RESPONSE OF PIN CHERRY TO FIRE, CANOPY DISTURBANCE, AND DEER HERBIVORY ON THE WESTVACO WILDLIFE AND ECOSYSTEM RESEARCH FOREST

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ABSTRACT.—We studied the impact of fire, canopy disturbance, and deer herbivory on the germination and development of pin cherry in four Appalachian hardwood stands located on the Westvaco Wildlife and Ecosystem Research Forest in Randolph County, West Virginia. Plots with simulated gaps and woven-wire fences were used to evaluate impacts of light and deer on regeneration. All four stands were burned in spring 1999. One month following prescribed fire, average initial pin cherry densities ranged from 23,500 seedlings ha^{-1} on plots that had gaps but no fences to 63,000 seedlings ha^{-1} on plots without either fences or gaps. By the end of the second growing season, seedling densities ranged from a low of 12,750 seedlings ha^{-1} in plots with gaps but no fences to 28,500 seedlings ha^{-1} on plots with gaps and fences. Maximum heights in fenced plots exceeded 2 m. We found that characteristic attributes of understory pin cherry communities in our study area are principally a function of deer herbivory.

Improved timber production in high-valued natural hardwood stands can be achieved by reducing the proportion of undesirable species that are present in stands, thereby assuring that all the stems in a stand are producing wood of high quality. Precommercial release and thinning operations are employed to eliminate or reduce these unwanted species from high quality stands (Church 1955). In some cases, stands can develop such heavy components of undesirable species that precommercial operations are forced to focus on eliminating the undesirables instead of selecting crop trees of exceptional grade. In northern and high-elevation regions of the Central Hardwood forest, pin cherry (*Prunus pensylvanica* L.f.) is an undesirable species for timber production, but it is one that can rapidly and aggressively acquire valuable canopy growing space in regenerating hardwood stands. Thus, control of the species is of interest to managers and landowners interested in maximizing timber revenues from forest properties.

Pin cherry has a complex life history. It is a pioneer species, highly intolerant of shade, and requires full sunlight for maximum growth (Wendel 1990). When open conditions are present, as they are in clearcuts, or following catastrophic wind damage, pin cherry grows faster than most species, even its congeneric black cherry (*Prunus serotina* Ehrh; Ristau and Horsley 1999). Hence, pin cherry has the ability to be the first species to position its crowns in the main canopy. Aiding in this rapid acquisition of canopy growing space is pin cherry's capacity to sucker from roots. We have observed suckers to grow 3 to 5 feet in the first season and occupy over 200 m^2 per clone following severance of the parent stem.

In addition to the capacity to sucker and dominate large areas in colonies, pin cherry begins flowering at very early ages. Seeds can persist in a dormant seed bank for 50 to 75 years (Marquis 1975, Wendel 1990) in various states of dormancy (Tierney and Fahey 1998). Following intense canopy disturbance or fires, tens of thousands of seeds per hectare germinate (Marquis 1975, Graber and Thompson 1978, Wendel 1987, McGill and others 1999). Further, Auchmoody (1979) found that nitrate

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nitrogen can stimulate the germination of these dormant seeds and proposed that repeated fertilizer applications might eventually deplete the persistent seed bank.

The purpose of this study is to examine the effects of multiple disturbances on fire cherry germination and development on the Westvaco Wildlife and Ecosystem Research Forest with the intent to learn more about factors that could lead to better pin cherry control strategies. In this paper our primary objective is to characterize patterns of pin cherry seed germination and seedling development under the effects of disturbance in the form of fire, canopy mortality, and deer herbivory.

METHODS

We monitored pin cherry germination and development over two growing seasons on plots established by Collins and Carson (1997) on the Westvaco Wildlife and Ecosystem Research Forest in Randolph County, West Virginia. The Westvaco Research Forest falls within the Allegheny Mountains Section of the Central Appalachian Broadleaf Forest (McNab and Avers 1994) and the vegetation therein is classified as mixed-mesophytic (Braun 1950). Dominant overstory species often include sugar maple (*Acer saccharum* Marsh.), basswood (*Tilia americana* L.), yellow-poplar (*Liriodendron tulipifera* L.), red maple (*A. rubrum* L.), and northern red oak (*Quercus rubra* L.). Red oak site indices 50 average about 70-75 on mesic sites.

Specifically, the experimental plots we used were a subset of a larger study directed at assessing factors affecting oak regeneration in central Appalachian hardwood stands (Collins and Carson 1997). This study has as a main factor “burning”, hence, each of the four stands has a burned half and an unburned half. The subset that we used to monitor pin cherry comprised the half of each stand that was subjected to prescribed fire. Fires were applied to two stands on 1999 April 30 and two stands on 1999 May 4. Further discussion of this study applies only to the work and measurements in these burned stands.

Measurements

In 1998, prior to the application of prescribed fire, four experimental 20 m X 20 m (400 m^2) plots in each of two blocks per stand were laid out for a total of 32 plots. Four treatments were applied to these plots:

1) Fenced and simulated gap (F×G),
2) Fenced and no gap (F×NG),
3) No fence and simulated gap (NF×G), and
4) No fence and no gap (NF×NG).

The simulated gaps were created in the spring of 1998 by a combination of double girdling with a chainsaw and tree injection using herbicide (glyphosate) on trees with diameters at breast height (dbh) greater than 10 cm. Gaps were designed to be roughly 18 m in diameter, or 250 m^2. Injected trees were located in the center of each plot. Average basal area in these stands was about 29 m^2 ha^{-1} with gaps reduced to about 9 m^2 ha^{-1}. Deer proof fences were erected around 16 plots, two in each block, immediately following the girdling and herbicide treatments. Fences are 2 m tall and constructed with woven-wire fencing reinforced with rebar and metal posts.

In each of the thirty-two, 400 m^2 main treatment plots are five internal, and randomly placed 1 m^2 plots designed to subsample seedling regeneration. On these plots, we measured the heights and age of pin cherry seedlings that germinated as a result of the spring 1999 fires. In this paper, we report our observations from four dates in the 1999 growing season and three dates in the 2000 growing season.

Numerical Analyses

Graphical analysis and analysis of variance were used to characterize the patterns of and factors affecting pin cherry germination and development. We used a blocked, two factor factorial model with interaction to assess differences in pin cherry parameters of interest. Our two main factors (both binary) are 1) fence and 2) gap, and are randomized within two blocks nested in each of four stands. We carried out our statistical tests using SAS (SAS Institute, Cary, NC). F-tests resulting in p-values less than 0.10 were deemed statistically significant. Spreadsheets were used for graphical analyses.

Response parameters of interest included the number of seedlings ha^{-1}, mean seedling height, sum of seedling heights, and average maximum seedling height. These parameters are used in different applications to characterize populations of extremely diverse regenerating natural hardwood communities. For example, the sum of heights is a commonly used measure that combines the number of seedlings with height in order to quantify hardwood competition in plantation studies; we found it to be useful in this study as well. We compared these attributes of young pin cherry populations at critical points over the two growing seasons that we monitored for this study. These critical points include the end of the first growing season (October 1999), the beginning of the second season (June 2000), and the end of the summer of the second growing season (August 2000).

RESULTS AND DISCUSSION

Pin cherry germination in the understories of our four research stands was evident only a few weeks following the prescribed fires in the spring of 1999. At the June 1999 measurement, average pin cherry germination densities were between 23,500 seedlings ha^{-1} (NF×G treatment) and 63,000 seedlings ha^{-1} (NF×NG treatment) with the overall average density equal to about 44,000 seedlings ha^{-1} (fig. 1). The maximum density observed in the NF×NG treatment, however, plummeted rapidly throughout the first growing season, ending the season with fewer seedlings (9,750 seedlings ha^{-1}) than all but the NF×G treatment.

Both fenced treatments maintained the most stable pin cherry seedling densities throughout the first growing season. The F×G treatment density averaged 55,250 seedlings ha^{-1} at the first measurement (June 1999) and decreased to 43,750 seedlings ha^{-1} by October 1999. Even considering the reduction, this treatment had the highest number of seedlings by season's end (fig. 1). The F×NG treatment finished the season ranking second highest in pin cherry seedling density despite the lack of a canopy gap to provide light and support vigorous growth of this highly intolerant species.

Seedling mortality during the first growing season is evident in the steep decline in the density levels for the unfenced treatments (fig. 1). Without fences to protect the young seedlings, most were browsed and we observed many that had been pulled up by the roots, likely dropped from herbivores' mouths as they browsed on the sparse, post-fire understory vegetation.

Pin cherry performance following germination has been exceptional on the F×G treatment plots. Figures 2 through 4 show the development of pin cherry seedlings using variables that characterize size development of this regeneration component; the F×G treatments clearly led the way in size development. Mean height of pin cherries (fig. 2) serves to show that F×G treatments had taller seedlings than other treatments through the 2 years, but the attribute does not well characterize the condition we

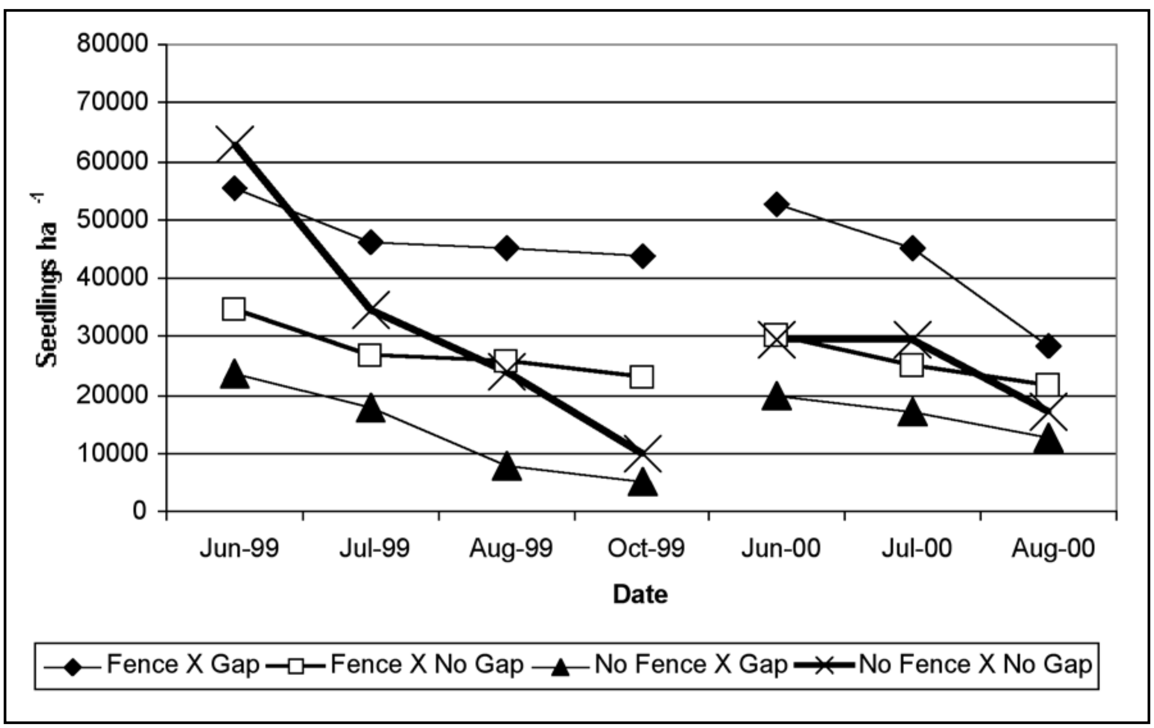

Figure 1.—*Understory pin cherry seedlings per hectare over two growing seasons on burned treatment plots. For each treatment there are eight observations, one per 400 m^2 treatment plot. Treatment plots are located in four stands on the Westvaco Research Forest in Randolph County, West Virginia.*

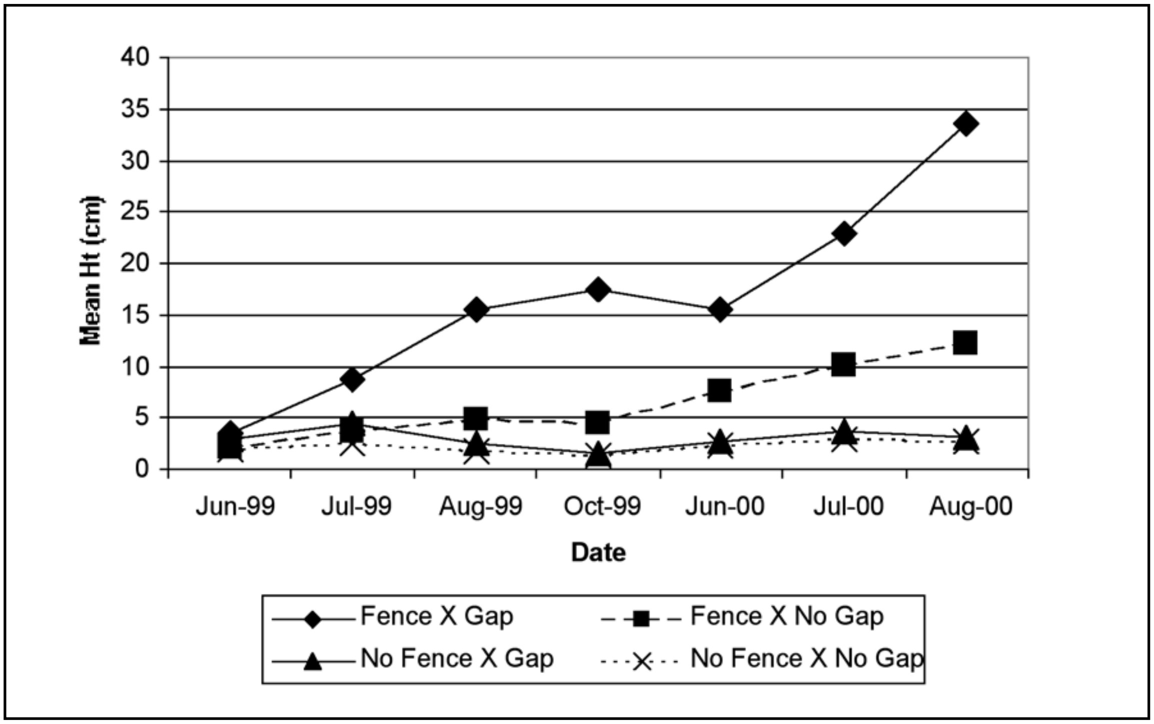

Figure 2.—*Mean height of understory pin cherry seedlings over two growing seasons on burned treatment plots. For each treatment, mean height is an average from eight 400 m^2 treatment plots.Treatment plots are located in four stands on the Westvaco Research Forest in Randolph County, West Virginia.*

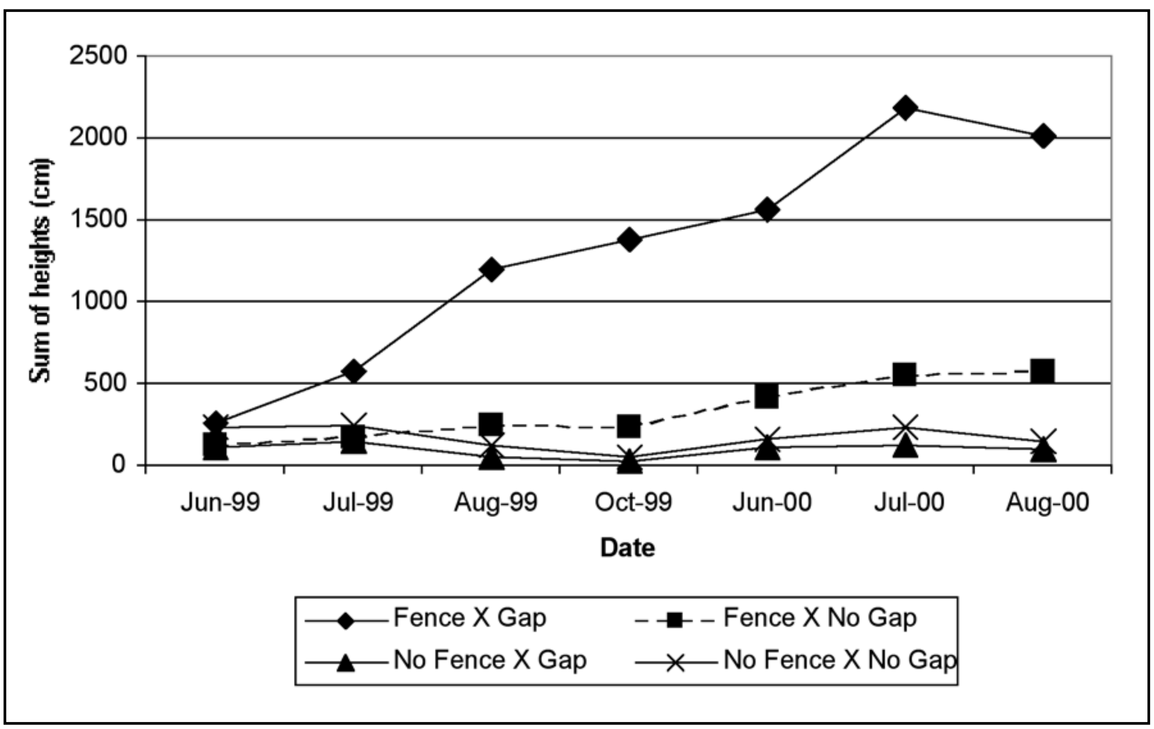

Figure 3.—*Mean sum of heights of understory pin cherry seedlings over two growing seasons on burned treatment plots. For each treatment there are eight observations, one per 400 m^2 treatment plot. Treatment plots are located in four stands on the Westvaco Research Forest in Randolph County, West Virginia.*

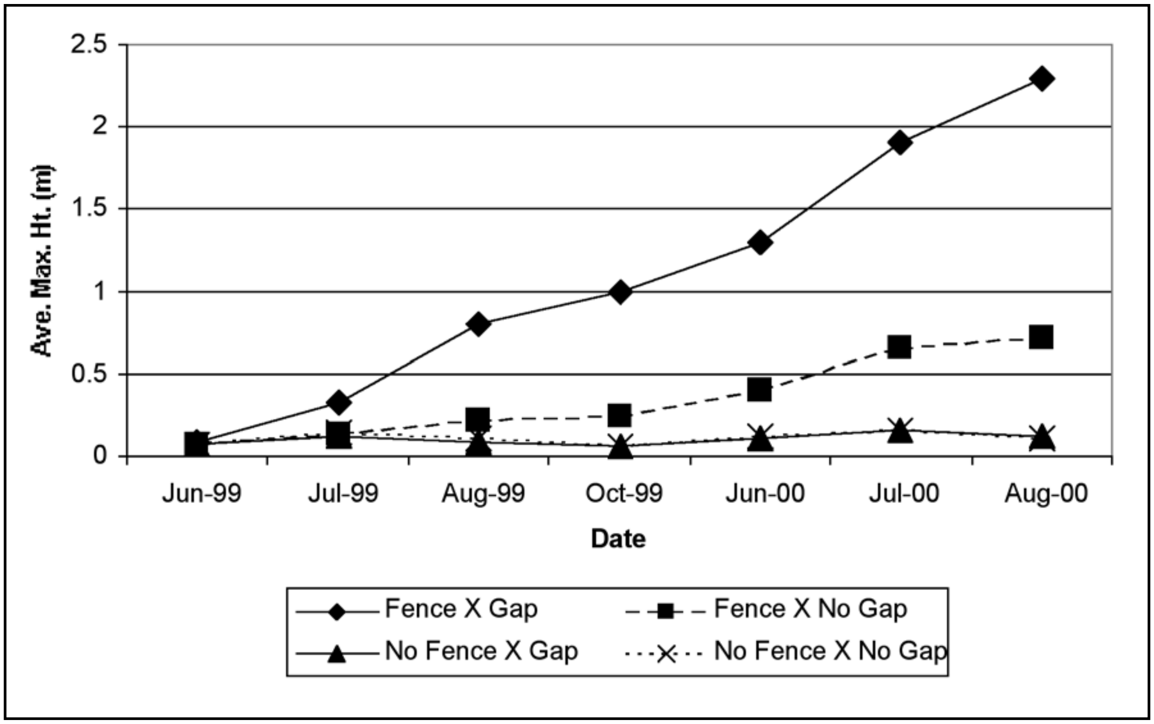

Figure 4.—*Mean maximum height of understory pin cherry seedlings over two growing seasons on burned treatment plots. For each treatment there are eight observations, one per 400 m^2 treatment plot. Treatment plots are located in four stands on the Westvaco Research Forest in Randolph County, West Virginia*.

found on these plots. The sum of the heights better exemplifies the abundance with the average summed heights exceeding 20 m at the end of the second growing season (fig. 3). At this time, the average maximum height of the pin cherry seedlings was well over 2 m in the F×G treatment plots (fig. 4). The F×NG treatment lagged at a distant second in this parameter, averaging 72 cm.

In spite of the seemingly clear pattern of development in our observed understory pin cherry densities and size attributes over the two growing seasons, we found an enormous amount of variation in pin cherry seedling density among the four study stands. Stands accounted for a significant amount of the variation in pin cherry seedling variables. Statistically, apart from the differences in pin cherry germination and development seen among stands, fencing explained significant variation in four variables for measurements made at the end of the first growing season (table 1). Fencing was a significant factor at the beginning and end of the second growing season only for mean height and average maximum height. In all cases where fencing resulted in significant hypothesis tests, fenced plots exceeded unfenced plots in pin cherry population density and size attributes.

At the beginning of the second growing season, we counted the number of new seedlings that emerged. Pin cherry exhibits epigeal germination with its cotyledons displayed above the soil surface. This feature is not only a distinguishing factor to separate pin from black cherry, but it is also evidence that a small seedling is a new germinant. Unfortunately, the presence of cotyledons is ephemeral, and they either wither and abscise rapidly, or are browsed. Consequently, distinction between 1- and 2-year-old seedlings in the second year became more uncertain in the second and third remeasurement occasions.

Figures 5 and 6 show the approximate proportions of new germinants in the second growing season. Again, without tags for individual seedlings it is impossible to say the exact number of new germinants in the latter two measurements of the second growing season. However, percentage of new germinants ranged from 35 percent (F×G treatment) to 67 percent (NF×G treatment) of the total seedlings at the June 2000 measurement. The F×G treatment did have the lowest percentage of new seedlings, but this represented an average of 18,500 new seedlings ha^{-1}.

Table 1.—Probability values (p-values) for testing factors affecting pin cherry germination and establishment in burned stands on the Westvaco Research Forest in Randolph County, WV. Response variables include number of seedlings ha^{-1}, mean height, sum of heights, and average maximum height for all pin cherry seedlings recorded at the three listed measurement dates. Measurement dates correspond to the end of the first growing season, the initial measurement of the second growing season, and the late summer measurement of the second growing season.

Source of Variation	October 1999	June 2000	August 2000
	Seedlings ha^{-1}		
Stand	0.048	0.012	0.010
Block(Stand)	0.159	0.218	0.384
Fence	0.035	0.252	0.288
Gap	0.487	0.661	0.884
Fence X Gap	0.284	0.280	0.551
	Mean height (cm)		
Stand	0.011	0.003	0.009
Block(Stand)	0.846	0.767	0.856
Fence	0.014	0.024	0.026
Gap	0.077	0.188	0.239
Fence X Gap	0.090	0.218	0.260
	Sum of heights (cm)		
Stand	0.176	0.069	0.066
Block(Stand)	0.396	0.390	0.608
Fence	0.097	0.102	0.122
Gap	0.213	0.283	0.356
Fence X Gap	0.198	0.241	0.317
	Average max. height (m)		
Stand	0.016	0.006	0.011
Block(Stand)	0.686	0.643	0.822
Fence	0.021	0.030	0.026
Gap	0.110	0.202	0.250
Fence X Gap	0.131	0.250	0.270

The appearance of pin cherry in understories following fire, points to germination mechanisms similar to those found in certain California chaparral species by Keely and Frotheringham (1997). They suggest that oxides of nitrogen like those generated in wildfires initiate seed germination of a number of chaparral species; this is suggestive of a timing mechanism to key germination to correspond with an open canopy (eliminated through fire). The researchers go on to suggest that similar compounds emitted by automobiles and other polluting agents, may have an unseen negative impact on the semiarid chaparral ecosystems of the western United States. Untimely germination of succulent seedlings in otherwise dry stands of chaparral may lead to the demise of these individuals.

Likewise, fires that burn under intact canopies will stimulate dormant pin cherry seeds to germinate (McGill and others 1999). In the presence of high deer populations, germinating pin cherry seedlings will likely succumb to browsing and eventual mortality. Hence, under management scenarios where pin cherry is a problematic species, a light prescribed fire or fires that stimulate pin cherry germination beneath these intact canopies may bring about a depletion or at least a reduction in both the pin cherry seedbank and in future pin cherry densities. Prescriptions using similar methods should consider the potentially harmful impact of fire on high valued crop trees. Finally, attention to pulpwood products should also be considered since carbon can be detrimental in certain manufacturing processes like papermaking.

CONCLUSIONS

1) Deer herbivory was the key factor in reducing pin cherry densities and hampering development of seedlings over two growing seasons.
2) Germination of new pin cherry seedlings will occur in stands for at least 2 years following a spring prescribed fire. Management prescriptions targeting depletion of pin cherry in stands of high-valued species should heed this fact and wait at least 2 to 3 years following a fire before applying regeneration methods.
3) Pin cherry seedlings, protected by fences, continued to develop and were nearly beyond the range of deer browsing near the end of the second growing season. Hence, in stands where fires result in conditions similar to those conducted in this study and have low deer populations, understory pin cherry is likely to reach the stage of development where seed production begins (age 2 to 4).
4) Without protection from deer herbivory, pin cherry seedbanks that germinate under intact or mostly intact canopies will likely succumb due to both high shade and deer browsing. This conclusion suggests the possibility for prescriptions that call for low intensity prescribed fires to deplete pin cherry seedbanks prior to stand regeneration.

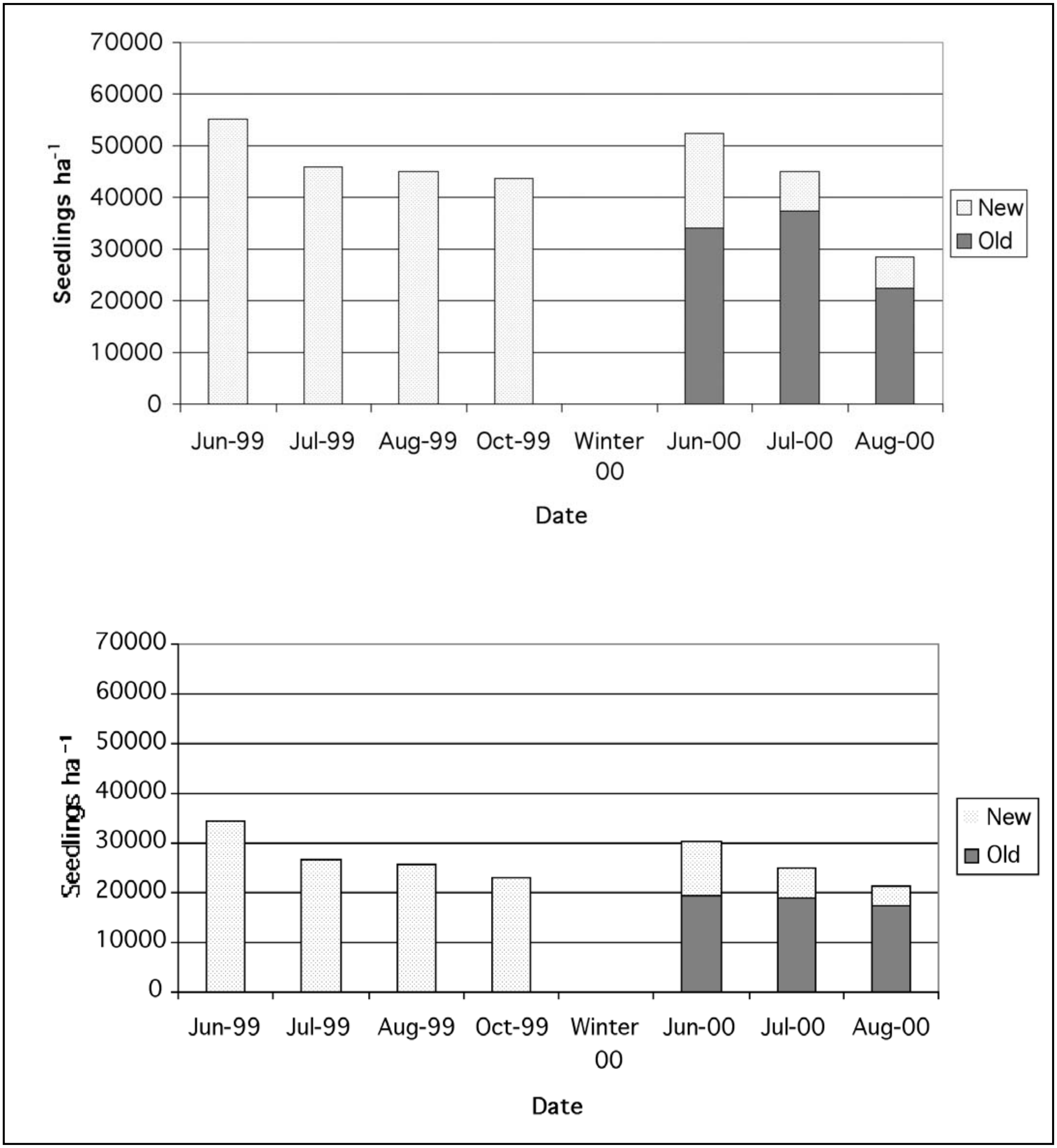

Figure 5.—*Number of pin cherry seedlings by age over two growing seasons on F×G and F×NG treatment plots. "New" seedlings are germinants from the growing season in which the measurement took place. "Old" seedlings germinated in during the first growing season. For each treatment, "seedlings per hectare" is an average of eight 400 m^2 treatment plots. Treatment plots are located in four stands on the Westvaco Research Forest in Randolph County, West Virginia.*

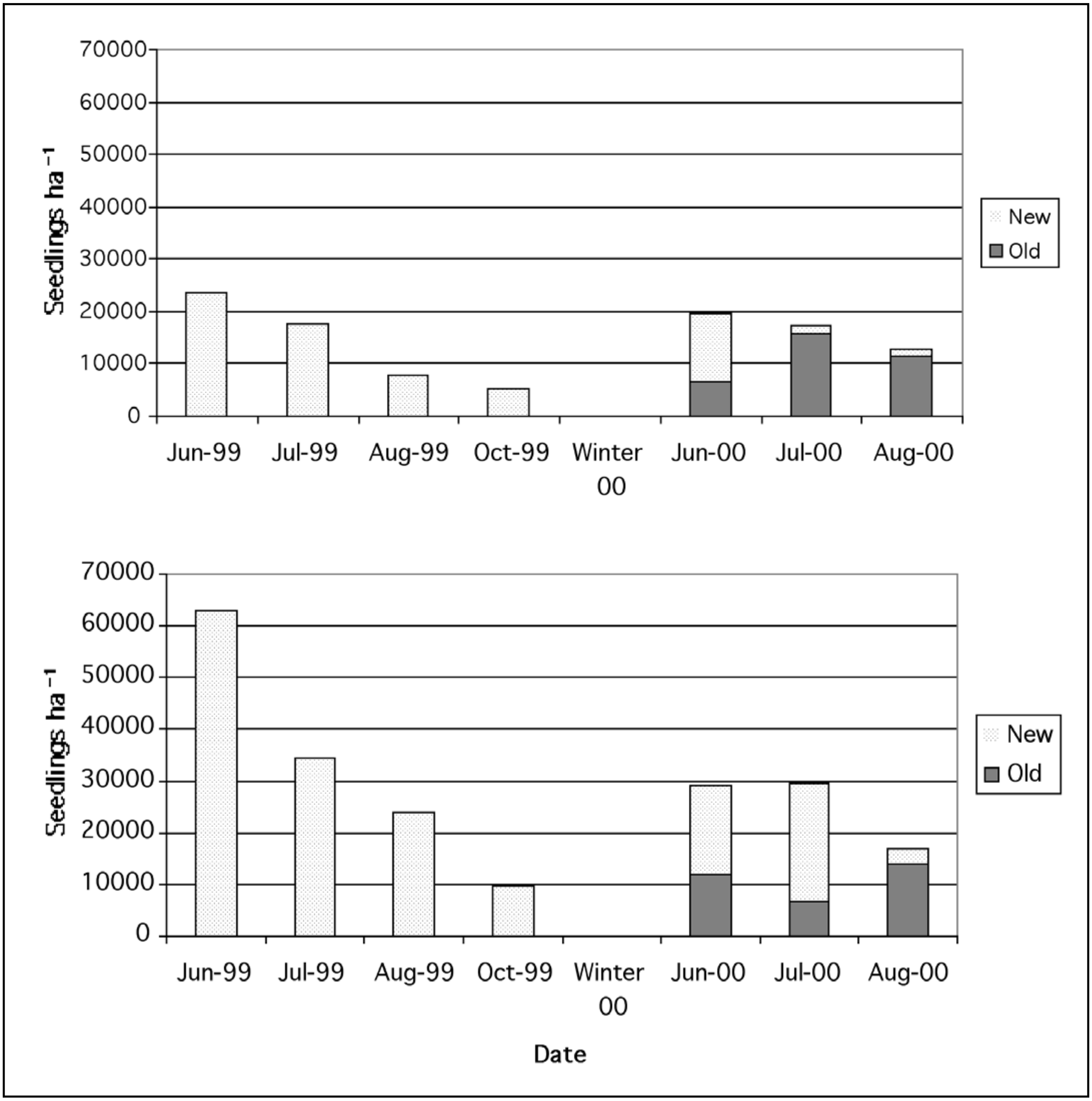

Figure 6.—Number of pin cherry seedlings by age over two growing seasons on NF×G and NF×NG treatment plots. "New" seedlings are germinants from the growing season in which the measurement took place. "Old" seedlings germinated in during the first growing season. For each treatment, "seedlings per hectare" is an average of eight 400 m² treatment plots. Treatment plots are located in four stands on the Westvaco Research Forest in Randolph County, West Virginia.

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