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Site Productivity and Diversity of the Middle Mountain Long-term Soil Productivity Study, WV: Pre-experimental Site Characterization

Mary Beth Adams

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Abstract

To better understand the impacts of a changing environment and interactions with forest management options for forest resources, including soil, large long-term experiments are required. Such experiments require careful documentation of reference or pre-experimental conditions. This publication describes the Middle Mountain Long-term Soil Productivity (LTSP) Study, located within the Loop Road Research Area of the Monongahela National Forest, WV. This study was initiated in 1997 and pretreatment soil, vegetation, nutrient cycling, and climatic conditions were carefully documented. The Middle Mountain LTSP Study site is a high elevation site and supports a cherry-maple stand of moderate productivity. There is some variability in soil nutrients and plant diversity across the site prior to the initiation of treatments. This site is generally less diverse than the Fork Mountain LTSP Study site in terms of overstory tree species. Experimental treatments started in 1998, and we continue to monitor this site's response to these treatments.

The Authors

MARY BETH ADAMS is a research soil scientist with the U.S. Forest Service, Northern Research Station in Morgantown, WV.

Cover Photo

Felling overstory trees during establishment of the Middle Mountain Long-term Soil Productivity Study, 1997. Photo by Darlene Madarish, USDA Forest Service.

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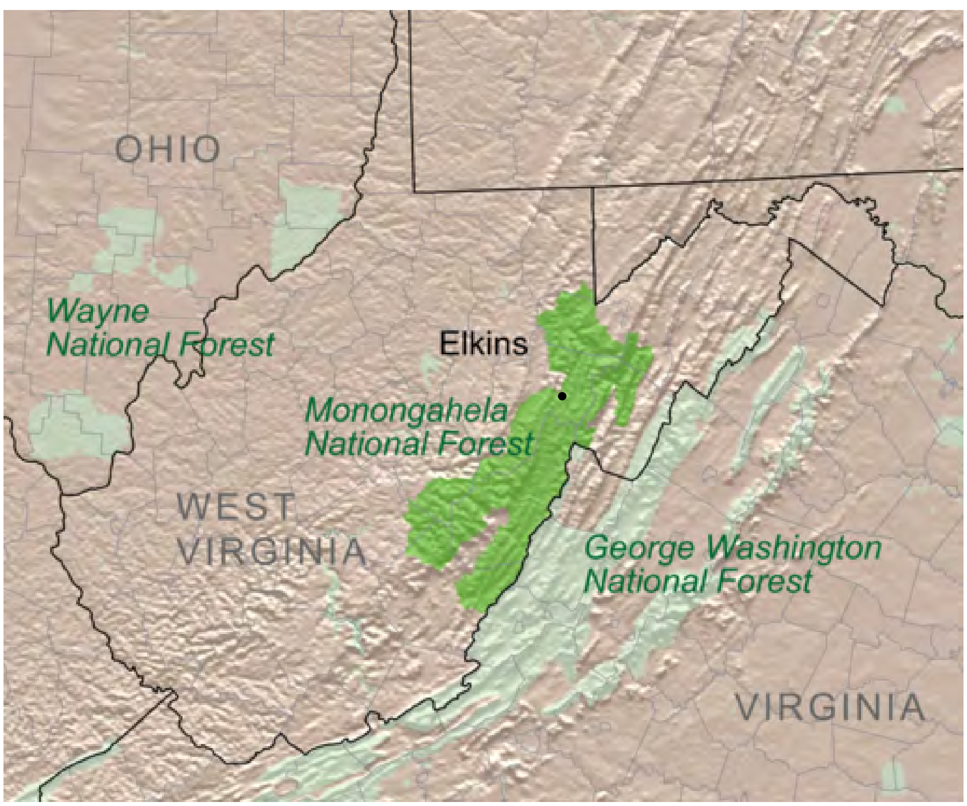

Black dot indicates site of Middle Mountain Long-term soil Productivity Study.
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Measuring tree heights for Middle Mountain Long-term Soil Productivity Study, 1997. Photo by Mary Beth Adams, USDA Forest Service.

INTRODUCTION

Environmental and forest management issues can be complex in space and time and often require large-scale research studies to sufficiently address this temporal and spatial variability. The effects of air pollution on forest productivity and ecosystem processes is an example of such an issue. Although a considerable amount of research has addressed the effects of air pollutants on trees and forests (Driscoll et al. 2001, Menz and Seip 2004), our understanding of air pollution and land management effects and their interactions, and interactions with other perturbations such as climate change, is incomplete (Adams et al. 2000). Long-term large-scale forest experiments can study these interactions and provide information to help manage forests sustainably into the future. Such long-term experiments require careful documentation and monitoring over time, and it may be years before research results become available (Bailey et al. 2015).

The U.S. Long-term Soil Productivity (LTSP) Study was initiated in 1989 as an integrated network to examine long-term consequences of soil disturbance on forest productivity (Powers et al. 1996). The project began as a grassroots effort that has since grown partnerships and affiliations with public and private sectors in the United States and Canada, including major universities and the private forest sector. Today, LTSP is an international project that includes more than 100 experimental sites across North America (Powers et al. 2014). Collectively, these sites represent the world's largest coordinated research network addressing basic and applied science issues related to soil science and forest productivity.

A major concern related to forest productivity and soil processes in the central Appalachians and globally is the issue of acidic deposition (particularly elevated levels of nitrogen [N] and sulfur [S] deposition), with resulting soil acidification, base cation depletion, N saturation, and effects on the productivity, diversity, and sustainability of central Appalachian hardwood forests (Adams 1999). To address these concerns, an experiment was initiated in 1996 on the Fernow Experimental Forest (Adams et al. 2004), as an affiliate of the North American LTSP Study. The first LTSP Study site in West Virginia is known as the Fork Mountain LTSP and is situated in a mesic mixed hardwoods forest. In 1997, a second experiment was initiated on the Loop Road Research Area of the Monongahela National Forest; the Loop Road area is managed by the Forest Service's Northern Research Station for silvicultural research. This second site was chosen because it represents a different forest type (a cherry-maple forest) than the Fork Mountain LTSP Study site, but it has the same objectives and hypotheses. Known as the Middle Mountain LTSP, it is also an affiliate of the North American LTSP Study program. This publication describes the Middle Mountain forest prior to initiation of the experiment and also describes its establishment.

Goals for the Middle Mountain LTSP Study include:

1) Characterize the productivity, diversity, and biogeochemistry of a forest system hypothesized to be sensitive to base cation removal through harvest removals and continuing inputs of nitrogen and sulfur.
2) Determine the response of this forest community to base cation removal.
3) Create new and modify existing vegetation/nutrient/hydrologic models to describe and simulate forest change in response to base removals, nitrogen and sulfur inputs, and mitigating base additions.

This publication addresses Goal 1. An approved study plan for the West Virginia Long-term Soil Productivity Study is on file at the USDA Forest Service Timber and Watershed Laboratory, Parsons, WV.

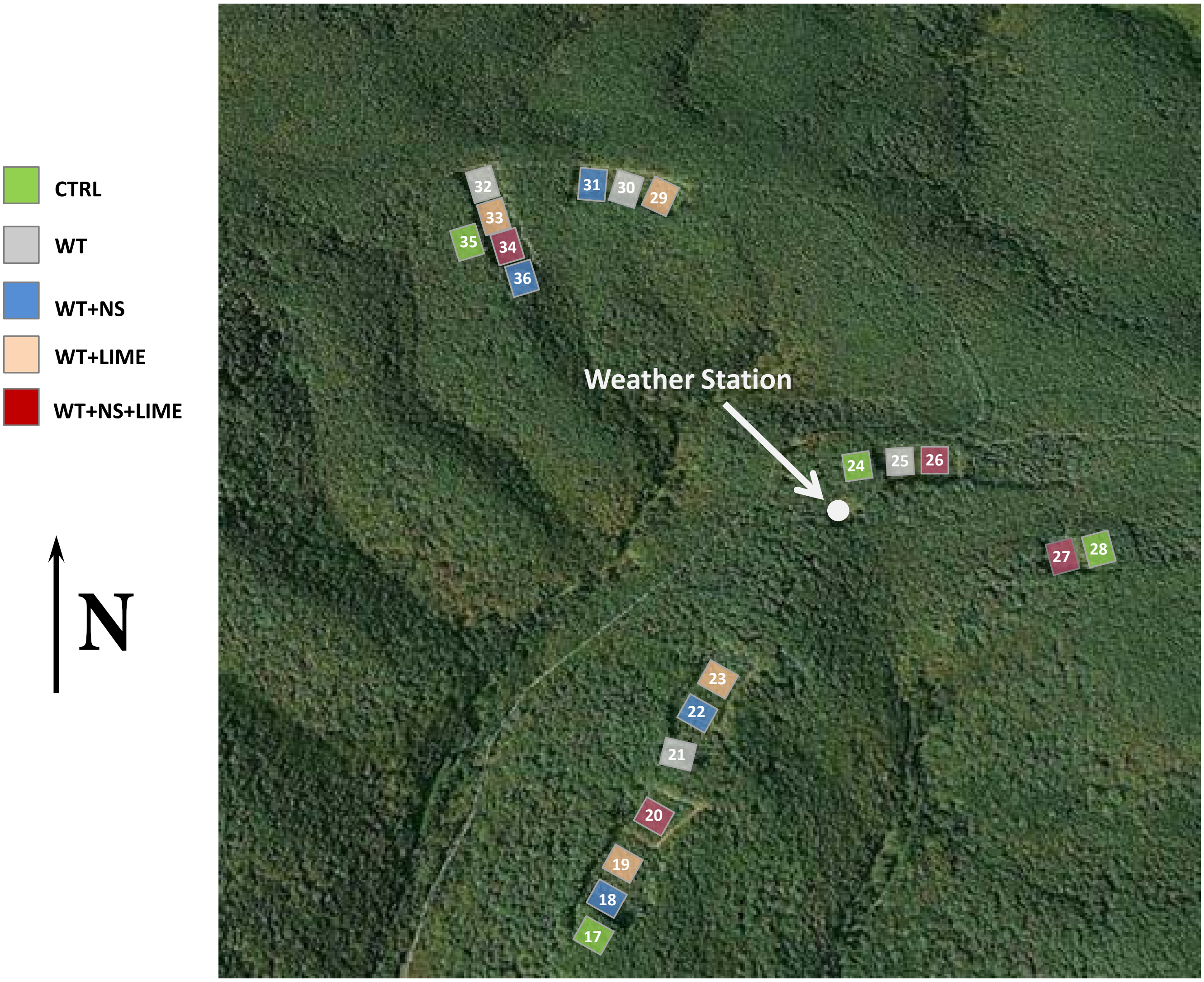

Figure 1.—Aerial view of Middle Mountain Long-term Soil Productivity Study showing plot arrangement and treatment assignments. For block assignments, see Table 1.

METHODS

Location of Experiment

The experiment is located on the Loop Road Research Area on Middle Mountain, within the Monongahela National Forest in Pocahontas County, West Virginia (38°38′15′N, 79°42′30″ W) (Fig. 1), and was established in the summer and autumn of 1997. The Loop Road Research Area was initially set aside for research use in 1980. Elevations range from 1072 to 1129 m (3520 to 3707 feet). Landforms include mostly convex ridgetops and sideslopes. Aspect is generally southern, although most of the plots (0.4047 ha) are located on or near the ridge tops, and slopes are generally less than 20 percent. Annual precipitation averaged 138 cm distributed evenly throughout the year (1961–1990), with 241 cm average annual snowfall. The average annual temperature was 7.55 °C. (http://usclimatedata.com/climate.php?location=USWV0285).

At the initiation of this study, trees on this forested site were mature. These stands originated following heavy timber cutting around 1920 (Miller 1997), and were typical of a black cherry-maple forest type (SAF forest cover type 28; Eyre 1980) of moderate fertility. The overstory included black cherry, American beech (for scientific names, see appendix 1), red maple, sugar maple, and striped maple. Site index for black cherry in the study area is 23 m at base age 50 years. The study area is located within M221B ecological region, the Allegheny Mountain Section of the Central Appalachian Broadleaf Forest Province (McNab and Avers 1994).

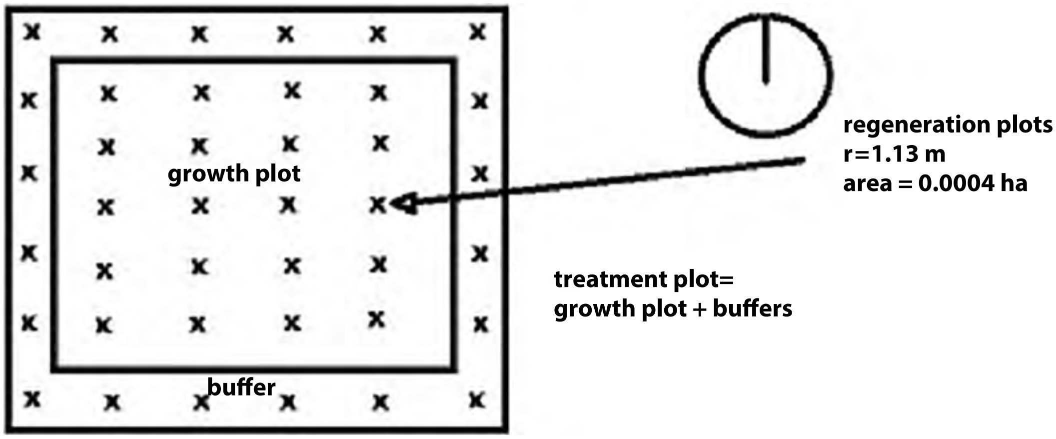

Figure 2.—Schematic of plots used in Middle Mountain LTSP Study. See text for details.

Table 1.—Percentage of subplots within growth plots with specific surface characteristics on Middle Mountain LTSP Study site, with block and treatment assignments

Growth Plot	Block	Treatment	Browsed	Slash	Stony surface
17	I	REF	0	95	0
18	I	WT+NS	5	95	0
19	I	WT+LIME	0	95	0
20	I	WT+NS+LIME	0	90	0
21	I	WT	10	100	0
22	II	WT+NS	0	100	0
23	II	WT+LIME	5	100	0
24	II	REF	0	85	5
25	II	WT	20	85	0
26	II	WT+NS+LIME	30	100	0
27	III	WT+NS+LIME	10	85	0
28	III	REF	5	95	20
29	III	WT+LIME	15	95	0
30	III	WT	10	100	0
31	III	WT+NS	0	100	0
32	IV	WT	15	95	0
33	IV	WT+LIME	10	95	0
34	IV	WT+NS+LIME	15	15	0
35	IV	REF	15	100	0
36	IV	WT+NS	25	100	0
Mean			9.5	91.25	1.25

Description of Experiment

Treatment plots consisted of a growth plot 0.2 ha in size (45.7 m on a side corrected for slope), bordered by a 7.6 m wide buffer strip on each side for a total treatment plot area of 0.4047 ha (Fig. 2). There are four blocks, designed to take into account spatial variation across the site, while capturing available ridgetop sites (Table 1). The experimental design is a randomized complete block design. Each of the 20 treatment plots received one of five experimental treatments:

- Whole tree harvest (all aboveground woody biomass removed >10-cm diameter; WT)
- Whole tree harvest + ammonium sulfate additions (WT+NS)
- Whole tree harvest + liming only (WT+Lime)
- Whole tree harvest + ammonium sulfate + liming (WT+NS+Lime)
- No treatment (REF)

The ammonium sulfate fertilizer addition is designed to accelerate base cation leaching from the soil and is based on other research (Adams et al. 1997, Peterjohn et al. 1996), which demonstrated a significant increase in leaching of Ca and Mg in response to fertilization at rates equal to twice ambient N and S deposition rates. Ambient rates of deposition in throughfall on the Fernow Experimental Forest were estimated to be 15 kg N/ha/yr and 17 kg S/ha/yr (Helvey and Kunkle 1986). Fertilizer treatments are applied three times per year (March, July, November), with treatments starting in March 1998. The addition of dolomitic lime (WT+NS+Lime) tested whether simple amelioration techniques can be used to mitigate base cation losses and evaluate whether a pre-existing Ca or Mg deficiency existed on this site (WT+Lime). Dolomitic lime is applied at a rate twice that of the export rate of Ca from a reference watershed on the Fernow Experimental Forest. Stream water exports from that watershed are approximately 11.25 kg Ca/ha/yr and 5.83 kg Mg/ha/yr (Adams et al. 1997). Control plots will provide an untreated, uncut reference (See Fig. 1 for treatment assignments to plots). The vegetation was allowed to regenerate naturally on all harvested plots after the whole tree harvest.

Felling and harvesting occurred between August and November 1997. On each plot, trees were felled at the ground line and skidded off the plots using a cable and logging crane to minimize disturbance. Tops and slash were pushed off the plots with a bulldozer in a minimal number of passes; note that disturbance to the site was minimal, as leaf litter was mostly intact, and there was no obvious compaction. All logging decks were seeded, limed, and fertilized after completion.

Sampling and Measurements — Site Characteristics

Prior to tree removal, various surface properties were assessed at each of the regeneration plots, including evidence of deer browsing, presence of slash taller than 1.2 m, presence of soil disturbance, soil compaction, surface stoniness (defined as >35 percent surface stone), and surface wetness. These parameters were estimated visually and classified according to whether they might interfere with tree regeneration. For each growth plot, the presence or absence of these parameters was recorded at each regeneration plot and values expressed as percentage of regeneration plots with these characteristics.

Sampling and Measurements — Productivity and Diversity

Forest productivity measurements included growth of aboveground vegetation (trees, shrubs, herbs), as well as vegetative species diversity. An important component of future forest productivity is reproductive capability, so regeneration also was evaluated in terms of existing tree seedlings and sprouts and the regeneration potential of stored seed in the forest floor (seedbed potential). Methods are similar to those described in Adams et al. (2004), so are abbreviated here.

Overstory Vegetation

Diameter at breast height (d.b.h.), total height, number of logs, crown class, and condition were recorded for all trees greater than 2.54 cm diameter on each growth plot in the spring of 1997. Standing dead trees also were tallied. On the control growth plots (those designated not to receive treatment), all trees greater than 2.54 cm d.b.h. were tagged with permanent metal tags so growth could be followed over time. Basal area (m^2/ha) and density (stems/ha) were summed by species across the 20 plots from these censuses.

Pretreatment aboveground biomass was determined for each growth plot. To accomplish this, unbiased estimates of the green whole-tree biomass weights of all trees greater than 12.7 cm d.b.h. on each growth plot were obtained using the first stage of the probability proportional to size (PPS) method described by Valentine et al. (1987), as applied in Adams et al. (2004). The number of trees weighed on each growth plot, as a percentage of the total number of trees with a d.b.h. greater than 12.7 cm, averaged 6.25 percent and ranged from 4 to 8 percent. The biomass estimates for trees greater than 12.7 cm d.b.h. do not include the weight of foliage. However, tree weights were obtained during August - November 1997. As a result, not all trees were weighed without foliage. For trees weighed with leaves on, green weight minus foliage was estimated by deducting 4 percent of the total weight, based on estimates by Keays (1975) and Young et al. (1979). The dry-weight estimates were calculated by multiplying the treatment plot green-weight estimates by a green-weight-to-dry-weight conversion factor (GDCF). These tree weights were estimated using both the green and dry biomass equations developed by Brenneman et al. (1978) for Appalachian hardwood tree species, such that the GDCF obtained for each treatment plot reflects both the species composition and diameter distribution unique to that plot. For the 16 treated (noncontrol) plots, GDCF values were relatively consistent, ranging from 0.589 to 0.627. Because trees were not cut on the four control plots, it was not possible to estimate biomass using the same PPS methods applied to the treated plots. However, tree weight data collected from the adjacent treatment plots was incorporated into the estimates of control plot biomass.

The mass of trees between 2.54 and 12.7 cm d.b.h. was estimated using Brenneman et al. (1978) equations. All woody vegetation smaller than 2.54 cm d.b.h. and taller than 0.3 m also was removed and weighed for each treated growth plot. Estimates for the control plots were calculated from the mean of the values for the treated plots in the same block.

Regeneration, Shrubs, and Herb Layer Plots

Twenty 0.0004-ha circular regeneration plots were established on each growth plot (Fig. 2), and the center marked with a metal stake (radius =1.13 m). Each of these regeneration plots was visited in late June/early July 1997 and woody regeneration was counted by species, height class, and origin (seedling versus sprout). The percentage surface cover was estimated for woody regeneration and competing vegetation. All herbs and shrubs were then tallied on one-fourth of each regeneration plot. An additional 20 regeneration plots were established in the buffer area around each measurement plot and woody regeneration, herbs, and shrubs tallied on these plots. On five of these buffer regeneration plots, one-fourth of each plot served as a clip plot, where all aboveground vegetation (herbs and shrubs/trees <2.54 cm diameter, and <1 m height) was clipped at the ground line, placed in paper bags, oven-dried, and weighed.

Seedbed Potential

To characterize regeneration potential of the seedbed, we used methods similar to those of Wendel (1987) and as described in Schuler et al. (2010). In March 1997, five 30 cm × 30 cm × 10 cm deep samples of the forest floor and mineral soil were collected from each of the treatment plots. To minimize disturbance from repeated samples and sampling, four of these samples were collected from the buffer areas, and one sample from the interior of the growth plots. Samples were placed in wooden trays with screen fabric bottoms and transported to the Timber and Watershed Laboratory, where they were watered regularly and seeds were germinated. Woody regeneration was tallied by species in each tray twice during the growing season: in July and September. The counts were averaged per plot and densities calculated. Only the September data are presented here.

Leaf Fall Mass

Freshly fallen leaf litter samples were collected in autumn 1997 from the control plots, using 0.9 m × 0.9 m collectors. One collector was placed in the center of each control plot, the litter collected several times during autumn leaf fall, and samples were dried and weighed.

Coarse Woody Debris

All downed woody debris larger than 10 cm diameter and longer than 30 cm, and all stumps less than 1.4 m tall (snags were captured in tree tally) were measured on each growth plot. Two diameters (large end and small end; on very long pieces, several diameters, to capture taper) and length of each piece of down wood were recorded along with species and decay class (See Adams and Owens 2001 for a description of the decay classes; generally, class I is the least decayed, and class IV the most decayed). Samples also were collected for nutrient analyses by species. Volume of down wood was calculated using Smalian's equation (Husch et al. 1972) for log volume:

$$\mathbf{V = ((B+S)/2)\ L}$$

where B = cross sectional area at butt end, S = cross sectional area at small end, and L=length. Biomass was calculated using published specific gravity values for each species and decay class (Adams and Owens 2001). Biomass of standing dead trees was estimated from diameters and heights, and density values for class II dead wood from Adams and Owens (2001) were used for the appropriate species.

Vegetation Diversity

Species richness and diversity were estimated from measurements collected on growth plots as described above. Richness is defined as the total number of tree or plant species recorded on the growth plots. Tree inventory data were used to calculate relative density (RD), relative basal area (RBA), and an importance value (IV) for each overstory species on each growth plot and for the entire site; importance value = (RD+RBA)/2 (Jenkins and Parker 1997). Relative importance values also were calculated for herbs and shrubs (based on number of plants/species relative to total number). The Shannon diversity index (H′) and Simpson's evenness also were calculated for each vegetation strata for each growth plot (Magurran 1988).

Sampling and Measurements — Biogeochemistry

Vegetation and soil nutrient pools and solution chemistry were estimated during spring and summer 1997. All tissue and soil nutrient analyses were conducted at the University of Maine Soil and Plant Testing Laboratory using protocols described by Adams et al. (1995). Soil solution samples were analyzed at the USDA Forest Service Timber and Watershed Laboratory in Parsons, WV (Adams et al. 2006, Edwards and Wood 1993).

Foliar Chemistry

Foliage was collected from dominant/codominant trees of four species (American beech, black cherry, red maple, and sweet birch) during July 1997. Samples were collected from the upper crown of two trees/species/treatment plot, where present. However, not all tree species were found on all plots, and significant missing values make statistical analysis impractical. Foliage samples were dried and ground (1-mm mesh) and analyzed for N, Ca, K, Mg, P Al, B, Cu, Fe, Mn, and Zn at the University of Maine Analytical Laboratory, using established techniques (Adams et al. 2004).

Soil Properties

In June of 1997, soils were sampled from three randomly located pits per treatment plot. A 30.5 cm × 30.5 cm square template was placed on the soil surface, and the surface organic horizons were collected from within the template by cutting around the edge with a knife (Oi and Oe+Oa layers, separated), and placed in paper bags. Then the top mineral soil layer (0-15 cm) was removed within the same 30.5 × 30.5 cm area, gravels and cobble-sized materials were removed. The soil was removed from the 15-30 cm horizon, subsampled, and the process repeated for the 30-45 cm layer. These depths roughly correspond with mineral soil horizons (A, BA, and the Bw, BE, or BC) determined from the soil reconnaissance (See appendix 2 for soil profile descriptions). To calculate nutrient contents, bulk density values from Mandy soils were used (Jenkins 2002).

N Cycling in the Soil

Nitrogen mineralization and nitrification were assessed June through mid-August of 1997 using techniques of Gilliam et al. (1996, 2016). On each of four subplots within a treatment plot, the surface litter layer was removed from a small area, and soil samples collected to a depth of 10 cm and placed in plastic bags. One bag was returned to the soil to incubate *in situ* for a month, and the other was returned to the laboratory. All samples were stored on ice for transport and until processing. Rocks and twigs were removed and samples gently sieved, and about 15 g subsamples weighed into plastic jars. Into each 15-g sample, 150 mL 1N KCl was added, the sample shaken for 30 seconds, then filtered after 24 hours. Net mineralization and net nitrification were determined from the change in nitrate and ammonium pools over the 1-month incubation period and averaged across subplots. An additional 10 g sample was used to determine moisture content and organic matter content (loss on ignition).

Soil Solution Chemistry

Tension lysimeters were installed within the growth plots in March 1997, and the first samples were collected in April 1997. Three lysimeters per growth plot were installed to a depth of about 1 m (to be below the rooting zone) at approximately a 45-degree angle. Lysimeters were placed to capture the variability of each growth plot. Samples were collected approximately monthly when sufficient solution was available. On the harvested plots, lysimeters were removed during the harvesting, and soil solution was only collected from control plots. Soil solution was analyzed for ammonium (NH_4), nitrate (NO_3), Ca, Mg, Na, K, Cl, SO_4, pH, and alkalinity, using methods and QA/QC protocols detailed in Edwards and Wood (1993). Lysimeters that were removed prior to harvesting were reinstalled in November 1997.

Other Measurements

Soils were described by Don Flegel, USDA Natural Resources Conservation Service soil scientist, from three pits distributed across the study area. Descriptions are provided in appendix 2. Based on these descriptions, soils are classified as Mandy series (loamy skeletal, mixed active Frigid Spodic Dystrudepts). Soils are derived from shale or sandstone and shale.

Table 2.—Basal area, mean d.b.h., and standard deviation, density, and relative importance value by species of live trees >2.54 cm diameter. Basal area and density are summed across twenty 0.2-ha growth plots on Middle Mountain LTSP Study, 1997.

Species	Basal area	Mean d.b.h. (std. dev.)	Density	Importance value
	m^2/ha	*cm*	*number/ha*	
Black cherry	21.990	32.58 (7.30)	251	32.84
Red maple	13.270	18.82 (8.46)	396	27.12
American beech	2.460	6.27 (4.18)	551	19.26
Sugar maple	2.990	12.29 (9.06)	164	8.33
Red spruce	0.770	6.20 (2.55)	218	7.38
Sweet birch	0.700	18.57 (7.78)	22	1.46
Striped maple	0.080	4.54 (2.76)	35	1.13
Downy serviceberry	0.250	13.00 (3.96)	17	0.80
White ash	0.460	27.99 (7.96)	7	0.74
Cucumbertree	0.290	25.04 (16.16)	4	0.46
Yellow birch	0.080	15.70 (6.75)	4	0.21
Eastern hemlock	0.010	5.87 (2.57)	4	0.13
Northern spicebush	0.003	3.25 (0.72)	4	0.12
Blackgum	0.001	3.89 (1.69)	1	0.03
Fraser magnolia	0.010	18.67 (3.41)	1	0.03
Total	43.374		1679	100.00

Statistical Analyses

For descriptive and characterization purposes, means and standard deviations were calculated across the area, by plot and by block, and ranges are provided for some variables. To analyze for spatial variability within the site, the data were analyzed using SAS GLM program (SAS Institute, Cary, NC), with the following model: Variable = block treatment. All effects are fixed effects. A significant block effect was interpreted as an indication of spatial patterns worthy of additional review. Data were transformed as necessary to meet the assumptions of normality. Results were evaluated at the 95 percent probability level to determine statistical significance.

RESULTS AND DISCUSSION

Site and Plot Characteristics

Prior to initiation of the experiment, the research area was relatively unaffected by recent disturbance, with the exception of deer browsing. Seventy percent of the growth plots had some signs of recent browsing by deer (Table 1). Slash and small woody debris less than 120 cm tall were reported on most of the growth plots. Ten percent were described as stony, and none were compacted or wet or otherwise disturbed.

Productivity and Diversity

Twelve commercial tree species and three noncommercial species were recorded in the pretreatment survey of stems greater than 2.54 cm d.b.h. Stand density was 1679 stems/ha (Table 2), and nearly 60 percent of these stems were less than 12.7 cm d.b.h. These values are comparable to those reported by Miller (1997) for an adjacent study area. The overstory (trees >12.7 cm d.b.h.) was dominated by four tree species: black cherry, red maple, American beech, and sugar maple. The largest diameter tree recorded on the plot was a 71.1 cm sugar maple. Average tree height across all species was 22.6 m (standard deviation [std. dev.] = 4.8 m). Understory trees (2.54 to 12.7 cm d.b.h.) were predominantly American beech (52 percent of stems) followed by red spruce, sugar maple, and red maple. Black cherry was ranked highest in importance value, closely followed by red maple. The abundance of small red spruce was sufficient to rank it fifth in importance value. The number of tree species found on a growth plot ranged from 6 to 12 (species richness). The average plot-level Shannon index (H') for tree species was 1.768, and the Simpson's evenness value was 0.211.

There were 262 standing dead trees per hectare across the site with a total basal area of 3.51 m^2/ha (Table 3). Most (62.6 percent) of the standing dead trees were

Table 3.—Standing dead trees from 1997 tree survey. All trees >2.54 cm d.b.h. Basal area and density are summed across twenty 0.2-ha growth plots on Middle Mountain LTSP Study, 1997. Scientific names for all species are listed in appendix 1.

Species	Number of trees	Basal area (m^2/ha)	Density (trees/ha)	Relative basal area	Relative density	Importance value
Black cherry	323	1.833	79.8	52.270	30.520	41.400
Red maple	251	0.611	62.0	17.430	23.720	20.570
Beech	198	0.205	48.9	5.860	18.710	12.280
Sweet birch	63	0.383	15.6	10.940	5.954	8.450
Sugar maple	94	0.215	23.2	6.147	8.884	7.516
Red spruce	53	0.062	13.1	1.786	5.009	3.397
Common serviceberry	22	0.055	5.4	1.582	2.079	1.830
Striped maple	17	0.040	4.2	1.167	1.606	1.387
Hemlock	21	0.019	5.2	0.558	1.984	1.271
Yellow birch	9	0.046	2.2	1.315	0.850	1.083
White ash	2	0.011	0.5	0.335	0.189	0.262
Bigtooth aspen	1	0.012	0.2	0.342	0.094	0.218
Pin cherry	1	0.007	0.2	0.206	0.094	0.150
Northern spicebush	2	0.001	0.5	0.014	0.189	0.101
Fraser magnolia	1	0.002	0.2	0.046	0.094	0.070
Total	1058	3.502	261.2	99.998	99.976	99.985

Table 4.—Number and volume of coarse woody debris pieces by species for Middle Mountain LTSP Study site, 1997, by decay class, summed across twenty 0.2-ha growth plots. Decay class I (DC I) is the least decayed, and class IV is the most decayed.

Species	Pieces	Volume (m^3/ha)	Trees per decay class I	II	III	IV
Black cherry	312	86.30	64	50	107	91
Sweet birch	169	58.72	32	33	69	35
Red maple	161	31.07	56	30	55	20
American beech	19	13.55	12	3	4	0
Sugar maple	28	11.15	11	6	9	2
Yellow birch	35	8.49	4	9	15	7
Striped maple	18	4.11	5	5	6	2
Red spruce	6	3.21	3	0	3	0
Common serviceberry	5	1.08	4	0	1	0
Cucumbertree	1	1.05	1	0	0	0
White ash	4	0.61	0	2	2	0
Unknown	3	0.44	0	0	0	3
Sum across all plots	761	219.78	192	138	271	160

less than 12.7 cm d.b.h. and only four trees (less than 1 percent) were larger than 38 cm d.b.h. Standing dead trees reflect the overstory composition, as black cherry, red maple, and beech made up almost 75 percent of the standing dead trees based on importance value.

Only four stumps were recorded across the site (three black cherry and one beech stump), providing further evidence that there has been relatively little recent harvesting. Coarse woody debris volume across the growth plots averaged 11.2 m^3/ha (Table 4) and was fairly evenly distributed among the four decay classes. The species composition of coarse woody debris also approximated that of the overstory: black cherry was the most abundant, followed by sweet birch, red maple, and beech. The largest piece of coarse woody debris (sugar maple) had a large end diameter of 59 cm.

In the herbaceous layer, 39 species of plants were identified, including 9 tree species. In addition, there

Table 5.—Herb layer species density and importance value, summed across twenty 0.2-ha growth plots on Middle Mountain LTSP Study, 1997

Species	Density (plants/ha)	Importance value
Black cherry	321,100	45.28
Yellow oxalis	86,549	12.21
Unknown/unable to identify	57,551	8.12
Striped maple	49,400	6.97
Red maple	29,714	4.19
Wood anemone	28,405	4.01
Canada mayflower	26,269	3.71
Eastern hayscented fern	12,048	1.70
Christmas fern	10,827	1.53
Greenbrier	9,139	1.29
Spinulose woodfern	8,707	1.23
Indian cucumber	8,186	1.54
Sedge, American beech, blackberry, ramp, partridgeberry, lettuce, trillium, sugar maple, Carolina springbeauty, smooth Solomon's seal	2,000-6,000	6.58
Violet, wild yam, Indian cucumber, grass, cucumbertree, deciduous holly, birch, hawthorne	500-2,000	1.64
All others	<500	
Total	709,090	

was a significant number of plants that were not identified ("unknown" in Table 5; see appendix 1 for a list of all plant species encountered on these plots). The most abundant plants in the herb layer census were black cherry seedlings, which made up about 45 percent of the herb layer, and yellow wood sorrel. Striped maple and red maple seedlings also made up a substantial part of the herb layer. While ferns were found on all but one plot, the three fern species collectively accounted for 4.45 percent of the total cover, and only on two of the plots did fern cover exceed 20 percent (plots 26 and 33). Herb biomass averaged 375 kg/ha (std. dev. = 730). The mean plot-level Shannon's diversity index (H') for the herb layer was 2.851 with an evenness value of 0.773.

Fifteen woody species were recorded during the woody regeneration survey (Table 6). However, two species (striped maple and black cherry) made up almost 50 percent of the woody regeneration, and four species (adding beech and red maple) accounted for 75 percent of the woody regeneration. Although red spruce was a substantial part of the overstory (IV = 7.38; Table 2), red spruce regeneration made up less than 1 percent of the regeneration tallied across the site. Most regenerants were of seedling origin, with 15 percent as sprouts on average; almost all of the beech were of sprout origin (83 percent), while among the three maple species, less than 8 percent were sprouts. Very little of the regeneration was sapling size (1 m in height), and 68 percent of stems were less than 15 cm in height.

The seedbed potential survey identified a density of about 115 seedlings per m^2 (463,914 per acre), which is similar to the values reported by Wendell (1987) for a lower site index site near the Fernow Experimental Forest and are also comparable to those reported in Schuler et al. (2010) prior to prescribed burning, although the species mixtures are different. For the Middle Mountain LTSP Study site, three tree species dominated the survey of seedbed regeneration potential: pin cherry, sweet birch, and black cherry (Fig. 3). Thus, the seedbed potential reflected the overstory species, but with some significant exceptions. There was a significant amount of pin cherry in the seedbed, but this species was lacking in the overstory. Beech was not observed in the seedbed potential study but made up 32 percent of stems in the overstory. Finally, Hercules club showed up only in the seedbed potential survey, not in the overstory or woody regeneration plots. In this region, beech predominantly regenerate via root suckers (sprouts), and true seedlings are rare. Therefore beech would be unlikely to show

Table 6.—Woody regeneration, summed across twenty 0.2-ha growth plots on Middle Mountain LTSP Study, 1997

Species	% of total	% seedlings	% sprouts
Striped maple	26.31	96.21	3.79
Black cherry	21.86	99.05	0.95
Beech	14.67	17.28	82.72
Red maple	13.72	92.42	7.58
Common serviceberry	8.98	97.69	2.31
Sugar maple	5.69	91.97	8.03
Greenbrier	3.33	100.00	0.0
Cucumbertree	2.12	100.00	0.0
Blackberry	1.58	100.00	0.0
Others:	<1 % each	97.62	2.31
Mountain ash			
Deciduous holly			
Hawthorn			
Black locust			
Sweet Birch			
Red spruce			

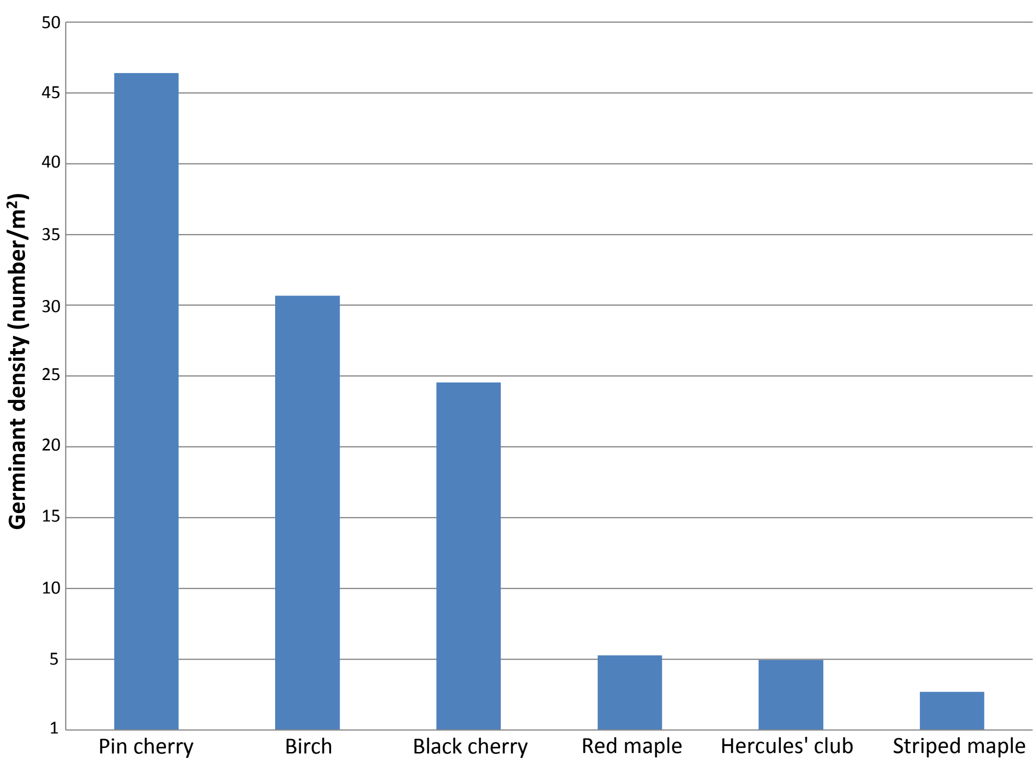

Figure 3.—Density of germinants of six dominant species of trees, summed across all plots, from seedbed potential assay from Middle Mountain LTSP Study, 1997.

up in the seedbed. Pin cherry and Hercules club are relatively short-lived trees (~30 years) (Stevens and Perkins 1992, Wendel 1990), and both are shade-intolerant, therefore, these species may have already exited the overstory years ago. Pin cherry seed can remain viable for 10 years or more in the forest floor (Grisez et al. 2008). Though seeds from *Aralia* spp. have been found in seed banks, the longevity of the seed is not known (Zasada and Blum 2008). Seeds from these species often germinate readily after a disturbance that creates light on the forest floor. By removing the seedbed samples to a greenhouse, the amount of light to the seedbed substantially increased, simulating such a disturbance and stimulating germination.

Table 7.—Aboveground vegetative biomass by plot, Middle Mountain LTSP Study site, 1997

	Aboveground biomass (kg/ha)				
Plot number	Trees >12.7 cm d.b.h.	Trees 2.54 to 12.6 cm d.b.h.	Trees <2.54 cm d.b.h.	Herbs	Total
17	251,276	43,187	184.0	107.9	294,755
18	202,997	55,734	352.0	116.9	259,200
19	244,534	29,661	121.0	95.3	274,412
20	221,188	95,436	154.0	177.2	316,955
21	274,223	50,829	110.0	287.5	325,450
22	271,847	70,133	247.5	219.8	342,448
23	232,503	86,497	198.0	549.0	319,747
24	193,982	44,187	176.0	149.7	238,495
25	215,795	42,426	104.5	269.8	258,596
26	224,282	30,161	154.0	176.8	254,774
27	205,667	54,616	99.0	50.4	260,443
28	209,406	39,530	297.0	160.7	249,394
29	203,464	48,742	407.0	315.6	252,929
30	199,928	73,458	286.0	97.3	272,769
31	220,731	58,379	396.0	996.1	280,503
32	237,804	80,359	517.0	51.7	318,732
33	275,388	43,213	302.5	96.7	319,000
34	262,565	37,031	143.0	110.5	299,850
35	198,880	99,675	274.0	136.4	298,966
36	260,186	52,033	132.0	1112.9	313,464
Mean	230,332.3	56,764.7	232.7	263.9	287543.6
Standard deviation	27,669.9	20,806.9	118.2	294.0	31010.4

Table 8.—Mean and standard deviation of nutrient concentrations in foliage by tree species, collected in 1997, Middle Mountain LTSP Study site

	Sweet birch		American beech		Black cherry		Red maple	
	(n=14)		(n=20)		(n=20)		(n=20)	
Variable	Mean	std. dev.	Mean	std. dev.	Mean	std. dev.	Mean	std. dev.
N (%)	2.32	0.71	2.21	0.24	2.83	0.26	1.93	0.18
P (mg/kg)	1303.6	116.3	1217.8	124.2	1459.5	146.8	1117.0	69.9
Ca (mg/kg)	6595.0	1699.9	5115.5	1503.8	5537.0	850.2	5315.5	1339.6
K (mg/kg)	9007.1	2226.4	6402.5	1360.5	10666.0	1848.8	7816.5	1219.5
Mg (mg/kg)	1701.4	444.0	1148.0	179.4	2281.0	280.6	950.4	200.8
Al (mg/kg)	29.71	8.62	27.41	16.9	39.75	7.91	19.84	7.13
B (mg/kg)	34.91	6.07	29.87	5.38	20.49	2.86	28.32	6.75
Cu (mg/kg)	6.96	1.11	7.20	1.28	6.35	1.07	5.97	1.10
Fe (mg/kg)	66.19	18.31	67.91	22.88	128.58	287.9	51.31	10.13
Mn (mg/kg)	2420.7	269.6	1566.8	375.84	1586.4	613.7	1529.3	600.46
Zn (mg/kg)	161.3	57.2	23.62	4.89	23.15	6.37	20.14	3.90

The estimated aboveground biomass for each growth plot is shown in Table 7. Biomass of large trees averaged about 230,000 kg/ha, ranging from 193,000 to 275,000 kg/ha. Autumn leaf fall mass in 1997 averaged 2600 kg/ha (2.6 metric tons/ha) across the four reference plots (data not shown), or about 1 percent of total biomass.

Biogeochemistry

Foliar nutrient values for the four tree species sampled are presented in Table 8. These mean concentration values generally fall within the range reported for these species on the Fernow Experimental Forest (Adams et al. 1995, 2004). Foliar concentrations of Ca, Mg, Al,

Table 9.—Mean mass and nutrient concentration of organic soil layers (standard deviation) Middle Mountain LTSP Study site, 1997

Variable	Oi layer (n=60)	Oe+Oa layer (n=59)
Mass (kg/ha)	6827.1 (1645.1)	10604.2 (6120.9)
N (%)	1.48 (0.21)	1.85 (0.21)
C (%)	49.35 (5.48)	46.15 (3.22)
Ca (mg/kg)	6628.5 (1381.2)	5831.2 (1661.8)
K (mg/kg)	830.3 (231.9)	949.3 (283.4)
Mg (mg/kg)	517.8 (142.9)	613.5 (171.7)
P (mg/kg)	608.0 (148.5)	842.5 (163.5)
Al (mg/kg)	272.68 (177.22)	1470.41 (1073.97)
B (mg/kg)	12.60 (2.43)	16.45 (6.60)
Cu (mg/kg)	8.26 (1.36)	11.51 (1.95)
Fe (mg/kg)	317.96 (256.68)	2824.85 (2590.51)
Mn (mg/kg)	1901.4 (961.4)	2667.3 (1405.8)
Zn (mg/kg)	32.8 (8.6)	40.9 (10.8)

Table 10.—Mineral soil chemical variables by depth, mean, and standard deviation, Middle Mountain LTSP Study site 1997 (n=20 per depth)

	0-15 cm		15-30 cm		30-45 cm	
Variable	Mean	std. dev.	Mean	std. dev.	Mean	std. dev.
Total C (%)	6.41	4.64	2.69	1.16	1.66	0.87
pH_{water}	3.54	0.50	3.81	0.26	3.97	0.69
Loss on ignition (%)	12.72	5.46	8.05	1.69	6.33	1.83
Total N (%)	0.37	0.16	0.19	0.04	0.13	.05
Ca (mg/kg)	126.00	47.38	46.88	19.71	28.94	11.56
K (mg/kg)	80.10	25.30	49.06	10.49	39.88	10.90
Mg (mg/kg)	32.64	10.53	13.76	3.53	7.80	2.28
P (mg/kg)	13.68	13.94	5.84	2.26	3.39	1.38
Al (mg/kg)	744.63	265.20	1092.46	1351.10	611.12	258.03
Exchangeable acidity ($cmol^+/kg$)	14.12	3.46	17.28	15.67	10.48	3.81
ECEC($cmol^+/kg$)	15.24	3.32	17.76	14.66	10.80	3.88
% Base saturation	7.84	3.78	3.40	1.34	3.08	0.748

and Mn are consistently lower for Middle Mountain sweet birch and black cherry relative to these species on the Fork Mountain LTSP Study (Adams et al. 2004), although nutrient concentrations for red maple are consistent between the two sites.

Mean mass and nutrient concentrations of the organic soil layers (forest floor) are shown in Table 9, and mineral soil chemistry data are shown in Table 10. These soils are quite acidic, with pH values less than 4, although pH increased with depth. Total carbon is highest in the organic soil layers averaging around 45–50 percent. In the mineral soil, the C content decreases from about 6 percent in the 0-15 cm depth to less than 2 percent in the 30-45 cm depth. This pattern holds true for most of the exchangeable nutrients, but not for acidity. Exchangeable acidity increases in the 15–30 cm depth, then declines again in the 30–45 cm depth, while pH increases consistently with depth. Base saturation is highest in the 0–15 cm depth, averaging 7.84 percent and declines significantly with depth.

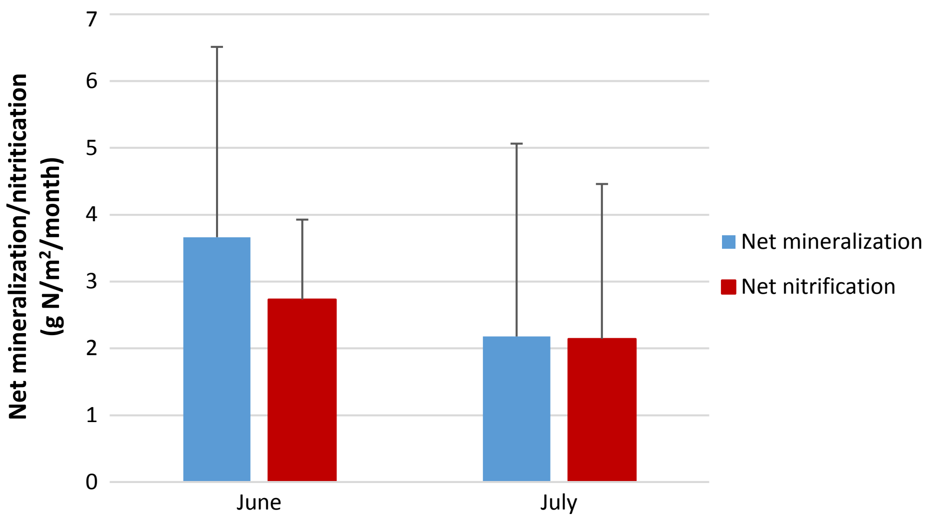

Figure 4.—Mean net mineralization and nitrification in mineral soil (0-10 cm), summer 1997. Vertical bars represent one standard deviation.

Table 11.—Total mass and nutrient stocks, Middle Mountain LTSP Study site, 1997

	Mass	N	P	K	Ca	Mg
	kg/ha					
Big trees (> 12.7 cm d.b.h.)	230,283	466.9	32.9	193.3	676.9	41.9
Small trees (≤ 12.7 cm d.b.h.)	56,997	94.2	6.2	47.6	121.3	10.1
Foliage	2,391	56.5	3.1	20.7	13.0	3.7
Herb layer	264	5.5	1.6	33.9	5.3	4.8
Coarse woody debris	4,715	12.6	0.6	2.2	10.5	0.9
Total aboveground	294,650	635.7	44.4	297.8	827.0	61.4
Forest floor						
Oi+Oe+Oa	17,432	297.2	12.8	15.4	100.6	9.6
Mineral Soil						
0-15 cm	156,000	2921.1	10.7	62.5	98.3	25.4
15-30 cm	322,500	2983.1	9.4	79.1	75.6	22.1
30-45 cm	370,500	2334.2	6.3	73.1	53.6	14.4
Total belowground	866,432	8535.6	39.2	230.1	328.1	71.5

Mean nitrogen mineralization rates ranged from 0.56 g N/m^2/month to 8.05 g N/m^2/month (Fig. 4). Net nitrification ranged from 0.30 to 8.3 g N/m^2/mo. On average, nitrification rates were equal to mineralization rates for the July-August incubation period. These rates of N processing are similar to those reported on the Fernow Experimental Forest (Adams et al. 2004, Gilliam et al. 1996).

Soil solution samples were collected monthly from most plots between May and October 1997, with the exception of plots 21 and 23, from which no samples were collected. (Note: samples were collected from these plots in later years, however). During August-October, soil solution was only collected from the control plots. Mean monthly conductivity ranged from 27-85 µs/cm (Fig. 5) and generally declined through the course of the 1997 sampling period. Soil solution pH, collected below the rooting zone, averaged 5.40 (range = 4.46 to 7.11), so was less acidic than the soil. Variability in solute concentration was also generally greater in the initial months (data not shown), reflecting the effects of the soil disturbance during installation. For most analytes, values declined to a relatively stable value after a few months, with the exception of NO_3 and NH_4, for which the highest concentrations were recorded in October.

Nutrient stocks for the site are presented in Table 11. Most of the N stocks are found belowground in the

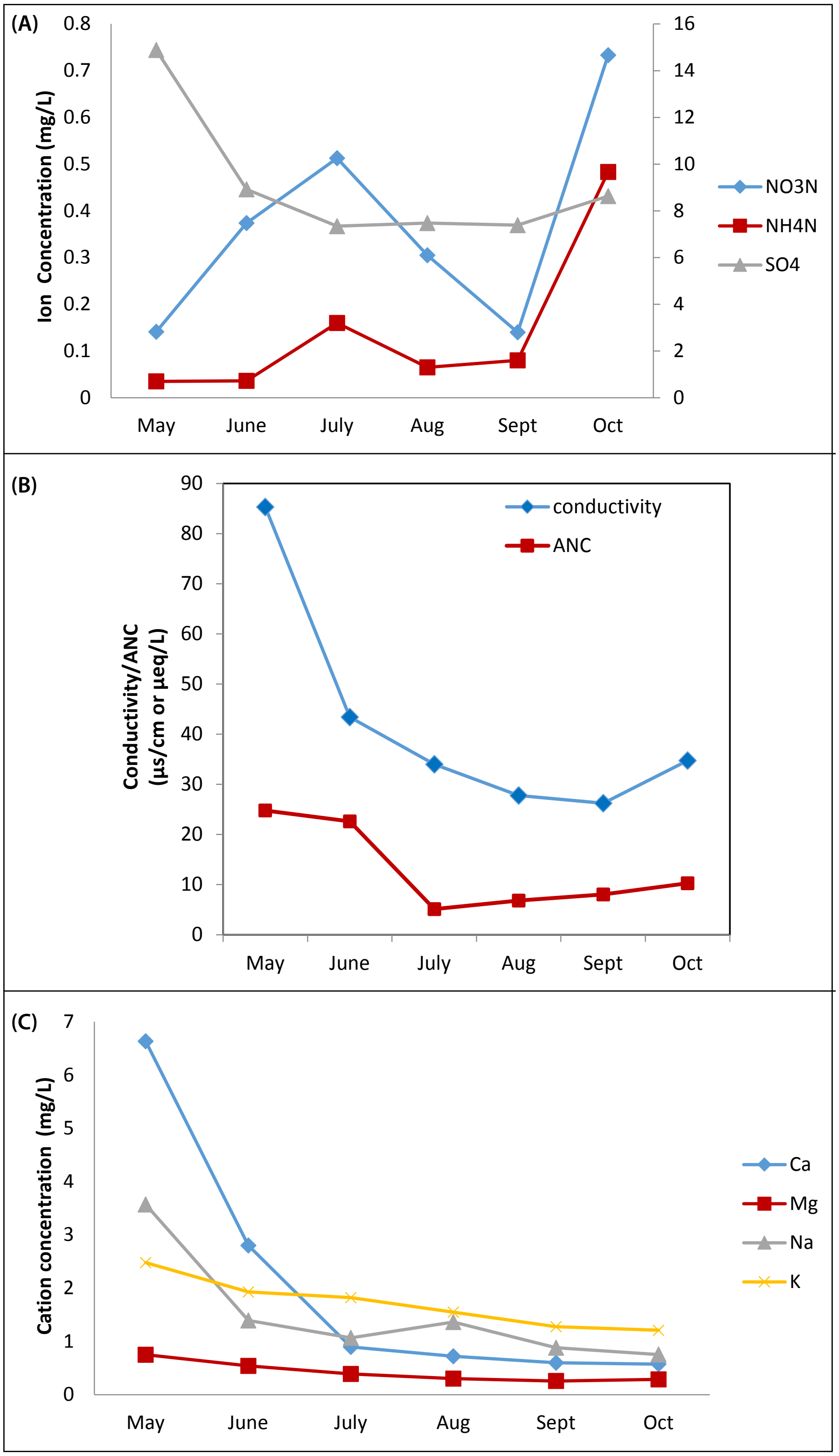

Figure 5.—Pre-experiment soil solution chemistry, collected using tension lysimeters, summer 1997, Middle Mountain LTSP Study site. (A) Mean concentrations of nitrate-N, ammonium-N, and sulfate; (B) mean conductivity and acid neutralizing capacity (ANC); (C) mean cation concentrations.

mineral soil while the aboveground Ca is twice that present in the soil. Other nutrients are relatively evenly distributed between aboveground vegetation pools and soil pools. Overall, mass and nutrients capital values are lower for Middle Mountain than for the Fork Mountain LTSP Study site.

Spatial Variability

The plots are generally ridge-top sites, relatively flat, so that aspect and slope are not highly variable; we hypothesized aspect and slope would not significantly influence site processes and characteristics. However, the plots were replicated in blocks to take into account spatial variability while optimizing use of the flatter ridge top sites. Thus, one indication of spatial variability would be a significant BLOCK effect, and we analyzed vegetative mass and diversity and soil nutrient properties using GLM to evaluate that effect. Statistically significant differences among the blocks were not detected for most of the vegetative biomass parameters (Table 12), with the exception of mass of coarse woody debris, which was significantly greater in block II relative to blocks III and IV (Fig. 6). This difference may reflect differences in species composition (more spruce and hemlock on blocks III and IV, which were generally smaller trees). The mass of the Oe+Oa layers also varied significantly among the blocks, and was significantly greater in block IV relative to block I. (Fig. 7).

Diversity of the overstory (as measured by Shannon's H′ index of diversity) did differ significantly among blocks, as did evenness (Table 12). The most diverse overstory was found in block IV (Fig. 8), followed by block III. Overstory richness (number of species) did not differ among blocks, but there were some species which were not found on all plots. Most notably, red spruce was only found in blocks III and IV, and hemlock was only observed in block IV. Beech and black cherry were the only tree species recorded on all plots.

The diversity of the herb layer (which included small woody vegetation) did not vary among blocks, but woody regeneration diversity and evenness were found to vary among blocks, although the values for diversity were relatively low. Diversity of woody regeneration was highest in block II, in contrast to overstory vegetation (Fig. 9).

A significant block effect was detected for many of the soil variables we sampled, suggesting significant spatial variability in soil nutrients, both across the site and within the soil profiles (Table 13). Potassium (K) concentrations differed significantly among blocks for four out of the five horizons (organic and mineral) analyzed, and Ca, Mg, P, and Al concentrations varied for three of the five horizons. Mineral soil pH was the lowest in block III and was significantly less than block IV for the 15-30 and 30-45 cm depths (Fig. 10). We might expect that exchangeable cations would be the least in the more acidic soils (lower pH), but this is not the case. In the mineral soils, when there was a trend and statistically significant differences, values for exchangeable cations (Ca, Mg, K) were generally highest in block III (data not shown). In the organic horizons, the highest concentrations of base cations were generally found in block I. Interestingly, N concentration did not vary among the blocks, while N cycling, particularly N mineralization, did vary with seasonal average N mineralization rates being greater in block III (Fig. 11).

Table 12.—Results of analysis of variance for Middle Mountain LTSP vegetation. Values represent p values. NS= not statistically significant (p>=0.05).

Variable	Block
Aboveground vegetative mass	
Trees >12.7 cm d.b.h.	NS
Trees 2.5-12.6 cm d.b.h.	NS
Trees < 2.5 cm d.b.h.	NS
Herb layer	NS
Standing dead wood	NS
Coarse woody debris	0.0241**
Total aboveground biomass	NS
Forest floor mass	
Oi mass	NS
Oe+Oa mass	0.0196**
Total forest floor (O horizon) mass	NS
Diversity	
Overstory (tree) diversity (H′)	0.0100**
Overstory (tree) evenness	0.0148**
Overstory (tree) richness	NS
Herb layer diversity	NS
Herb layer evenness	NS
Herb layer richness	NS
Woody regeneration diversity	0.0333**
Woody regeneration evenness	0.0016**
Woody regeneration richness	NS

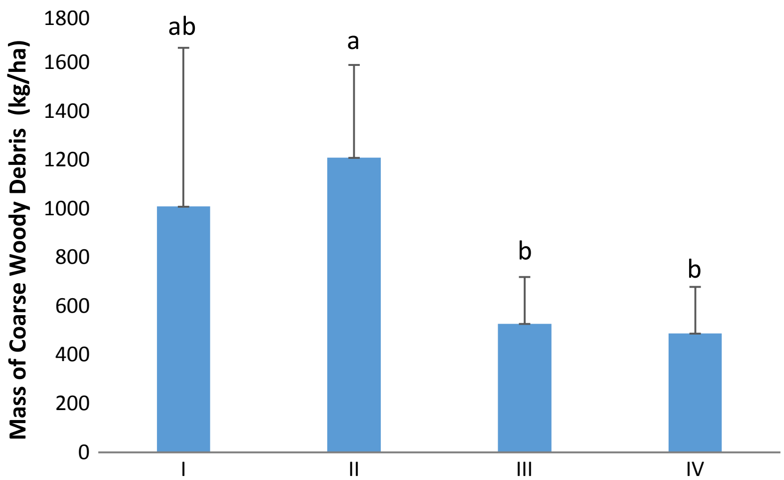

Figure 6.—Mean mass of coarse woody debris, by block, from Middle Mountain LTSP Study site, 1997. Different letters indicate values that are significantly different at p=0.05. Vertical bars represent one standard deviation.

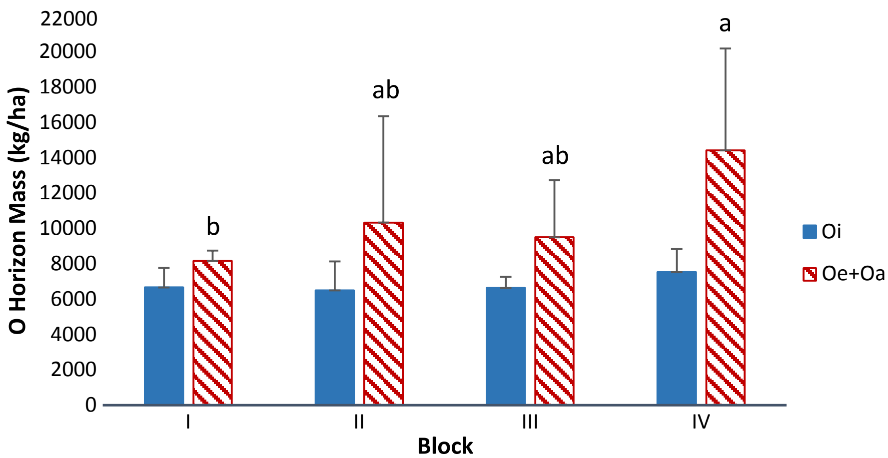

Figure 7.—Mean mass of organic soil layers (forest floor) from Middle Mountain LTSP Study site, 1997, by block. Vertical bars represent one standard deviation. Different letters indicate values that are significantly different at p=0.05.

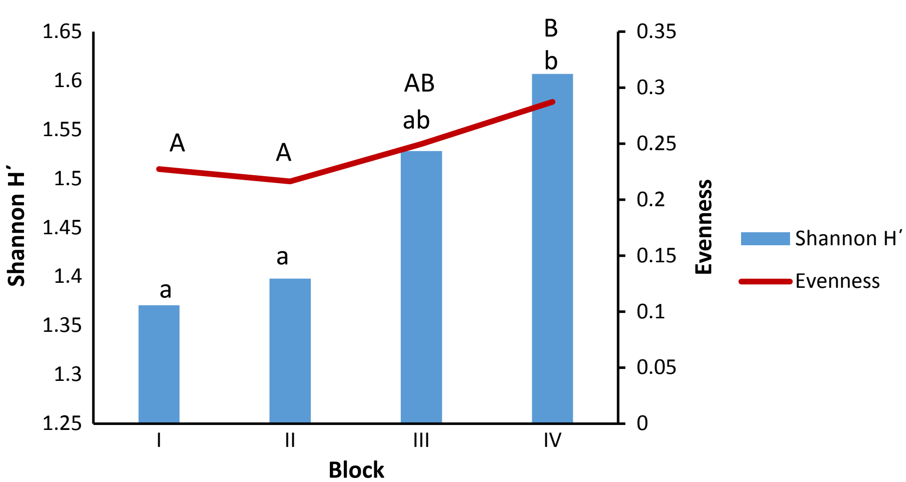

Figure 8.—Average values of Shannon diversity index (H’) and evenness of overstory vegetation, Middle Mountain LTSP Study site, 1997, by block. Different letters indicate values that are significantly different at p=0.05 (lower case letters for Shannon H′, upper case letters for evenness).

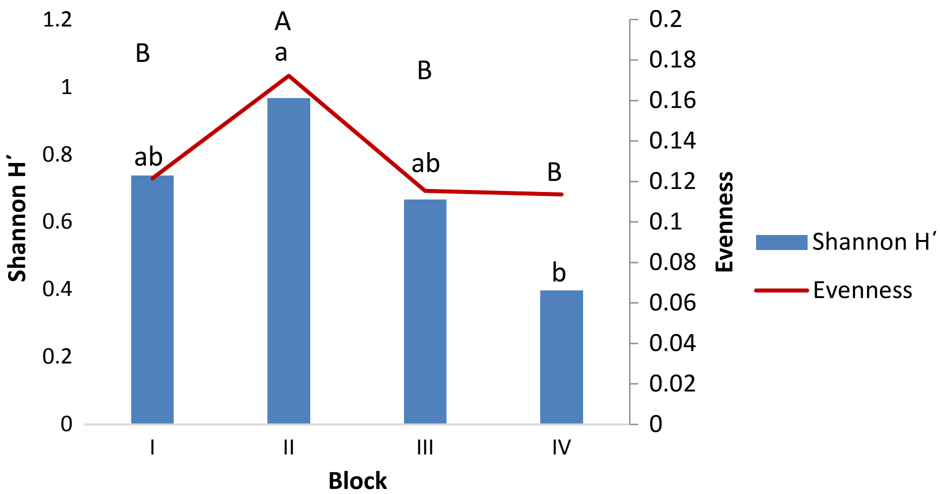

Figure 9.—Average values of Shannon diversity index (H′) and evenness of woody regeneration on the Middle Mountain LTSP Study site, 1997, by block. Different letters indicate values that are significantly different at p=0.05 (lower case letters for Shannon H′, upper case letters for evenness).

Table 13.—Pre-experiment analysis of variance results for a block effect on soil properties, Middle Mountain LTSP Study site. Values represent p values; NS= not statistically significant.

Variable			
Forest floor nutrients	**Oi**	**Oe+Oa**	
Total N concentration	NS	NS	
Total C concentration	NS	0.0398**	
Ca concentration	NS	0.0045**	
Mg concentration	0.0480**	0.0266**	
K concentration	0.0036**	0.0220**	
P concentration	0.0245**	NS	
Al concentration	NS	0.0194**	
		Depth	
Mineral soil nutrients	**0-15 cm**	**15-30 cm**	**30-45 cm**
pH	NS	0.0144**	0.0152**
Total nitrogen conc.	NS	NS	NS
Total carbon concentration	NS	NS	NS
Ca concentration	NS	0.0211**	0.0129**
Mg concentration	NS	NS	0.0003**
K concentration	0.0440**	0.0684*	NS
P concentration	NS	0.0181**	0.0563*
Al concentration	0.0223**	NS	<0.0001**
Nitrogen cycling			
Nitrogen mineralization	0.0030**		
Net nitrification	0.0746*		

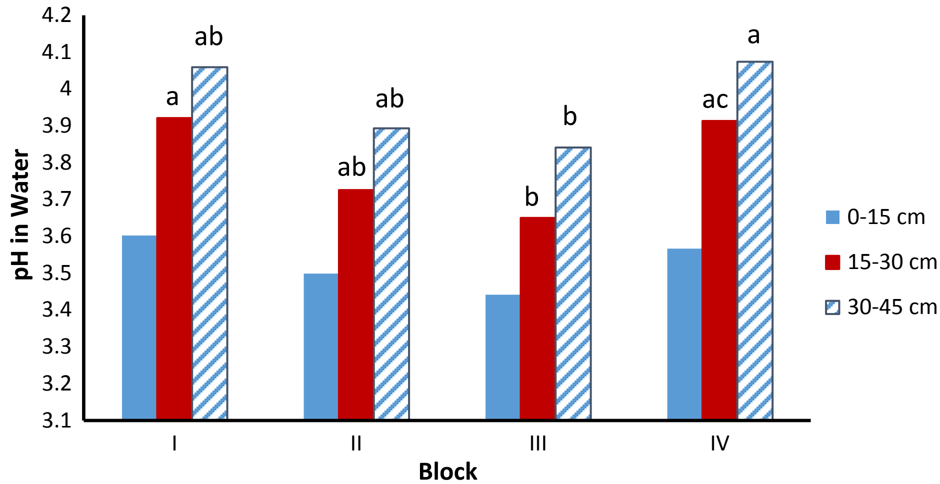

Figure 10.—Mineral soil pH by depth and by block, from Middle Mountain LTSP Study site, 1997. Different letters indicate values that are significantly different at p=0.05.

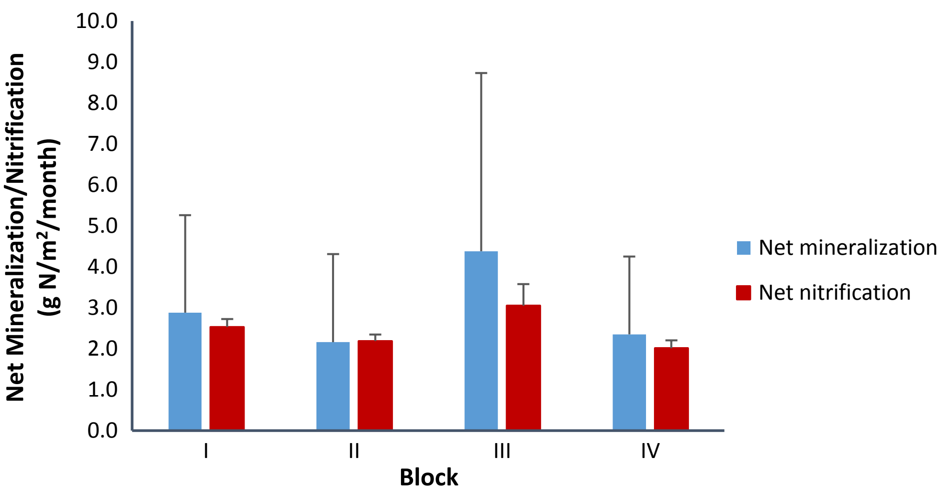

Figure 11.—Mean rates of net N mineralization and nitrification by block, Middle Mountain LTSP Study site, 1997. Vertical bars represent one standard deviation.

CONCLUSIONS

This site represents a black cherry-maple forest type (SAF forest type 28), with some inclusion of red spruce-sugar maple-beech forest type (SAF forest type 31). The soils are acidic throughout the profile, but the site did not appear to be particularly nutrient limited at the initiation of this experiment.

Spatial differences exist in diversity of the overstory trees and woody regeneration. This local spatial variability may or may not reflect the spatial variability inherent in the region or larger geographic context. Some of the observed differences in overstory diversity may be reflected in soil properties, particularly in terms of the organic soil horizons. In the future, this spatial variability will need to be considered when evaluating the impacts of the experimental treatments, particularly over time.

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APPENDIX 1

List of common and scientific names for plants described on Middle Mountain LTSP Study site, 1997

Trees and Shrubs

Common name	Scientific name
Striped maple	*Acer pensylvanicum* L.
Red maple	*Acer rubrum* L.
Sugar maple	*Acer saccharum* Marsh.
Common serviceberry	*Amelanchier arborea* (Michx. f.) Fernald var. *arborea*
Devil's walkingstick or Hercules' club	*Aralia spinosa* L.
Sweet birch	*Betula lenta* L.
Yellow birch	*Betula lutea* Michx.
Hawthorn	*Crataegus* L. sp.
American beech	*Fagus grandifolia* Ehrh.
White ash	*Fraxinus americana* L.
Deciduous holly or possumhaw	*Ilex decidua* Walter
Northern spicebush	*Lindera benzoin* L. (Blume)
Cucumbertree	*Magnolia acuminata* L.
Fraser magnolia	*Magnolia fraseri* Walt.
Blackgum	*Nyssa sylvatica* Marsh.
Red spruce	*Picea rubens* Sarg.
Bigtooth aspen	*Populus grandidentata* Michx.
Pin cherry	*Prunus pensylvanica* L.
Black cherry	*Prunus serotina* Ehrh.
Black locust	*Robinia pseudoacacia* L.
Mountain ash	*Sorbus americana* Marshall
Eastern hemlock	*Tsuga canadensis* L.

Woody Vines, Ferns, and Herbs

Common name	Scientific name
Ramp	*Allium tricoccum* Aiton
Wood anemone	*Anemone quinquefolia* L.
Jack in the pulpit	*Arisaema triphyllum* (L.) Schott
Sedge	*Carex* L. sp.
Carolina springbeauty	*Claytonia caroliniana* (Michx.)
Eastern hayscented fern	*Dennstaedtia punctilobula* (Michx.) Moore
Wild yam	*Dioscorea villosa* L.
Spinulose woodfern	*Dryopteris carthusiana* (Vill.) H.P. Fuchs
Clubmoss	*Lycopodium* Holub sp.
Canada mayflower	*Maianthemum canadense* Desf.
Indian cucumber	*Medeola virginiana* L.
Partridgeberry	*Mitchella repens* L.
Common yellow oxalis	*Oxalis stricta* L.
Smooth Solomon's seal	*Polygonatum biflorum* (Walter) Elliott var. *commutatum* (Schult. & Schult. f.) Morong
Christmas fern	*Polystichum acrostichoides* (Michx.) Schott.
Blackberry	*Rubus* L. sp.
Woodland stonecrop	*Sedum ternatum* Michx.
Greenbrier	*Smilax* L. sp.
Trillium	*Trillium* L. sp.
Violet	*Viola* L. sp.
Grape	*Vitis* L. sp.

APPENDIX 2

Characterization soil profiles, described by Natural Resources Conservation Service (1996)

Identification: A

Location: 10 ft east buffer stake 26-2

Parent Material: siltstone/shale – Pocono formation

Slope: 4%

Aspect 272

Horizon	Description
Oi	2-4 cm
Oe	0-2 cm
A	0-6 cm, 15% coarse fragments; 10YR 3/2, silt loam, friable; /granular structure; many very fine to coarse roots; abrupt wavy boundary
BA	6-19 cm, 10 % coarse fragments; 10YR 5/6 silt loam; friable; subangular blocky structure; common very fine to coarse roots; clear wavy boundary
Bw	19-54cm; 35% coarse fragments; 10 YR 6/6; silt loam, subangular blocky structure; few fine to coarse roots; gradual wavy boundary
B/C	54-71 cm; 35% coarse fragments; silt loam; subangular blocky structure; few Fine to medium roots; gradual wavy boundary
C	71-92 cm; 65% coarse fragments; 7.5 YR 5/3 and 5/6; silty clay loam; massive structure; few fine roots; gradual wavy boundary
Cr	92-117cm; siltstone

Identification: B

Location: halfway between plot 20-8 and 20-7

Parent material: siltstone –olivine

Slope: 7%

Aspect: 164

Horizon	Description
Oi	2-4 cm
Oe	0-2 cm
A	0-5 cm; 30% coarse fragments; 10YR 3/1; loam; granular structure; many very fine to medium roots; abrupt smooth boundary;
BA	5-10 cm; 30% coarse fragments; 10YR 4/4; loam; granular to subangular blocky structure; many very fine to medium roots; abrupt wavy boundary
Bw	10-38 cm; 40% coarse fragments; loam; subangular blocky; common very fine to medium roots; cleary wavy boundary
BC	38-56 cm; 55% coarse fragments; 10 YR 5/6; loam; subangular blocky few very fine to fine roots; clear wavy boundary
Cr	56-100 cm;

Identification: C

Location: Plot 30-1 stake below road

Parent material: fine grained interbedded sandstone

Slope: 18%

Aspect: 54

Horizon	Description
Oi	
Oe	
A	0-3 cm; 40% coarse fragments; 2.5 YR 3/1; loam; weak granular structure; common very fine to coarse roots; abrupt wavy boundary
E	3-9 cm; 45% coarse fragments; 10 YR 5/2; common very fine to coarse roots; clear wavy boundary
BE	9-17 cm; 35% coarse fragments; loam; 10 YR 6/6; moderately firm subangular blocky structure; common very fine to coarse roots; gradual wavy boundary
Bw1	17-41 cm; 35% coarse fragments; 10 YR 5/8; silt loam; medium firm subangular blocky; common very fine to coarse roots; gradual wavy boundary
Bw2	41-77 cm; 30% coarse fragments; 10YR 6/6; silt loam; moderate subangular blocky structure; few very fine to fine roots; clear wavy boundary
C	77-122 cm; 70% coarse fragments; 10YR 5/6; silt loam; massive structure; few fine to medium roots

Adams, Mary Beth. 2018. **Site productivity and diversity of the Middle Mountain long-term soil productivity study, West Virginia: Pre-experimental site characterization.** Gen. Tech. Rep. NRS-176. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 24 p. https://doi.org/10.2737/NRS-GTR-176.

To better understand the impacts of a changing environment and interactions with forest management options for forest resources, including soil, large long-term experiments are required. Such experiments require careful documentation of reference or pre-experimental conditions. This publication describes the Middle Mountain Long-term Soil Productivity (LTSP) Study, located within the Loop Road Research Area of the Monongahela National Forest, WV. This study was initiated in 1997 and pretreatment soil, vegetation, nutrient cycling, and climatic conditions were carefully documented. The Middle Mountain LTSP Study site is a high elevation site and supports a cherry-maple stand of moderate productivity. There is some variability in soil nutrients and plant diversity across the site prior to the initiation of treatments. This site is generally less diverse than the Fork Mountain LTSP Study site in terms of overstory tree species. Experimental treatments started in 1998, and we continue to monitor this site's response to these treatments.

KEY WORDS: acidic deposition, vegetative diversity, Appalachian forests, eastern hardwoods, red spruce

Middle Mountain weather station after an early season snowfall. Photo by Mary Beth Adams, USDA Forest Service.

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