Short-Term Effect of Three Mechanical Site Preparation Methods on Species Diversity

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Three mechanical site preparation methods were compared for their effects on species diversity, as measured by Shannon's index of diversity. Diversity of frequency and of density both increased as the intensity of site preparation increased. A high-intensity site preparation resulted in the occurrence of more herbaceous species than were observed with low-intensity site preparation. The results obtained are discussed in relation to the control of competing vegetation during the establishment phase of planted tree seedlings. Tree Planters' Notes 41(4):39-42; 1990.

Clearcutting alters both biotic and abiotic ecosystem characteristics to varying extents. In most instances, one objective of clearcutting is to establish a seral (that is, successional) tree species as the next crop. Thus, it becomes desirable to create biotic and abiotic conditions favoring the establishment and growth of that species. This requires the creation of appropriate microclimatic conditions, minimal invasion of competing species, and optimal conditions of the soil on the forest floor. Clearcutting may achieve, at least partially, the first two conditions, whereas mechanical site preparation may achieve the second and third. In many instances, site preparation is required to partially control competing species (8) and obtain adequate survival of conifer stock (10). Walstad and others (18) recently reviewed the principal advantages and disadvantages of different site preparation methods. However, there are very few published reports on the short-term and long-term effects of site preparation on plant species richness (that is, the abundance of each species) and diversity (the number of species), notably for eastern North America.

In some ecological systems, logging operations and site preparation often increase species richness and diversity (1, 16). A direct consequence of such increases are that crop species (in many instances, planted tree seedlings) will need to compete against invading and opportunistic species. Therefore adequate mechanical site preparation should help ensure minimal invasion by species that compete with the seral tree species forming the next crop.

The objective of this study was to compare the effect of three intensities of mechanical site preparation on species richness and diversity in a clearcut site in eastern Quebec.

Materials and Methods

The experimental site, 4.5 ha in size, is located in eastern Quebec; it is characterized by flat terrain and a clay-loam soil (pH 4.1; organic matter 4.3%, sand 36%, silt 33%, and clay 31 %). The site was clearcut in 1985 and divided into three experimental blocks. The first block was prepared with V-blade, which formed bands of exposed mineral soil of about 3 m between piles of woody debris (high-intensity site preparation, SP1). The second block was prepared with a toothed brush rake (minimal or no exposition of the mineral soil), which formed areas about 40 m wide between piles of woody debris (medium-intensity preparation, SP2). The third block was prepared by disking (low-intensity site preparation, SP3). These site preparation operations took place in August and September 1987.

The vegetation was surveyed in August 1988. A total of forty 1-m^2 plots were randomly selected in each of the three blocks. In one plot, the trees, shrubs, grasses, and ferns were recorded by species. The average number of individual species per square meter was taken as a measure of species density. The proportion of plots on which the species occurred at least once was taken as a measure of the frequency of that species *(2).*

Characterization of the composition of a plant community is usually described by assessments of species richness and diversity *(12).* The variations in species composition induced by various site

Table 1—*Plant species density and frequency after high-intensity (SP1), medium-intensity (SP2), and low-intensity (SP3) site preparation in balsam fir–spruce forests of eastern Quebec (forty 1-m² plots per site preparation)*

	V-blade (SP1)		Brush-rake (SP2)		Disk (SP3)	
Species	Density (sp/m²)	Frequency (%)	Density (sp/m²)	Frequency (%)	Density (sp/m²)	Frequency (%)
Trees and Shrubs						
Red maple (*Acer rubrum* L.)	—	—	0.03	2.5	—	—
Sugar maple (*A. saccharum* Marsh)	0.03	2.5	—	—	—	—
Mountain maple (*A. spicatum* Lam.)	0.2	10.0	—	—	—	—
Speckled alder (*Alnus rugosa* [Du Roi] Spreng.)	—	—	0.2	5.0	—	—
Paper birch (*Betula papyrifera* Marsh.)	0.3	2.5	—	—	—	—
Pin cherry (*Prunus pensylvanica* L.)	—	—	—	—	0.1	7.5
Red raspberry (*Rubus idaeus* L.)	7.4	60.0	16.2	92.5	33.9	100.0
Willows (*Salix spp.*)	0.1	10.0	—	—	—	—
Scarlet elder (*Sambucus pubens* Michx.)	0.2	12.5	0.1	2.5	0.03	2.5
Forbs						
Actaea sp.	—	—	0.1	2.5	—	—
Anaphalis margaritacea (L.) Benth.	0.2	5.0	—	—	—	—
Aralia nudicaulis L.	0.8	22.5	0.2	7.5	0.2	2.5
Cornus canadensis L.	3.2	22.5	0.3	7.5	1.0	22.5
Epilobium angustifolium	9.6	77.5	7.4	82.5	1.3	30.0
Epilobium spp.	7.6	40.0	13.9	65.0	0.03	2.5
Hieracium sp.	0.6	5.0	0.2	15.0	—	—
Impatiens capensis	0.1	10.0	—	—	—	—
Maienthemum canadense	0.6	10.0	—	—	—	—
Nemopanthus mucronatus	0.1	2.5	—	—	—	—
Prenanthes spp.	0.3	10.0	—	—	—	—
Grasses	6.3	70.0	0.8	22.5	0.6	7.5
Ferns						
Osmunda cinnamoma L.	0.03	2.5	—	—	0.1	5.0
All plants	37.7	375.0	39.43	305.0	37.29	180.0
No. of species	18	—	11	—	9	—
Diversity	1.93	2.35	1.28	1.75	0.44	1.43
Standard deviation of H′	0.13	0.10	0.15	0.13	0.04	0.11

$(H' = -\sum_j p_j \log p)$

preparation methods, therefore, may be assessed using these statistics (16). Pielou (12) pointed out that indexes of diversity are applicable to various measures of abundance, such as numbers of individuals and frequency. The most widely applied measure of species diversity-for example, that used by Conde et al. (3)-is that of Shannon (14), namely, the negative sum over all species of the product of the proportion, p_j, of the j^{th} species and the logarithm of p_j, that is:

$$H' = - \sum_j P_j \log p_j$$

This index gives a measure of diversity of density and a measure of frequency diversity for each treatment applied.

Results and Discussion

Shannon's measures of diversity of density and frequency diversity both increased with the intensity of soil-site preparation (table 1). Frequency diversity was 1.43 for the site prepared by disking (low intensity) and reached 2.35 for the site prepared with a V-blade (high intensity). There were 34.03 individual tree and shrub species per square meter on block SP3, as compared to 8.23 on block SPI. Inversely, there were 2.53 and 23.1 individual herbaceous species per square meter on block SP3 and SP1, respectively (table 1).

This is in accordance with previous reports, which indicated that soil site preparation creates modifications that stimulate germination of buried seeds (9, 13, 18, 19). The increase in diversity observed could be attributed mainly to the occurrence of a higher number of herbaceous species on the SP2 and SP1 blocks. Tree and shrub species, on the other hand, formed the principal species on block SP3. This agrees with Oliver (11), who found that the intensity of disturbances determined species composition through its relationship to the reproductive strategy of the various species. The results obtained in this study confirmed those previously reported by Burger and Pritchett (1). They found that woody vegetation made up the largest proportion of the total biomass on the chopped plots (low-intensity site preparation), followed by grass and forbs. Inversely, intensively prepared sites restricted the occurrence of woody vegetation (1).

If residual vegetation capable of sprouting is not uprooted (low-intensity site preparation), it will quickly reoccupy the site. On the other hand, if the site is extensively scarified, an ideal seedbed is created for a host of invading herbaceous species. Site preparation by disking seems to disturb the forest floor soil conditions to such an extent that seral tree species recover more rapidly. The two other site preparation techniques used in this experiment appeared to favor the establishment of early successional species. When required, control of competing vegetation is generally made during the first few years after site preparation and plantation, to ensure maximum tree seedling survival and growth. The choice of a vegetation control treatment, if required, is obviously determined by the composition of the plant community. So, an appropriate choice of site preparation treatment could greatly influence the following:

1. The need of future vegetation control treatment during the establishment phase of the plantation.
2. The choice of a treatment (mechanical, chemical, or manual) to control competing species, notably in regard to new treatment strategies now under study (4, 5, 7).
3. The export of nutrients, especially NO_3-N, from the site (6, 17).

From the results obtained in this study, it is evident that intensive disturbance of the forest-floor soil conditions in eastern Quebec can modify biotic and abiotic conditions, which in turn favor the establishment of early transitional species. The choice of the intensity of a site preparation treatment should take into account variations expected in a plant community as part of a management strategy for tree plantations.

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