United States
Department of
Agriculture

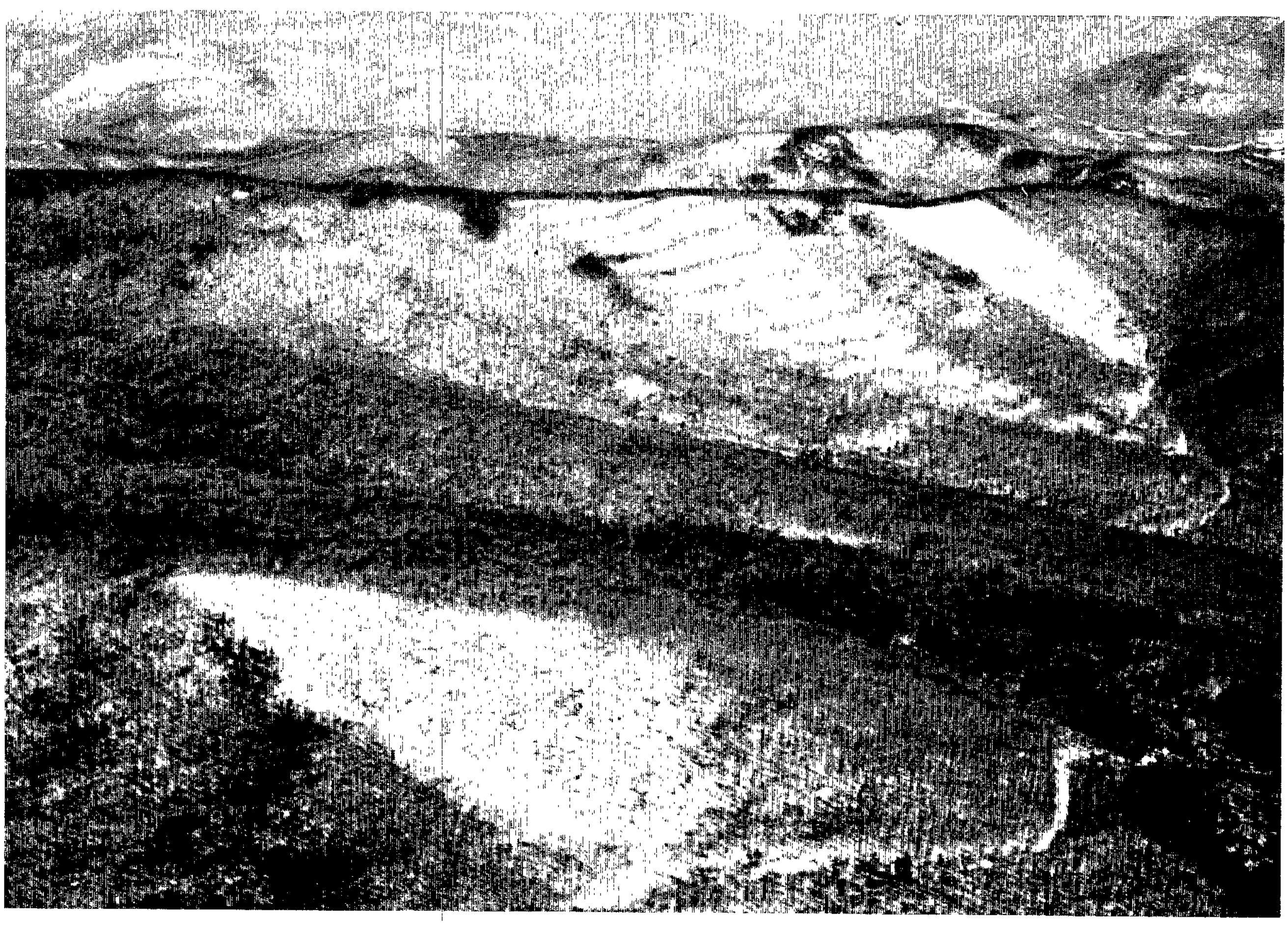
Forest Service

**Northeastern Forest
Experiment Station**

Research Paper NE-625

Revegetation After Strip Cutting and Block Clearcutting in Northern Hardwoods: A 10-Year History

C. Wayne Martin
James W. Hornbeck



Abstract

Revegetation was studied during the first 10 years after clearcutting two sites in the northern hardwood forest of New Hampshire. One site was a 12-ha block clearcut; the other was a 36-ha progressive strip cut harvested in three phases. Permanent plots on each site were measured at 1-to 4-year intervals. Changes in the density and biomass of trees, shrubs, and herbs are presented with emphasis on the major commercial species and their primary noncommercial competitors.

The Authors

C. WAYNE MARTIN is a research forester with the Northeastern Forest Experiment Station at the Hubbard Brook Experimental Forest, Campton, New Hampshire.

JAMES W. HORNBECK is a research forester with the Northeastern Forest Experiment Station, Durham, New Hampshire.

Manuscript received for publication 9 February 1989.

Acknowledgment

Vincent Levasseur, forest technician at the Hubbard Brook Experimental Forest, maintained the permanent inventory plots and played a vital role in collecting the data. Susan Karsten assisted with data collection, and Pat Downer and Robert Smith assisted with data analysis.

COVER PHOTO. — Southwest-to-northeast view, showing block clearcut in the foreground. The strip cut and an earlier deforestation cutting are in the upper right.

Northeastern Forest Experiment Station
370 Reed Road, Broomall, PA 19008
August 1989

Introduction

This is a report on the dynamics of the revegetation of a block clearcut and a progressive stripcut in the northern hardwood type at the Hubbard Brook Experimental Forest within the White Mountain National Forest of central New Hampshire. We present the rate of revegetation in terms of density and biomass accumulation, proportion of density and biomass in the floristic groups of herbs, shrubs, and trees, and the dynamics of individual tree species for 10 years after cutting.

Northern hardwoods are one of the major forest cover types in the northeastern United States, covering more than 6 million ha (Filip and Leak 1973, Kingsley 1985, Leak and others 1969). The important timber species and principal components of this forest type are sugar maple (*Acer saccharum* Marsh.), beech (*Fagus grandifolia* Ehrh.), and yellow birch (*Betula alleghaniensis* Britton). Other important but less common timber species include red maple (*Acer rubrum* L.), paper birch (*Betula papyrifera* Marsh.), white ash (*Fraxinus americana* L.), hemlock (*Tsuga canadensis* (L.) Carr.), balsam fir (*Abies balsamea* (L.) Mill.), and red spruce (*Picea rubens* Sarg.) (Bormann and Likens 1979, Leak and others 1969). Associated noncommercial and early successional tree species include pin cherry (*Prunus pensylvanica* L.), striped maple (*Acer pensylvanicum* L.), and mountain maple (*Acer spicatum* Lam.) (Bormann and Likens 1979, Marks 1974).

Forest management and harvesting practices of the first half of the 20th century favored the shade-tolerant sugar maple and beech to the exclusion of the currently valuable yellow birch. By 1969, a shortage of yellow birch for lumber and veneer and a shortage of young birch stands for future supplies were predicted (Cliff 1969, Marquis 1969). Research by the Northeastern Forest Experiment Station at the Bartlett Experimental Forest, within the White Mountain National Forest in northern New Hampshire, indicated that on small patch cuts 3 years after cutting, regeneration of merchantable species, especially yellow birch, was best on disturbed sites, such as skid roads, and poorest on undisturbed humus (Marquis 1965).

Further work at Bartlett indicated that the temperature and moisture conditions of the surface soil greatly affected seed germination and seedling establishment of yellow birch (Marquis 1969). Marquis (1969) found that surface soil moisture remained substantially higher and surface soil temperatures substantially lower on exposed mineral soil than on humus or litter. Both of these conditions favored yellow birch germination and establishment. However, he also found that once established, yellow birch grew much better on humus than on mineral soil because of nutrient deficiencies of mineral soils. Marquis (1969) also found that birches were more productive when grown in full sunlight rather than in shade because of better root growth. Adequate seed supply is also essential to regeneration, and Marquis (1969) reported that only 15 percent as many yellow birch seeds were found two tree heights from the source as directly under it.

On the basis of these results, progressive strip cutting evolved from block clearcutting in an attempt to further favor regeneration of birches by more closely controlling variables such as distance to seed sources, light, moisture, and scarification of the seed bed. The strip cutting involved cutting strips oriented east to west approximately 25 m wide with 50-m-wide uncut strips between each of them. After a 2-year period for establishment of regeneration, a second series of 25-m-wide strips was cut to the south of each of the original cuts. The final series of 25-m-wide strips was then cut after a second establishment period of 2 years. As in block clearcutting, all merchantable stems were removed and scarification encouraged by confining skidding to cut strips, with appropriate measures to avoid erosion (Filip 1969, Marquis 1969, Safford 1983).

After the first strip cutting, the strip received shade from the trees on its southerly border, providing favorable conditions for germinaton and early survival. When the second strip was cut, it received shade for initial establishment, but also allowed the first strip to receive direct sunlight. Both the first and second strips thus received shade for seedling establishment and then direct sunlight for best growth. During these harvests, seed sources were nearby in the uncut strips. When the third strip was cut, it received only minimal shade, and seed sources were more distant except for buried seeds. However, birch and maple seedlings that survived the 1st year or two of direct sunlight then had optimal growing conditions in terms of light and moisture.

The strip cutting obviously required more effort and expense than clearcutting of a single block. A major reason for our study was to determine whether strip cutting results in more desirable species composition and stand development than does block clearcutting.

Study Area

The study was conducted at the Hubbard Brook Experimental Forest within the White Mountain National Forest in central New Hampshire. Two small watersheds were used for this study. The block clearcut (cover photo, foreground) is 12 ha and ranges in elevation from 470 m to 595 m. The strip cut (background) is 36 ha ranges from 440 m to 730 m in elevation. Both watersheds have southerly aspects and slopes of 20 to 30 percent. Red spruce is thought to have been first cut on the experimental forest in 1909. Heavier logging for additional species occurred in 1917 (Bormann and Likens 1979). The forest, at the beginning of our study in 1970, contained trees rising from natural regeneration after the initial harvests, plus a few older trees not taken during the early cuttings. This 55- to 60-year-old forest was described in detail by Bormann and others (1970), Siccama and others (1970), and Whittaker and others (1974).

Soils on the study watersheds were derived from coarse-textured, glacial till that has been subjected to frost action, erosion, and deposition since glacial retreat about 14,000 years ago. Till depths range from 0 m to 5 m. The surficial layers have weathered to form fine sandy loams classed as Lithic and Typic Haplorthods. Soil profiles are often mixed due to tree blowdown, but usual development includes O, E, Bhs, Bs, and C horizons (Soil Survey Staff 1988) that differ markedly in physical and chemical properties. The more common soil series include Marlow, Lyman, Peru, Hermon, and Monadnock. Much of the soil is underlain by dense basal till nearly impermeable to roots and water.

Methods

In preparation for harvest, the strip cut was surveyed into 49 strips, each 25 m wide. The strips were oriented from east to west roughly parallel to the watershed contour. The first series of strips (first strips) was harvested from September 28 to October 29, 1970, the second series (second strips) from September 7 to October 1, 1972, and the third series (third strips) from October 1 to November 1, 1974 (Fig. 1). The third series contained one additional strip to complete the cutting of the entire watershed. The block clearcut was harvested from October 30 to November 28, 1970. In Figures 2 and 3, the 1st year before cutting refers to the growing season immediately prior to cutting; the 1st year after cutting refers to the growing season immediately after cutting.

On both the strip cut and block clearcut, all trees and snags >2.5 cm d.b.h. were felled. Commercial portions of

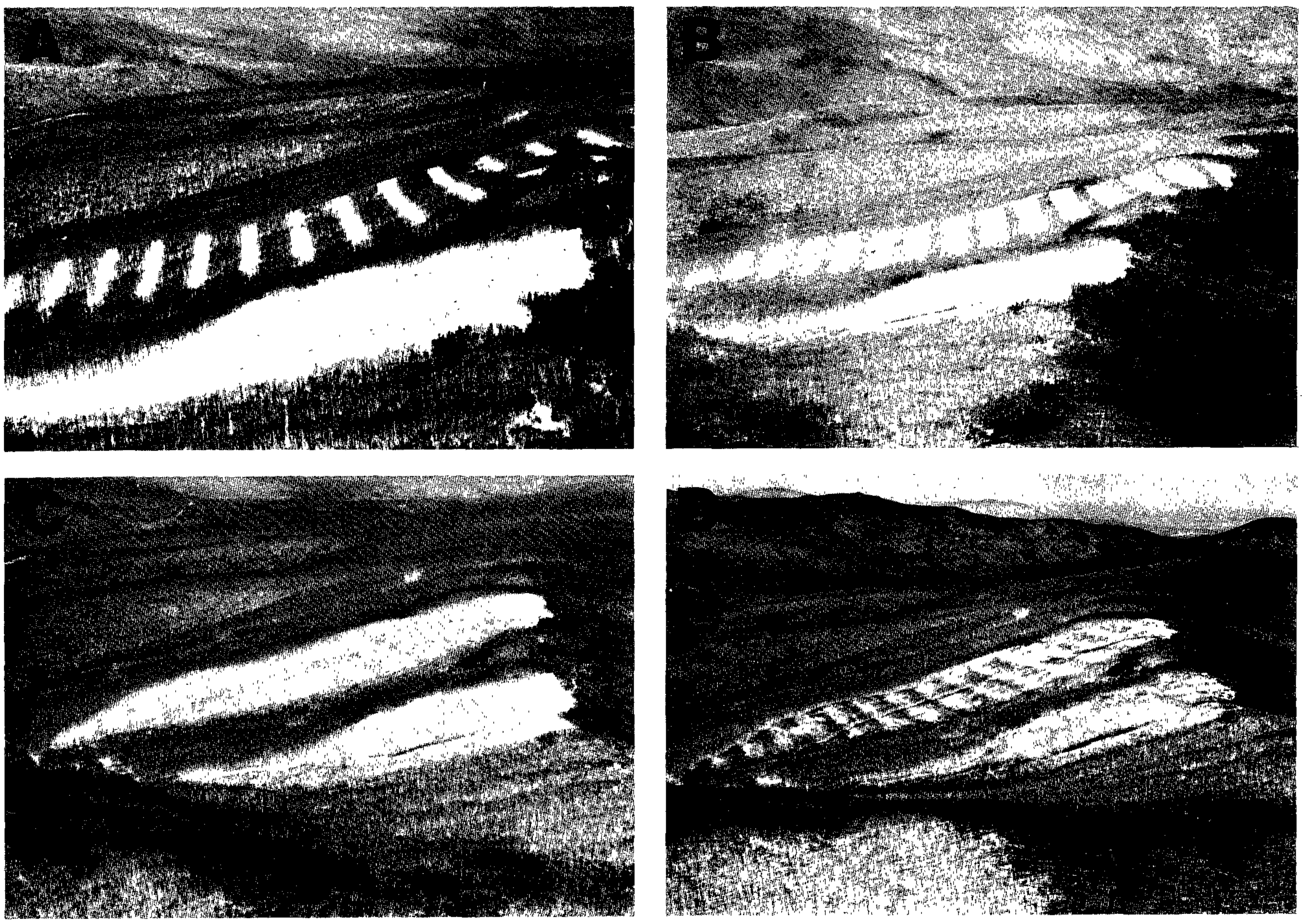


Figure 1. — East-to-west views across the strip cut watershed showing, rear foreground: (A) first strip cut, (B) first and second strips cut, (C) all strips cut, (D) regeneration at 10 years after initial harvest. The cleared area in near foreground is an earlier deforestation cutting.

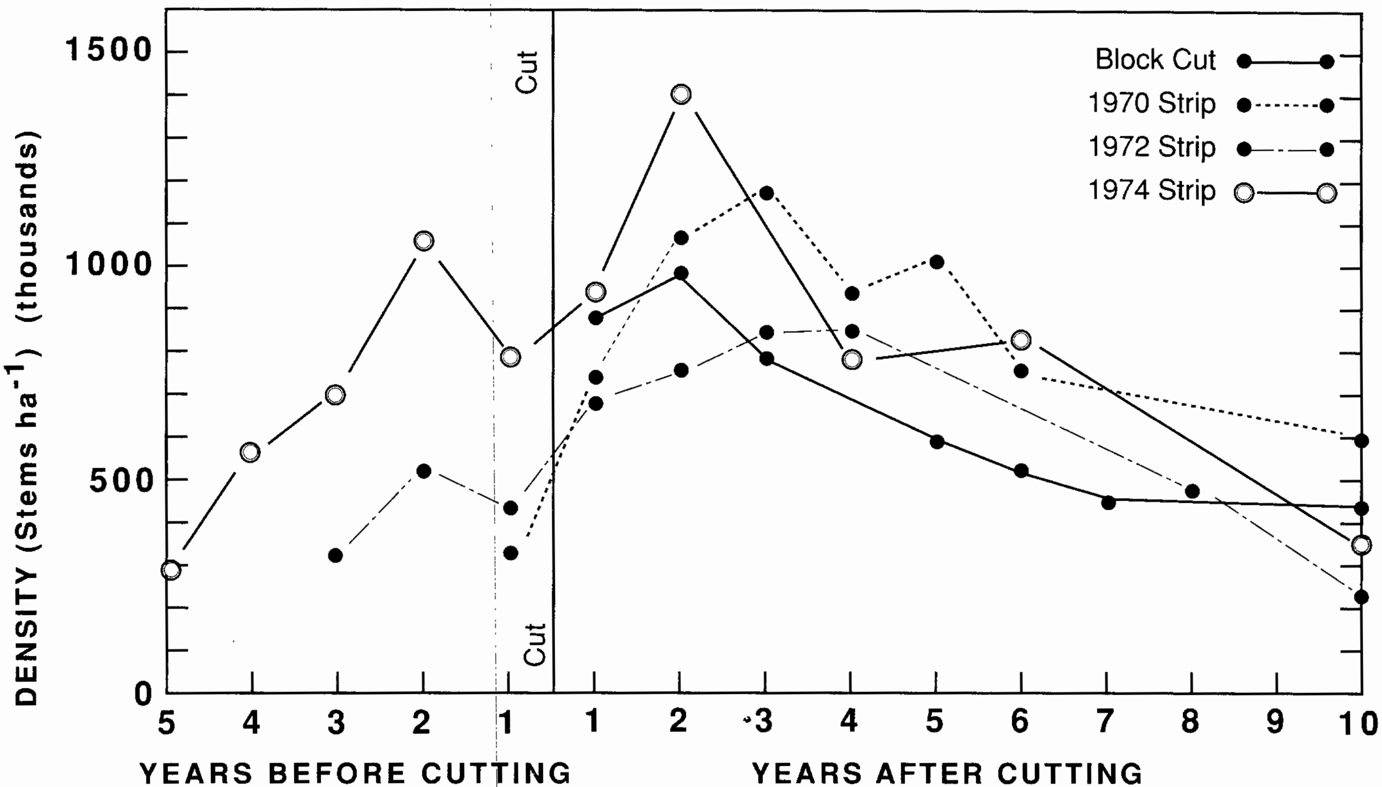


Figure 2. — Density of stems of all species <10 cm d.b.h. The data before cutting exclude trees >10 cm d.b.h. There were no stems >10 cm d.b.h. during the 10 years after cutting.

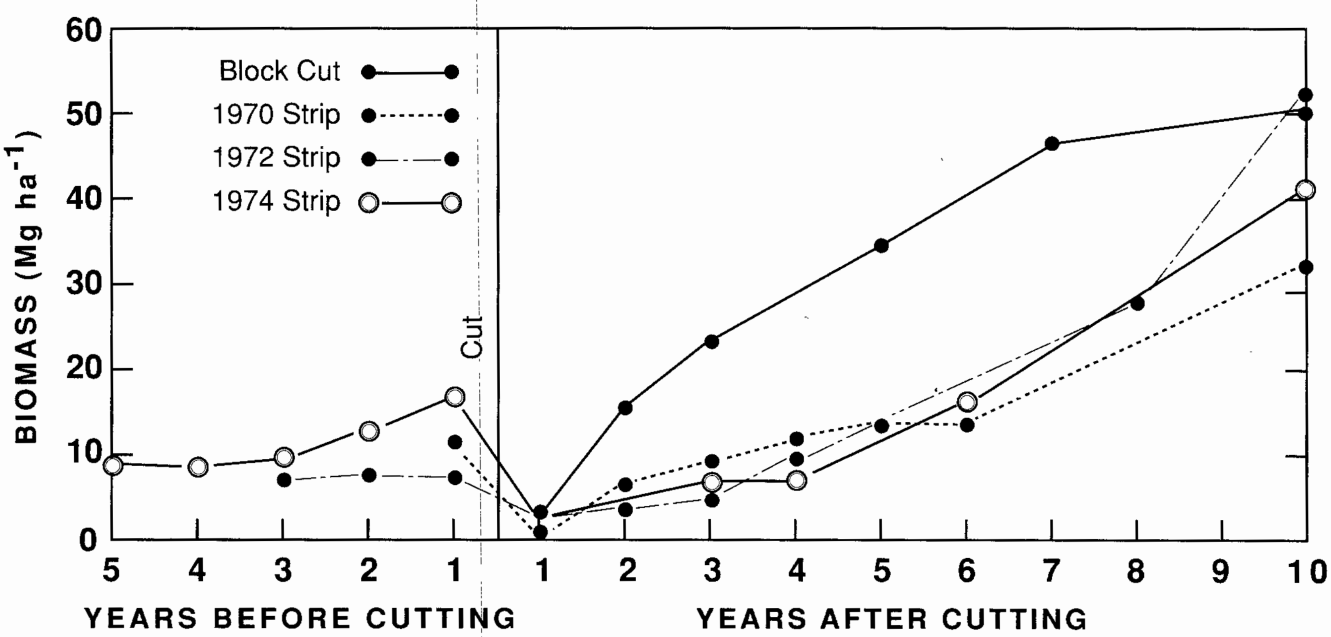


Figure 3. — Oven-dry weight of above-ground living biomass of all stems <10 cm d.b.h. of all species of trees, shrubs, and herbs. Data before cutting do not include trees >10 cm d.b.h. There were no trees >10 cm d.b.h. during the 10 years after cutting. Each megagram per hectare represents one half ton per acre.

the trees were transported by rubber-tired skidders to landing areas adjacent to the base of the harvested watersheds. Skidder operators were encouraged to vary their routes to provide scarified conditions necessary for successful regeneration of birch.

Regeneration on the block clearcut and strip cut has been surveyed on permanent plots at 1- to 4-year intervals since harvest. On the strip cut, fifty-seven 25-m X 25-m plots were selected. Nineteen plots were chosen randomly for each year of cut. These plots were later classified by elevation with 19 plots at low elevation (440 m to 550 m), 18 at mid-elevation (550 m to 650 m), and 20 at high elevation (650 m to 730). On the block clearcut, forty-eight 25-m X 25-m plots were chosen at random with no stratification since the harvest was completed in a single operation and the elevation range of the entire harvest area was about the same as for the mid-elevation plots on the strip cut. Surveys were conducted before cutting on each of the strips, but not on the block clearcut (Figs. 2 and 3).

Nested subplots were used. The entire 25-m X 25-m plot was used to sample trees >10 cm d.b.h. Trees between 2 cm and 10 cm d.b.h. were tallied on a 1-m X 25-m strip running the length of either the east or west side (decision by coin toss) of each plot. Saplings measured on these 1-m X 25-m subplots before cutting were considered to be advance regeneration (Figs. 2 and 3). Lesser vegetation was surveyed on four 1 m^2 subplots spaced evenly along the 1-m X 25-m strip plot. Within each of these subplots, stem counts were made by species for trees, shrubs, and herbs in two height classes, <0.5 m tall and >0.5 m tall. Data from the subplots were averaged to give stems per m^2 for each 1-m X 25-m strip. Visual estimates of percent of plot covered were used in place of stem counts for grasses, sedges, rushes, and mosses.

Estimates of aboveground biomass of regeneration were obtained by establishing 46 additional 1-m X 1-m plots on the strip cut, classified by elevation and year cut. From these plots, individual stems by species for trees, shrubs, and herbs classified as either <0.5 m tall or >0.5 m tall or by percentage of cover were clipped in July and August, dried at 105^0C, and weighed. An average weight per stem was calculated by species, height class, or percentage of cover, by year. These factors were then multiplied by the corresponding stem counts from both watersheds to obtain biomass estimates in kg ha^{-1}. Trees exceeding 2 cm d.b.h. were not clipped. Their biomass was estimated using appropriate equations selected from Tritton and Hornbeck (1982) (Appendix).

Results

Total Stem Counts

The maximum number of stems (trees, shrubs, and herbs) occurred before the 5th year after cutting on both the block clearcut and strip cut watersheds (Fig. 2). Maximum density on the block clearcut occurred during the 2nd year after cutting at 1,061,000 stems ha^{-1}. This number dropped to 447,000 by 10 years after cutting. The inventory of 1970, before any cutting, indicated that the density of vegetation <10 cm d.b.h. on each of the three sets of strips was similar at about 300,000 stems ha^{-1}. The density on the first strips, after cutting, peaked at 1,183,000 stems ha^{-1} the 3rd year, and dropped to 606,000 stems ha^{-1} 7 years later. The peak density in the second strips, also, occurred at 3 years after cutting, at 865,000 stems ha^{-1}, and dropped to 232,000 stems ha^{-1} by the 10th year after cutting. These lower numbers may have been due partly to damage that occurred 2 years after cutting, while the third set of strips was being harvested. The density and biomass of the advance regeneration at the time of cutting of the third strips was twice as great as at the cutting of the other strips, probably because of added light after the first and second harvests. Density on the third strips after cutting peaked at about 1,344,000 stems ha^{-1} 2 years after cutting, but dropped to 368,000 stems ha^{-1} by 10 years after cutting.

Total Biomass

In 1970, before any cutting had occurred, total biomass averaged 133 Mg ha^{-1} on the strip cut. The biomass of all stems <10 cm d.b.h., before cutting, averaged 8.9 Mg ha^{-1}, with a range from 6.9 Mg ha^{-1} to 11.2 Mg ha^{-1} (Fig. 3). Harvesting stimulated biomass production on both cut and uncut strips. By 1972, just before cutting, biomass of stems <10 cm d.b.h. in the second strips had increased from 6.9 Mg ha^{-1} to 8.2 Mg ha^{-1}. By 1974, just before cutting, biomass of stems <10 cm d.b.h. in the third strips had increased from 8.7 Mg ha^{-1} in 1970 to 16.9 Mg ha^{-1} (Fig. 3). This increase in biomass on the third strips before cutting may have been caused by greater light penetration after the adjacent strips were cut in 1970 and 1972 and by an increased supply of moisture and nutrients moving from cut to uncut strips (Hornbeck and others 1987). However, any advantage seems to have been lost during harvest, apparently because of breakage, crushing, and burial under the logging slash. All strips and the block clearcut had <3 Mg ha^{-1} the 1st year after cutting. Biomass production on the block clearcut accelerated much more rapidly than on the strip cut during the early years after cutting (Fig. 3). Biomass production was similar on all three sets of strips through year 8, and was much slower than on the block clearcut. Production on the strip cut seemed to accelerate after year 8 with biomass on the second set of strips nearly doubling from about 28 Mg ha^{-1} to 54 Mg ha^{-1} between years 8 and 10.

Differences With Elevation

For the first set of strips, the greatest density occurred at low elevation the 1st and 2nd years after cutting, at middle elevation during the 2nd through 4th years after cutting, and at high elevation from the 3rd through 5th years after cutting. For the second set of strips, the greatest density occurred at low and middle elevations during the first 4 years after cutting and at high elevation during the 3rd through the 8th year. On the third set, the highest density occurred at the middle elevation during the first 2 years. By the 4th year after cutting, the high elevation strips had the greatest number of stems (Table 1).

On the strip cut, biomass tended to accumulate most rapidly at low elevations and least rapidly at the higher elevations for all 3 cutting years (Table 2). Biomass accumulated more rapidly on the block clearcut than on the strip cut through the 8th year after cutting.

Table 1. — Number of stems per ha of all species by elevation and year of cutting on both the strip cut and block clearcut watersheds.

Year cut	Elevation	Years since cutting								
		1	2	3	4	5	6	7	8	10
					Thousands					
1970	High	475	861	1300	941	1490	894	—	—	930
	Mid	786	1399	1274	1051	797	782	—	—	422
	Low	992	1076	976	814	789	609	—	—	466
	Block	891	1061	815	—	542	—	467	—	447
1972	High	612	579	771	716	—	—	—	755	331
	Mid	637	874	910	873	—	—	—	351	167
	Low	866	865	915	991	—	—	—	397	198
1974	High	802	1072	—	909	—	1339	—	—	620
	Mid	1064	1497	—	696	—	592	—	—	185
	Low	919	1464	—	762	—	570	—	—	299

Table 2. — Biomass of all stems of all species by elevation and year of cutting on both strip cut and block clearcut watersheds. Each Mg ha^{-1} represents one-half ton per acre.

Year cut	Elevation	Years since cutting								
		1	2	3	4	5	6	7	8	10
					Mg ha^{-1}					
1970	High	0.5	3.2	5.5	9.6	10.5	11.2	—	—	28.4
	Mid	0.7	6.4	6.4	8.0	8.0	14.3	—	—	31.6
	Low	0.9	7.7	12.7	17.5	21.9	20.8	—	—	41.0
	Block	2.3	15.9	23.6	—	35.4	—	47.4	—	50.8
1972	High	1.3	3.1	4.5	7.6	—	—	—	19.4	40.8
	Mid	4.0	5.5	7.4	11.5	—	—	—	31.5	57.9
	Low	2.0	4.6	6.7	10.0	—	—	—	32.1	62.4
1974	High	1.4	3.1	—	6.8	—	11.3	—	—	32.6
	Mid	2.8	6.9	—	8.1	—	17.3	—	—	48.5
	Low	3.8	7.3	—	11.4	—	22.8	—	—	44.6

Proportion of Trees, Shrubs, and Herbs

Throughout the study, tree density generally declined, shrub density remained relatively constant, and herbaceous density increased. Generally, the highest elevations had the fewest trees and the most herbs, while the lowest elevations had the most trees and the fewest herbs. The 1st year after cutting, herbs accounted for less than 11 percent of the stems on the low and mid-elevations of the first strips and on the block clearcut (Fig. 4). At the high elevation strips, herbs accounted for approximately 33 percent of the vegetation. Density of shrubs ranged from 3 to 8 percent of all stems. Trees accounted for 85 percent of stems on middle and low elevation strips and on the block clearcut, but only 64 percent at high elevation.

Ten years after cutting, herbs accounted for 54 to 66 percent of stems on the first strips, depending upon elevation, and 41 percent on the block clearcut. Trees dwindled to 10 to 28 percent on the strip cut and to 52 percent on the block clearcut. On the second set of strips, depending on elevation, trees ranged from 40 to 54 percent of the total the 1st year after cutting, shrubs ranged from 7 to 12 percent, and herbs ranged from 34 to 53 percent. By 10 years after cutting, herbs comprised 54 to 71 percent of the stems, shrubs 8 to 17 percent, and trees only 12 to 30 percent.

On the third strips, trees comprised 56 percent of the stems at low elevation to only 22 percent at high elevation during the 1st year after cutting. Shrubs accounted for 6 to 14 percent and herbs 30 to 72 percent. By 10 years after cutting, trees accounted for 10 to 28 percent, shrubs 4 to 11 percent, and herbs 61 to 80 percent.

Although herbaceous density increased during regrowth, herbaceous biomass was relatively minor and decreased rapidly over time. On the block clearcut, herbs contributed 5 percent of the biomass during the 1st year after cutting (Fig. 5). Herbaceous biomass ranged from 3 to 28 percent of the total biomass during the 1st year after cutting on the three series of strip cuts. By the 5th year after cutting, herbaceous biomass dropped to less than 5 percent at all elevations on both watersheds. By the 10th year after cutting, herbaceous biomass was down to less than 0.1 percent.

Shrubs played a more major role in terms of biomass on both watersheds, especially during the first 5 years after cutting (Fig. 5). The 1st year after cutting, shrubs averaged 19 to 50 percent of the biomass with no clear trends by elevation. At the end of the 4th year after cutting, the range had dropped to 4 to 35 percent of the total. But by 10 years after cutting, shrubs accounted for less than 10 percent of the biomass on the first strips, less than 3

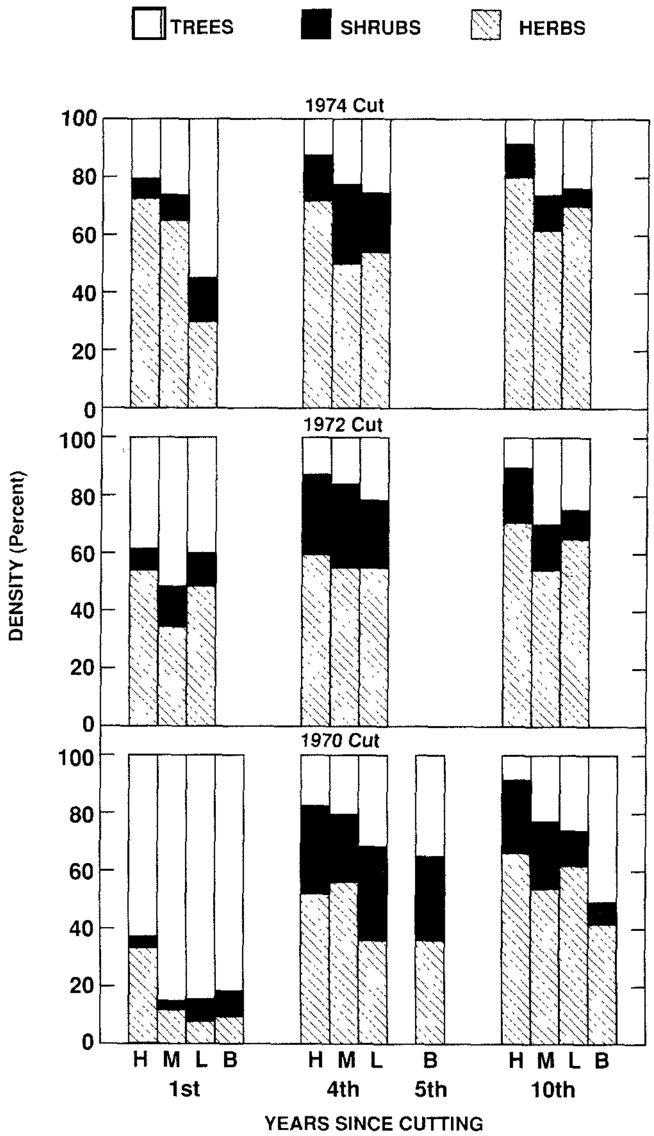


Figure 4. — Density of revegetation with herbs, shrubs, and trees expressed as a percent of the total by elevation and year of cut. H, M, L, and B represent high, mid, low elevation strips, and block clearcut, respectively. Herbs are represented by hatched bars, shrubs by dark bars, and trees by white bars.

percent on the third strips, and less than 2 percent on the block clearcut and on the second strips.

Trees accounted for 40 to 60 percent of the biomass the 1st year after cutting with a couple of exceptions. By 10 years after cutting, trees accounted for more than 90 percent of the biomass on the first strips, for more than 97 percent on the third strips, and for more than 98 percent on the second strips and on the block clearcut.

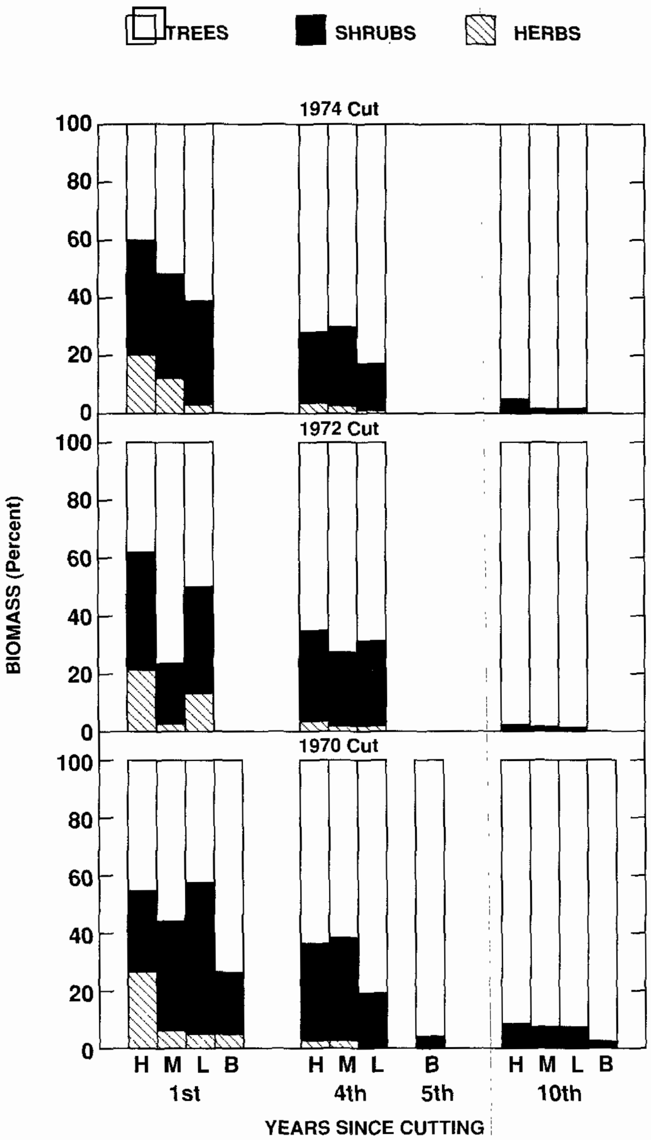


Figure 5. — Aboveground living biomass with herbs, shrubs, and trees expressed as a percent of the total by elevation and year of cut. H, M, L, and B represent high, mid, low elevation strips, and block clearcut, respectively. Herbs are represented by hatched bars, shrubs by dark bars, and trees by white bars.

Density of Trees

Density of commercial and noncommercial trees was generally greater on the block clearcut watershed than on the strip cut. On the strip cut, density was higher at low elevations than at high elevations, and the first strips were more dense than the others (Table 3). Furthermore, density of trees dropped dramatically during the 10 years after clearcutting.

Yellow birch was the most numerous tree on the block clearcut after cutting, with pin cherry second. At low elevation, yellow birch was the most numerous tree on the first strips, until the 10th year when sugar maple became more numerous (Table 4). In the second strips, yellow birch and sugar maple had similar densities and were more numerous than the other trees. In the third strips, sugar maple was clearly most numerous after the 1st year.

At the middle elevation, yellow birch was the most numerous tree, on the first strips, until the 5th growing season, when sugar maple assumed that role. In the second strips, yellow birch was most abundant the 1st year, beech the 2nd and 3rd years, and then sugar maple became most numerous. In the third strips at mid-elevation, sugar maple was clearly most numerous (Table 5).

At the high elevation, yellow birch was clearly the most abundant tree species in the first strips, but shared that role with sugar maple by the 10th year on the other two sets of strips (Table 6).

Table 3. — Number of stems of trees only, <10 cm d.b.h., per ha. There were no trees ⩾10 cm d.b.h. measured during the 10 years after cutting (see appendix for a list of species included as tree species).

Year cut	Elevation	Years since cutting 1	2	3	4	5	6	7	8	10
					Thousands					
1970	High	308	233	326	181	439	114	—	—	89
	Mid	671	521	369	224	181	177	—	—	95
	Low	860	593	440	277	258	211	—	—	131
	Block	734	661	402	—	226	—	204	—	231
1972	High	243	155	133	106	—	—	—	73	41
	Mid	342	282	192	162	—	—	—	103	52
	Low	368	253	257	234	—	—	—	95	53
1974	High	178	182	—	120	—	128	—	—	64
	Mid	291	316	—	173	—	104	—	—	49
	Low	513	428	—	216	—	136	—	—	71

Table 4. — Trees: block clearcut and low elevation strips, stems per ha (thousands).

Type of cut	Year cut	Years since cutting 1	2	3	4	5	6	7	8	10
					Yellow Birch					
Block	1970	484	283	214	—	90	—	79	—	145
Strip	1970	651	348	242	125	95	71	—	—	26
Strip	1972	185	81	112	88	—	—	—	17	6
Strip	1974	214	160	—	48	—	27	—	—	11
					Sugar Maple					
Block	1970	32	36	31	—	26	—	28	—	17
Strip	1970	46	57	50	47	60	55	—	—	37
Strip	1972	90	86	85	88	—	—	—	42	30
Strip	1974	184	172	—	122	—	75	—	—	39
					Beech					
Block	1970	59	59	32	—	25	—	23	—	15
Strip	1970	15	45	37	25	15	14	—	—	6
Strip	1972	24	16	16	18	—	—	—	9	5
Strip	1974	54	36	—	17	—	13	—	—	8
					Pin Cherry					
Block	1970	100	223	75	—	50	—	39	—	26
Strip	1970	46	47	22	15	26	8	—	—	13
Strip	1972	15	13	3	1	—	—	—	2	1
Strip	1974	20	32	—	4	—	5	—	—	2
					Striped Maple					
Block	1970	23	20	18	—	13	—	12	—	10
Strip	1970	22	15	16	8	7	7	—	—	6
Strip	1972	17	15	12	9	—	—	—	5	2
Strip	1974	11	8	—	3	—	3	—	—	5
					Mountain Maple					
Block	1970	1	1	1	—	1	—	1	—	0
Strip	1970	1	3	3	3	3	4	—	—	5
Strip	1972	1	3	3	2	—	—	—	4	4
Strip	1974	1	1	—	1	—	0	—	—	0

Table 5. — Trees: strip cutting, mid elevation, stems per ha (thousands).

Year cut	Years since cutting								
	1	2	3	4	5	6	7	8	10
					Yellow Birch				
1970	437	305	192	102	58	57	—	—	20
1972	126	91	35	21	—	—	—	13	5
1974	40	44	—	18	—	13	—	—	4
					Sugar Maple				
1970	108	138	102	86	94	84	—	—	46
1972	70	58	63	66	—	—	—	51	29
1974	189	206	—	117	—	64	—	—	37
					Beech				
1970	77	31	23	20	7	11	—	—	9
1972	118	106	68	52	—	—	—	23	8
1974	37	23	—	16	—	10	—	—	5
					Pin Cherry				
1970	13	19	21	3	9	6	—	—	5
1972	7	11	10	7	—	—	—	5	5
1974	4	9	—	2	—	2	—	—	1
					Striped Maple				
1970	30	16	21	6	9	13	—	—	9
1972	13	12	11	14	—	—	—	6	3
1974	9	14	—	8	—	5	—	—	6
					Mountain Maple				
1970	2	0	2	2	0	1	—	—	0
1972	2	2	2	1	—	—	—	1	0
1974	10	12	—	7	—	7	—	—	3

Table 6. — Trees: strip cut, high elevation, stems per ha (thousands).

Year cut	Years since cutting								
	1	2	3	4	5	6	7	8	10
					Yellow Birch				
1970	186	61	191	75	356	29	—	—	24
1972	131	60	56	43	—	—	—	18	8
1974	87	75	—	28	—	40	—	—	13
					Sugar Maple				
1970	37	49	38	31	25	24	—	—	19
1972	47	34	33	24	—	—	—	19	13
1974	30	15	—	18	—	15	—	—	10
					Beech				
1970	9	24	16	22	19	15	—	—	8
1972	9	14	8	6	—	—	—	8	4
1974	19	27	—	14	—	20	—	—	11
					Pin Cherry				
1970	5	17	7	6	3	3	—	—	3
1972	6	7	5	4	—	—	—	6	4
1974	3	4	—	3	—	3	—	—	2
					Striped Maple				
1970	35	5	8	4	8	6	—	—	5
1972	29	17	16	11	—	—	—	8	6
1974	21	16	—	9	—	10	—	—	10
					Mountain Maple				
1970	33	31	19	13	11	12	—	—	12
1972	15	11	9	8	—	—	—	5	2
1974	13	17	—	12	—	13	—	—	7

Biomass of Trees

Biomass of commercial and noncommercial trees was greater on the block clearcut than on the strip cut. By the 10th year after cutting, the biomass of trees on the second strips was much greater than on the third strips which, in turn, was greater than on the first strips (Table 7). In nearly all instances, biomass accumulated faster at lower elevations than at higher elevations.

At 10 years after cutting, commercial trees (sugar maple, yellow birch, beech, paper birch, and white ash) accounted for only 37 percent of the tree biomass on the block clearcut (Tables 8 and 9). This was the highest percentage since cutting; the lowest of 14 percent occurred the second year after cutting. At the high elevation of the first strips, commercial tree biomass went from 68 percent the 1st year after cutting to 72 percent by the 10th year. The low and mid-elevations went from 77 to 80 percent the 1st year down to only 36 percent of the total tree biomass. In the 10 years after cutting of the second and third strips, biomass of commercial trees stayed relatively constant or increased as a percent of the total tree biomass. The exception was a big drop between the 1st and 2nd years of the mid-elevation of the second strips from 92 percent to 37 percent.

Table 7. — Biomass of trees <10 cm d.b.h. per ha. There were no trees ≥10 cm d.b.h. measured during the 10 years after cutting. Each Mg ha $^{-1}$ represents one-half ton per acre.

Year cut	Elevation	Years since cutting 1	2	3	4	5	6	7	8	10
					Mg ha^{-1}					
1970	High	0.2	1.8	2.8	6.2	6.5	8.4	—	—	25.4
	Mid	0.4	4.5	3.6	4.9	5.6	11.5	—	—	29.3
	Low	0.4	5.9	9.7	14.2	18.9	18.6	—	—	37.9
	Block	1.7	14.6	21.9	—	33.9	—	45.8	—	50.1
1972	High	0.5	2.0	2.5	5.0	—	—	—	17.5	40.0
	Mid	3.1	3.4	4.6	8.3	—	—	—	30.0	57.5
	Low	1.0	2.8	4.4	7.0	—	—	—	30.1	61.5
1974	High	0.6	1.4	—	4.9	—	8.6	—	—	30.6
	Mid	1.5	3.8	—	5.6	—	15.4	—	—	48.0
	Low	2.3	4.4	—	9.5	—	21.5	—	—	42.8

Table 8. — Percentage of tree biomass accounted for by commercial tree species: sugar maple, yellow birch, beech, paper birch, white ash.

Year cut	Elevation	Years since cutting 1	2	3	4	5	6	7	8	10
1970	High	68	50	52	60	67	69	—	—	72
	Mid	77	60	66	61	50	35	—	—	36
	Low	80	32	47	50	39	46	—	—	37
	Block	21	14	20	—	24	—	28	—	37
1972	High	50	42	32	51	—	—	—	52	73
	Mid	92	37	65	58	—	—	—	55	65
	Low	77	74	77	83	—	—	—	61	65
1974	High	54	63	—	65	—	77	—	—	87
	Mid	81	77	—	77	—	69	—	—	76
	Low	68	68	—	70	—	64	—	—	65

Table 9. — Biomass of commercial trees: sugar maple, yellow birch, beech, paper birch, white ash. Each Mg ha^{-1} represents one-half ton per acre.

Year cut	Elevation	1	2	3	4	5	6	7	8	10
						Mg ha $^{-1}$				
1970	High	0.2	0.9	1.5	3.7	4.4	5.8	—	—	18.3
	Mid	0.3	2.7	2.4	3.0	2.8	4.0	—	—	10.6
	Low	0.3	1.9	4.5	7.0	7.4	8.5	—	—	13.9
	Block	0.3	2.1	4.4	—	8.0	—	13.0	—	18.3
1972	High	0.2	0.8	0.8	2.5	—	—	—	9.1	29.0
	Mid	2.8	1.3	3.0	4.8	—	—	—	16.5	37.6
	Low	0.8	2.1	3.4	5.8	—	—	—	18.5	39.7
1974	High	0.3	0.9	—	3.2	—	6.7	—	—	26.6
	Mid	1.2	2.9	—	4.3	—	10.6	—	—	36.5
	Low	1.5	3.0	—	6.7	—	13.8	—	—	28.0

On the block clearcut, pin cherry had the most biomass throughout the 10 years after clearcutting, with a maximum of over 31 Mg ha^{-1} occurring at about 7 years after cutting. The biomass of yellow birch steadily increased after cutting to 10.8 Mg ha^{-1} by the 10th year (Fig. 6).

In the first strips at low elevation, pin cherry had the most biomass throughout the 10 years, with 14 Mg ha^{-1} at the 10th year. After the 3rd year after cutting, yellow birch had the second highest biomass (Fig. 7). At the middle elevation, no single species was clearly dominant in terms of biomass until the 5th year after cutting, when pin cherry accumulated the most biomass, with sugar maple second. At the high elevation, yellow birch accumulated biomass faster than other species after the 6th year after cutting, with pin cherry next.

In the second strips at the low elevation, sugar maple had more biomass than any other species throughout the 10 years after cutting, reaching 17.5 Mg ha^{-1} by the 10th year. Yellow birch was the second commercial species in terms of biomass with more than 10 Mg ha^{-1} at 10 years (Fig. 8). In the middle elevation of the second strips, the biomass of the four major species was similar throughout the 10 years, but beech was always near the top. At 10 years after cutting, yellow birch had the most biomass at 12.2 Mg ha^{-1}, with beech next at 12.1 Mg ha^{-1}, then sugar maple at 10.3 Mg ha^{-1}, followed by pin cherry. At the highest elevation of the second strips, yellow birch had the most biomass with 14.5 Mg ha^{-1}, with beech second.

In the third strips, at low elevation, no species expressed dominance in terms of biomass for the first 4 years after cutting, then pin cherry and yellow birch emerged. By 10 years after cutting, yellow birch had accumulated 14.3 Mg ha^{-1} with pin cherry at 9.2 Mg ha^{-1} (Fig. 9). At mid-

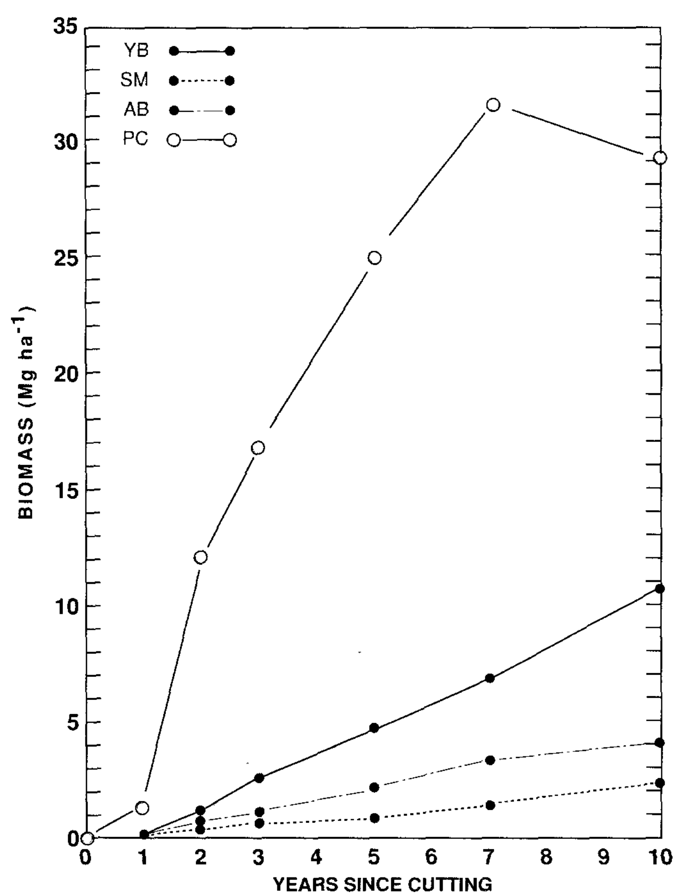


Figure 6. — Aboveground living biomass of yellow birch (YB), sugar maple (SM), American beech (AB), and pin cherry (PC) during the 10 years after clearcutting the block clearcut. Each megagram per hectare represents one half ton per acre.

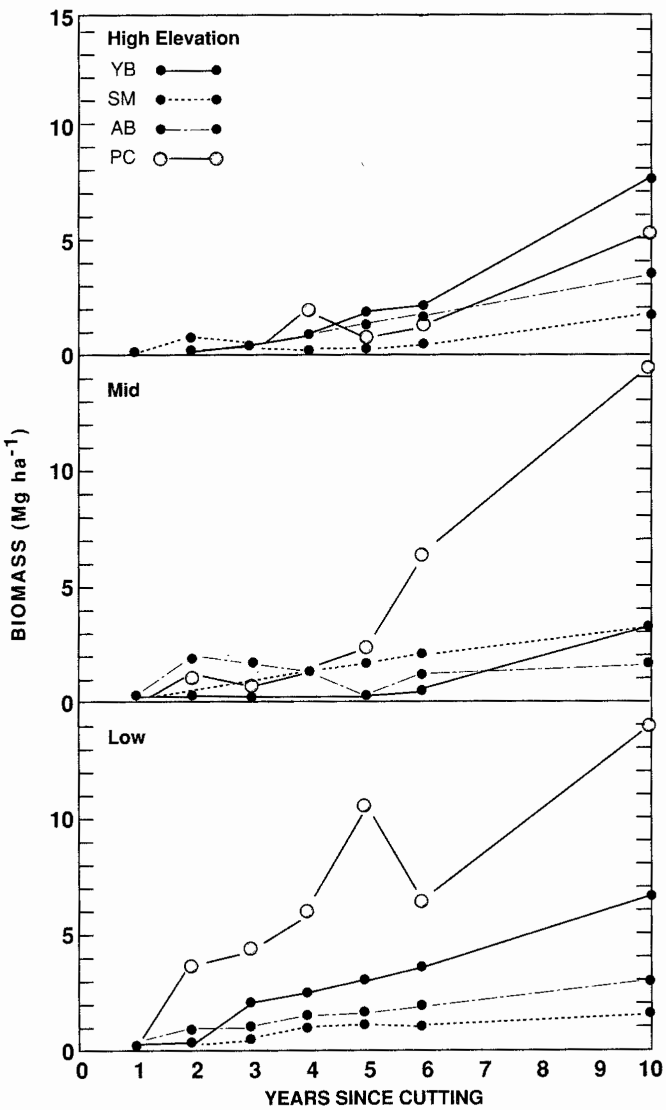


Figure 7. — Aboveground living biomass of yellow birch (YB), sugar maple (SM), American beech (AB), and pin cherry (PC) at three elevations of the first set of strips, the 1970 strip cut. Each megagram per hectare represents one-half ton per acre.

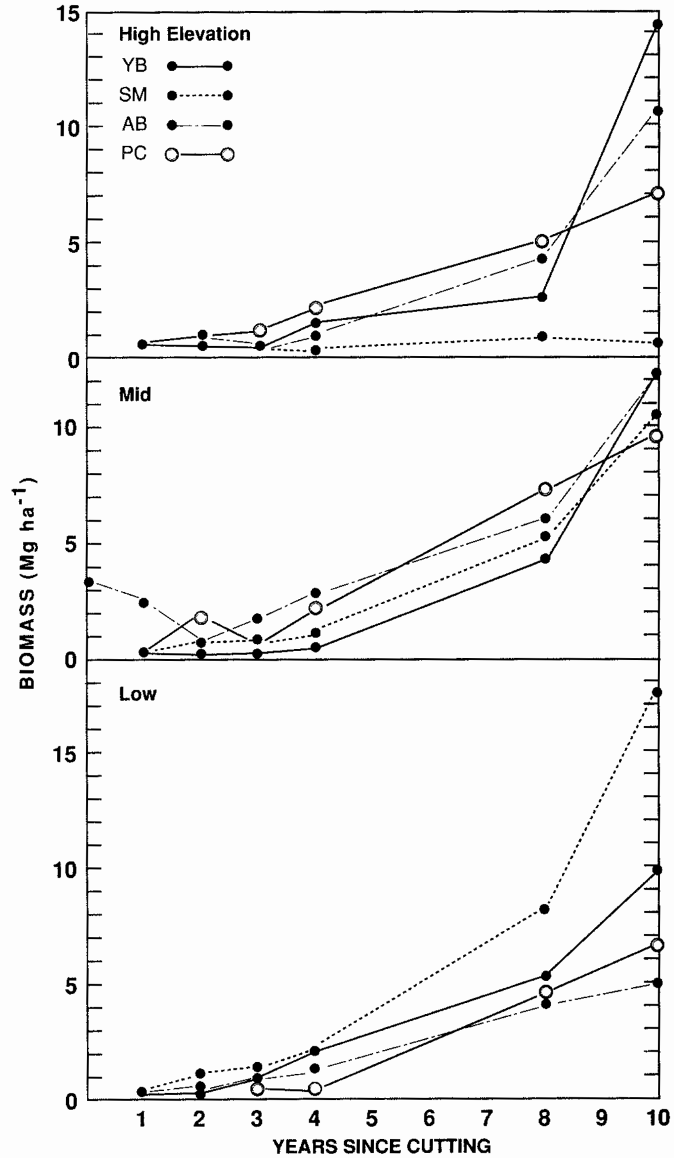


Figure 8. — Aboveground living biomass of yellow birch (YB), sugar maple (SM), American beech (AB), and pin cherry (PC) at three elevations of the second set of strips, the 1972 strip cut. Each megagram per hectare represents one-half ton per acre.

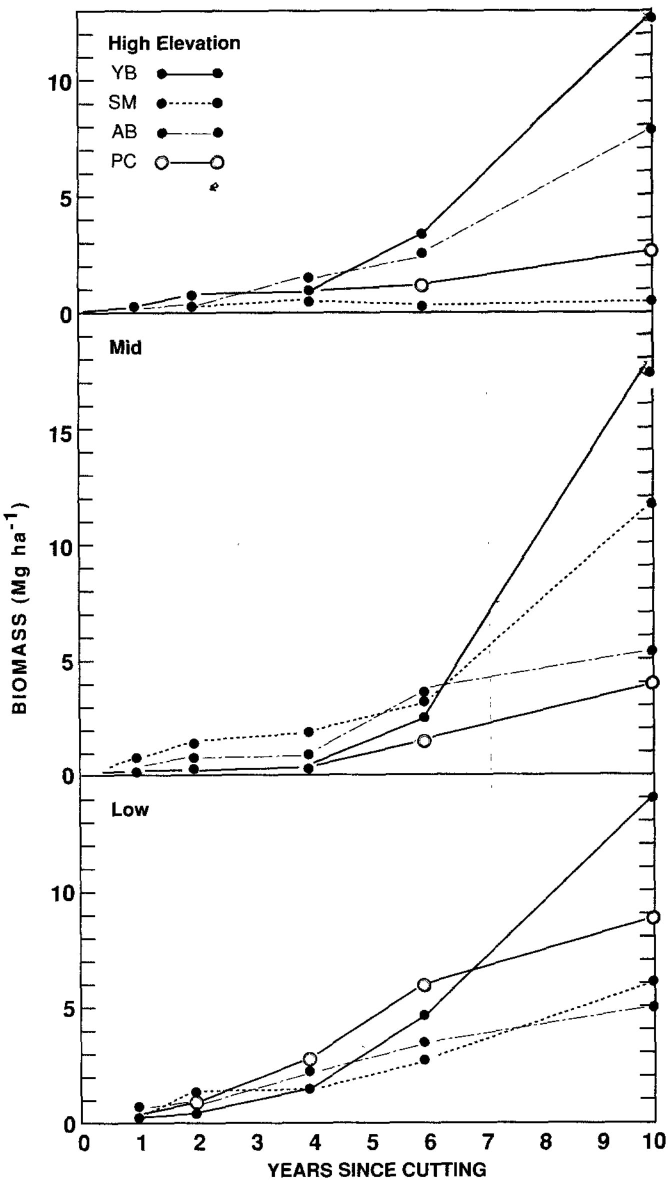


Figure 9. — Aboveground living biomass of yellow birch (YB), sugar maple (SM), American beech (AB), and pin cherry (PC) at three elevations of the third set of strips, the 1974 strip cut. Each megagram per hectare represents one half ton per acre.

elevation, pin cherry never really became a factor. By 10 years after cutting, yellow birch had accumulated 17.9 Mg ha^{-1}, with sugar maple at 11.6 Mg ha^{-1}. At the high elevation, 10 years after cutting, yellow birch had accumulated 12.7 Mg ha^{-1}, with beech next at 7.9 Mg ha^{-1}.

Size Classes at Year 10

By year 10, many of the trees had grown to sizes with measurable d.b.h. (Table 10). The rapid initial growth of pin cherry is illustrated by the large number of measurable trees on all three sets of strips and the block clearcut. Yellow birch had the second largest number of measurable stems and is expected to combine with sugar maple and beech to dominate the measurable trees when pin cherry begins its early die-off. No trees exceeded 10 cm d.b.h. by 10 years after harvest.

Discussion

On the basis of past studies, the site should be occupied by a full range of species including advanced regeneration, sprouts, seedlings of tolerant trees, seedlings of intolerants, shrubs, and herbs immediately after a major disturbance such as clearcutting. During the first 2 years, herbs should dominate, then shrubs, especially *Rubus;* and then between 3 and 5 years intolerant, unmerchantable tree species should take over (Bicknell 1979, Bormann and Likens 1979, Egler 1954, Marks 1974, Marquis 1967, Oliver 1981).

On our watersheds, the density of vegetation peaked between 2 and 4 years after cutting, but the individuals were very small seedlings of trees, shrubs, and herbs as indicated by very low biomass (Figs. 2 and 3). Advance regeneration was not a major factor, nor were sprouts. On the block clearcut and the first set of strips at all elevations, tree species were 64 to 86 percent of the stems the first year after cutting (Fig. 4). On the second set of strips, tree species accounted for 40 to 54 percent of the stems the first year (Fig. 4). On the third strips, trees accounted for only 22 to 56 percent, with the most trees at low elevation and the least at the high elevations.

Herbs generally increased in numbers throughout the first 10 years after cutting; but in terms of biomass, herbs were never very important. They were more important the 1st year after cutting than ever again, and they were more important at the high elevation than at the lower elevations.

Shrubs generally increased in number between the 1st and 3rd years after cutting, remained constant until at least the 6th year, and seemed to decline by the 10th year. However, these changes were not extreme and shrub density remained remarkably constant over the first 10 years after cutting. Shrub biomass was generally greatest during the first 2 years after cutting and declined to minor importance by 10 years after cutting (Fig. 5).

Pin cherry and the other unmerchantable species were more abundant on the block clearcut than on the strip cut.

Table 10. — Trees per ha (standard error), 10 years after cut, by diameter classes and year cut.

Cut	Elev.	d.b.h. (cm)			d.b.h. (cm)			d.b.h. (cm)		
		2.5-4.9	5.0-7.4	7.5-9.9	2.5-4.9	5.0-7.4	7.5-9.9	2.5-4.9	5.0-7.4	7.5-9.9
		First cut			Second cut			Third cut		
					Yellow Birch					
Strip	High	629 (260)	171 (171)	57 (57)	3143 (1540)	229 (119)	0	2333 (793)	267 (134)	0
	Mid	560 (204)	80 (80)	0	2467 (1703)	267 (134)	0	1600 (512)	743 (297)	114 (74)
	Low	743 (238)	57 (57)	0	1467 (528)	267 (136)	67 (67)	2067 (413)	467 (262)	0
Block		1450 (153)	42 (21)	8 (8)	—	—	—	—	—	—
					Sugar Maple					
Strip	High	343 (343)	0	0	0	0	0	67 (67)	0	0
	Mid	240 (98)	80 (80)	0	1467 (896)	267 (134)	0	1829 (732)	229 (119)	0
	Low	57 (57)	0	0	2533 (557)	333 (123)	67 (67)	1200 (432)	67 (67)	0
Block		341 (139)	17 (12)	0	—	—	—	—	—	—
					Beech					
Strip	High	571 (369)	0	0	1486 (608)	171 (118)	57 (57)	1200 (564)	67 (67)	0
	Mid	160 (98)	0	0	2600 (634)	0	0	629 (270)	57 (57)	57 (57)
	Low	343 (282)	57 (57)	0	1000 (554)	0	0	933 (327)	0	0
Block		434 (133)	0	8 (8)	—	—	—	—	—	—
					Pin Cherry					
Strip	High	857 (253)	171 (119)	171 (119)	971 (444)	514 (288)	57 (57)	200 (74)	133 (84)	0
	Mid	2000 (657)	1440 (601)	320 (196)	1533 (810)	1133 (544)	67 (67)	400 (21)	400 (160)	171 (111)
	Low	1943 (811)	1029 (313)	286 (168)	400 (146)	600 (306)	333 (260)	933 (429)	600 (306)	467 (135)
Block		6375 (393)	1183 (148)	67 (25)	—	—	—	—	—	—
					Striped Maple					
Strip	High	0	0	0	229 (114)	57 (57)	0	133 (84)	0	0
	Mid	560 (271)	80 (80)	0	1667 (317)	133 (84)	0	1086 (261)	57 (57)	0
	Low	686 (311)	400 (214)	0	867 (303)	0	0	733 (403)	133 (84)	0
Block		250 (70)	0	0	—	—	—	—	—	—
					Mountain Maple					
Strip	High	0	0	0	343 (158)	0	0	0	0	0
	Mid	0	0	0	400 (256)	0	0	229 (115)	0	0
	Low	229 (229)	0	0	1867 (502)	267 (168)	0	133 (84)	0	0
Block		8 (8)	0	0	—	—	—	—	—	—

But even there, the birch, beech, and maple accounted for 575,000 stems the 1st year, while there were only 124,000 unmerchantable stems. By the 5th year, there were 140,000 merchantable stems versus 64,000 unmerchantable, and by year 10, 177,000 merchantable and 36,000 unmerchantable (Table 4). Unmerchantable stems were even less important on the strip cut and were less abundant with increasing elevation (Tables 5 and 6). However, while there were fewer pin cherries than other tree species, their biomass was greater, at least on the block clearcut and on the first set of strips.

The most important consideration for the forest manager is emergence and development of commercial species. The 1st year or two after cutting, a forester visiting the site is confronted with a predominance of herbs and shrubs, notably asters and *Rubus.* However, by year 4 herbs are no longer competitors, and by year 10, shrubs have been relegated to the understory.

With regard to commercial tree species, in the 1st year after strip cutting, there was an average of over 400,000 tree seedlings ha^{-1}: 55 percent were yellow birch, 21 percent were beech, and 10 percent were sugar maple. On the block clearcut, over 750,000 seedlings ha^{-1} occurred: 64 percent were yellow birch, 11 percent beech, and 4 percent sugar maple.

By year 5 after harvest, the total number of tree seedlings had decreased to around 200,000 ha^{-1} on both the strip cut and block clearcut. On the strip cut, 32 percent of all seedlings were yellow birch, 12 percent were beech, and 35 percent were sugar maple. On the block clearcut, 40 percent were yellow birch, 11 percent were beech, and 11 percent were sugar maple.

By year 10, the total number of trees decreased to about 70,000 ha^{-1} on the strip cut, but remained at about 200,000 ha^{-1} on the block clearcut, largely due to continued germination of yellow birch. The composition at year 10 on the strip cut included 18 percent yellow birch, 10 percent beech, and 38 percent sugar maple. On the block clearcut, the composition was 63 percent yellow birch, 6 percent beech, and 7 percent sugar maple.

For the block clearcut, the percentages for individual commercial species were fairly stable through the first 10 years. However, on the strip cutting, there was a significant shift from domination by yellow birch in year 1 after harvest to domination by sugar maple at year 10. We do not know why this shift occurred, but do not view it as detrimental since sugar maple is commercially valuable.

Pin cherry was the principal competitor to commercial species on both the block clearcut and the strip cut throughout the 10 years. Pin cherry, which accumulated considerable biomass and was highly visible, accounted for <5 percent of the stems on the strip cut throughout the study. Pin cherry was much more of a factor on the block clearcut since it accounted for 22 percent of the tree seedlings during year 5 and 11 percent at year 10. Because of the short life of pin cherry, we anticipate that it will no longer be a competitor after another 10 years.

Solomon and Leak (1969) indicated that for a stand to be adequately stocked, there should be 956 stems ha^{-1} of commercial species having minimum diameters of 12.5 cm. They also gave a formula for estimating the number of 12.5 cm d.b.h. trees that could be expected to survive from smaller diameter trees. We suggest that there is ample stocking at 10 years. However, projected stocking from those merchantable species that have reached 2.5 cm d.b.h. in 10 years (Table 10) suggests that it may be premature to predict the stocking of the future stand at ten years of age.

Strip cutting in northern hardwoods has not gained acceptance or widespread application, partly because of the added work in locating the strips, and the need to reenter the stands on two added occasions. In our study, strip cutting failed to meet the objective of increasing the proportion of yellow birch in the regenerating stand. On the basis of our results, strip cutting does not appear to be worth the added effort silviculturally, and is thus not a viable option for managing northern hardwoods. However, as pointed out by Hornbeck and others (1987), strip cutting is a valuable tool for nutrient conservation.

Summary and Conclusions

- Maximum density occurred before the 5th year after cutting, at about 1,000,000 stems per ha of all species of plants.
- By 10 years after cutting, total density had returned nearly to precutting levels.
- Cutting of the early strips increased the density and biomass of the advance regeneration in the uncut strips, but this advance regeneration was destroyed during the subsequent logging and was not an overriding factor in the regeneration of the watersheds.
- At 10 years after cutting, the rate of biomass accumulation on the block clearcut seemed to be leveling off at 50 Mg ha^{-1}. On the strip cut, biomass still seemed to be accumulating exponentially at 35 to 50 Mg ha^{-1}.
- On the strip cut, maximum density was reached at low elevations 2 to 5 years before it was reached at high elevations.
- Total aboveground biomass increased much faster on the block clearcut than on the strip cut. On the strip cut, biomass accumulated faster at low elevation than at high.
- Density and biomass of tree species was greater on the block clearcut than on the strip cut and greatest at the low elevations of the strip cut. Density of regeneration was greatest on the first set of strips cut.
- Generally, on both watersheds the density of herbaceous stems increased over the first 10 years, shrub density remained constant, and tree density declined.
- Herbaceous biomass, while never very important, declined to very low levels by 10 years after cutting. Ten years after cutting trees accounted for more than 90 percent of the biomass.
- Ten years after cutting, yellow birch was the most numerous commercial tree on the block clearcut; sugar maple was the most numerous commercial tree on the strip cut.
- Pin cherry biomass was much higher on the block clearcut than on the strip cut and higher at lower elevations of the strip cut than at higher elevations.
- Yellow birch biomass was greatest on the block clearcut and at higher elevations of the strips.

Literature Cited

Bicknell, S.H. 1979. **Pattern and process of plant succession in a revegetating northern hardwood ecosystem.** New Haven, CT: Yale University. 218 p. Ph.D. dissertation.

Bormann, F.H.; Likens, G.E. 1979. **Pattern and process in a forested ecosystem.** New York: Springer-Verlag. 253 p.

Bormann, F.H.; Siccama, T.G.; Likens, G.E.; Whittaker, R.H 1970. **The Hubbard Brook Ecosystem Study: composition and dynamics of the tree stratum.** Ecological Monographs. 40:373-388.

Cliff, E.P. 1969. **Our birch resources.** In: Birch symposium proceedings; 1969 August 19-21; Durham, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 1-5.

Egler, F.E. 1954. **Vegetation science concepts: I. Initial floristic composition a factor in old-field vegetation development.** Vegetatio. 4:412-417.

Filip, S.M. 1969. **Natural regeneration of birch in New England.** In: Birch symposium proceedings; 1969 August 19-21; Durham, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 50-54.

Filip, S.M.; Leak, W.B. 1973. **Northeastern northern hardwoods.** In: Silvicultural systems for the major forest types of the United States. Agric. Handb. 445. Washington, DC: U.S. Department of Agriculture: 75-77.

Hornbeck, J.W.; Martin, C.W.; Pierce, R.S.; Bormann, F.H.; Likens, G.E.; Eaton, J.S. 1987. **The northern hardwood forest ecosystem: ten years of recovery from clearcutting.** Res. Pap. NE-596. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 30 p.

Kingsley, N.P. 1985. **A forester's atlas of the Northeast.** Gen. Tech. Rep. NE-95. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 96 p.

Leak, W.B.; Solomon, D.S.; Filip, S.M. 1969. **A silvicultural guide for northern hardwoods in the Northeast.** Res. Pap. NE-143. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 34 p.

MacLean, D.A.; Wein, R.W. 1976. **Biomass of jack pine and mixed hardwood stands in northeastern New Brunswick.** Canadian Journal of Forest Research. 6(4):441-447.

Marks, P.L. 1974. **The role of pin cherry** *(Prunus pensylvanica* L.) **in the maintenance of stability in northern hardwood ecosystems.** Ecological Monographs. 44:73-88.

Marquis, D.A. 1965. **Regeneration of birch and associated hardwoods after patch cutting.** Res. Pap. NE-32. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13 p.

Marquis, D.A. 1967. **Clearcutting in northern hardwoods: results after 30 years.** Res. Pap. NE-85. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 13 p.

Marquis, D.A. 1969. **Silvical requirements for natural birch regeneration.** In: Birch symposium proceedings: 1969 August 19-21; Durham, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 40-49.

Monteith, D.B. 1979. **Whole-tree weight tables for New York.** Applied Forestry Research Institute Res. Pap. 40 67 p.

Oliver, C.D. 1981. **Forest development in North America following major disturbances.** Forest Ecology and Management. 3:153-168.

Safford, L.O. 1983. **Silvicultural guide for paper birch in the northeast** (revised). Res. Pap. NE-535. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 29 p.

Siccama, T.G.; Bormann, F.H.; Likens, G.E. 1970. **The Hubbard Brook Ecosystem Study: productivity, nutrients, and phytosociology of the herbaceous layer.** Ecological Monographs. 40:389-402.

Soil Survey Staff, Department of Agronomy, Cornell University 1988. **Keys to soil taxonomy** (fourth printing). Soil Management Support Services Technical Monograph No. 6. Cornell University, Ithaca, NY: U.S. Department of Agriculture, Agency for International Development. 271-280.

Solomon, D.S.; Leak, W.B. 1969. **Stocking, growth, and yield of birch stands.** In: Birch symposium proceedings: 1969 August 19-21; Durham, NH. Upper Darby, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 106-118.

Solomon, D.S.; Leak, W.B. 1986. **Simulated yields for managed northern hardwood stands.** Res. Pap. NE-578. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 24 p.

Tritton, L.M.; Hornbeck, J.W. 1982. **Biomass equations for major tree species of the northeast.** Gen. Tech. Rep. NE-69. Broomall, PA; U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 46 p.

Whittaker, R.H.; Bormann, F.H.; Likens, G.E; Siccama, T.G 1974. **The Hubbard Brook Ecosystem Study: forest biomass and production.** Ecological Monographs. 44:233-254.

Young, H.E.; Ribe, J.H.; Wainwright, K. 1980. **Weight tables for tree and shrub species in Maine.** Misc. Rep. 230. Orono, ME: Univ. of Maine, Life Sci. and Agric. Exp. Stn. 84 p.

Appendix

Oven dry weight of above-ground biomass regression equations (Tritton and Hornbeck 1982); "log" refers to the logarithm to the base 10, and "ln" is the natural logarithm:

Sugar maple (Young 1980):
$\ln \text{weight (lbs)} = 1.2451 + 2.3329 \ln \text{d.b.h. (in)}$

Yellow birch (Young 1980):
$\ln \text{weight (lbs)} = 1.1297 + 2.3376 \ln \text{d.b.h. (in)}$

Beech (Young 1980):
$\ln \text{weight (lbs)} = 1.3303 + 2.2988 \ln \text{d.b.h. (in)}$

Pin cherry (MacLean and Wein 1976):
$\log \text{weight (kg)} = -0.6657 + 1.7041 \log \text{d.b.h. (cm)}$

White ash (Montieth 1979):
$\text{weight (kg)} = 3.2031 - (0.2337 \text{ mm d.b.h.}) + (0.006061 \text{ mm d.b.h.}^2)$

Striped maple (Whittaker 1974-*A. spicatum*):
$\log \text{weight (g)} = 2.3096 + 2.2524 \log \text{d.b.h. (cm)}$

Balsam fir (MacLean and Wein 1976):
$\log \text{weight (kg)} = -0.4081 + 1.6217 \log \text{d.b.h. (cm)}$

Red spruce (MacLean and Wein 1976):
$\log \text{weight (kg)} = -0.2112 + 1.5639 \log \text{d.b.h. (cm)}$

Red maple (MacLean and Wein 1976):
$\log \text{weight (kg)} = -0.5881 + 1.6728 \log \text{d.b.h. (cm)}$

Paper birch (MacLean and Wein 1976):
$\log \text{weight (kg)} = -0.5012 + 1.7284 \log \text{d.b.h. (cm)}$

Aspen (MacLean and Wein 1976):
$\log \text{weight (kg)} = -0.7891 + 2.0673 \log \text{d.b.h. (cm)}$

Martin, C.W.; Hornbeck, J.W. 1989. **Revegetation after strip cutting and block clearcutting in northern hardwoods: a 10-year history.** Res. Pap. NE-625. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 17 p.

Changes in the density and biomass of trees, shrubs, and herbs were measured periodically over 10 years following a progressive strip cutting and block clearcutting of northern hardwoods. At 10 years after clearcutting, yellow birch was the most numerous commercial or uncommercial tree on the block clearcut; sugar maple on the strip cut. Pin cherry dominated the biomass on the block clearcut and the first set of strips throughout the 10 years; yellow birch and sugar maple on the second and third sets of strips at 10 years.

Keywords: biomass; Hubbard Brook; pin cherry; regeneration; stocking; sugar maple; yellow birch.

Headquarters of the Northeastern Forest Experiment Station is in Broomall, Pennsylvania. Field laboratories are maintained at:

Amherst, Massachusetts, in cooperation with the University of Massachusetts

Berea, Kentucky, in cooperation with Berea College

Burlington, Vermont, in cooperation with the University of Vermont

Delaware, Ohio

Durham, New Hampshire, in cooperation with the University of New Hampshire

Hamden, Connecticut, in cooperation with Yale University

Morgantown, West Virginia, in cooperation with West Virginia University

Orono, Maine, in cooperation with the University of Maine

Parsons, West Virginia

Princeton, West Virginia

Syracuse, New York, in cooperation with the State University of New York, College of Environmental Sciences and Forestry at Syracuse University

University Park, Pennsylvania, in cooperation with The Pennsylvania State University

Warren, Pennsylvania
