 PCG5A3. This illustrates that the threshold is not an absolute value.

Effect of Pin Cherry on Numbers of Stems and Heights

Table 2 compares mean stem densities at age 15 for seedling-origin and stump sprout stems at four stands, with more than 30% of sample plots above the critical level of seven stems per 6-ft-radius plot at age 3 versus four stands

Table 2. Tree density (stems/ac) 15 years after overstory removal in stands with or without a pin cherry problem. *P*-values are from a *t*-test with pooled variance. Means are from eight low-deer-impact stands (four with a problem, four without). Where *P*-values are absent, there were not enough data for a test.

	Seedling origin			Stump sprout origin		
Species	With	Without	*P*-value	With	Without	*P*-value
Acer rubrum	12	35	0.426	124	296	0.304
Acer saccharum	1	2	0.664	14	9	0.688
Betula sp.	527	710	0.620	0	4	
Fagus grandifolia	308	125	0.240	18	3	0.376
Fraxinus americana	28	21	0.742	1	8	0.481
Prunus pensylvanica	2101	1130	0.108	0	0	
Prunus serotina	254	929	<0.001	134	325	0.141
All desirables (mostly *Prunus serotina*)	305	1002	0.001	276	640	0.159

classified as not having a pin cherry problem. Those below the critical level of pin cherry stocking had a species composition similar to those above the critical level, but with only 305/ac of desirable trees. By contrast, stands with pin cherry below the critical threshold level had more than three times as many desirable stems (1,002/ac). Most of the desirable stems were black cherry. Stands with pin cherry below the critical level had more seedling-origin ($P < 0.001$) black cherry than those with pin cherry above the critical level.

Discussion

Our current assessment indicated that for 6-ft-radius plots, having more than seven PCG5A3 negatively affected the stocking of desirable stems by age 15. Ristau and Horsley (1999) also showed a negative impact on seedling height growth for some species. The regression line accounted for 54% of the variability in number of desirable seedlings on plots at age 15. Accounting for variability among our data, we recognize that as few as two PCG5A3 could negatively affect survival of desirable seedlings, or as many as 23 PCG5A3 might not reduce stocking below critical levels.

Since we used plots pooled from four different stands, differences in site conditions may have contributed to the variability. So might have the different plot sizes used at various ages. Expanding milacre plot seedling densities to 6-ft equivalents assumes uniformity and proportional numbers of seedlings in the area around the sampled plots. In cases where this assumption was not met, there would be error in plot classification. The same is true for the 1/40-ac plots used at age 15. The fact that 54% of the variability in desirable stocking at age 15 was described by only a single variable, pin cherry density at age 3, suggests that it is important to consider and control.

The regression line suggested a critical level of seven PCG5A3 and we chose to use it as a somewhat conservative threshold. Some concern for 6-ft-radius plots with as few as two PCG5A3 is warranted if desirable stocking on the plot is marginal or if the pin cherry stems are larger than average for the stand. Setting the threshold for negative effects at seven PCG5A3 showed significant differences for number of seedling-origin desirable species, primarily black cherry. It did not show differences for stump sprout-origin stems or for species of intermediate or high shade tolerance. Plots with pin cherry above the threshold level had one-third as many desirable seedlings (Table 2). When this lower level of desirable species is projected to rotation age, it suggests that stand value will be greatly reduced. Pin cherry will die at age 40–50, leaving a large portion of unoccupied space in stands that initially had it at a high density.

Our results support the hypothesis of Marks (1974) that pin cherry at high density may interfere with associated species. They also are consistent with findings from other research in northern hardwoods (Safford and Filip 1974, Leak 1988, Heitzman and Nyland 1994, Ristau and Horsley 1999). Furthermore, Marks (1974) suggested that only the shade-tolerant species could survive in dense pin cherry. Our results confirmed that pin cherry had negative impacts on shade-intolerant species (e.g., black cherry), likely due to the early taller height of pin cherry (Ristau and Horsley 1999). Heitzman and Nyland (1994) also found fewer sugar maple stems at age 20 when pin cherry density exceeded 3 stems ≥3 ft tall per milacre at age 3. When these observations are coupled with other findings that diameter and volume development are slowed on plots with high initial pin cherry density (Ristau and Horsley 1999), our results suggest a benefit from early intervention to reduce pin cherry density early in emerging even-aged stands.

Preventing High-Density Pin Cherry

Pin cherry will only become a problem where there is a seed bank present in the forest floor. After a stand-replacing disturbance, such as clearcutting, the light levels and high nitrate levels from decaying organic matter trigger pin cherry germination (Marks 1974, Auchmoody 1979). In the absence of herbivory by white-tailed deer, the new seedlings grow rapidly and become dominant (Ristau and Horsley 1999, Horsley et al. 2003). These three primary factors (seed bank, disturbance, and deer) influence our recommendations for dealing with potentially negative pin cherry effects following clearcutting or heavy shelterwood method seed cutting. In the case of the seed bank, pin cherry produces seed for up to 40 years, and it remains viable in the forest floor for another 50–75 years. In stands where the overstory was disturbed more than 115 years ago, little viable seed will likely remain in the seed bank (Marquis 1975, Marks 1974, Auchmoody 1979, Peterson and Carson 1996). Lengthening the rotation age to a point beyond that of viable pin cherry seed has potential for prevention of pin cherry problems. If rotation ages cannot be lengthened (because of value loss, for example), then stimulation of the seed bank to cause germination of seed without providing adequate light for establishment could be used. Available evidence shows that pin cherry will not become a dominating member of the new cohort following shelterwood seed cutting to ≥60% relative density. Under these conditions, pin cherry seed germinates, but the seedlings do not survive because of the low light levels (Horsley and Marquis 1983). Fertilization of uncut stands with nitrate containing fertilizers provides another alternative to stimulate pin cherry germination. Auchmoody (1979) showed that 2 years after fertilization with nitrogen, as many as 270,000 pin cherry seedlings/ac germinated.

Pin cherry is heavily browsed by deer and does not become established under high deer pressure. Yet deer at high densities also browse on many desirable species and may affect regeneration success. Finding a deer density at which desirable regeneration can be spared while eliminating pin cherry would address the problem but may not be practical or even possible.

Recognizing a Pin Cherry Problem

After clearcutting of stands with a pin cherry seed bank and low deer impact, pin cherry will become dominant (Horsley et al. 2003), so it is important to follow up overstory removal with an assessment of regeneration success,

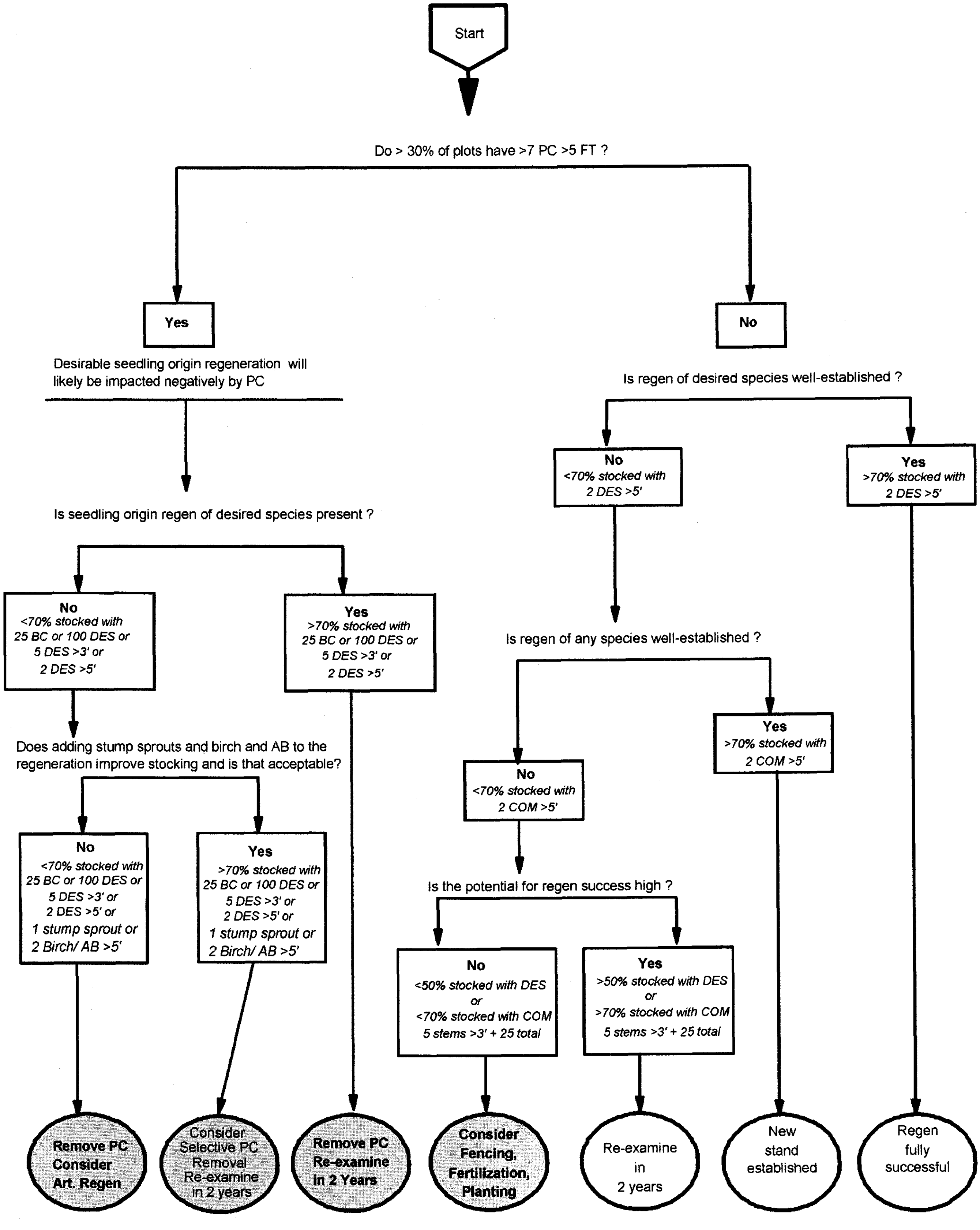

Figure 2. Flow chart for regeneration followup, including pin cherry thresholds using the Silviculture of Allegheny Hardwoods (SILVAH) system of stand inventory analysis and prescription. Shaded circles represent recommendations that require an investment. AB, American beech; BC, black cherry; COM, commercial; DES, desirable; FT, feet tall; PC, pin cherry.

using our findings to guide decisions about mitigating any potential problems. The SILVAH system recommends such a followup assessment. If done early in stand development, any pin cherry problem can be addressed in a timely fashion.

Figure 2 provides a regeneration followup assessment flow chart from SILVAH, modified to reflect our findings from this study. A checkmark tally of plots can be used to assess stocking with desirable regeneration and can also assess whether pin cherry densities are above problem levels. Determining the percentage of plots with either condition allows the chart in Figure 2 to be used. The chart suggests that if more than 30% of regeneration plots have more than seven PCG5A3, the stand will not likely become adequately stocked with desirable seedling-origin trees by age 15. Professional judgment must guide decisions about the risk of failure. Yet we believe that if more than 70% of the sampled plots are adequately stocked with regeneration (have 25 black cherry seedlings or 100 desirable stems, five desirable stems over 3 ft tall, or two stems over 5 ft tall) and also have at least seven PCG5A3, then a release treatment seems appropriate to consider. If desirable stocking is not adequate, then there are other things to consider, including artificial regeneration in the worst case.

These guidelines apply to Allegheny hardwood stands with a large component of black cherry. Our threshold level is in line with those from northern hardwood stands of New York, where three pin cherry stems $\geq$3 ft tall on a milacre (7.77 per 6-ft radius) had negative effects (Heitzman and Nyland 1994). Whether or not this threshold can be effectively used in areas outside of the Allegheny hardwood region requires further testing.

Dealing with High-Density Pin Cherry

Some well-documented treatments can be used to treat stands with a high density of pin cherry. Cleaning can remove pin cherry that interferes with desirable species. In Allegheny hardwoods, released crop trees have grown significantly faster than those without release (Ostrom and Hough 1944, Church 1955). Much information has been reported about effects of cleaning and related precommercial treatments (e.g., see Smith and Lamson 1986). However, this information is generally parochial in nature and short-term in duration (Heitzman and Nyland 1991), and more long-term research is needed. Costs of precommercial treatments can be effectively carried for up to 40 years, but only under certain combinations of stand and site (Miller 1986). Experience indicates that sprouting after mechanical cleaning is usually not a serious problem. Herbicide applied directly to the stems of pin cherry trees in place of mechanical removal may also be effective.

Use of broadcast herbicides such as glyphosate at a rate of 1.5 lbs active ingredient (ai)/ac (Jeffrey Kochel, International Paper Company, personal communication, 1999) to remove pin cherry is possible when height differentiation is such that pin cherry is taller than subordinate desirable seedlings but has not eliminated them. Use of backpack spray equipment or using large mist blowers with lower nozzles turned so that herbicide only makes contact with the larger pin cherry trees can eliminate the competition and allow subordinate desirable regeneration to grow.

High pin cherry density will reduce mean annual increment and height growth and increase rotation length (Heitzman and Nyland 1994, Heitzman and Nyland 1991, Ristau and Horsley 1999). Although the cost of a treatment often is high, that of no treatment may be higher in terms of long-term timber production and the resultant income that landowners would derive from well-stocked stands containing commercially desirable species.

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