New York State Energy Research and Development Authority

Effects of Acidic Deposition and Soil Acidification on Sugar Maple Trees in the Adirondack Mountains, New York

Final Report

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Effects of Acidic Deposition and Soil Acidification on Sugar Maple Trees in the Adirondack Mountains, New York

Final Report

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Abstract

This study documents the effects of acidic deposition and soil acid-base chemistry on the growth, regeneration, and canopy condition of sugar maple (SM) trees in the Adirondack Mountains of New York. Sugar maple is the dominant canopy species throughout much of the northern hardwood forest in the State. A field study was conducted in 2009 in which 50 study plots within 20 small Adirondack watersheds were sampled and evaluated for soil acid-base chemistry and SM growth, canopy condition, and regeneration. Atmospheric sulfur (S) and nitrogen (N) deposition were estimated for each plot. Trees growing on soils with poor acid-base chemistry (low exchangeable calcium and % base saturation) that receive relatively high levels of atmospheric S and N deposition exhibited little to no SM seedling regeneration, decreased canopy condition, and short-to long-term growth declines compared with study plots having better soil condition and lower levels of atmospheric deposition. These results suggest that the ecosystem services provided by SM in the western and central Adirondack Mountain region, including aesthetic, cultural, and monetary values, are at risk from ongoing soil acidification caused in large part by acidic deposition.

Key Words: Sugar maple; calcium; soil base saturation; acidification; sulfur

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1 Introduction

Damage to ecosystems in the Adirondack Mountains of New York has been substantial in response to high levels of atmospheric sulfur (S) and nitrogen (N) deposition (Driscoll *et al.* 2003). Efforts to quantify damage have largely focused on aquatic effects (Sullivan 2000, Lawrence *et al.* 2008a). However, limited recovery of surface water acid-base chemistry in response to recent large (>40%) decreases in S deposition have been attributed to depletion of base cations on the soil and an apparent continued deterioration of soil acid-base chemistry (Lawrence *et al.* 1999, Sullivan *et al.* 2006a). Furthermore, mathematical model forecasts of the responses of soil and lake water to assumed scenarios of emissions controls suggested that soil base status may continue to decline in the future unless there are additional cuts in emissions (Sullivan *et al.* 2006a).

Sugar maple (SM; *Acer saccharum*) is one of the major deciduous tree species of the northern hardwood forest, along with red maple (*Acer rubrum*), American beech (*Fagus grandifolia*) and yellow birch (*Betula alleghaniensis*). Sugar maple is often the dominant tree species in forests of the Adirondack Mountain region and contributes greatly to autumn foliage color in the region, an important tourist draw. It is a valuable timber species, providing wood for the furniture making industry, and it also supports a vibrant maple syrup industry, which dates back to the period of pre-European settlement (Wittstock 1993).

Associations between the presence of SM and various soil characteristics have previously been reported elsewhere. Lovett *et al.* (2004) demonstrated that this species promotes the formation of nitrate (NO_3^-) in soil via nitrification and therefore enhances NO_3^- leaching in drainage water. Sugar maple is also known to have a relatively high demand for soil calcium (Ca; van Breemen *et al.* 1997, Horsley *et al.* 2000, Lovett *et al.* 2004, Hallett *et al.* 2006, Long *et al.* 2009).

Fertilization with dolomite resulted in the recovery of a SM stand on the Allegheny Plateau of Pennsylvania where canopy dieback and elevated mortality were underway (Long *et al.* 1997). High SM mortality in Pennsylvania was attributed to a lack of resistance to defoliating insects at sites where soil Ca and magnesium (Mg) availability was low (Horsley *et al.* 2000) and had been reduced by acidic deposition during the preceding three decades (Bailey *et al.* 2005). Horsley *et al.* (2000) proposed that acidic deposition reduced supplies of nutrient cations, thereby lowering the ability of the trees to withstand stresses, including drought, freeze-thaw cycles, and insect infestation, although atmospheric deposition of N has recently been associated with increased growth of SM elsewhere in the northeastern U.S. (Thomas *et al.* 2010).

Moore and Ouimet (2006b) found that SM trees showed reduced levels of crown dieback and a near doubling of basal area increment ten years after lime application in a base-poor northern hardwood stand in Quebec. A regional assessment of the relationship between imbalances of nutrient cations and SM decline in the Allegheny Plateau and the northeastern U.S. showed that poor tree health was correlated with low concentrations of foliar Ca and Mg. Trees in Pennsylvania appeared to be less prone to decline where Ca^{2+}

and Mg^{2+} supplies were high (Hallett *et al.* 2006). Vigor increased on low base cation sites treated with limestone (Long *et al.* 1997, Moore and Ouimet 2006b). In the study plots outside of the Allegheny Plateau, however, defoliation and high mortality were not occurring, suggesting that these areas were not affected by decline (Hallett *et al.* 2006).

Recent research has strengthened the link between nutrient base cation availability and SM health. Moore and Ouimet (2006a) found that SM trees showed greatly reduced levels of crown dieback and a near doubling of basal area increment ten years after lime application at the Hubbard Brook Experimental Forest, New Hampshire. The addition of wollastonite ($CaSiO_3$) to a small experimental watershed resulted in a much healthier canopy, increased seedling survival and growth, and greater mycorrhizal colonization than in the reference watershed (Juice *et al.* 2006). A single Ca-Mg fertilization to a severely Ca-depleted soil in the Catskill Mountains also resulted in substantially higher germination of SM seedlings in fertilized plots than in control plots, but seedling survival was poor, and by the third year, seedling densities of fertilized plots and control plots were similarly low. A regional assessment of the relationship between imbalances of nutrient cations (Ca, Mg) and manganese (Mn) and SM decline disease in the Allegheny Plateau of Pennsylvania and New York, central and western New York, Vermont, and New Hampshire showed that poor health was correlated with high concentrations of foliar Mn and low concentrations of foliar Ca and Mg. In the study plots outside of the Allegheny Plateau, however, defoliation and high mortality were not occurring, suggesting that these areas were not affected by decline. Nevertheless, these areas showed a strong relationship between base cation nutrition and fine twig dieback (Hallett *et al.* 2006).

The resistance of SM trees to defoliating insects may be lessened by low availability of Ca. Furthermore, insect defoliation may be exacerbated by the fertilization effect of N deposition, which leads to increased concentrations of N in foliage and can have a positive effect on the performance of insect populations (Throop and Lerdau 2004). Low ratios of C:N in soil, a result of high foliar N concentrations, have also been shown to lead to elevated rates of net nitrification and associated acidification of soils (Aber *et al.* 2003). Watersheds with a high abundance of SM tend to export higher amounts of NO_3^- in stream water than watersheds forested with other species (Lovett and Mitchell 2004). These results raise the question of whether SM stands are more prone than other tree species to N saturation and associated effects such as increased acidification of soil and water and reduced availability of base cations.

The only study (grey literature) published to date on SM health in the western Adirondack region (Jenkins *et al.* 1999) found that SM sapling densities were substantially lower than what would be expected based on the proportion of SM in the canopy. Several tree cores collected in the western Adirondacks in 2004 (G.B. Lawrence, unpublished data) suggested that SM in this region may have experienced unusually high growth rates from 1950 to 1975, but substantial decreases in growth from 1975 to 2004. Such a growth pattern may reflect an increase in soil nutrient availability prior to 1975, which reversed when base cation concentrations became depleted and aluminum (Al) mobilization followed. Increased growth followed by decline of red spruce (*Picea rubens*) in the Northeast has been attributed to this process (Shortle *et al.*

1997), as have similar growth patterns of Norway spruce (*Picea abies*) in western Russia, where analysis of archived soil samples revealed historic base cation depletion (Lawrence *et al.* 2005).

Improved understanding of the relationships between soil acid-base chemical condition and the abundance, growth, health, and regeneration of SM is needed to help to calculate the critical load of acidic deposition that will be protective of this important tree species and to aid in forest management decisions regarding insect and disease suppression efforts. Knowledge of areas where SM trees are stressed by soil acid-base chemical conditions may improve the ability of land managers to respond to insect infestations in the face of limited insect suppression resources (Horsley *et al.* 2008).

In the research reported here, the effects of acidic deposition and soil acidification on the growth, canopy health, and regeneration of SM trees were investigated in the Adirondack Mountains, New York. Fifty plots with SM commonly present in the canopy were established within 20 watersheds that were selected to represent a range of Ca availability based on stream water and soil chemistry determined in previous studies (Lawrence *et al.* 2008a, Page and Mitchell 2008). At each 20 x 50 m plot, trees were enumerated and evaluated for canopy condition, seedlings were enumerated on five 1x1-m subplots, saplings were enumerated on one 10x10 m subplot, surface soil horizons (O_e, O_a, A) were sampled for chemical analysis at five subplots, and subsoil horizons (upper and lower B, Cd) were sampled from one soil pit. Three representative SM trees on most plots were cored (two cores per tree) for dendrochronological analysis.

The goal of the project reported here was to assess the effects of acidic deposition on the current growth, health, and regeneration of SM, and the extent to which SM response is associated with soil conditions in small upland watersheds within the Oswegatchie-Black River Basins of the southwestern Adirondack Mountains. Specific objectives were to 1) assess the visible health of dominant and codominant SM through systematic evaluation of canopy condition; 2) analyze historical growth trends through dendrochronology; 3) assess regeneration as reflected in seedling and sapling density; 4) assess soil chemistry; 5) determine relationships among SM canopy condition, soil chemistry, and stream chemistry; 6) evaluate the extent to which poor soil base cation status and/or vegetative condition can be inferred from existing stream water chemistry data in low-order stream watersheds; and 7) develop an integrated ecosystem assessment of soil, stream water, and SM condition that can be applied to the western Adirondack region.

This project represents a critical step in the assessment of chemical and biological acidification impacts and recovery responses of Adirondack terrestrial resources in response to changing levels of acidic deposition. The timing of past SM growth declines in the western Adirondack Mountains was determined relative to estimated trends in atmospheric S deposition. The relationships between chemical indicators of soil acid-base chemistry (e.g., base saturation, exchangeable Ca^{2+}, exchangeable Mg^{2+}) and biological indicators of acidification effect on SM (e.g., growth, health, regeneration) were quantified.

2 Methods

2.1 Study Site Selection

Watersheds were selected for study using a randomized process. It was based on the sampling design of the Western Adirondack Stream Study (WASS; Lawrence *et al.* 2008a), which provided an assessment of stream acidification for 565 small watersheds in the western Adirondack region through the sampling of 200 randomly selected streams.

Fifty plots located in 20 small watersheds were selected for study of SM condition here by ranking the 200 WASS study watersheds according to stream water base cation surplus (BCS) value (Lawrence *et al.* 2008a), reflecting the supply of Ca and other base cations. The watersheds were then divided into 20 groups that maintained their ranking. Watersheds were excluded if they did not contain sufficient SM trees to establish a 20 m x 50 m plot that included at least eight SM in the canopy. Watersheds were also excluded if effects of logging on stand composition were apparent, especially if selective logging for SM had occurred. At least one watershed met these requirements for each of 15 of the 20 strata. If more than one watershed was appropriate within a stratum, selection was random. Most of the 15 selected WASS watersheds had streams that were acidified to varying degrees; so 5 additional watersheds were specifically selected to provide soils with relatively high calcium availability.

Two or three 50 x 20 m plots were established in representative portions of each selected watershed that included SM trees. Each plot was located to include at least three canopy sugar maple trees over 35 cm dbh, without deformities that would preclude coring. Landscape characteristics were evaluated through the use of geographic information system (GIS) databases, aerial photography and field reconnaissance to select locations that were generally representative of each watershed. A total of 50 plots were established. Study watershed and plot locations are shown in Figure 2-1.

2.2 Field Investigation

All plots were sampled once during the summer of 2009. Measurements and samples were collected as outlined in Table 2-1. Soil samples were placed in plastic bags in the field and subsequently transported back to the field laboratory to begin air-drying.

General site indicators were recorded for each plot. These included variables that reflect physiography, in accordance with the approach of the North American Sugar Maple Decline Project (Cooke *et al.* 1998). This was because trees growing in lower topographic positions may have access to greater supplies of Ca^{2+} and Mg^{2+} from relatively deep water flows such as seeps and lateral flows that bring weathering products from lower soil horizons or geologic materials into the rooting zone (Horsley *et al.* 2008). Soil pH in lower topographic positions can be higher as a result (Horsley *et al.* 2008).

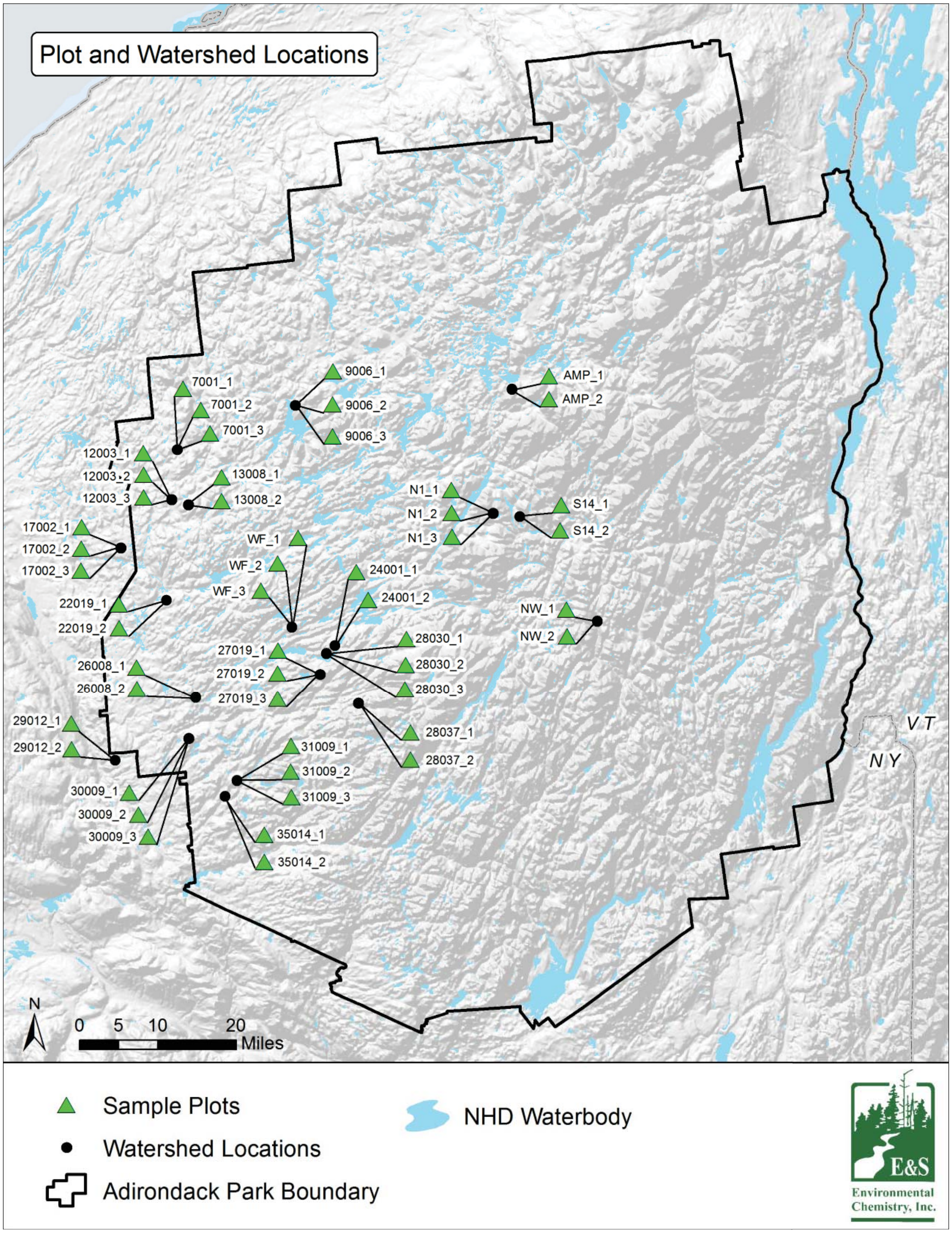

Figure 2-1. Map showing locations of the 20 study watersheds and 50 study plots sampled for this research.

Table 2-1. Measurements and samples collected at each study plot.

1.	Measurement of DBH of all trees >10 cm DBH within plots
2.	Assessment of sugar maple canopy condition and vigor
3.	Dendrochronology of sugar maple trees
4.	Seedling and sapling counts in subplots
5.	Organic soil pin block sampling at five locations in each plot
6.	Mineral soil profile sampling in each plot

2.2.1 Vegetation Tally

For each tree greater than 10 cm diameter at breast height (DBH) occurring within the plot, the species, DBH, crown position, and vigor were recorded. Dieback, transparency, defoliation, and foliage discoloration were visually estimated for all trees except American beech (AB). For the latter species, dominant and co-dominate trees were identified, measured, and recorded, and a canopy health evaluation was made; but for trees of this species that were found to be either intermediate or suppressed, only species, DBH, crown position, and vigor were noted.

A 10 x 10 m subplot located in a pre-specified corner of the overall plot was designated for sapling enumeration. Within this sapling subplot, the species and DBH were recorded of all sapling stems greater than 1 cm and less than 10 cm DBH. Each stem was recorded as being live or dead.

At each of five pre-determined locations at 10 m increments along the centerline of the overall plot, a 1x1m seedling subplot was established. If a large rock or log covered a substantial portion of the pre-determined seedling subplot location, the subplot was moved to the first available location along the centerline. Within each seedling subplot, the number and species identification of each tree seedling were recorded by size class. Minimum specifications for seedling inclusion were that it had to be at least 5 cm tall and have at least two fully formed leaves. The maximum specification for seedling inclusion was that it be less than 1 cm DBH. Each seedling was identified to species and classified into one of five size classes, with height breaks at 5, 15, 30, 60, and 150 cm.

2.2.2 Increment Cores

Three SM trees were selected for increment coring to represent each plot. Candidate trees were selected from among those in the dominant or codominant crown position, that appeared to be the healthiest of the trees in the plot, typically in vigor class 1 or sometimes 2, and having as large DBH as possible. Trees expected to have rotted cores, as indicated by irregularly shaped bole, bole wounds, seams, or excessive borer damage, were avoided. Two cores were collected from each selected tree, from opposite sides of the tree. If good, intact cores could not be obtained from three trees within a plot, alternate nearby trees were selected to represent that plot. Only ten trees out of a total of over 150 were cored outside the plot, and all were within 10 m of the plot. For each cored tree, its location, DBH, and crown rating were noted. Each core was labeled and placed into a plastic straw, with ends secured, for transport to the field laboratory, where they were partially air dried prior to shipment to the analytical laboratory.

2.2.3 Canopy Health Assessment

The crown condition of each SM tree on each plot was assessed and recorded. Crown condition measurements were made as ocular estimates determined from ground level. Intensive training of field staff and the use of two people to rate each tree enhanced repeatability and comparability of these measurements.

All standing living and dead trees >10 cm DBH in each plot were evaluated by species, DBH, and crown class (dominant, codominant, intermediate, suppressed). Vigor classes were defined according to Cooke *et al.* (1998), as outlined in Table 2-2, with an assumed acceptable error of plus or minus one vigor class. Vigor was estimated independent of the crown damage assessment. The latter included measurements of dieback, crown transparency, discoloration, and defoliation. Two trained raters made each estimate. When the two estimates disagreed, the raters discussed their observations and agreed on a final determination.

Table 2-2. Tree vigor classes (Cooke *et al.* 1998).

Vigor Rating	Description
1	Healthy
2	Slight decline
3	Moderate decline
4	Severe decline
5	Dead (natural)
6	Dead (human-caused, e.g., removed, cut)

Branch dieback was defined as branch mortality that begins at the terminal portion of a limb and progresses inward toward the bole. It is assumed to result from stress. Dieback estimates were limited to branches approximately 2.5 cm in diameter or less at the point of attachment to another branch or to the bole. Branch mortality at the base of the crown is believed to result from shading and is not included in the measurement. The branch mortality measurement is an estimate of the proportion of the crown silhouette that shows evidence of dieback, expressed in classes. This category was rated using a twelve-class damage rating system represented as shown in Table 2-3 (also used for foliage transparency and foliage discoloration categories).

Table 2-3. Twelve class rating system used to record the percent of the canopy of a given tree affected by branch dieback, transparency and foliar discoloration.

Class Code	Class Range	Acceptable Observer Variability
0	0	0-5
5	1-5	0-15
10	6-15	1-25
20	16-25	6-35
30	26-35	16-45
40	36-45	26-55
50	46-55	36-65
60	56-65	46-75
70	66-75	56-85
80	76-85	66-95
90	86-95	76-100
99	96-100	86-100

Transparency was estimated as the amount of skylight visible through the foliated portions of branches and averaged for the crown. It included normal characteristics of foliage density and reduced density caused by insect damage, disease, or other stress. Portions of the canopy included in the dieback designation were not rated for transparency. It is assumed that increased transparency over time indicates reduced vigor that may lead to branch dieback.

Discoloration was estimated for the foliated portions of the crown (excluding areas where branches were dead or absent). A leaf was considered discolored if at least 50% of its area gave an overall appearance that the leaf was more red, yellow or brown than green. Percent dead SM basal area was calculated from the crown vigor index as the proportion of the SM basal area in category 5 (dead) compared with the total stand basal area of SM.

Insect defoliation was estimated in four classes as follows:

- 0 – none to light defoliation
- 1 – less than 30% of crown defoliated
- 2 – 31-60% crown defoliation
- 3 – > 60% crown defoliation.

2.2.4 Organic Soil Sampling

At each of five pre-selected locations situated along the overall plot centerline, opposite the five seedling subplot locations, one 10 x 10 cm pin block of forest floor material was collected down to the top of an E or B horizon, whichever occurred first (Yanai *et al.* 2000). The surface fresh litter was gently brushed away without disturbing the O_e horizon. The five pin-block samples were separated into A, O_a and O_e horizons and placed in zipper-locked bags by horizon.

2.2.5 Mineral Soil Sampling

Three to five small reconnaissance soil pits were opened in each plot. From among these reconnaissance pits, the intermediate location in terms of horizon presence and thickness was selected for full pit excavation and mineral soil sampling. At the selected site a pit approximately 1 m^2 in area was excavated into the C horizon, and then photographed, described, and sampled. Horizons were identified based on observed differences in organic content, color, texture, structure, root density, rock content, and redoximorphic features according to National Resource Conservation Service protocols (Schoeneberger *et al.* 2002). Horizon thicknesses were measured at representative locations along the soil pit face.

Representative soil samples were collected from the face of the pit in each of the uppermost and bottom 10 cm of the B horizon, and from a representative portion of the C horizon. The relatively inert E horizon, where it occurred, was not sampled. The upper portion of the mineral B horizon was expected to best reflect differences in soil chemistry as a function of atmospheric deposition (Lawrence *et al.* 1995), and keeping the thickness of this increment constant assured the highest comparability among sampled locations.

A total of 10 mineral soil pits were replicated during the course of the field sampling program to quantify local variability in soil conditions. Results for key soil parameters are plotted in Figure 2-2**;** additional parameters are shown in Appendix A. If concentrations from each pit within the same plot were the same for respective horizons, plotting values from one pit against the other would yield a linear relationship with a slope of 1 and a y-intercept of 0. Concentrations vary among horizons, but in these graphical plots,

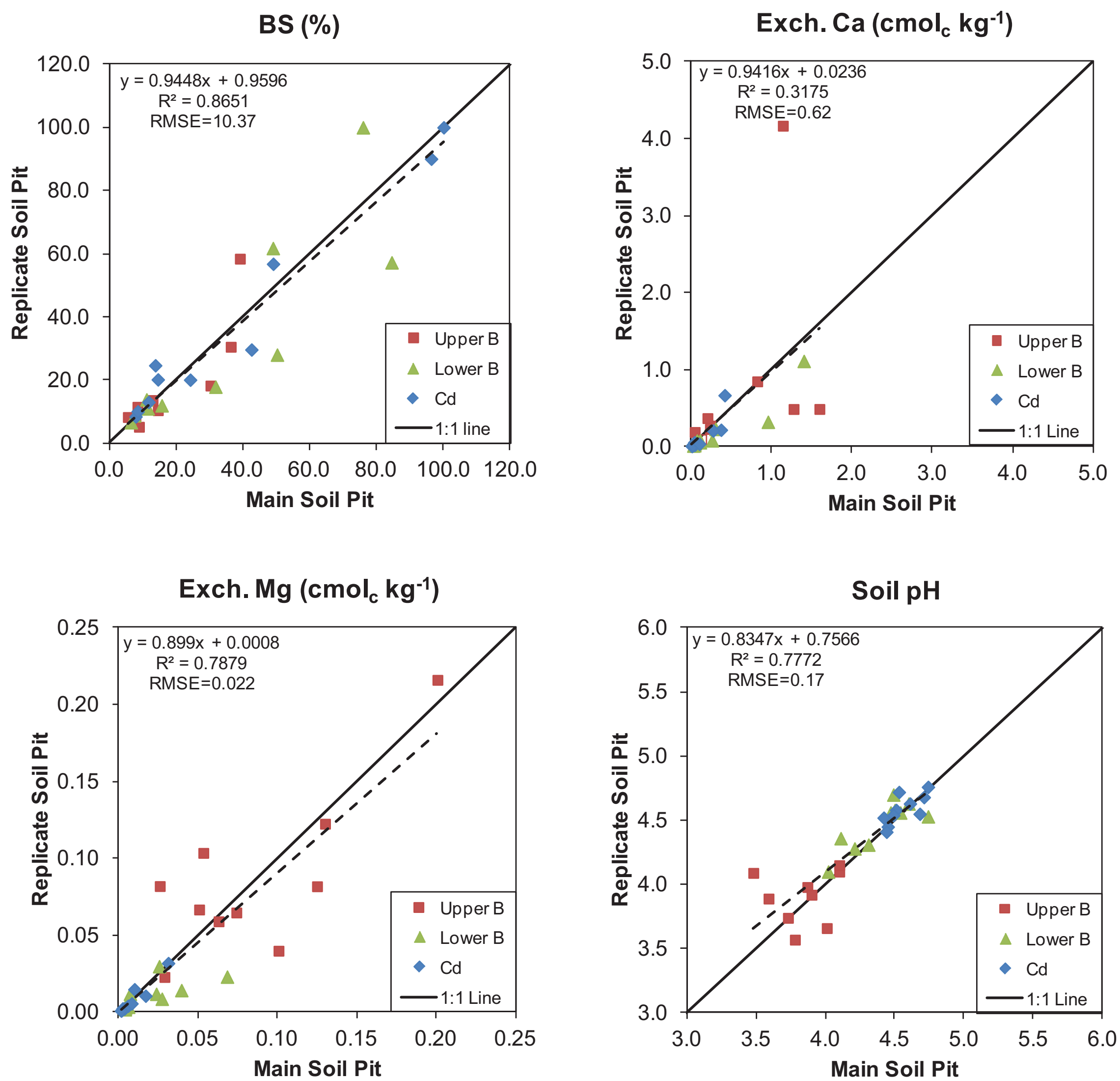

Figure 2-2. Soil chemistry analytical results for 10 replicated mineral soil pits: A) base saturation, B) exchangeable calcium (Ca), C) exchangeable magnesium (Mg), D) soil pH in H2O. Data are reported by horizon for upper B (square), lower B (triangle), and C (diamonds) horizons. None of the slopes are significantly different from 1; none of the y-intercepts are significantly different from 0 ($p \leq 0.05$).

data points would fall along the slope of one if there was no variation between replicated samples. Greater scatter in these plots reflects greater difference in soil condition between pairs of pits excavated in a given plot.

For most analyses, variation between pits was lowest in the C horizon and highest in the upper B horizon. This is expected because, compared to other mineral soil horizons, the upper B horizon has the highest level of root activity, the highest organic carbon (C) concentration, and the highest microbial activity, all factors that tend to vary within the soil profile. Nevertheless, the data for all three horizons do approximate slopes of 1 and intercepts of 0 for nearly all of the measurements. This result confirms that a single pit is reasonably representative of the soil conditions in the study plots for these three mineral soil horizons.

Some exceptions were noted in this comparison, however. The concentration data for exchangeable hydrogen was the most scattered of the analyses. This is partly the result of the indirect method of determining the value of this parameter (total acidity minus exchangeable Al). As a result of poor precision, some estimates were negative and scatter was much higher than for other analyses.

2.3 Laboratory Analyses

All chemical analyses were expressed on an oven-dried soil mass basis (70^{o} C for O horizons and 105^{o} C for mineral soils). Analyses included loss-on-ignition (LOI), pH (in 0.01 M $CaCl_2$), exchangeable Ca, Mg, potassium (K), sodium (Na), iron (Fe), Mn and extractable phosphorus (P) (unbuffered 1 N NH_4Cl), exchangeable H^+ and Al (KCl extraction), extractable sulfate, and total C and N (C/N analyzer). These methods are essentially the same as those of the USDA Forest Service, Forest Response Project (Robarge and Fernandez 1986), which are typically followed in forest soil studies in the Northeast. Quality assurance accounted for approximately 10−20% of the total sample load and included field replicates, sample replicates, blanks, and samples with known concentrations established through repeated analyses and inter-laboratory comparisons.

Selected samples from all soil profiles were analyzed for bulk elemental composition. Samples were converted to glass via lithium-borate fusion, and then dissolved in a weak solution of hydrochloric acid. Resulting solutions were analyzed on an ICP at the Forestry Sciences Laboratory, Durham, NH. Calcium concentrations were evaluated as an index of weatherable mineral content. Deeper (lower B and C horizon) soils were evaluated because weatherable minerals may have been depleted from shallower horizons because these are the horizons that acidic deposition contacts first. High Ca concentrations indicate a greater capacity of soils to release base cations in a form that can buffer soil acidity, recharge base cations on soil exchange sites, and provide essential plant nutrients.

2.4 Dendrochronological Analyses

The dendrochronology data obtained in this study were primarily used to evaluate patterns of growth decline among the sampled trees. The preferred method for characterizing tree growth patterns is through analysis of annual growth expressed as basal area increments. Calculation of basal area increments requires growth increment data for each year of record. However, data gaps were present during the period of 1950 to 2008 for 25 of the 149 sampled trees. Cored SM trees with sufficient data were classified into groups of trees showing evidence of growth decline (Figure 2-3, left panel) and those showing no evidence of growth decline (Figure 2-3, right panel), as described below. Examination of individual tree growth time series plots showed a variety of response types including no change, linear change, and a number of trees that showed abrupt changes of slope in the middle of the time series. Therefore, we classified each tree time series into categories of no significant change, linear change, and non-linear change using regression. Both a simple linear model (growth=a+b*time) and a quadratic model (growth=a+b_1*time+b_2*time^2) were fit to the time series data. Model slope coefficients were tested for significant difference from zero using a t-test based on the model coefficient and its standard error. If both the linear and quadratic coefficients were not significantly different from zero at $p < 0.01$ then the tree was classified as having no significant change over time. If the linear model coefficient was significant but the quadratic coefficient was not ($p < 0.01$), then the tree was classified as having linear change and the slope of the time series was determined from the simple linear regression model. If the quadratic coefficient for the model was significant, the tree core was considered to have a non-linear time series response, and a piecewise regression model was fit to the data. A piecewise regression model was chosen because of the likelihood that a growth increase due to N fertilization might precede a growth decline due to soil acidification for some trees.

With one breakpoint, the piecewise regression model can be written as:

$$\text{Growth}=A_1+B_1*\text{time (for time} \leq \text{C), and}$$

$$\text{Growth}=A_2+B_2*\text{time (for time} > \text{C)}$$

Where C is the point on the time-axis where the slope break occurs. As described by Ryan and Porth (2007), these equations can be rearranged and converted to a piecewise regression model that is continuous at time=C with the equations:

$$\text{Growth}=A_1+B_1*\text{time (for time} \leq \text{C), and}$$

$$\text{Growth}=[A_1+C*(B_1-B_2)] + B_2*\text{time (for time} > \text{C).}$$

The model coefficients were fit by nonlinear least squares regression using PROC NLIN in SAS/STAT software version 9. The model fit was achieved iteratively following the Marquardt method, and the initial starting point was selected from the point of lowest sum of squares error following a gridded search covering the possible range of each of the four model coefficients.

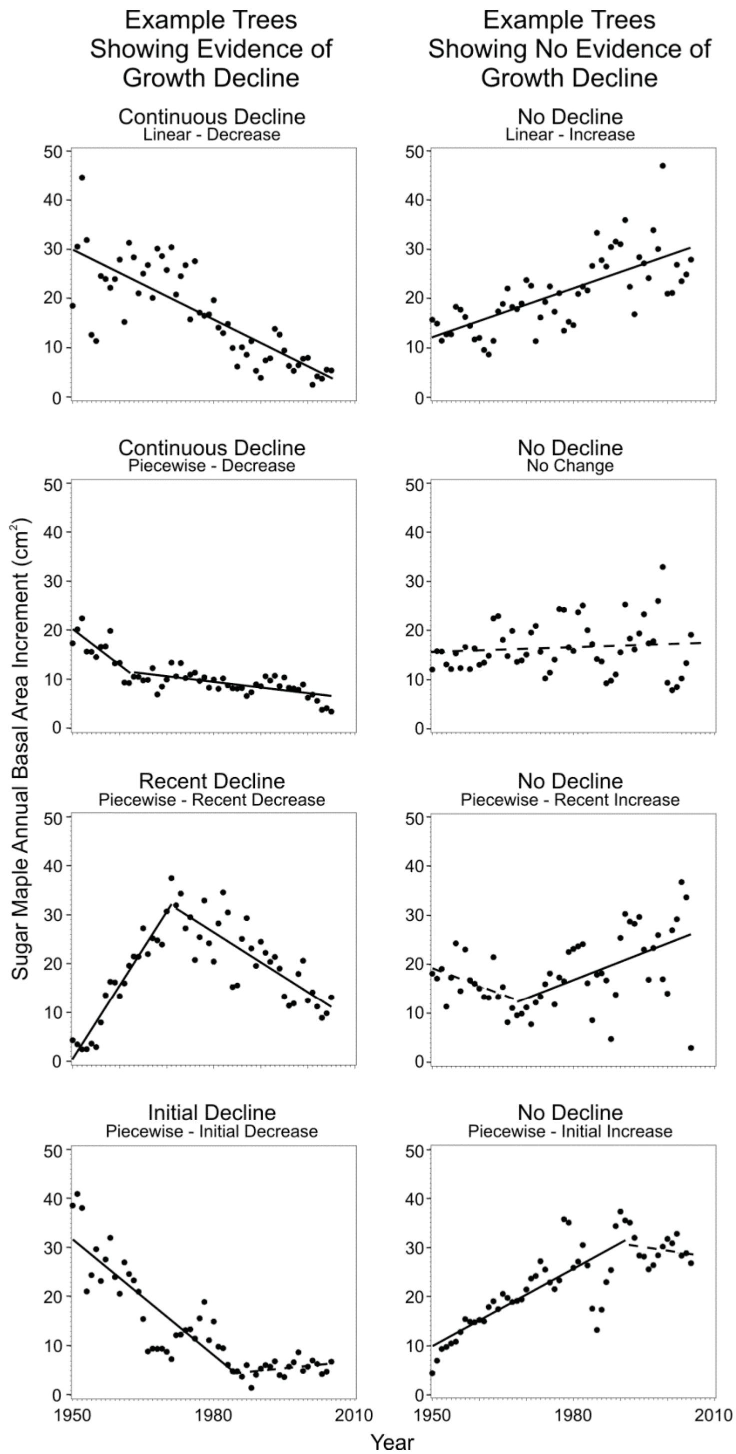

Figure 2-3. Representative examples of sugar maple annual basal area increment for cored trees showing evidence of growth decline (left panels) and those lacking evidence of growth decline (right panels). Regressions were evaluated either as a continuous function or as two contrasting functions with a breakpoint. Segments showing statistically significant ($p \leq 0.01$) changes over time were represented by a solid line through the data; a dashed line represents segments that were not statistically significant.

2.5 Atmospheric Deposition

Wet atmospheric S and N deposition estimates were derived from the National Atmospheric Deposition Program/National Trends Network (NADP/NTN). Wet deposition measurements by NADP/NTN were interpolated by J. Grimm for each year of a five-year period centered on 2002 (Grimm and Lynch 1997). Dry deposition was estimated using output from the CMAQ model for 2002 (R. Dennis, U.S. EPA, personal communication) to establish dry to wet ratios for S and N. For each plot, aerially weighted total wet plus dry S and N deposition was calculated using the interpolated NADP wet deposition and the CMAQ dry to wet ratios.

2.6 Landscape Analyses

A set of variables that characterize the landscape position of each plot was generated for analysis of variance (ANOVA) among various plot groupings. Landscape variables included elevation, physiographic position, slope, and light availability to the forest floor. The categorical variable for physiographic position was coded numerically in sequence from crest to toeslope as:

crest	1
shoulder	2
backslope/midslope	3
footslope	4
toeslope	5

Slope was calculated as an average of the field calculated slope facing up and down the slope of each plot. Elevation was extracted from a 30 m digital elevation model (DEM; USGS 1999).

Total solar radiation for each plot was estimated using a GIS model based on topographic characteristics, adjusted using an estimate of canopy cover. These two datasets were combined to represent forest floor light availability on the plots as:

Light = TSR x (1 – Cover), where:

TSR = Total potential solar radiation (watt hours/m^2), and

Cover = Percent canopy cover (as a fraction of 1)

The amount of total potential solar radiation was determined from a GIS-based model designed to calculate total (direct + diffuse) solar radiation (Fu and Rich 2002). A 30 m DEM was used as the basis for generating surfaces of slope and aspect. The variable path of the sun over the course of the year was also represented in the model. The model was run for a full year, generating the total amount of solar radiation reaching each 30 m grid cell in watt hours/m^2. The resulting solar radiation values are for “bare earth” (no vegetation) and assume a generally clear sky.

Two methods were used for determining canopy cover. The U.S. Geological Survey (USGS) GAP Analysis Program generated a 30 m grid representing percent canopy cover (USGS 2011). The data were derived using the approach detailed in Huang *et al.* (2001). For the first approach, percent canopy cover was modeled using aerial photography along with Landsat 7 satellite data. The 1 m grid cells of the aerial photos were classified as either canopy or no-canopy. Then, these values were tabulated based on the 30 m Landsat grid to represent the percent canopy cover within each grid cell. Finally, the relationship between percent canopy cover and Landsat spectral values was modeled using regression trees. This model was then used to predict percent canopy cover from the Landsat spectral values.

Percent canopy cover was also estimated from photographs taken by the field crew looking straight up above the main soil pit in each study plot. Graphics editing software was used to analyze the color spectrum within each photo to identify areas unobstructed by tree cover. Details of this method can be found in Appendix B. The two methods for estimating canopy cover produced similar values. Neither method predicted less than 75% canopy cover at any study plot, and most values were more than 85%.

2.7 Stream Chemistry

One goal of this study was to determine the extent to which the chemistry of small streams reflected the acid-base status of the soil in watersheds showing adverse impacts on SM condition, growth, and/or regeneration. For these analyses, stream chemistry data were taken from the WASS (Lawrence *et al.* 2008a).

3 Results and Discussion

A large number of scatterplot matrices were generated to evaluate relationships among soil chemistry, landscape variables, SM canopy conditions, SM growth, and SM regeneration**.** Selected examples of these are shown in the following sections of this report.

3.1 Species Composition

There were 14 tree species observed during field sampling (Table 3-1). All plots contained SM trees and almost all (98%) contained AB trees (Figure 3-1a). The primary tree species on the plots were SM and AB, with SM as the dominant tree species on almost all plots. Of the 50 plots, 46 contained more SM tree basal area than AB tree basal area and SM trees accounted for more than twice the basal area as compared with AB on 40 of the 50 plots. Nevertheless, SM sapling abundance was generally considerably lower than AB sapling abundance (Figure 3-1b). The median SM seedling abundance was also lower than for AB, although more than half of the total seedling count was comprised of SM seedlings on 14 of the sampled plots (Figure 3-1c). American beech saplings were present on 49 of the 50 plots, whereas SM saplings were present on less than half of the plots (Figure 3-1b). Similar numbers of plots contained RM, StM, and SM seedlings. American beech seedlings occurred on the most plots (n=39; Figure 3-1c). The highest median tree basal area (18 m^2/ha) was observed for SM followed by AB (Figure 3-2a). American beech was the only species that had median sapling basal area greater than 0 (Figure 3-2b). Red maple and AB seedlings showed the highest median seedling densities (Figure 3-2c). In general, SM sapling presence was inversely associated with AB sapling presence (Figure 3-3).

Table 3-1. Listing of tree species observed on sampling plots, with acronyms used in this report.

Acronym	Species	Common Name
AB	*Fagus grandifolia*	American beech
BC	*Prunus serotina*	Black cherry
BF	*Abies balsamea*	Balsam fir
BW	*Tilia americana*	Basswood
EH	*Tsuga canadensis*	Hemlock
HH	*Ostrya virginiana*	Hophornbeam
QA	*Populus tremuloides*	Quaking aspen
RM	*Acer rubrum*	Red maple
RS	*Picea rubens*	Red spruce
SM	*Acer saccharum*	Sugar maple
StM	*Acer pensylvanicum*	Striped maple
WA	*Fraxinus americana*	White ash
YB	*Betula alleghaniensis*	Yellow birch
BlA	*Fraxinus nigra*	Black ash

There was no clear relationship between the abundances of SM seedlings and SM trees (Figure 3-4). More than half of the plots (*n*=28) contained less than 20% SM seedlings despite occurring on plots characterized by a wide range of SM tree abundance. Thus, there is little evidence to suggest that the low numbers of SM seedlings were caused by low numbers of SM trees.

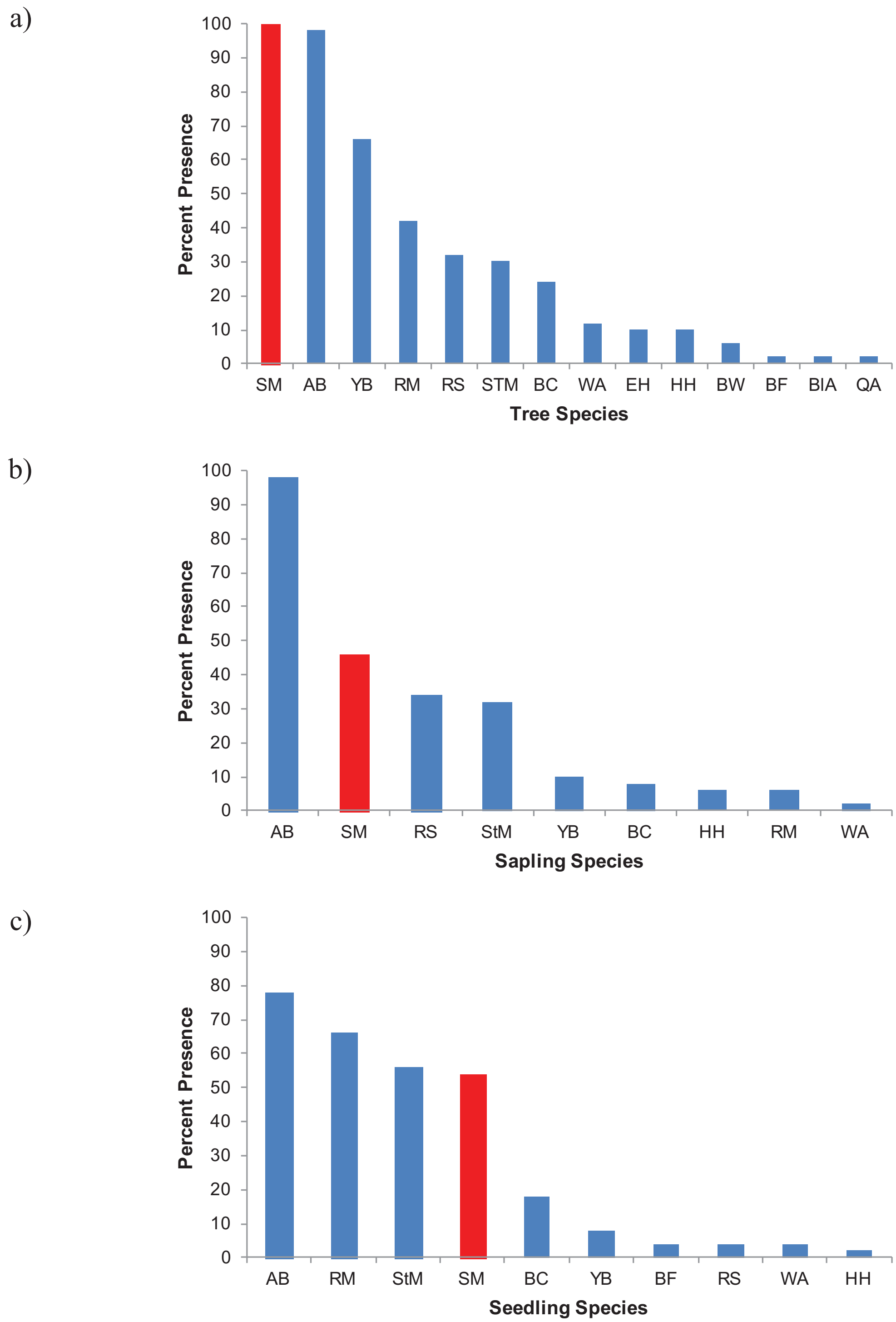

Figure 3-1. Percentage of plots containing various tree species shown by growth stage: a) trees, b) saplings, and c) seedlings. Sugar maple is highlighted in red. Species abbreviations are defined in Table 3-1.

a)

b)

c)

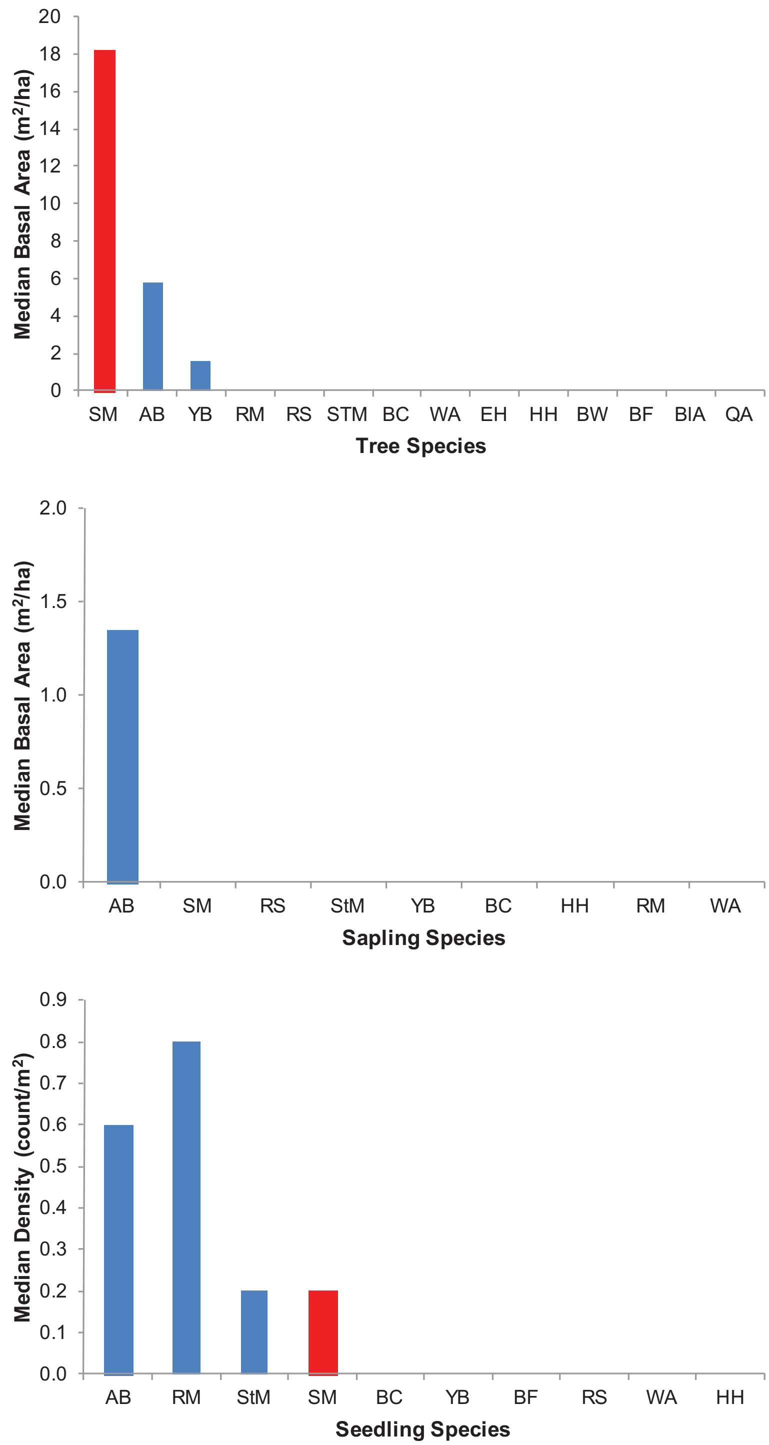

Figure 3-2. Median basal area, by species, among the 50 plots for a) trees and b) saplings. Seedlings are depicted in the lower graph (c) as seedling density (count per unit area). Sugar maple is highlighted in red. Species that lack data (no bar present) represent species for which the median plot had no trees, saplings, or seedlings present of that species. Thus, each species represented by a bar occurred on at least half of the study plots.

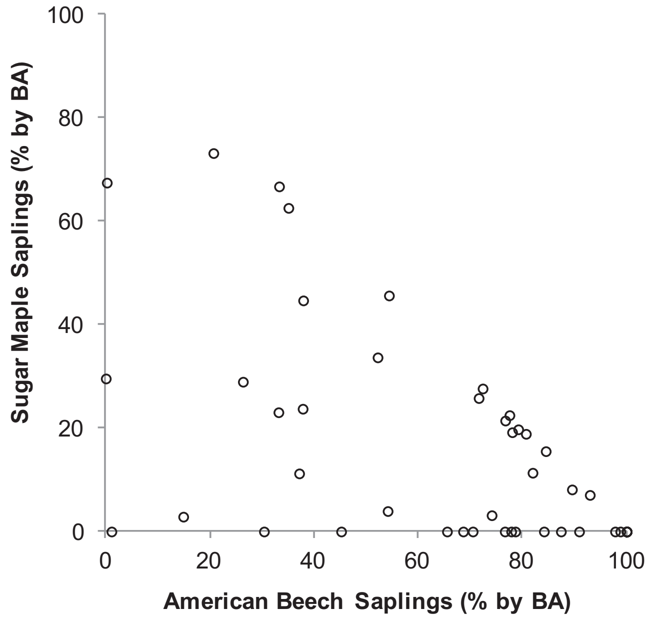

Figure 3-3. Relationship between the percent abundance of SM and American beech sapling basal area (BA), expressed as the percentage of plot total sapling BA.

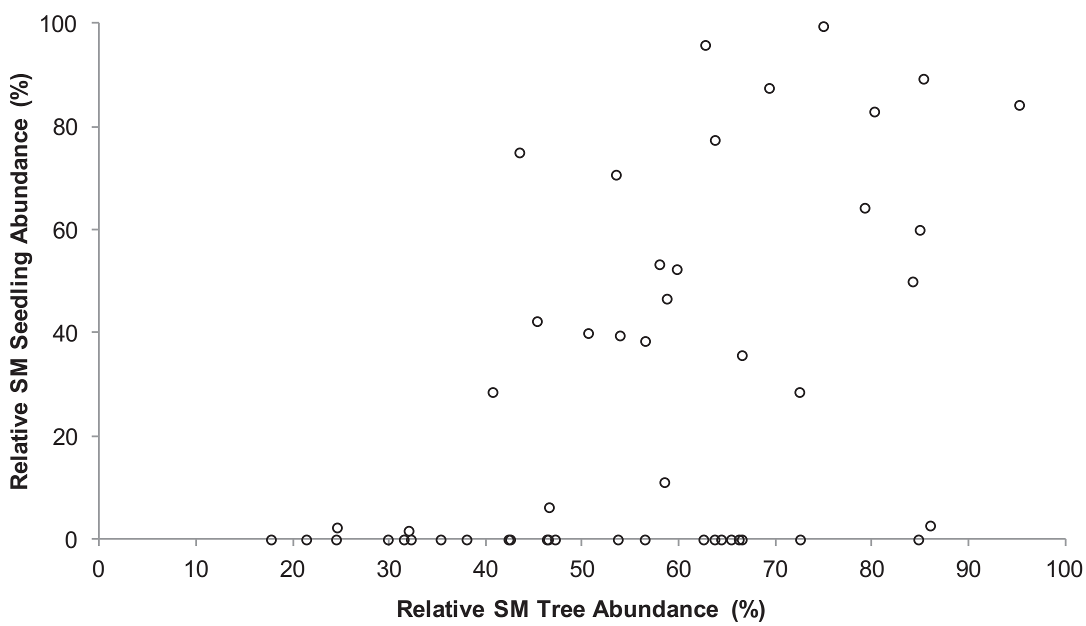

Figure 3-4. Relationship between SM seedling abundance and SM tree abundance on each of the 50 sample plots. Abundance was calculated as the proportion of SM relative to all tree species found on the plot. Seedling abundance was expressed as count; tree abundance was expressed as BA.

Sample plots located in the southwestern portion of the Adirondacks contained the lowest proportion (less than 15% of total seedlings) of SM seedlings (Figure 3-5a). Low SM sapling abundance was found throughout the study region (Figure 3-5b). Sugar maple tree abundance was generally greater than 45%, although several plots in the southwestern portion of the Adirondacks were comprised of less than 45% SM trees (Figure 3-5c). Additional tables and figures that show relative abundance of the primary overstory species can be found in Appendices C and D.

3.2 Canopy Condition

Canopy condition of SM trees was variable across the study region (Figure 3-6). Ten plots showed average vigor in vigor class 4 (severe decline) for SM, mostly in the southwestern Adirondacks (Figure 3-6 left panel). In contrast, none of the plots showed AB in severe decline (Figure 3-6 middle panel). Nearly twice as many plots showed AB average vigor rated as healthy or in slight decline as compared with SM average vigor. Numerical values of average canopy condition for SM are included in Appendices E and F.

3.3 Regeneration

Sugar maple sapling abundance was generally low across the sample plots. Nearly half of the plots had no SM saplings, and 36 of the 50 plots contained no more than two SM saplings (Figure 3-7). Seedling abundance of SM was also generally low (Figure 3-8).

3.4 Growth

Analyses revealed that 65 of 124 cored SM trees showed evidence of growth increment decline since 1950 based on statistical analysis of the dendrochronological data. Most of the trees showing growth declines showed either a continuous linear decline (*n*=15) or a recent piecewise decline (*n*=41). Of the 59 trees that showed no evidence of growth decline, most (*n*=34) showed a continuous linear increase in growth (Table 3-2). Growth response functions that were used as the basis for classifying each of the cored trees are shown in Appendix G. The full dendrochronology record for each of the cored trees is shown in Appendix H.

Table 3-2. Number of cored sugar maple trees within each type of modeled growth response function[1].

Response	Model	Type	# of Trees
Decline	Linear	Continuous	15
	Piecewise	Continuous	2
	Piecewise	Initial	7
	Piecewise	Recent	41
No Decline	Linear	Continuous	34
	Piecewise	Continuous	1
	Piecewise	Initial	10
	Piecewise	Recent	9
	Piecewise	No change	5

[1] See Appendix G for examples of the identified growth responses

a)

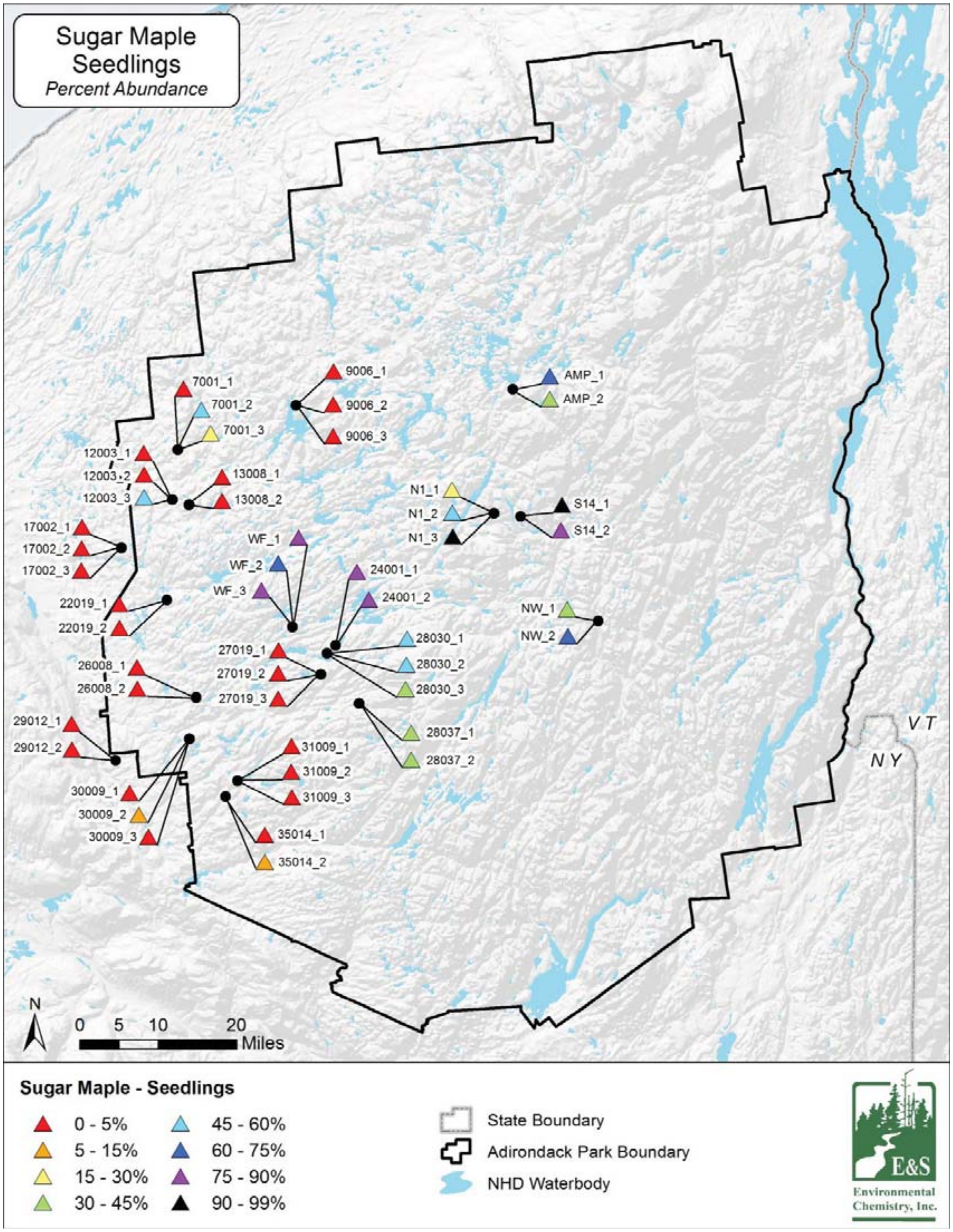

Figure 3-5. Mapped classes of percent abundance for SM a) seedlings, b) saplings, and c) trees. Abundance is measured as the percent of total plot BA for trees and saplings and as a percentage of total plot count for seedlings.

b)

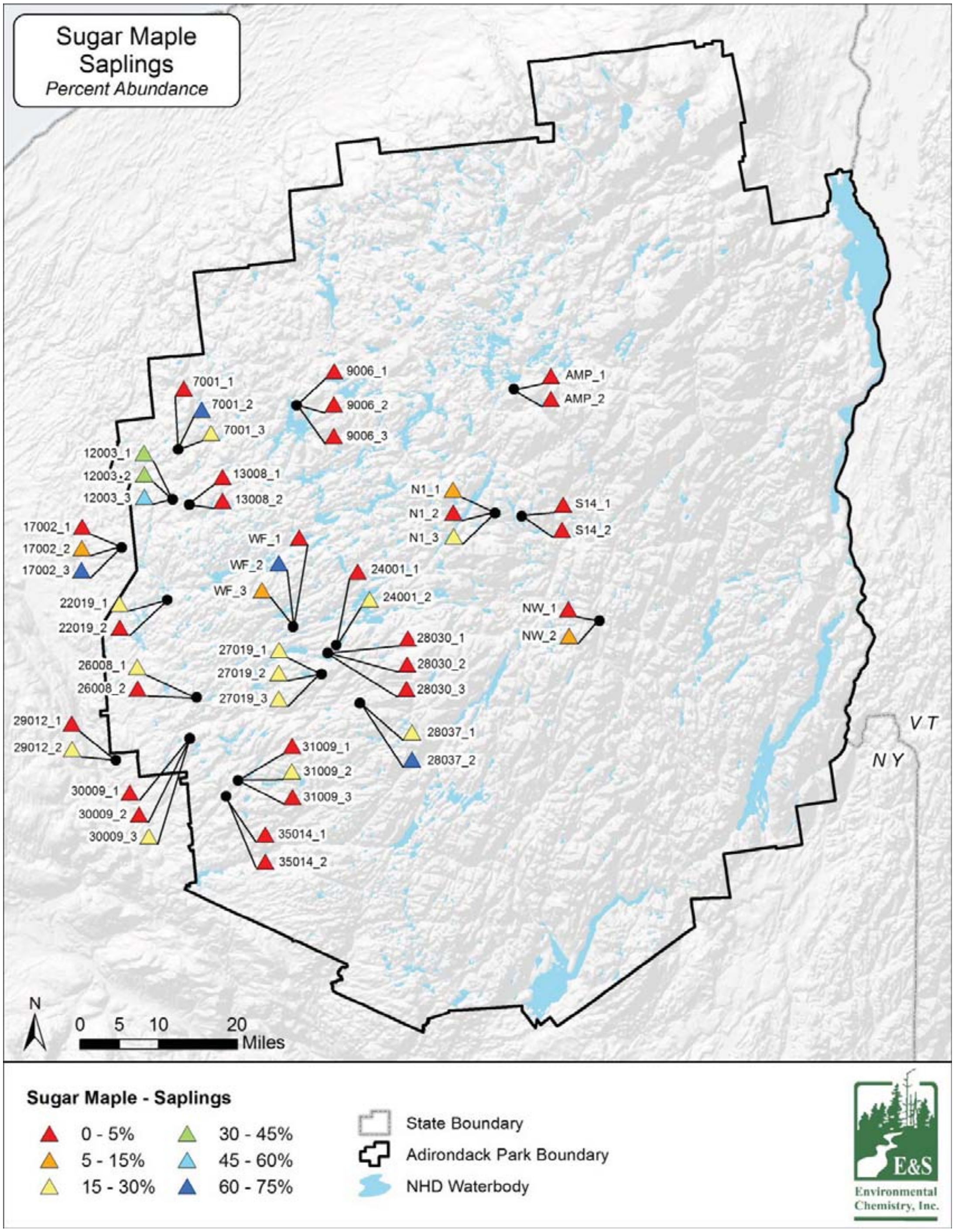

Figure 3-5. Continued.

c)

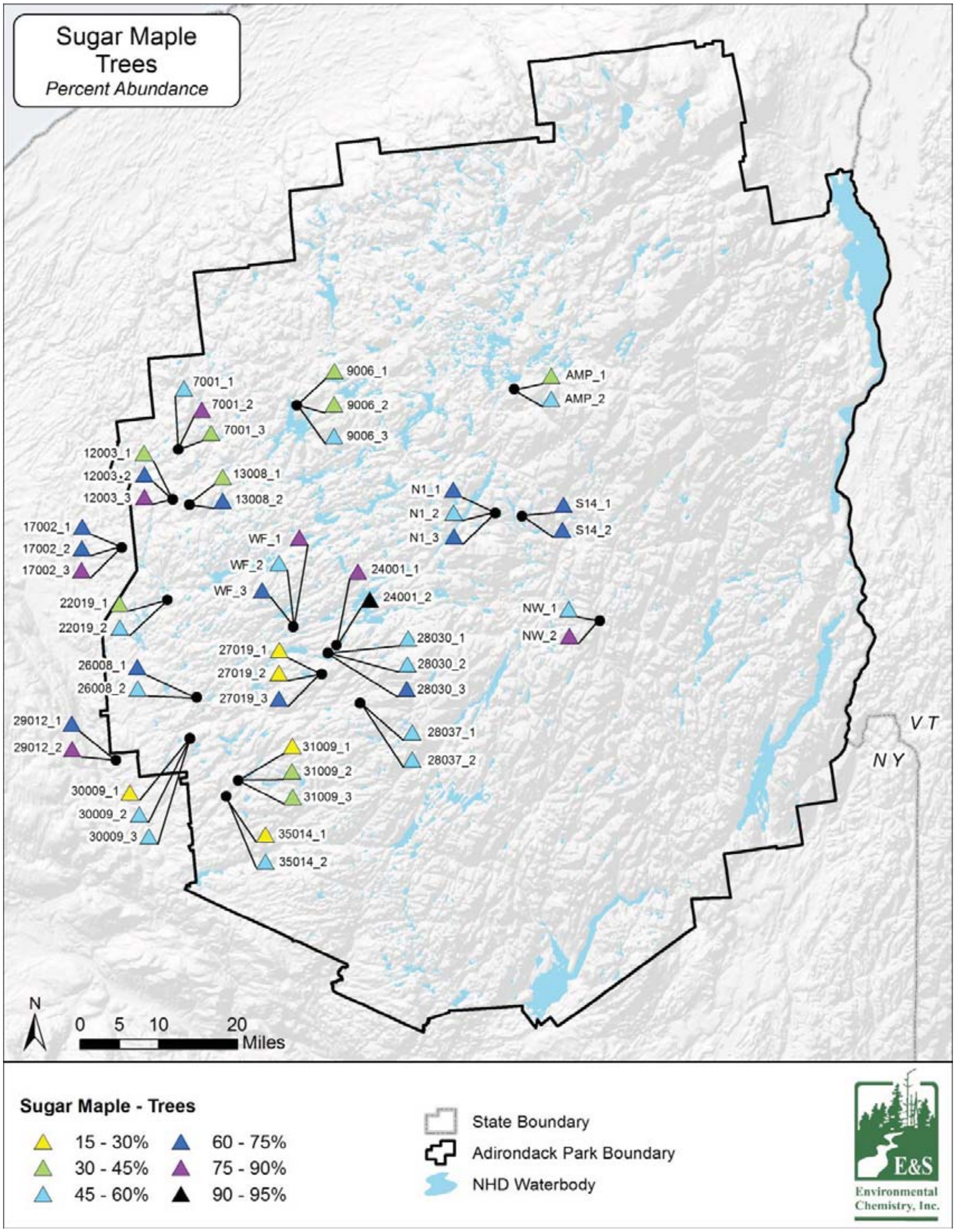

Figure 3-5. Continued.

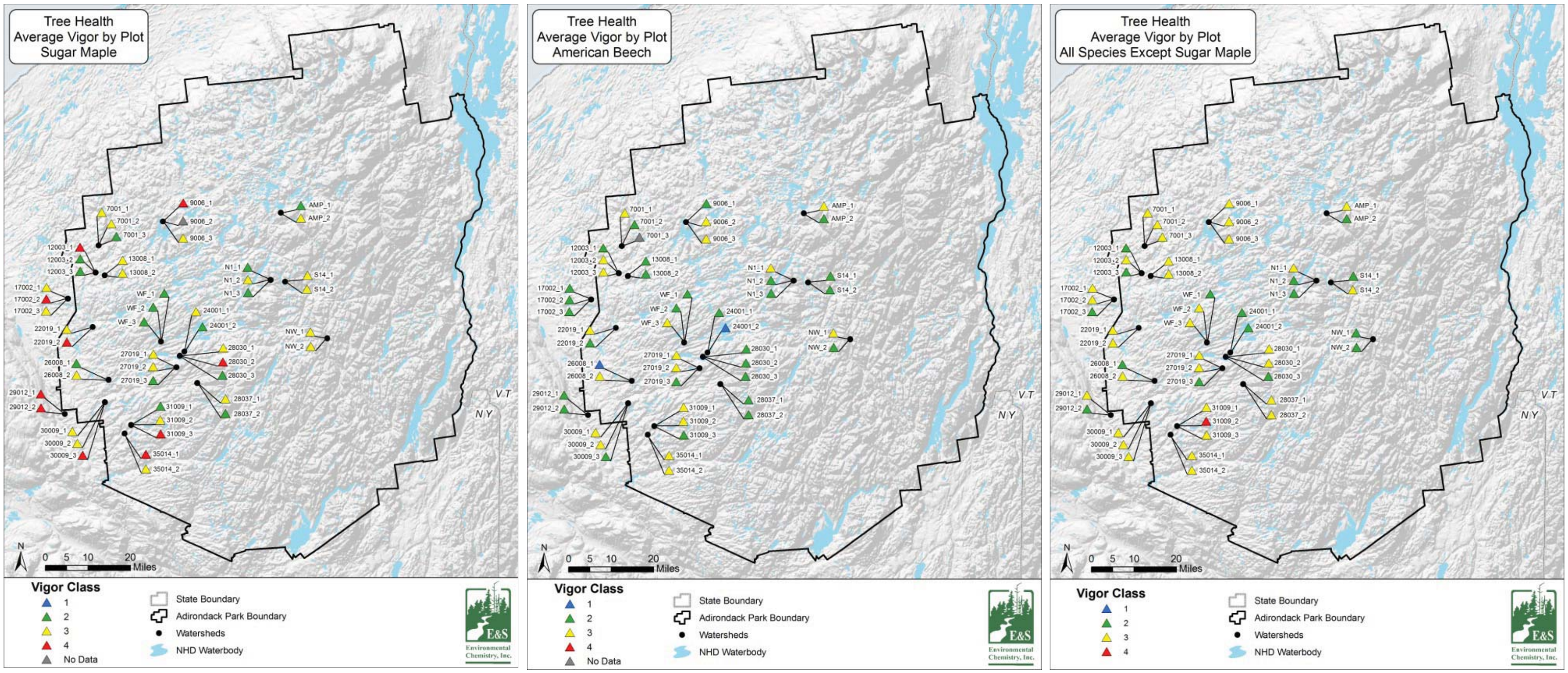

Figure 3-6. Plot averaged vigor for a) SM, b) AB, and c) all species except SM.

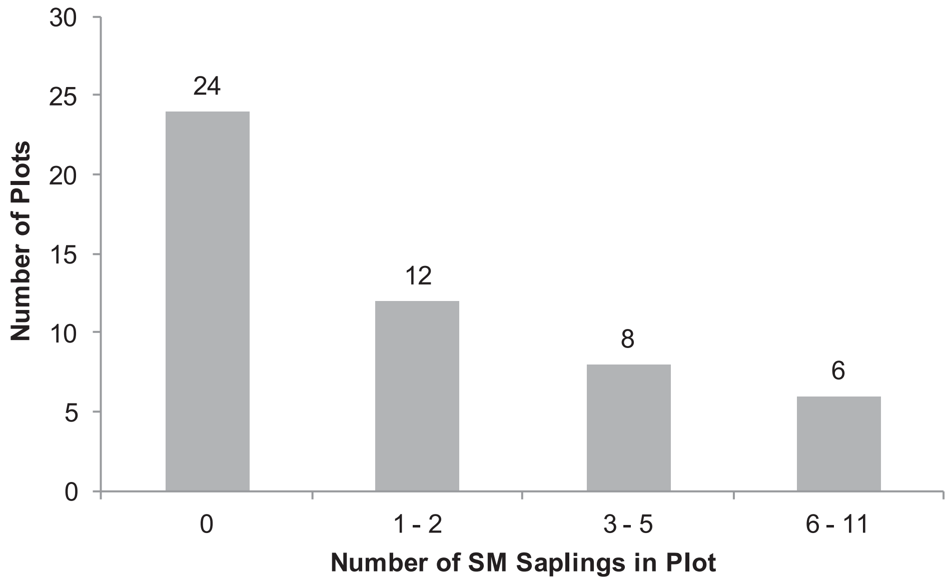

Figure 3-7. Frequency distribution showing the number of plots having varying numbers of SM saplings.

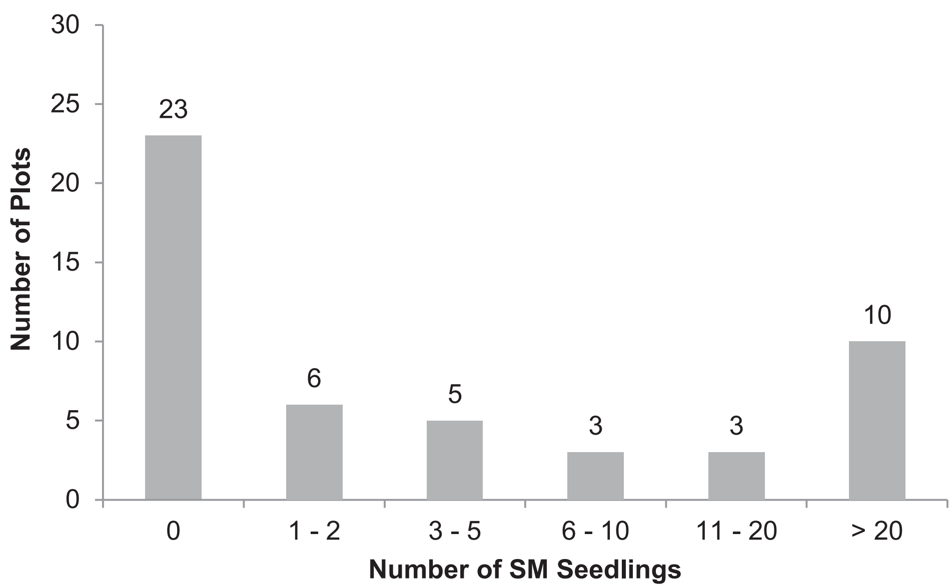

Figure 3-8. Frequency distribution showing the number of plots having varying numbers of SM seedlings.

Cored SM trees classified as having growth decline generally followed patterns of increasing growth from 1950 to approximately 1972 (Figure 3-9). From 1972 to 2005, these trees showed a consistent overall trend of decreasing growth increment.

The group of 59 SM trees with no observed decline in growth showed relatively stable patterns of growth from 1950 to approximately 1970. These trees showed an overall trend of increasing basal area growth increment from 1970 to 2005. Many of the trees considered to not be in decline were located on plots with low soil BS. The reason for this response pattern is unclear.

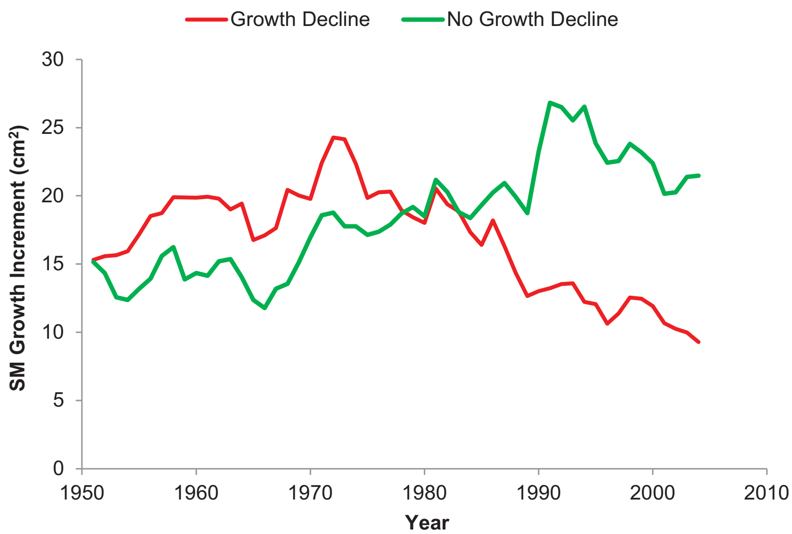

Figure 3-9. Time-series (1950−2005) of SM annual growth increment, represented as a three-year rolling average for trees that exhibited recent growth decline (red; *n*=65) and those that did not exhibit a recent decline in growth (green; *n*=59). Values represent the median growth increment value of all trees within each response class.

3.5 Soil Condition

Exchangeable Ca concentration averaged across the 50 soil pits was highest in the Oe horizon, with decreasing concentrations found in progressively lower soil horizons (Figure 3-10a). Median exchangeable Ca was 22.2 and 12.1 $cmol_c\ kg^{-1}$ in the Oe and Oa horizons, respectively (The interquartile range[4] [IQR] Oe: 16.3 to 33.9 $cmol_c\ kg^{-1}$; IQR Oa: 8.4 to 20.3 $cmol_c\ kg^{-1}$). The A and upper B horizons had median exchangeable Ca values of 3.1 and 0.3 $cmol_c\ kg^{-1}$, respectively (IQR A: 1.7 to 6.0 $cmol_c\ kg^{-1}$; IQR upper B: 0.2 to 1.0 $cmol_c\ kg^{-1}$). The same general pattern was observed for soil % BS (Figure 3-10b). Upper B soil % BS was generally less than was found for surface horizons (Oe, Oa, and A). However, seven plots had

[4] Interquartile range is the range from the 25th to 75th percentiles of the data distribution.

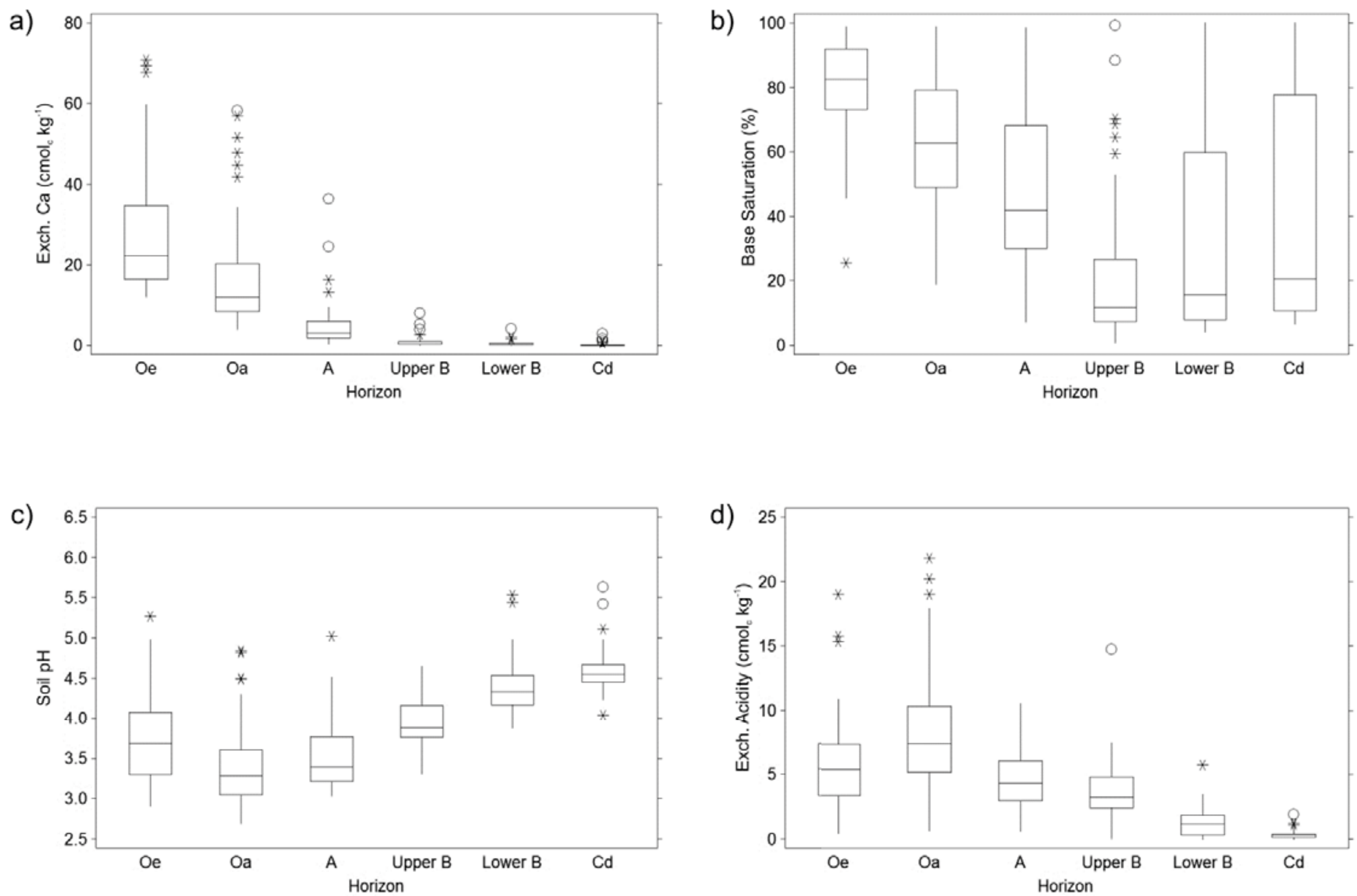

Figure 3-10. Distribution shown as box-plots of major soil chemical parameters in organic and mineral soil horizons across all 50 sampled plots. Data were averaged for multiple samples that occurred within the same horizon on a plot. Parameters shown include: a) exchangeable calcium (Ca) concentration, b) base saturation, c) soil pH, and d) exchangeable acidity (one outlier of 54.4 for exchangeable acidity in the Oe horizon is not shown). Distributions for the remainder of the soil chemical variables can be found in Appendix I.

upper B soil % BS values greater than 50%. Soil pH was typically between 3.0 and 4.0 in upper soil horizons and 3.5 to 4.5 in the B horizon (Figure 3-10c). Total exchangeable acidity was highest in the Oa horizon (median = 7.4 $cmol_c\ kg^{-1}$; IQR 5.3 to 10.2 $cmol_c\ kg^{-1}$), with decreasing concentrations observed in lower soil horizons. The upper B horizon had a median exchangeable acidity of 3.3 $cmol_c\ kg^{-1}$ and an IQR of 2.4 to 4.8 $cmol_c\ kg^{-1}$ (Figure 3-10d). Distributions of values for the remainder of the soil chemical parameters are included in Appendix I. In general, exchangeable Ca in surface soil horizons (Oe, Oa, and A) was correlated with exchangeable Ca in the upper B horizon (Figure 3-11).

The full set of laboratory-analyzed soil chemical results are included in tabular form for each horizon on each plot in Appendix J. Soil chemistry data are also plotted as line charts (Appendix K). The line charts show patterns of increasing and decreasing concentration for each soil chemical parameter across the individual plots.

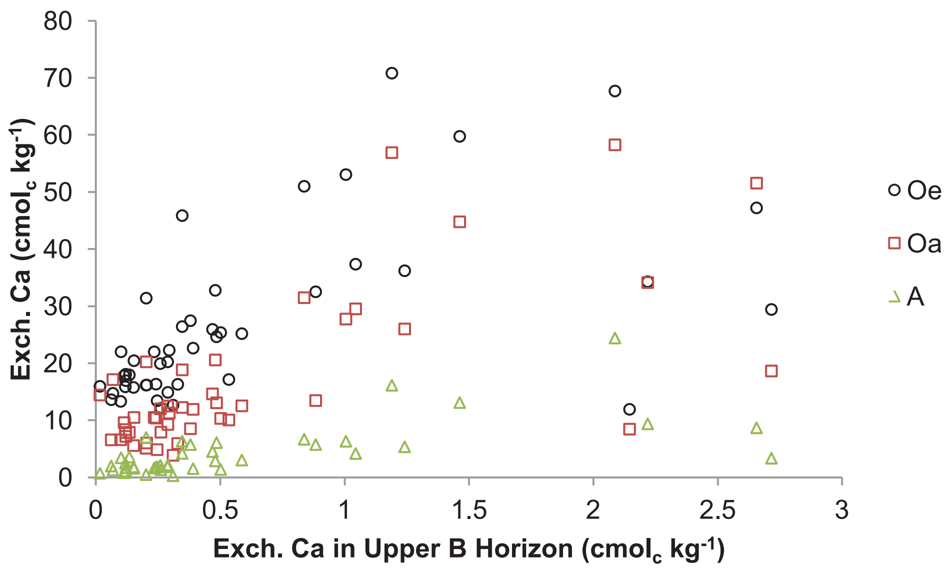

Figure 3-11. Relationship between exchangeable calcium (Ca) in the upper B horizon and the Oe (black), Oa (red), and A (green) horizons.

3.6 Associations Among Sugar Maple Condition, Soil Chemistry, and Atmospheric Deposition

3.6.1 Seedlings and Saplings

The acid-base status of soils in plots where SM seedlings occurred differed significantly from those where SM seedlings were absent (Figure 3-12). Results of statistical analyses are summarized in Table 3-3. Plots that did not contain any SM seedlings had significantly lower base saturation (BS) and exchangeable Ca in Oa, A, and upper B soil horizons ($p < 0.01$) and lower C:N in A and upper B horizons ($p < 0.01$). Plots without SM seedlings were also estimated to be subjected to higher rates of atmospheric deposition of S, N, and S + N ($p < 0.01$). Plots that lacked both SM seedlings and saplings had lower ($p < 0.01$) BS and exchangeable Ca and Mg in all surface soil horizons (Oe, Oa, A) as compared with plots that contained SM seedlings.

Plots that contained SM seedlings had significantly higher ($p < 0.01$) soil BS, exchangeable Ca, exchangeable Mg, and Ca:Al ratio in organic and mineral soil horizons as compared with plots that lacked SM seedlings (Table 3-4). Highly significant differences ($p < 0.01$) were also observed for pH in the organic soil horizons, less so ($p < 0.05$) for B-horizon soil. For example, the average soil BS in the upper B horizon for plots that did not contain any SM seedlings was 8.4%, as compared with 33.7% for plots that did contain SM seedlings. Plots with SM seedlings absent were associated with higher exchangeable acidity, exchangeable H, and received higher N and S deposition. The same patterns were generally observed regardless of the number of SM trees that occurred on a given plot (Appendix L).

Sugar maple seedling abundance varied with soil BS and was lowest on plots with soil BS less than 12% (Figure 3-13a) and highest on plots with soil BS greater than 20% (Figure 3-13c). Figure 3-14 shows soil BS, with the plots split into two groups; those that contained greater than and those that contained less than 50% SM tree abundance. The median and IQR of soil BS within each group of plots were both relatively low; with the 75th percentile soil BS in the upper B horizon below 12% in both groups. This suggests that soil BS is typically low on plots with low SM seedling abundance regardless of the abundance of SM trees.

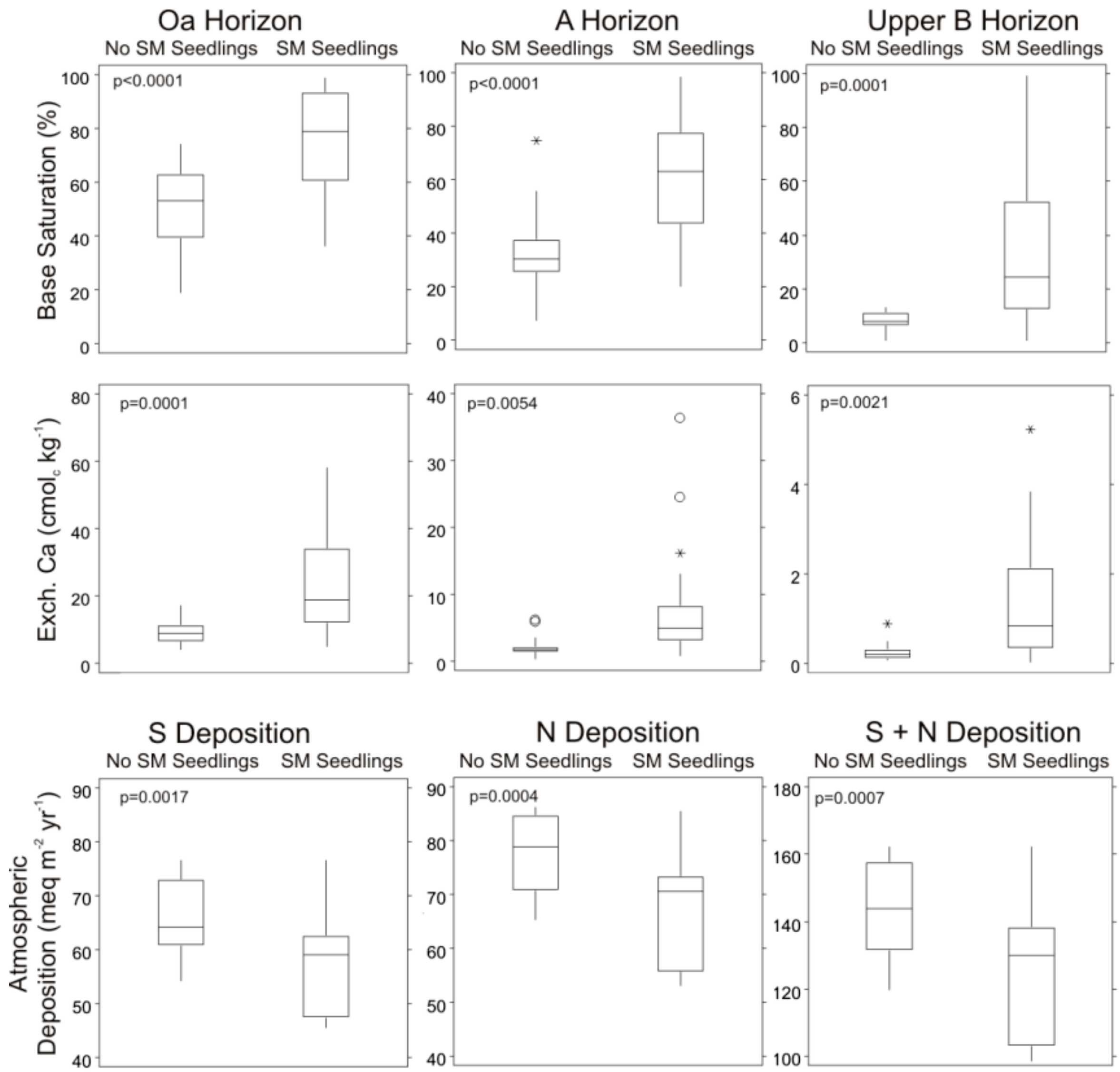

Figure 3-12. Box and whisker plots of soil % base saturation and exchangeable calcium (Ca) in three soil horizons (Oa, A, upper B) for two groups of study plots: those containing and those not containing SM seedlings. Shown at the bottom of the figure is the distribution of atmospheric deposition estimates for the same two groups of study plots.

Table 3-3. Summary of primary statistical results relating to the association between SM condition and soil nutrient base cation supply and sulfur + nitrogen deposition.

Variable	SM Seedlings Absent	SM Seedlings Present	*p*-value
Seedling Presence			
Mean % BS in the upper B horizon	8.4	33.7	< 0.0001
Mean exch. Ca in the Oa horizon ($cmol_c \cdot kg^{-1}$)	9.2	24.5	< 0.001
Mean total S + N deposition ($meq \cdot m^{-2} \cdot yr^{-1}$)	143.3	125.8	< 0.001

	Low Canopy Vigor[1]	High Canopy Vigor[2]	*p*-value
Canopy Condition Response			
Mean % BS in the A horizon	37.3	55.9	< 0.05

	Linear R^2	*p*-value
Seedling Proportion		
Proportion of SM seedlings vs. Oa horizon exch. Ca	0.59	< 0 .0001

[1] Bottom third of the distribution across sites
[2] Top third of the distribution across sites

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Table 3-4. ANOVA results from comparison of plot attributes between groups of plots based on sugar maple (SM) seedling presence/absence. "+" indicates that higher values were associated with SM seedlings presence. "-" indicates that higher values were associated with SM seedling absence. The number of "+" or "-" indicates the level of significance: 1 = *p* < 0.1, 2 = *p* < 0.05, 3 = *p* < 0.01, 4 = *p* < 0.001, and 5 = *p* < 0.0001. Matrix cells are also color coded for ease of comparison. The highest level of significance is coded red, followed sequentially by orange, yellow, green, and blue.

Variable	Horizon	*p*-value[c]	SM Seedlings Absent (n = 27)[a] mean (SE)	SM Seedlings Present (n = 23)[b] mean (SE)
Soil Chemistry				
BS	Oe	+ + + +	72.0 (2.7)	87.8 (2.5)
	Oa	+ + + + +	50.7 (3.7)	74.4 (3.3)
	A	+ + + + +	33.0 (4.6)	61.2 (4.1)
	UB	+ + + +	8.4 (4.2)	33.7 (3.9)
	LB	+ + +	18.6 (6.3)	45.4 (5.9)
Exch. Ca	Oe	+ + + + +	18.6 (2.8)	36.0 (2.6)
	Oa	+ + + +	9.2 (2.6)	24.5 (2.3)
	A	+ + +	2.1 (1.4)	7.6 (1.2)
	UB	+ + +	0.3 (0.3)	1.5 (0.3)
	LB	+ + + +	0.1 (0.2)	0.9 (0.2)
Exch. Mg	Oe	+ + + +	2.6 (0.3)	4.2 (0.3)
	Oa	+ + + +	1.2 (0.2)	2.5 (0.2)
	A	+ + +	0.4 (0.1)	0.8 (0.1)
	UB	+ + +	0.1 (0)	0.2 (0)
	LB	+ + +	0.0 (0)	0.1 (0)
Exch. Ca + Exch. Mg	Oe	+ + + + +	21.1 (3.1)	40.1 (2.8)
	Oa	+ + + +	10.3 (2.8)	27.0 (2.5)
	A	+ + +	2.5 (1.5)	8.4 (1.3)
	UB	+ + +	0.3 (0.3)	1.7 (0.3)
	LB	+ + + +	0.1 (0.2)	1.0 (0.2)
Exch Ca: Exch. Al	Oe	+ + +	55.6 (51)	268.9 (47)
	Oa	+ + +	8.3 (22.2)	90.1 (20.1)
	A			
	UB			
	LB			
pH ($CaCl_2$ method)	Oe	+ + + + +	3.5 (0.1)	4.0 (0.1)
	Oa	+ + + +	3.1 (0.1)	3.6 (0.1)
	A	+ + + +	3.3 (0.1)	3.7 (0.1)
	UB	+ +	3.9 (0.1)	4.0 (0.1)
	LB	+ +	4.3 (0.1)	4.5 (0.1)
Exch Acidity	Oe	- -	9.8 (1.5)	4.3 (1.4)
	Oa	- - -	10.3 (1)	6.6 (0.9)
	A	- -	5.4 (0.5)	3.9 (0.5)
	UB	- -	4.8 (0.5)	3.2 (0.4)
	LB			
Exch. Al	Oe			
	Oa			
	A			
	UB			
	LB			
Exch. H	Oe	- -	8.4 (1.4)	3.6 (1.3)
	Oa	- -	6.8 (0.7)	4.6 (0.6)
	A			
	UB			
	LB	- -	0.3 (0.1)	0.1 (0.1)

Variable	Horizon	*p*-value[c]	SM Seedlings Absent (n = 27)[a] mean (SE)	SM Seedlings Present (n = 23)[b] mean (SE)
Soil Chemistry				
C	Oe			
	Oa			
	A			
	UB			
	LB			
N	Oe			
	Oa			
	A	+ +	0.7 (0.1)	0.9 (0.1)
	UB			
	LB			
C:N	Oe	+ + + + +	8.8 (1.2)	16.4 (1.1)
	Oa			
	A	- - - -	17.6 (0.4)	15.7 (0.3)
	UB	+ + +	0.9 (1.1)	5.9 (1)
	LB	+ + +	0.9 (2.4)	9.7 (2.1)
Landscape				
Elevation		+	521.1 (16.4)	561.0 (15.2)
Slope		+ +	13.2 (2)	19.8 (1.8)
Physiographic Position				
Light Availability (photo)				
Light Availability (model)		- -	141,102 (16,813)	90,260 (15,517)
Total S Deposition		- - -	65.9 (1.7)	58.1 (1.6)
Total N Deposition		- - - -	77.4 (1.9)	67.7 (1.7)
Total S + N Deposition		- - - -	143.3 (3.6)	125.8 (3.3)

[a] n = 24 for A horizon
[b] n = 19 for A horizon
[c] Data completeness was 94 percent for soil pH data and greater than or equal to 98 percent for the remaining soil chemical parameters

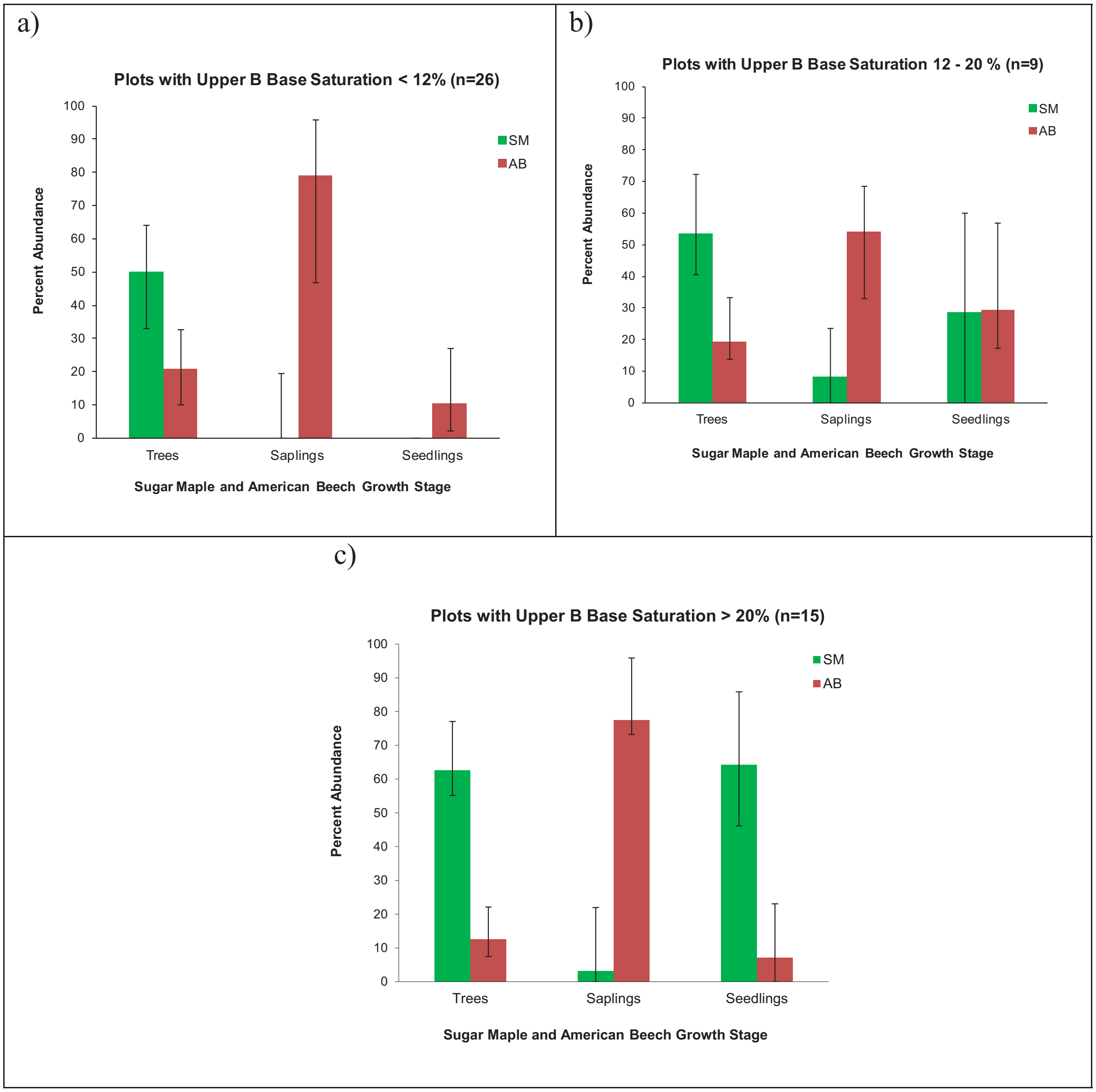


Figure 3-13. Growth stage abundance of SM and AB on plots having soil BS a) less than 12%, b) 12 - 20%, and c) greater than 20%. Abundance is represented as a percent of the total plot basal area for trees and saplings, and as a percentage of the total plot count for seedlings.

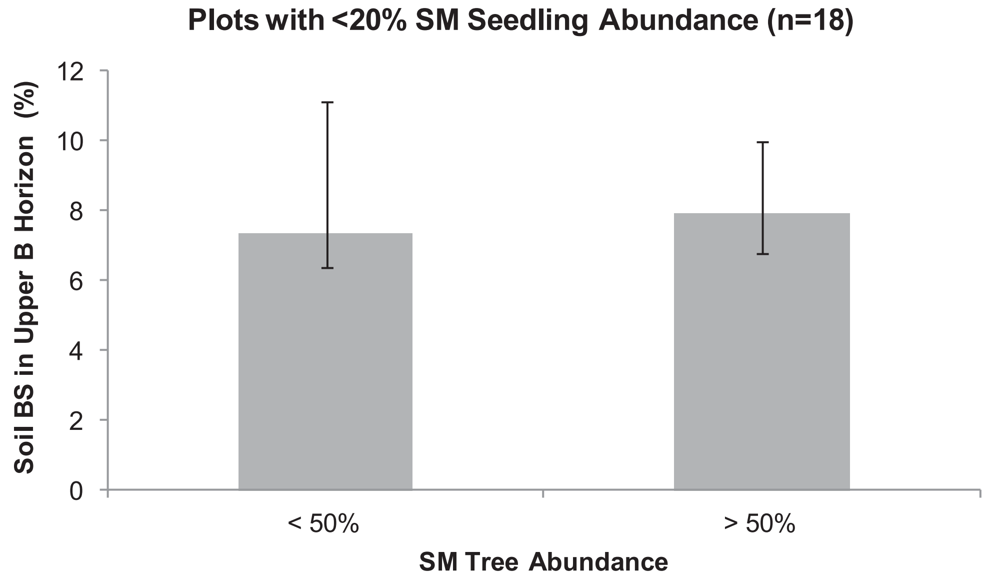


Figure 3-14. Median (columns) and quartile (error bars) soil BS in the upper B horizon on plots having low (< 20%) SM tree abundance. Data are shown for plots that contain both less than 50% (left column) and greater than 50% (right column) SM tree abundance.

Box-plots showing the distributions of three key variables associated with soil acidification processes (soil BS, exchangeable Ca, acidic deposition) among plots with and without SM seedlings indicate that SM seedlings generally occurred on plots having higher soil BS and exchangeable Ca in the Oa, A, and upper B horizons and that were subject to lower N and S deposition (Figure 3-12).

Sugar maple seedling abundance was evaluated based on plot averaged soil exchangeable Ca and BS. Seedling abundance represented by SM seedling count was positively correlated with exchangeable Ca but only about a third of the variance in SM seedling count was explained (Figure 3-15). Stronger relationships between seedling abundance and surface soil horizon exchangeable Ca were observed when abundance was expressed as the ratio of SM seedlings to the total number of seedlings of all species (Figure 3-16). The strongest relationship occurred with exchangeable Ca in the Oa horizon (R^2 = 0.59; Figure 3-16b). In each case, study plots that lacked SM seedlings were clustered toward lower concentrations of exchangeable Ca. Similar patterns between SM seedling abundance and soil BS in surface and upper B soils were observed (Figures 3-17 and 3-18). The SM seedling ratio was most strongly correlated with soil BS in the Oa (R^2 = 0.51) and A (R^2 = 0.58) horizons (Figures 3-18b and 3-18c). Sugar maple seedlings were present on all plots that had soil upper B horizon BS greater than 13.3% (Figures 3-17d and 3-18d).

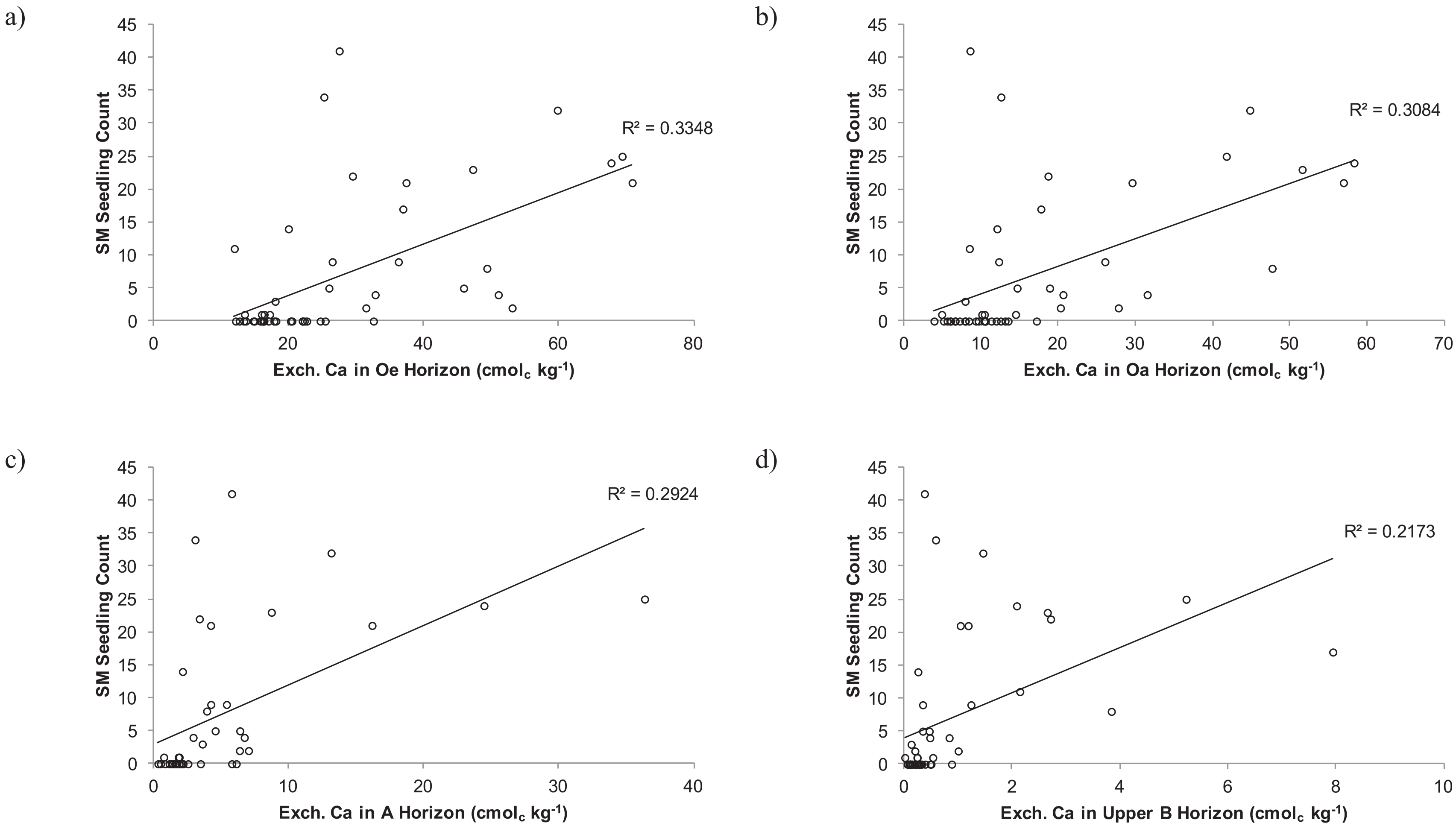


Figure 3-15. Relationship between exchangeable calcium (Ca), by horizon, and the number of SM seedlings sampled on each plot. Results for one outlier plot with 189 SM seedlings are not shown.

a) b) c) d)

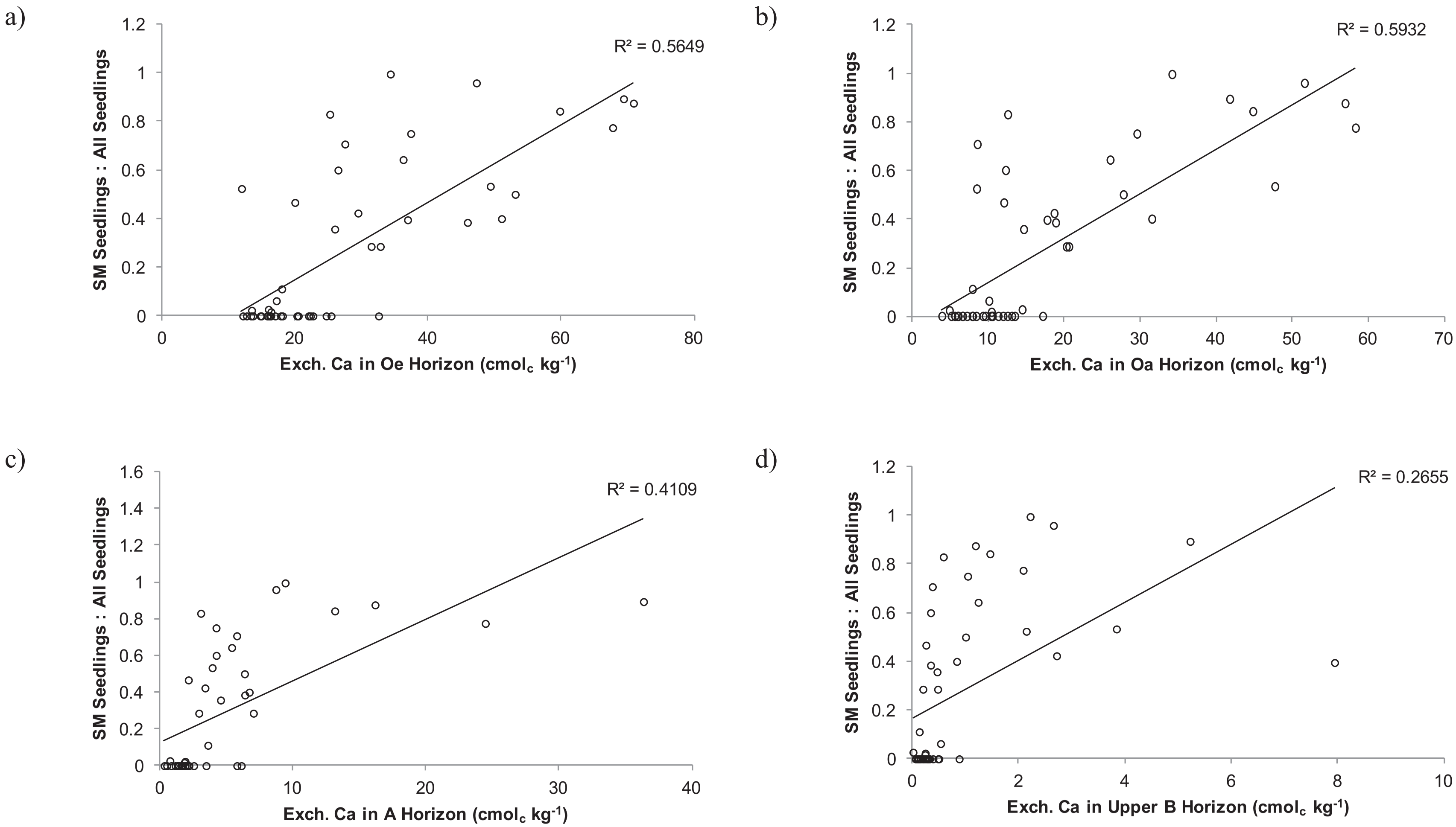


Figure 3-16. Relationship between exchangeable calcium (Ca), by horizon, and the ratio of SM seedlings to all seedlings enumerated on each plot.

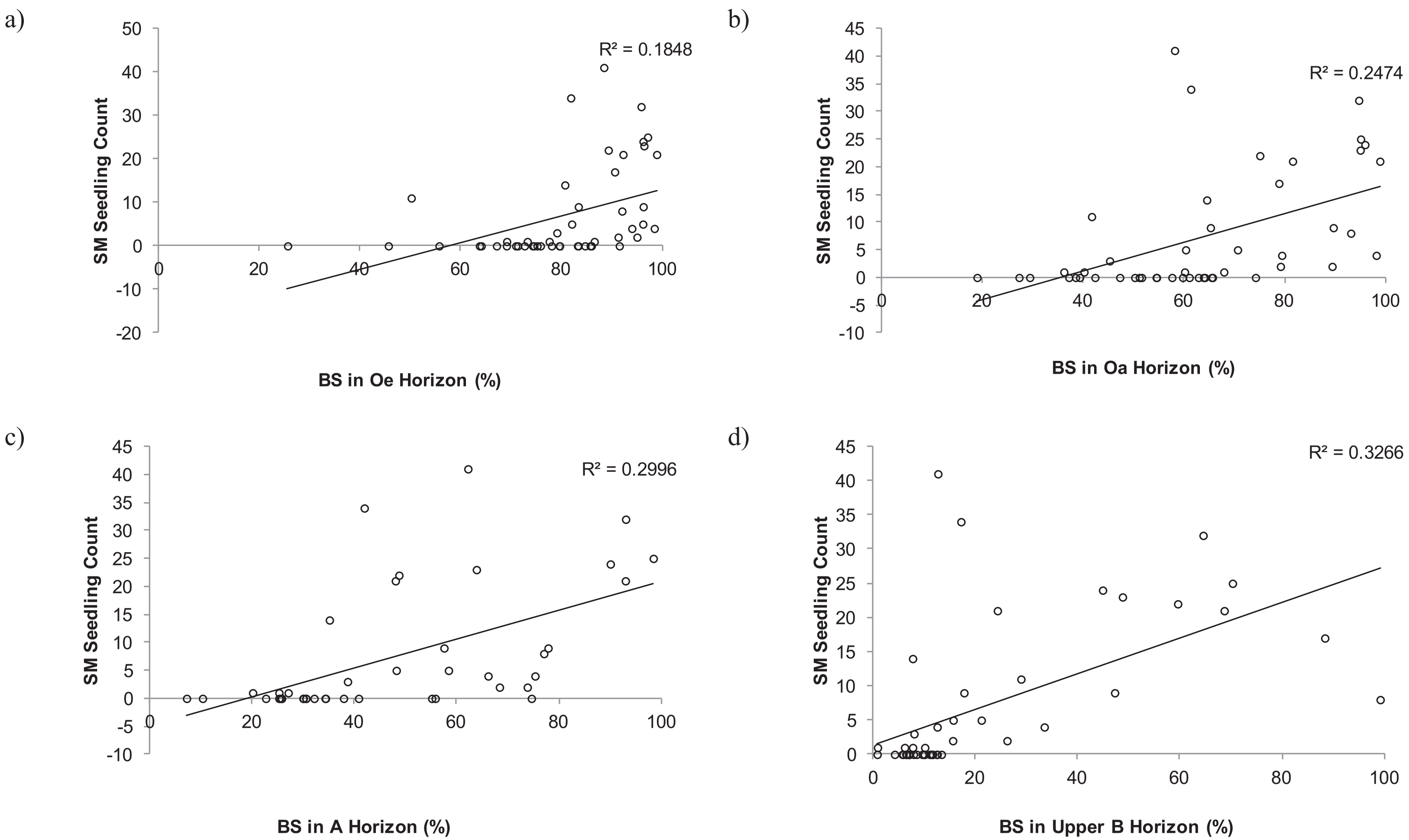


Figure 3-17. Relationship between soil BS, by horizon, and the number of SM seedlings sampled on each plot. Results for one outlier plot with 189 SM seedlings are not shown.

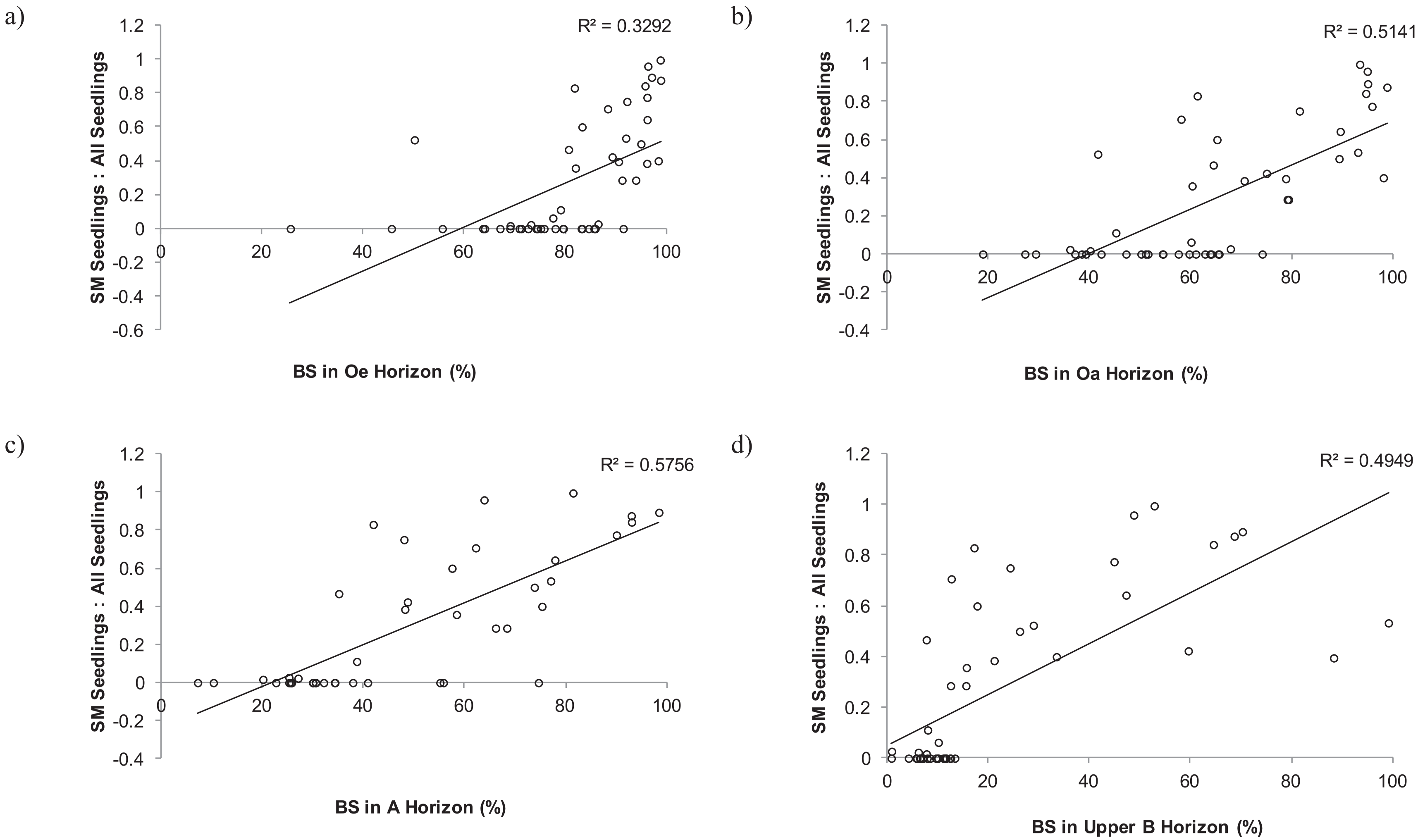


Figure 3-18. Relationship between soil BS, by horizon, and the ratio of SM seedlings to all seedlings sampled on each plot.

To further elucidate patterns between SM seedling proportion and soil BS, plots were rank ordered based on soil BS, and a rolling five-plot average was applied to the soil BS and the SM seedling proportion data. The same data represented in Figure 3-18 were used to generate Figure 3-19, but Figure 3-19 represents the data as a five-plot rolling average. Similar patterns of higher SM seedling proportion with higher soil BS are shown. Of particular note are two threshold values of 12% and 20% soil BS in the upper B horizon (Figure 3-19c). Averaged soil BS of less than 12% corresponded with low (< 12%) SM seedling proportion. Plots with averaged soil BS between 12% and 20% showed a sharp increasing trend in SM seedling proportion. Averaged soil BS greater than 20% was consistently associated with averaged SM seedling proportions in excess of 50%. Similar results were found for exchangeable Ca (Figure 3-20). For B horizon data, the SM seedling proportion increased with increasing exchangeable Ca up to a threshold of 1.3 $cmol_c\ kg^{-1}$.

The relationship between soil exchangeable Ca and the ratio of tree seedlings that were SM was further explained by combining plots in classes according to exchangeable Ca concentration. Plots were ranked based on exchangeable Ca concentrations and classified into 9 bins (five plots per bin, except three plots in bin 9 for the A horizon data, and four plots in bin 10 for the Oa horizon data). Median and quartile SM seedling proportion in each bin was less than 3% in the first four bins of exchangeable Ca in the Oa and A horizons, with the exception of bin 3 in the Oa horizon (Figure 3-21a). In contrast, the median SM seedling count as a percentage of all seedlings on plots having exchangeable Ca higher than 2.9 $cmol_c\ kg^{-1}$ was in all cases higher than 28%, and the 75^{th} percentile was consistently higher than 42%. These data indicate a near complete absence of SM regeneration on sites having exchangeable Ca in the A horizon less than 2.5 $cmol_c\ kg^{-1}$. Similar results were found for sites having upper B horizon BS above and below 12 percent (Appendix M).

The seedling abundance data were also classified into nine bins of increasing BS, and analyzed as shown in Figure 3-22. Plots with soil BS in the first four bins also showed median and quartile seedling proportion of less than 3% (Figure 3-22b). In contrast, bins reflecting high BS consistently showed high SM seedling proportions.

There was no consistent relationship between SM sapling proportion within various classes of soil BS. Nevertheless, SM sapling proportion was generally less than 20% on plots within the three lowest soil BS classes for each soil horizon. Similarly, SM sapling proportion was generally less than 30% within the two lowest exchangeable Ca classes. No significant differences were observed in soil chemistry or landscape differences between groups of plots with and without SM saplings.

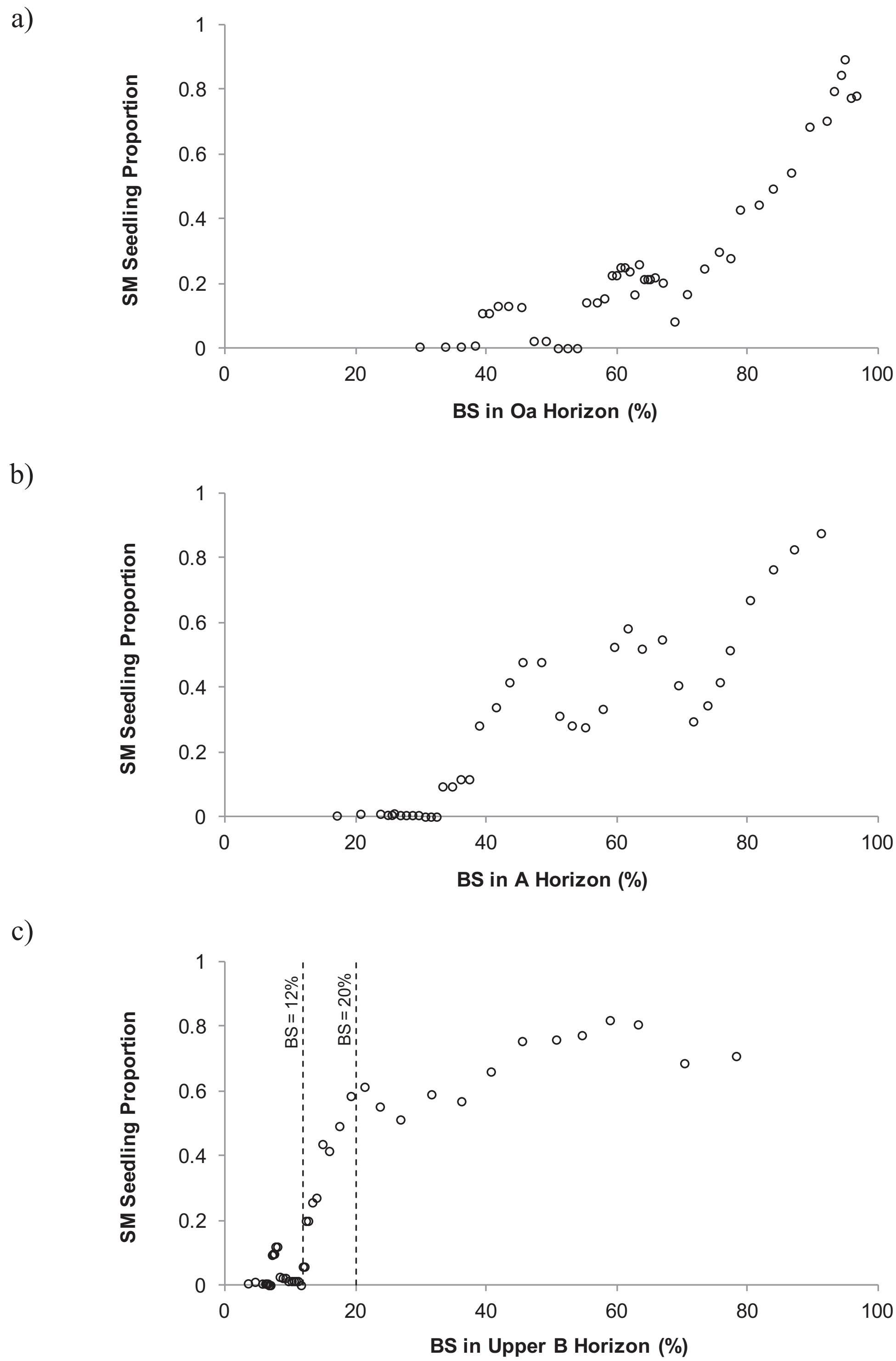
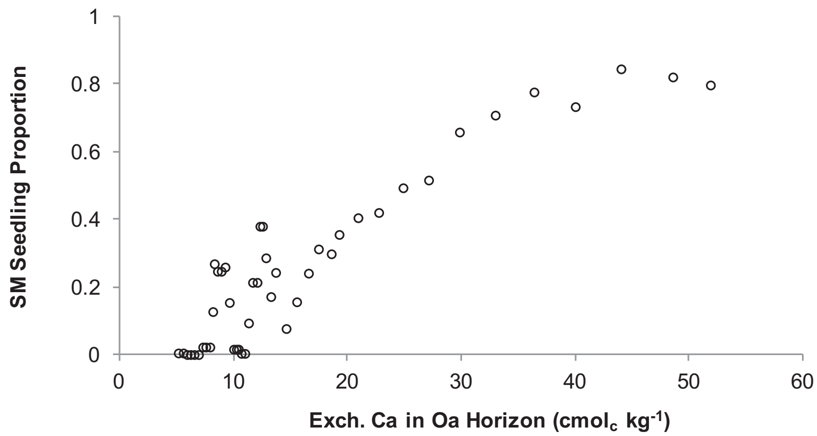
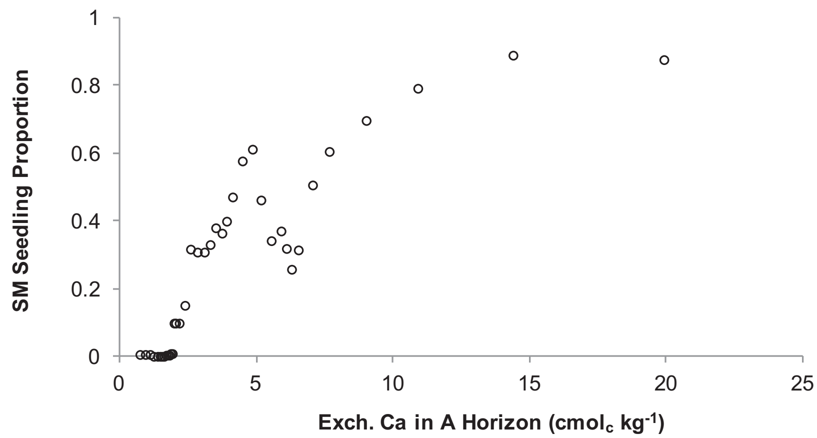


Figure 3-19. Relationship between the proportion of seedlings that were sugar maple (SM) and soil BS in the a) Oa horizon, b) A horizon, and c) upper B horizon. Plots were rank ordered based on soil BS and a five-plot rolling average was applied to both the soil BS and the seedling proportion data.

a)



b)



c)

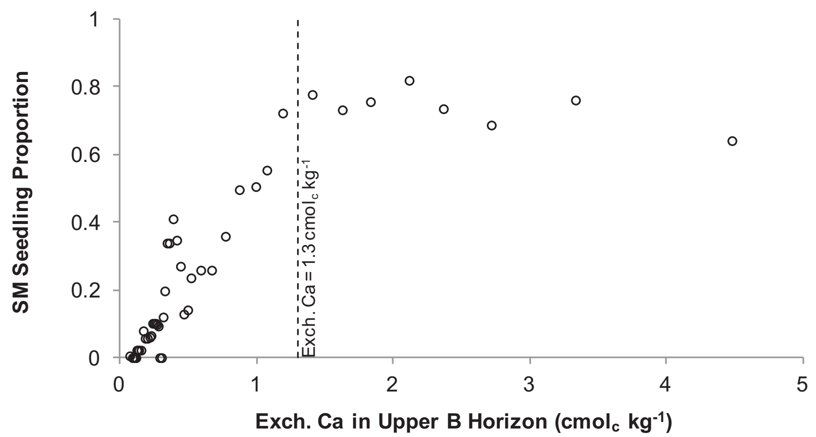
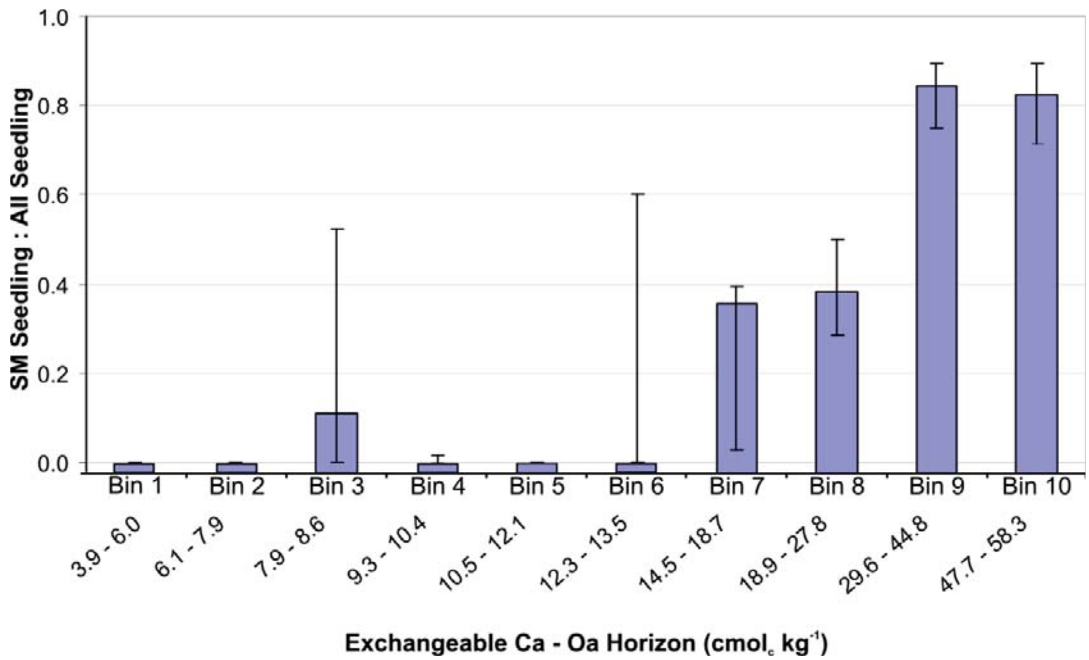


Figure 3-20. Relationship between the proportion of seedlings that were SM and exchangeable calcium (Ca) in the a) Oa horizon, b) A horizon, and c) upper B horizon. Plots were rank ordered based on soil exchangeable Ca and a five-plot rolling average was applied to both the soil exchangeable Ca and the seedling proportion data.

a)



b)

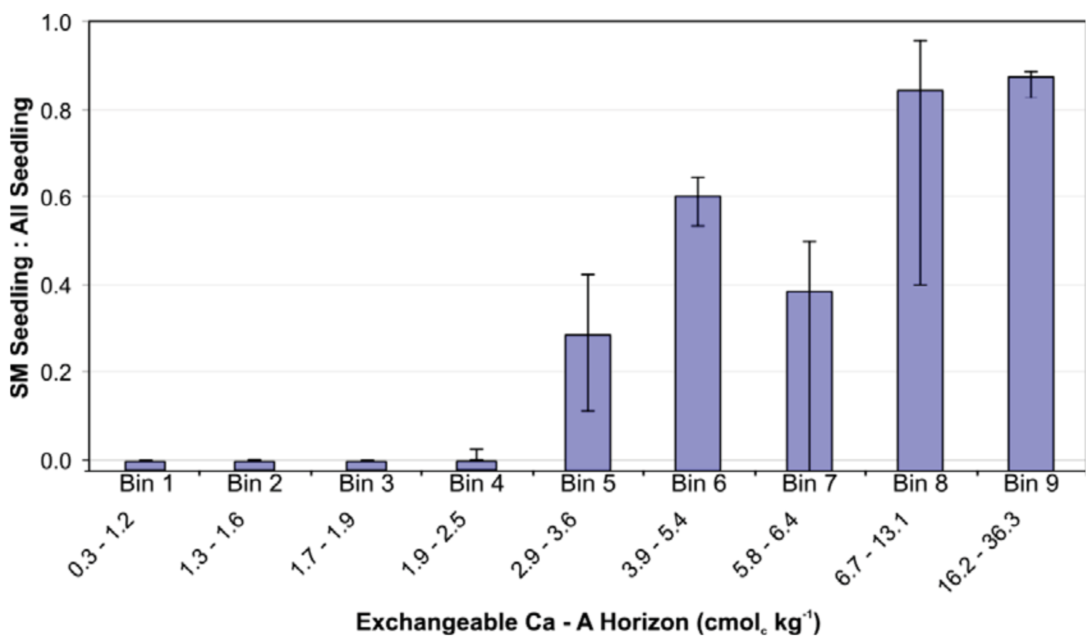
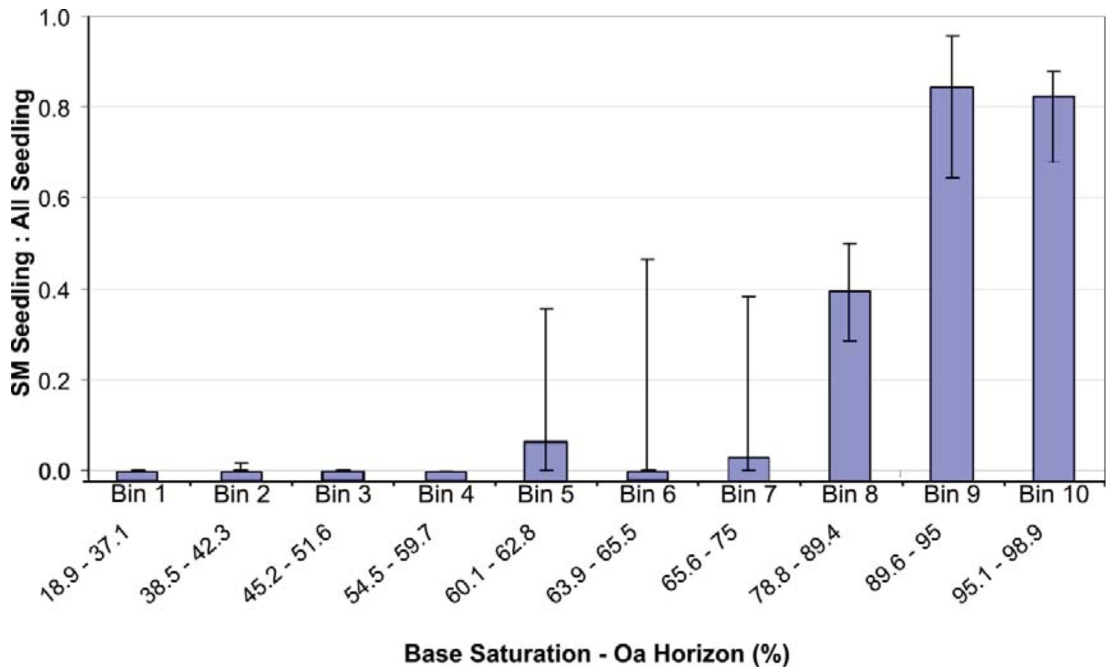


Figure 3-21. Median (columns) and quartile (error bars) ratio of sugar maple (SM) seedlings to all seedlings within various classes of exchangeable calcium (Ca) within a) the Oa horizon and b) the A horizon. Each bin contains five plots, except for bin 10 of the Oa and bin 9 of the A horizon data. These bins contain 4 and 3 plots, respectively.

a)



b)

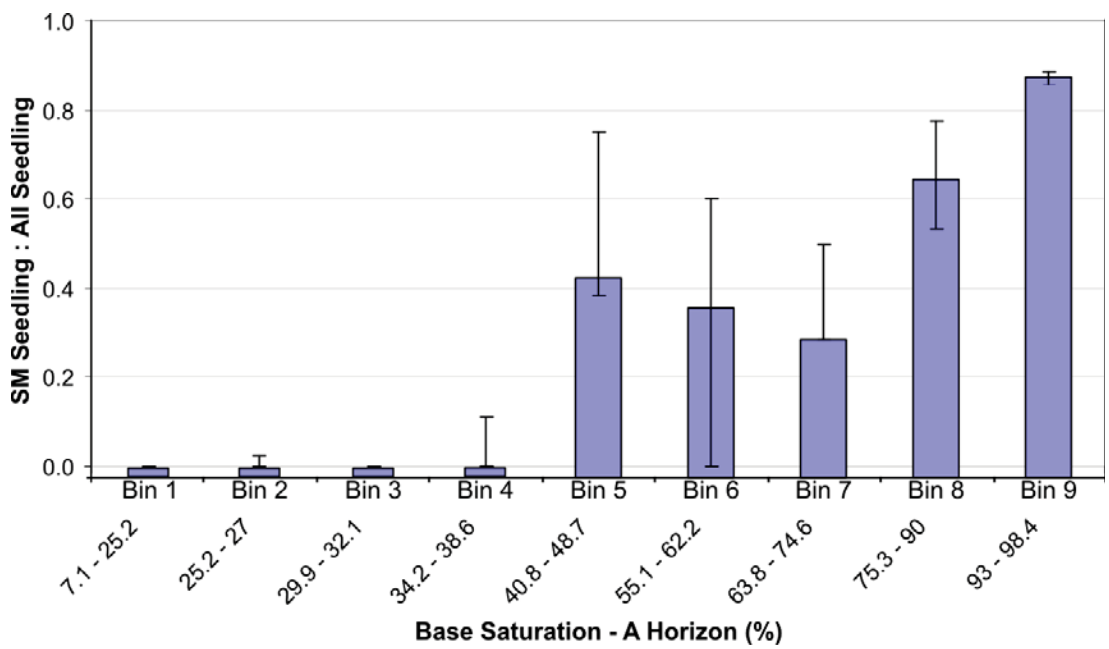


Figure 3-22. Median (columns) and quartile (error bars) ratio of SM seedlings to all seedlings within various classes of soil base saturation within a) the Oa horizon and b) the A horizon. Each bin contains five plots, except for bin 10 of the Oa and bin 9 of the A horizon data. These bins contain 4 and 3 plots, respectively.

Plots that contained both SM saplings and seedlings had significantly higher ($p < 0.05$) soil BS, exchangeable Ca, and exchangeable Mg in organic and mineral soil horizons than plots that contained SM saplings and did not contain SM seedlings (Table 3-5). Groups of plots containing and not containing SM seedlings were further broken down based on the presence/absence of SM saplings (Figure 3-23). Plots that did not contain either SM saplings or seedlings were associated with base depleted soils that were low in pH, and were subjected to high rates of N + S deposition. Plots that did not contain SM saplings but did contain SM seedlings (group C) had more hospitable soil acid-base chemistry and received lower rates of N + S deposition. Thus, soil chemistry appears to control seedling presence more than sapling presence. The most notable observed sapling pattern on these plots was their general absence (Figure 3-24).

Herbivory by white-tailed deer (*Odocoileus virginianus*) may be a causal factor affecting SM regeneration. However, deer densities are generally low in northern New York (Didier and Porter 2003) and declined over the last half of the 20th Century (Nesslage and Porter 2001). Furthermore, analyses by Didier and Porter (2003) did not find an association between SM reproductive success and deer density ($p = 0.61$; n=143) in northern New York.

3.6.2 Canopy Condition

Variables reflecting canopy condition, averaged across study plots, were also correlated with soil chemistry measurements, although some relationships were not statistically significant. Sugar maple foliar transparency was inversely correlated with % BS in the upper B ($p \leq 0.01$) and lower B ($p \leq 0.05$) soil horizons and soil pH in the A horizon ($p < 0.05$). Transparency was lower on plots having higher C:N in the upper B ($p \leq 0.01$) horizon and at higher elevation ($p \leq 0.0001$). More canopy dieback was associated with lower pH in the Oa and A horizons ($p < 0.05$) and lower elevation ($p < 0.001$). Sugar maple tree canopy had generally higher vigor ratings on plots with higher % BS and exchangeable Ca in the Oa, A, and upper B horizons. Differences were statistically significant for the A horizon comparisons (Figure 3-25). Both % BS and exchangeable Ca in the A horizon were significantly lower ($p < 0.05$) on plots with low SM vigor. Healthy SM canopy condition (based on vigor, dieback, discoloration, and transparency variables) was associated with significantly higher ($p < 0.05$) soil BS, exchangeable Ca, and exchangeable Mg in the A horizon. Lower amounts of defoliation were also associated with higher exchangeable Ca and exchangeable Mg in the A horizon, although the differences between groups were less pronounced. There was no relationship between the percentage of standing dead SM trees, however, and soil BS in the upper B horizon (Figure 3-26).

Table 3-5. ANOVA results from comparison of plot attributes between groups of plots based on SM seedling presence/absence on plots that contained SM saplings. "+" indicates that higher values were associated with SM seedling presence. "-" indicates that higher values were associated with SM seedling absence. The number of "+" or "-" indicates the level of significance as given in the legend for Table 3-4.

Variable	Horizon	SM Seedling Presence/Absence on Plots with SM Saplings	SM Seedling Presence/Absence on Plots with SM Saplings[a,b] SM Seed Absence (n = 12) mean (SE)	SM Seed Absence (n = 12) mean (SE)
BS	Oe	+ + + +	73.1 (2.4)	87.4 (2.4)
	Oa	+ + +	49.6 (5.0)	72.1 (5.0)
	A			
	UB	+ +	7.3 (6.3)	31.8 (6.3)
	LB			
Exch. Ca	Oe	+ + +	17.4 (4.2)	37.0 (4.2)
	Oa	+ + +	9.0 (3.6)	24.0 (3.6)
	A	+	1.4 (2.5)	8.1 (2.3)
	UB	+ +	0.2 (0.3)	1.2 (0.3)
	LB	+	0.1 (0.2)	0.8 (0.2)
Exch. Mg	Oe	+ +	2.4 (0.5)	4.1 (0.5)
	Oa	+ +	1.2 (0.3)	2.5 (0.3)
	A	+ +	0.3 (0.2)	0.9 (0.1)
	UB	+	0.1 (0.0)	0.2 (0.0)
	LB			
Exch. Ca + Exch. Mg	Oe	+ + +	19.8 (4.6)	41.1 (4.6)
	Oa	+ + +	10.1 (3.9)	26.5 (3.9)
	A	+	1.7 (2.7)	9.0 (2.4)
	UB	+ +	0.2 (0.4)	1.4 (0.4)
	LB	+	0.1 (0.3)	0.8 (0.3)
Exch Ca: Exch. Al	Oe	+ +	32.9 (75.9)	298.1 (75.9)
	Oa	+	9.5 (33.7)	102.4 (33.7)
	A			
	UB			
	LB			
pH ($CaCl_2$ method)	Oe	+ +	3.4 (0.2)	4.0 (0.2)
	Oa	+ +	3.1 (0.1)	3.6 (0.1)
	A	+ +	3.3 (0.2)	3.8 (0.1)
	UB			
	LB	+ +	4.3 (0.1)	4.6 (0.1)
Exch Acidity	Oe	- - - -	7.7 (0.6)	4.2 (0.6)
	Oa	-	9.7 (1.1)	7.0 (1.1)
	A			
	UB			
	LB			
Exch. Al	Oe	-	1.4 (0.4)	0.4 (0.4)
	Oa			
	A			
	UB			
	LB			
Exch. H	Oe	- - -	6.3 0.5	3.9 (0.5)
	Oa			
	A			
	UB			
	LB			

Variable	Horizon	SM Seedling Presence/Absence on Plots with SM Saplings	SM Seedling Presence/Absence on Plots with SM Saplings[a,b] SM Seed Absence (n = 12) mean (SE)	SM Seed Absence (n = 12) mean (SE)
C	Oe			
	Oa			
	A			
	UB			
	LB			
N	Oe			
	Oa			
	A	+	0.7 (0.1)	0.9 (0.1)
	UB			
	LB			
C:N	Oe	+ + +	8.3 (1.9)	16.9 (1.9)
	Oa			
	A	-	17.6 (0.7)	15.9 (0.6)
	UB	+	0.7 (1.9)	6.0 (1.9)
	LB			
Elevation		+ +	515.3 (17.1)	565.8 (17.1)
Slope		+ +	8.7 (2.6)	17.3 (2.6)
Physiographic Position				
Light Availability (photo)				
Light Availability (model)		-	142,962.0 (23,225.0)	76,891.0 (23,225.0)
Total S Deposition				
Total N Deposition		- -	77.8 (2.8)	69.2 (2.8)
Total S + N Deposition		-	143.8 (5.4)	129.6 (5.4)

[a] n= 9 for A horizon data on plots with SM seedling presence and n = 11 for A horizon data on plots with SM seedling absence

[b] Data completeness was 94 percent for soil pH data and greater than or equal to 98 percent for the remaining soil chemical parameters

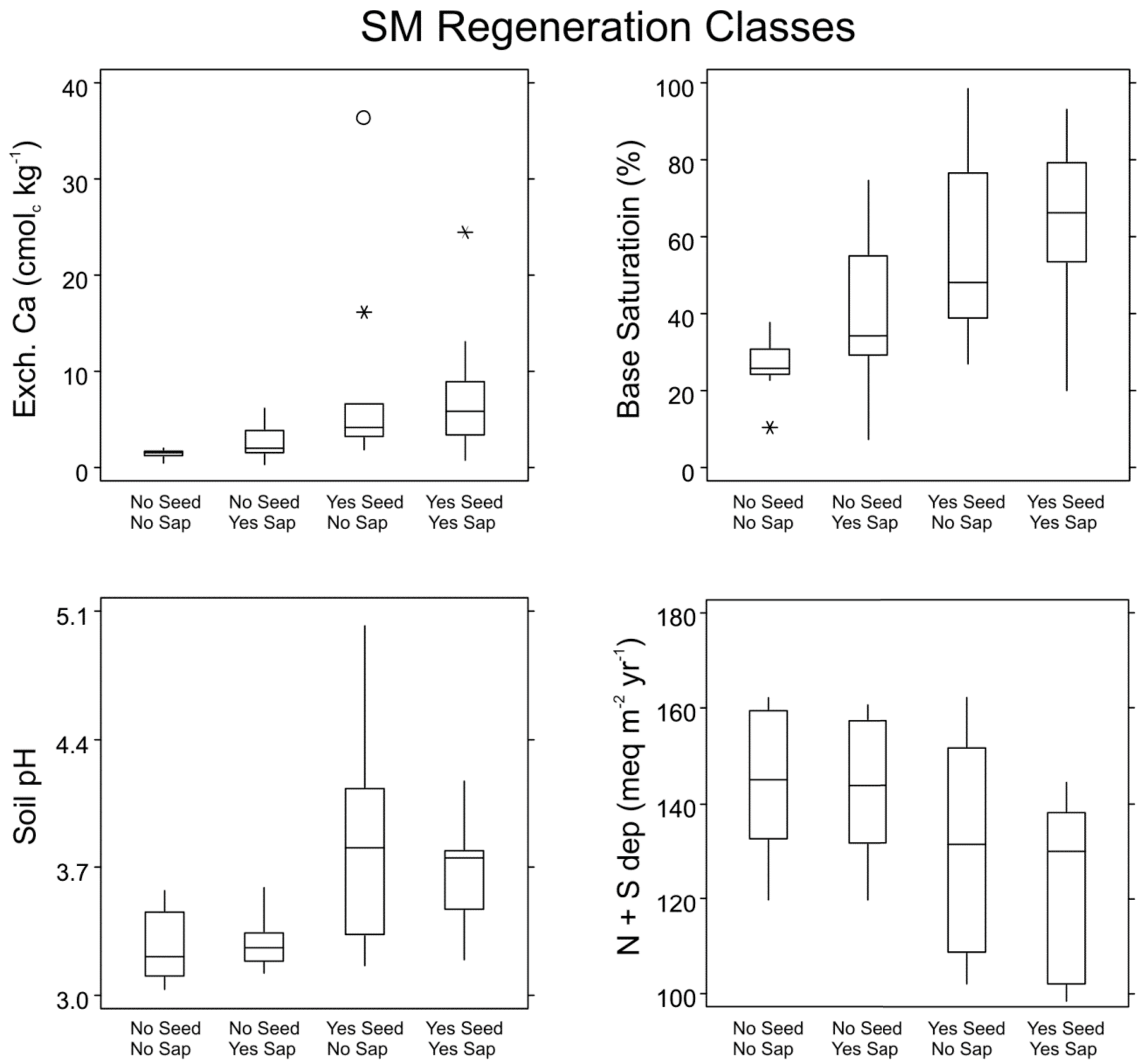


Figure 3-23. Box and whisker plots of exchangeable calcium (Ca), soil base saturation, and soil pH in the A horizon, along with total nitrogen (N) + sulfur (S) deposition for four groups of plots: those not containing either sugar maple seedlings or sugar maple saplings (No Seed, No Sap), those containing sugar maple saplings but not containing sugar maple seedlings (No Seed, Yes Sap), those not containing sugar maple saplings but containing sugar maple seedlings (Yes Seed, No Sap), and those containing both sugar maple saplings and sugar maple seedlings (Yes Seed, Yes Sap).

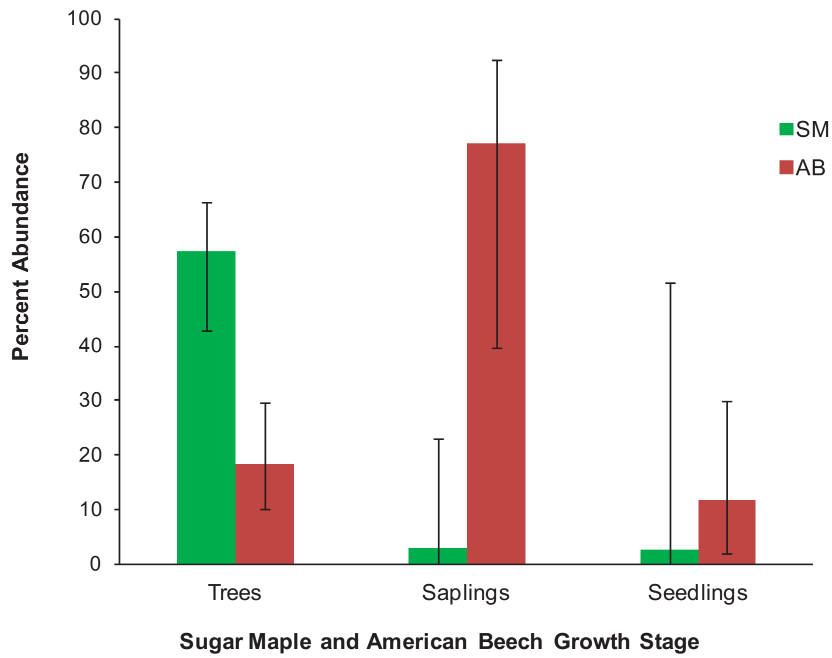


Figure 3-24. Growth stage abundance of SM and AB. Abundance is represented as a percent of the total plot basal area for trees and saplings, and as a percentage of the total plot count for seedlings.

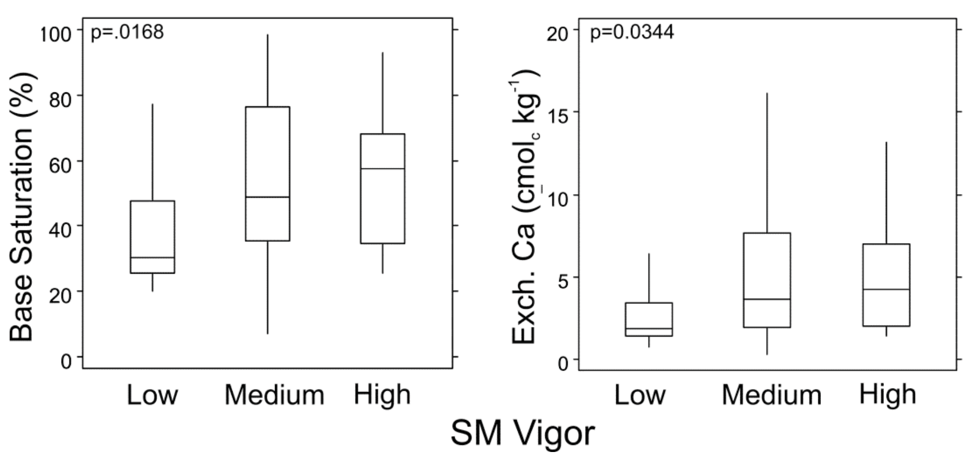


Figure 3-25. Distribution of soil BS (left) and exchangeable calcium (Ca; right) in the A horizon among plots with low, moderate, and high average sugar maple (SM) canopy vigor. P-values are shown in the top-left of each panel to indicate the significance level of differences in mean values between low and high vigor. Both differences were significant at $p \leq 0.05$.

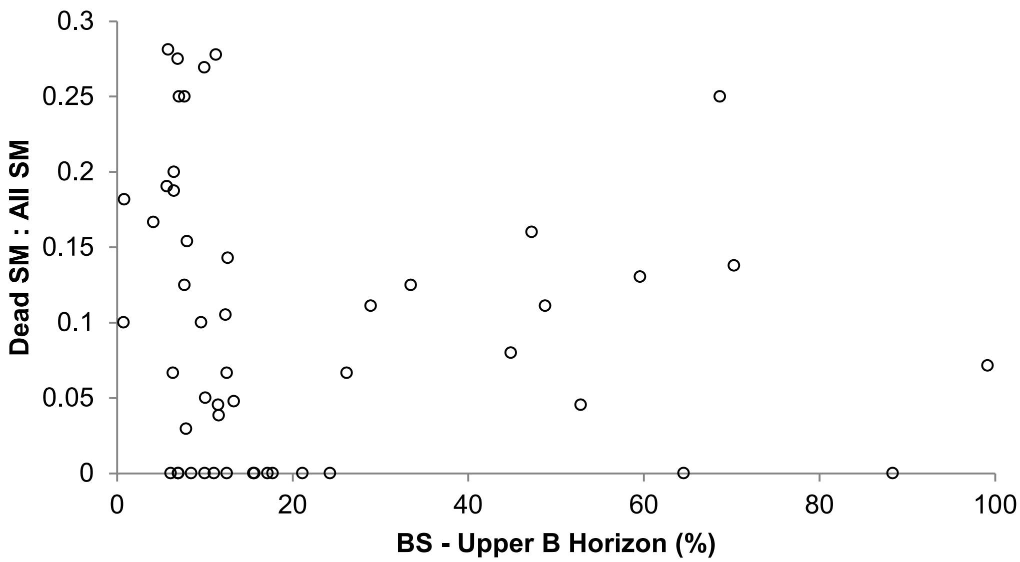


Figure 3-26. Relationship between the ratio of dead SM trees to all sugar maple trees and soil base saturation (BS) in the upper B horizon.

Healthy SM canopy conditions (vigor, dieback, discoloration, and transparency) were associated with significantly higher ($p < 0.05$) soil BS, exchangeable Ca, and exchangeable Mg in the A horizon. Lower amounts of defoliation were also associated with higher exchangeable Ca and exchangeable Mg in the A horizon, although the differences between groups were less significant ($p < 0.1$; Table 3-6, Figure 3-27, Appendix N).

3.6.3 Growth

Groups of SM trees that showed declines in growth increment and those with no growth increment decline were generally associated with similar soil chemistry characteristics. Sugar maple trees with growth declines tended to occur on plots that were subjected to higher rates of S deposition than SM trees without growth declines. On plots with low (less than 12%) soil upper B horizon BS, most (60%) trees exhibited growth declines (Figure 3-28). Observed growth decline for smaller trees was more common on plots with soil BS less than 12% (Figure 3-29a). This same pattern was observed for different size classes of cored SM trees (Figure 3-29). For cored trees in the small (31.6 – 39.9 cm DBH; n = 38) and moderate (40.2 – 50.0 cm DBH; n = 54) size ranges, the vast majority (71% of small trees and 70% of moderate size trees) of cored trees that showed growth declines had soil upper B horizon BS less than 12% (Figure 3-29). The larger cored trees (50.1 – 83.0 cm DBH; n = 32) showing growth decline were well distributed across the spectrum of upper B horizon BS, including 14 trees (44%) on plots having BS higher than 40%. Thus, it appears that SM growth declines at the study plots can be attributed to both soil chemistry and, for the larger trees, some factor other than soil BS. This factor may be tree maturation, that resulted in a slowing of growth in some of the largest trees. Additional coring of large trees would be needed to verify this effect. There were 60 small and moderate sized cored trees on plots having soil BS < 12%.

Table 3-6. ANOVA results from comparison of plot attributes between groups of plots based on plot averaged canopy condition ratings. Plots were grouped into three classes "Low", "Moderate", and "High" for each canopy condition category based on the 33rd and 66th percentile of the data range. P-values reflect differences in means between the "Low" and "High" groups, where "Low" refers to relatively poorer health and "High" refers to relatively better health. "+" indicates that higher values were associated with "High" ratings. "-" indicates that higher values were associated with "Low" ratings. The number of "+" or "-" and matrix cell color indicate the level of significance as given in the legend for Table 3-4.

Variable	Horizon	SM Vigor *p*-value	SM Defoliation *p*-value	SM Dieback *p*-value	SM Discoloration *p*-value	SM Transparency *p*-value
BS	Oe	++			+	
	Oa					
	A	++		++	++	+
	UB					+++
	LB					++
Exch. Ca	Oe			+		
	Oa					
	A	++	+	++	++	++
	UB					++
	LB					++
Exch. Mg	Oe					
	Oa					
	A	+++	++	+++	+++	++
	UB					++
	LB					
Exch. Ca + Exch. Mg	Oe			+		
	Oa					
	A	++	+	++	++	++
	UB					++
	LB					++
Exch Ca: Exch. Al	Oe					
	Oa					
	A				+	
	UB					
	LB					
pH ($CaCl_2$ method)	Oe					
	Oa			++		
	A			++	++	++
	UB					
	LB					
Exch Acidity	Oe	-				
	Oa					
	A					
	UB					
	LB					
Exch. Al	Oe	-				
	Oa					
	A					
	UB					
	LB					
Exch. H	Oe					
	Oa					
	A					
	UB					
	LB					

Variable	Horizon	SM Vigor *p*-value	SM Defoliation *p*-value	SM Dieback *p*-value	SM Discoloration *p*-value	SM Transparency *p*-value
C	Oe	++		+		++
	Oa					
	A		+			
	UB					
	LB					
N	Oe	++	++	++	++	++
	Oa				+	
	A					
	UB					
	LB					
C:N	Oe					
	Oa					
	A					
	UB					+++
	LB					+
Elevation		++++	+	++++	++	+++++
Slope		++		++		
Physiographic Position						
Light Availability (photo)		--	--	--	--	--
Light Availability (model)						
Total S Deposition						
Total N Deposition		-				
Total S + N Deposition						

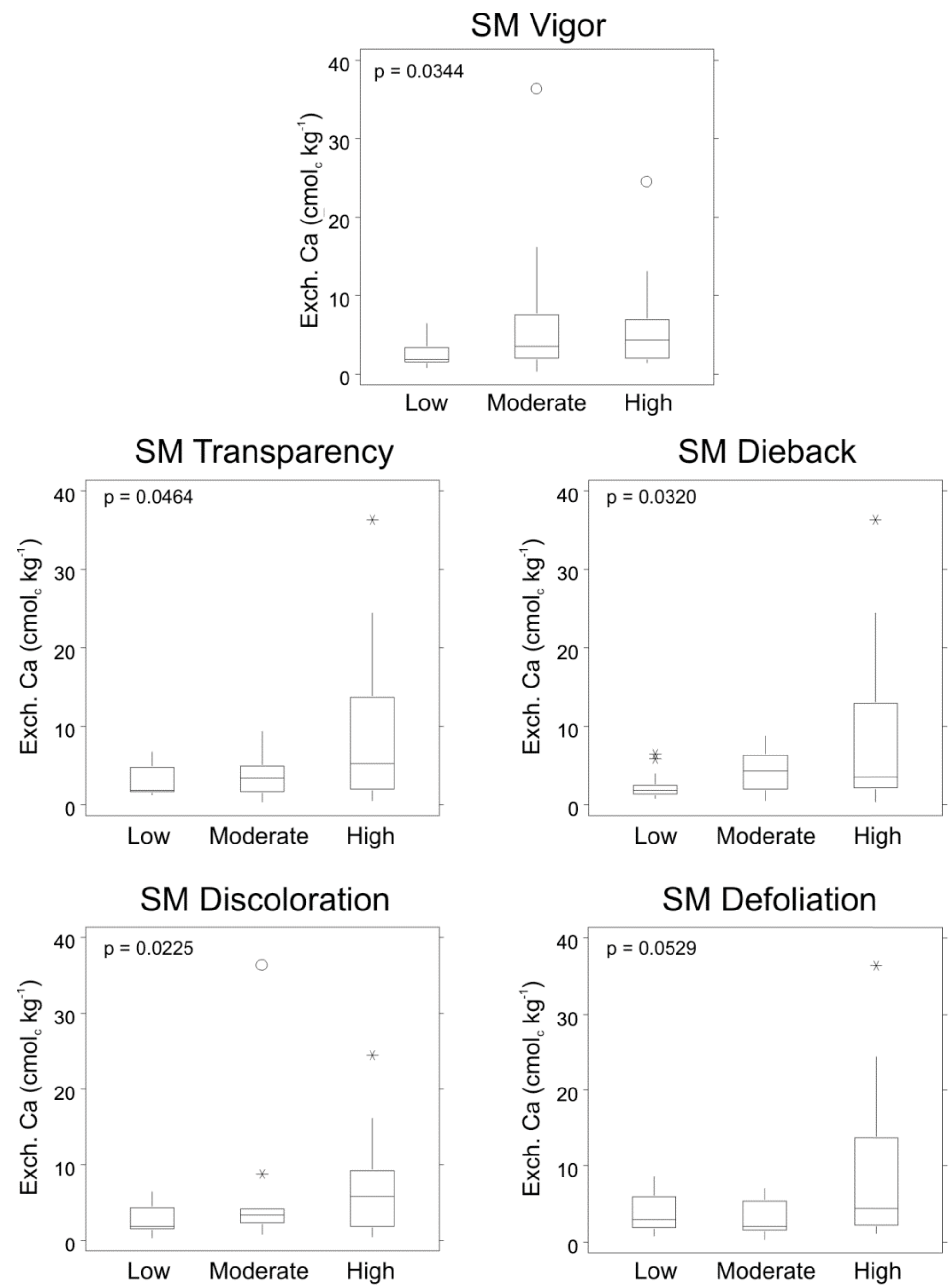
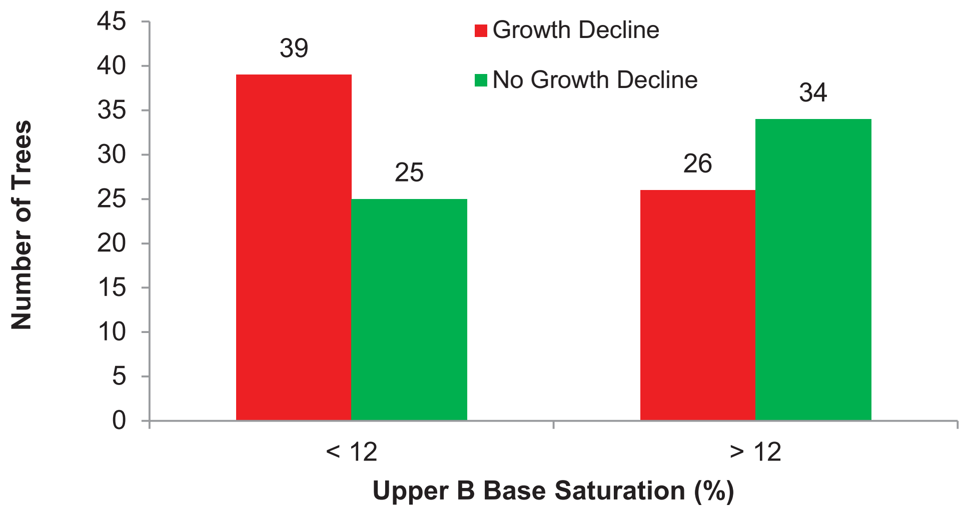


Figure 3-27. Box and whisker plots of exchangeable calcium (Ca) in the A horizon for three groups of plots: those with low, moderate, and high canopy condition ratings. Plot groupings were established based on the 33rd and 66th percentile of the range of ratings within each condition type.

a)



b)

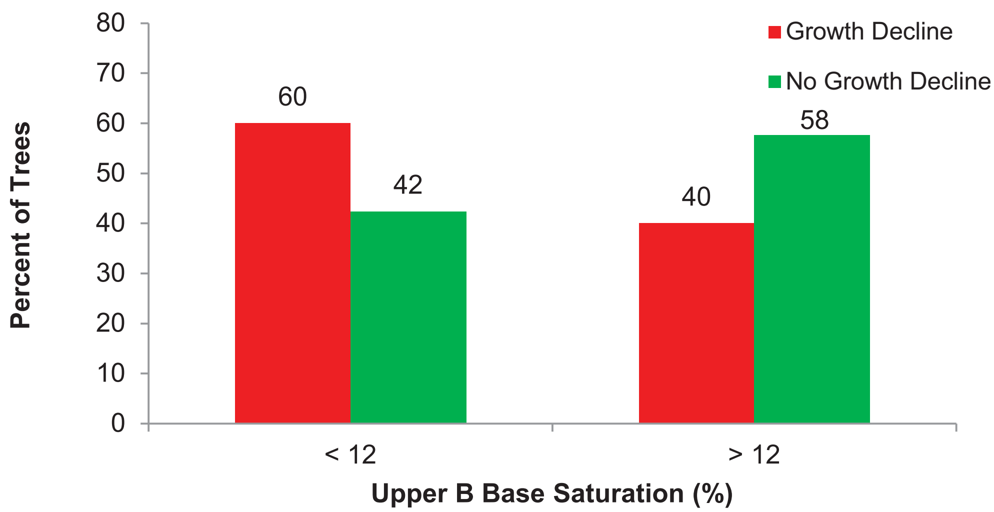


Figure 3-28. Distribution of cored sugar maple trees exhibiting growth decline (red) and showing no evidence of growth decline (green) on plots having soil base saturation above and below 12%. Data are summarized by a) number of trees, and b) percent of trees within each growth response class.

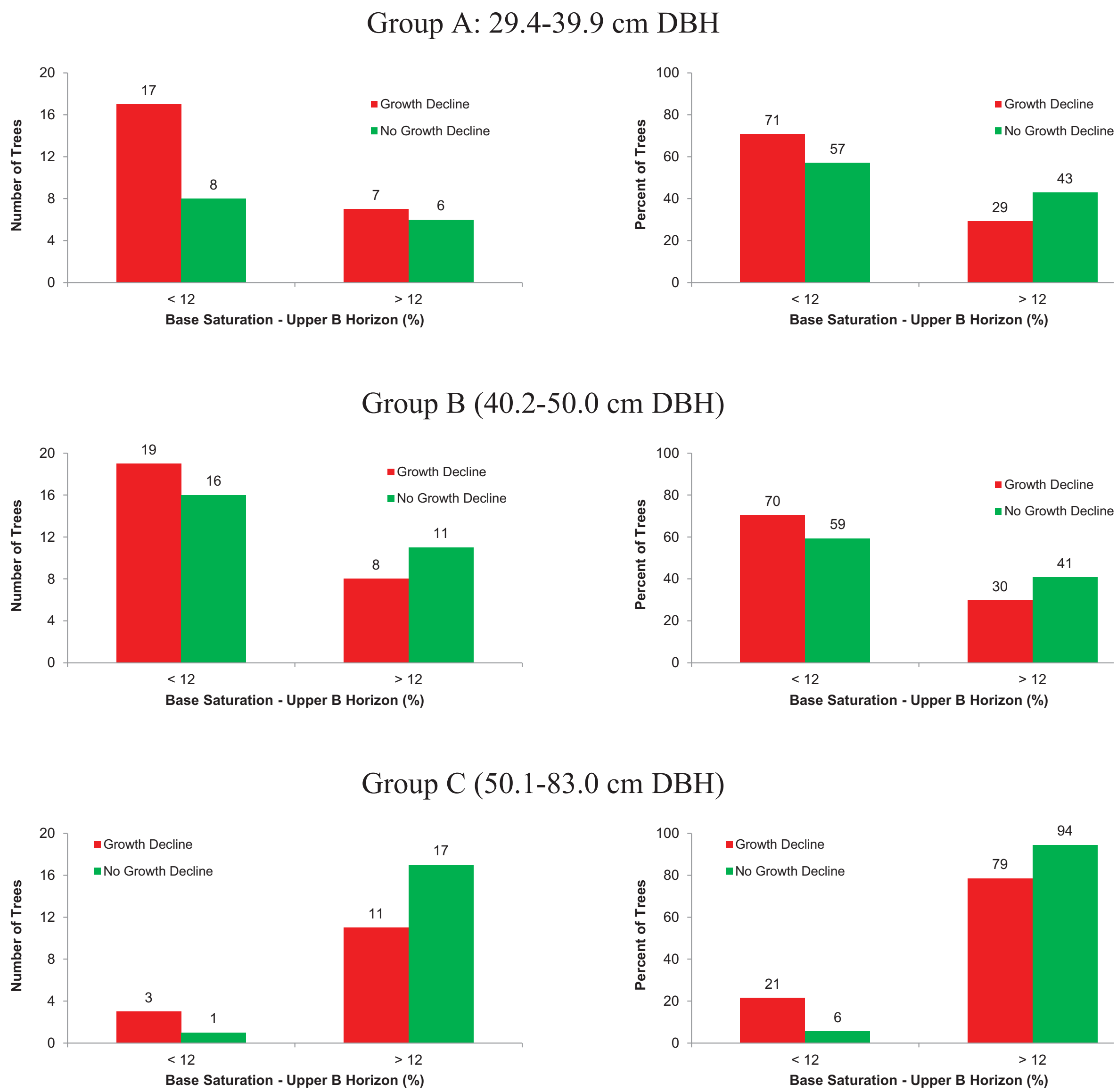


Figure 3-29. Distribution of cored sugar maple trees exhibiting growth decline (red) and showing no evidence of growth decline (green) on plots with soil base saturation above and below 12%. Data are summarized by number of trees and as percent of trees within each growth response class for a) size group A (29.4-39.9 cm DBH), b) size group B (40.2-50.0 cm DBH), and c) size group C (50.1-83.0 cm DBH).

3.6.4 *Relationships with Stream Chemistry*

Previous research in the Adirondacks indicated that stream chemistry in small, low-order stream watersheds, particularly during high flow conditions, reflects the chemistry of the upper soil profile (Lawrence *et al.* 2008a). This earlier result was based on data from 11 watersheds, 9 of which were Ca depleted based on having values of base cation surplus in stream water less than zero during high flow. The BCS is an index of surface water acidification similar to acid-neutralizing capacity, but developed to explicitly include strongly acidic organic anions (Lawrence *et al.* 2007, Lawrence *et al.* 2008b). With this feature, the BCS correlates closely with inorganic Al below a BCS threshold value of zero, regardless of varying concentrations of dissolved organic carbon. By providing data from 20 additional watersheds having a much wider range of Ca availability, this assessment of SM condition enabled soil-stream relationships to be more fully evaluated for the overall region. One finding developed from analysis of this more comprehensive data set was that an area in the western Adirondacks in the general vicinity of Booneville has deep excessively drained soils formed in glacial-fluvial sand. These soils have been identified as belonging to the Adams Series (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm; accessed May 2012). Because of the extremely high transmissivity of water in these soils, nearly all soil water moves vertically downward into deep zones of saturation before emerging into stream channels that have become deeply incised despite relatively flat terrain. Drainage water following this type of flow path fails to show the influence of soil chemistry under nearly all flow conditions, reflecting instead the geochemical influence of deep aquifers. Two of the watersheds in this study had this type of soil, and therefore were not included in the soil-stream analysis presented below.

To evaluate possible relationships between soil chemistry and stream chemistry, values for the two or three plots in each study watershed were averaged to provide a single value for each soil measurement to represent each watershed. Plot locations had been selected to be generally representative of the landscape variability within the watershed where possible. However, to meet the requirements of the study design plots needed to include SM trees. The SM trees were often distributed within the watersheds in patches, particularly in the watersheds having lowest soil Ca (Figure 3-30). Therefore, the plot locations may not have been fully representative of the variability of watershed characteristics that was reflected in the stream chemistry measured at the base of the watershed. The coefficient of variation among plots in each watershed for BS in the Oa horizon suggests that variability decreased as availability of bases increased to BS values above about 0.75 (Figure 3-31). Because SM is a calciphilic species and only plots with SM present were selected for study, the study plots in the low-base watersheds may be biased towards elevated Ca relative to other locations within the study watersheds.

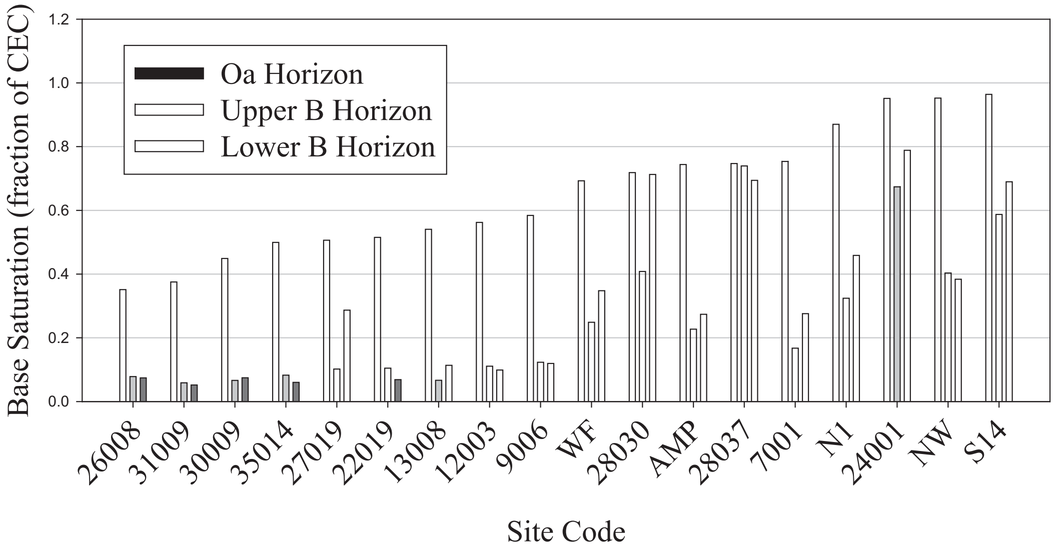


Figure 3-30. Base saturation of the Oa, upper B and lower B horizons, averaged by watershed and ordered from lowest to highest Oa base saturation.

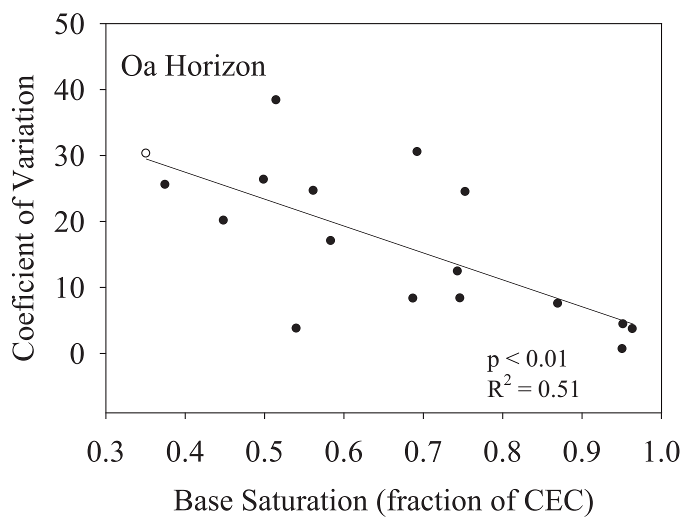


Figure 3-31. Variability in soil base saturation among plots within each study watershed, expressed as the coefficient of variation for the base saturation analysis.

Effective cation exchange capacity (CECe) tended to be higher in the Oa horizon in plots with higher Oa BS (Figure 3-32). This is consistent with the pH-dependent nature of CECe in these coarse-textured mineral soils (Sullivan *et al.* 2006b). However, CECe measurements in the upper and lower B horizons were less than 10 and 5 $cmol_c\ kg^{-1}$, respectively, in all watersheds, and were not correlated with BS. The low values of CECe in the mineral soil horizons (three to ten times lower than the CECe of the Oa horizon), indicate a much lower influence of soil acid-base chemistry on the chemical concentrations of mineral horizon soil water, as compared with the Oa horizon.

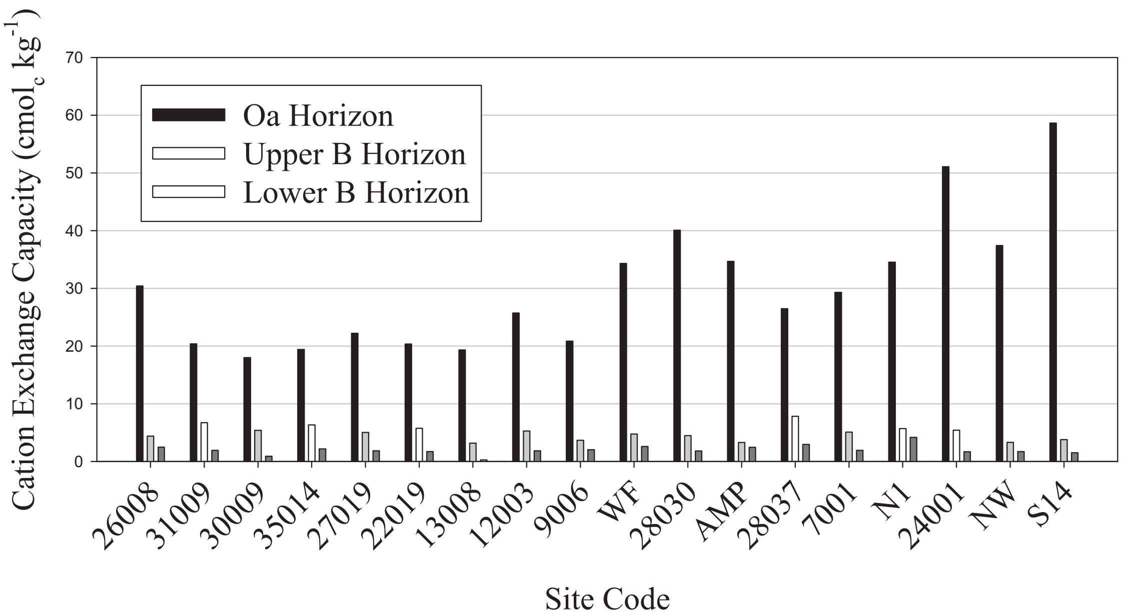


Figure 3-32. Cation exchange capacity of the Oa, upper B and lower B horizons, averaged by watershed and ordered from lowest to highest Oa base saturation.

The BCS in stream water during high flow increased ($p < 0.01$) along with increases in Oa horizon BS over the range of soil chemistry (Figure 3-33). However, a non-significant ($p > 0.1$) relationship was observed in the upper B horizon (Figure 3-34) and relatively weak relationships ($p < 0.01$) were observed in the lower B (Figure 3-35) and in the Oa horizons. Concentrations of Ca in stream water were strongly correlated ($p < 0.001$) with Oa horizon exchangeable Ca (Figure 3-36), but were not statistically correlated ($p > 0.1$) with exchangeable Ca in the upper B horizon (Figure 3-37), where exchangeable concentrations were an order of magnitude lower than in the Oa horizon. Nevertheless, Ca content of the lower B horizon was significantly correlated ($p < 0.01$) with the concentration of Ca in stream water (Figure 3-38). Stream water pH was significantly correlated with soil pH ($p < 0.01$) in all three horizons (Figures 3-39 through 3-41), but the weakest relationship was observed in the Oa horizon. The relationships between stream chemistry and Oa horizon soil chemistry in this study are similar to those found in Adirondack watersheds in the previous WASS study Lawrence *et al.* (2008a). This earlier work demonstrated that the correlations between soil BS and stream BCS values were higher during high flows than during base flows. As the watershed becomes wetter during high precipitation and or snowmelt, streams receive a larger fraction of water from shallow flow paths that reflect the soil chemistry of these flow paths (Lawrence 2002). Wetlands, common in the study region, contribute water that is typically rich in dissolved organic carbon, similar to organic soil horizons in the upper profile. However, the effect of wetlands on stream chemistry can both increase or decrease with increased flows depending on season and precipitation patterns (Lawrence *et al.* 2008b).

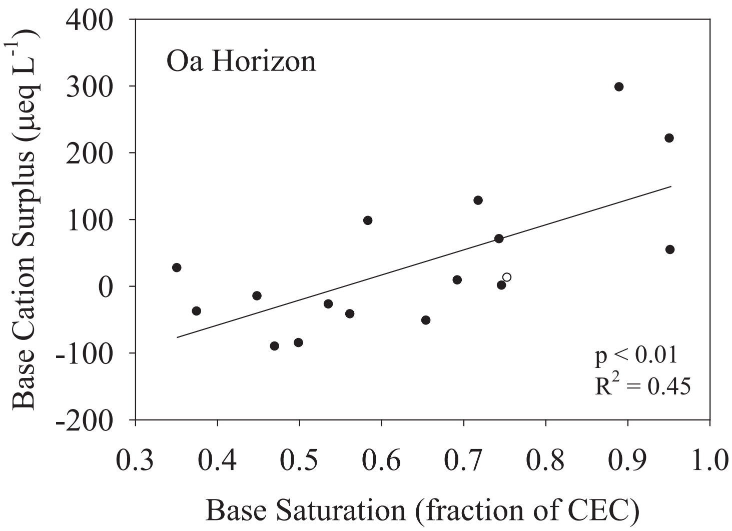


Figure 3-33. Base cation surplus in stream water as a function of soil base saturation in the Oa horizon, averaged by watershed.

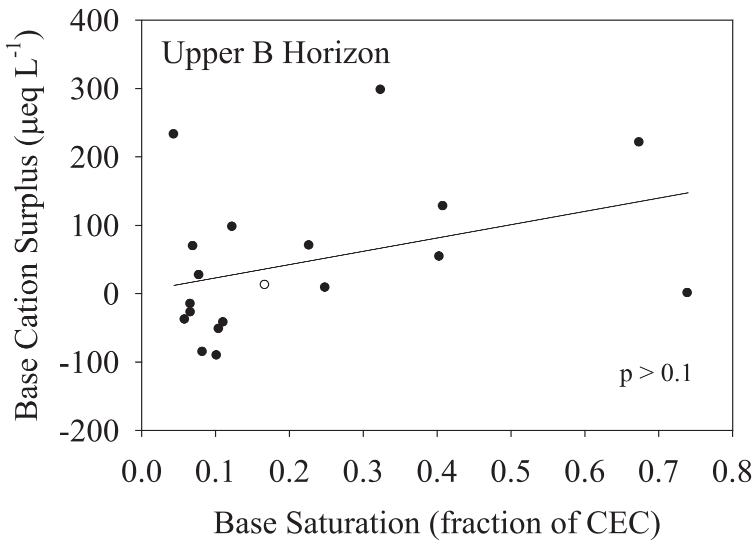


Figure 3-34. Base cation surplus in stream water as a function of soil base saturation in the upper B horizon, averaged by watershed.

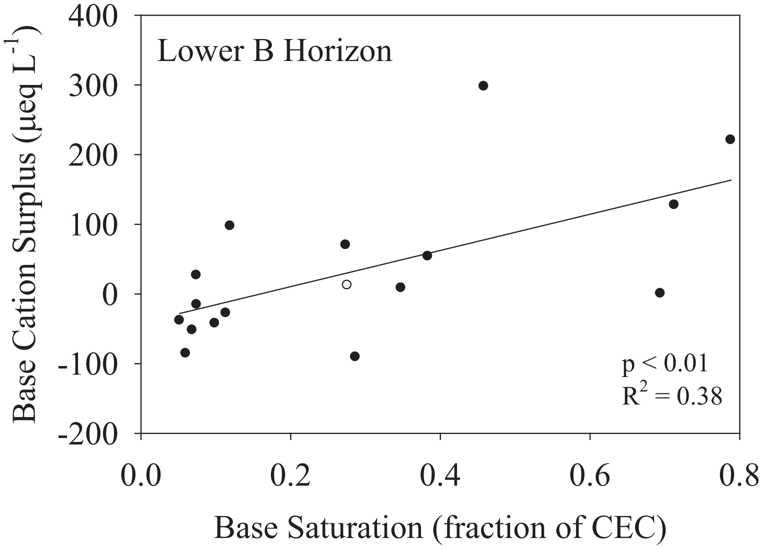


Figure 3-35. Base cation surplus in stream water as a function of soil base saturation in the lower B horizon, averaged by watershed.

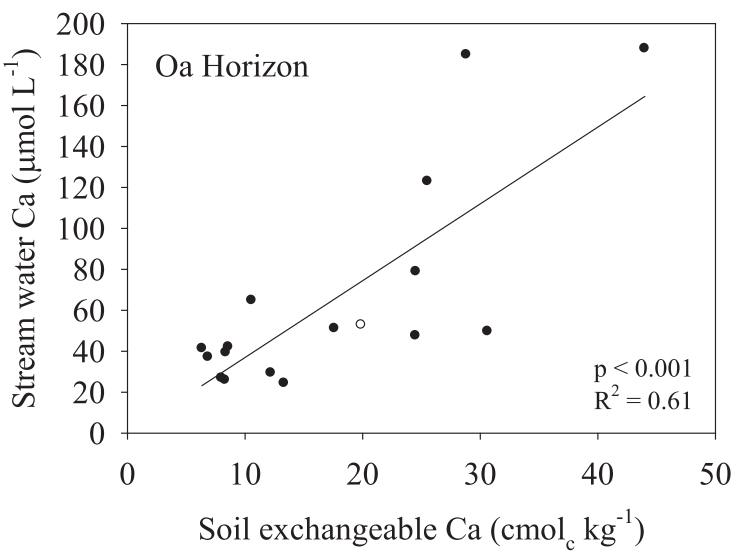


Figure 3-36. Calcium (Ca) concentration in stream water as a function of exchangeable Ca in the Oa soil horizon, averaged by watershed.

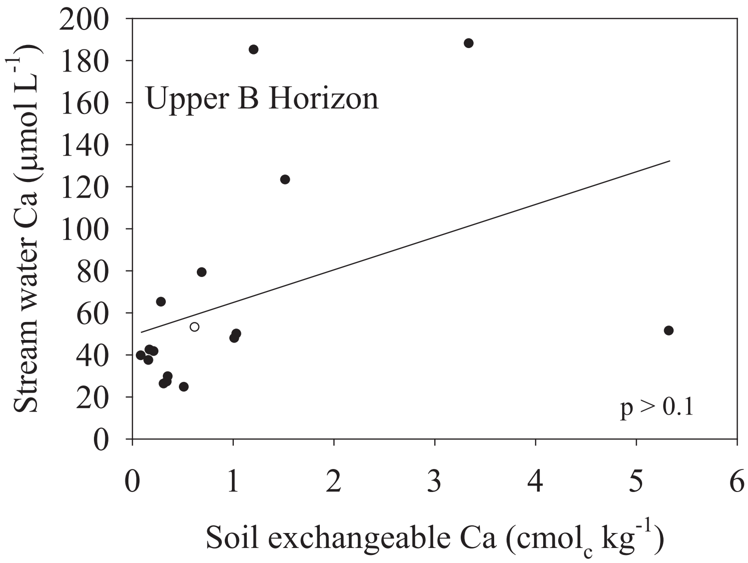


Figure 3-37. Calcium (Ca) concentration in stream water as a function of exchangeable Ca in the upper B soil horizon, averaged by watershed.

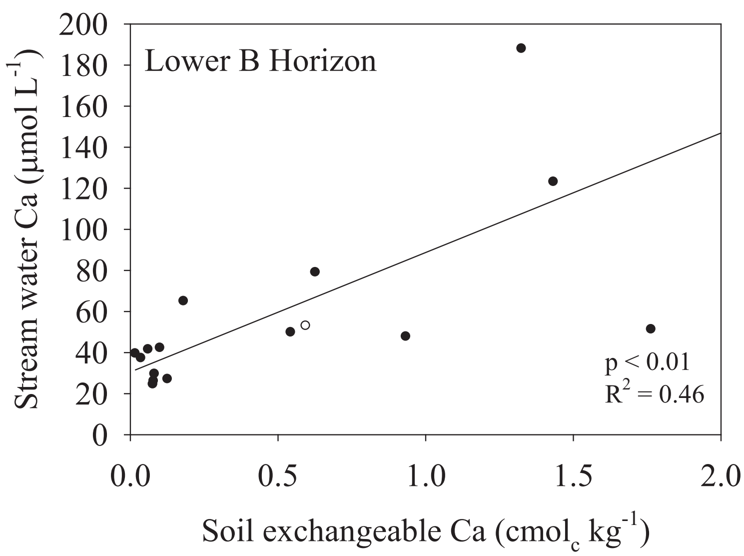


Figure 3-38. Calcium (Ca) concentration in stream water as a function of exchangeable Ca in the lower B soil horizon, averaged by watershed.

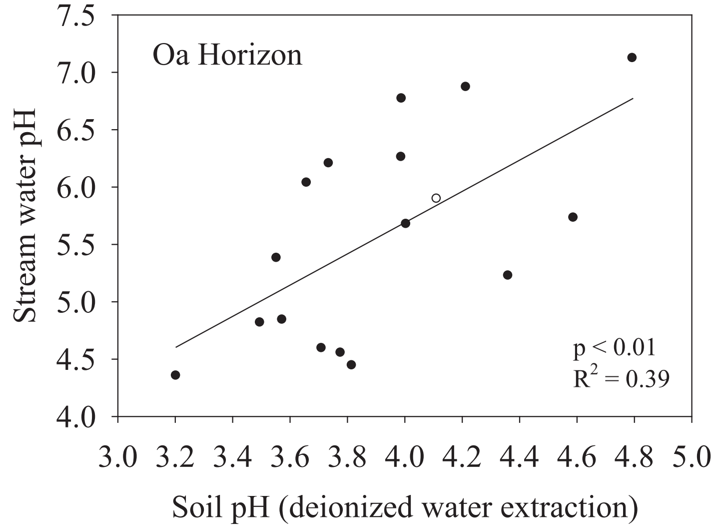


Figure 3-39. Stream water pH as a function of soil pH in the Oa horizon, averaged by watershed.

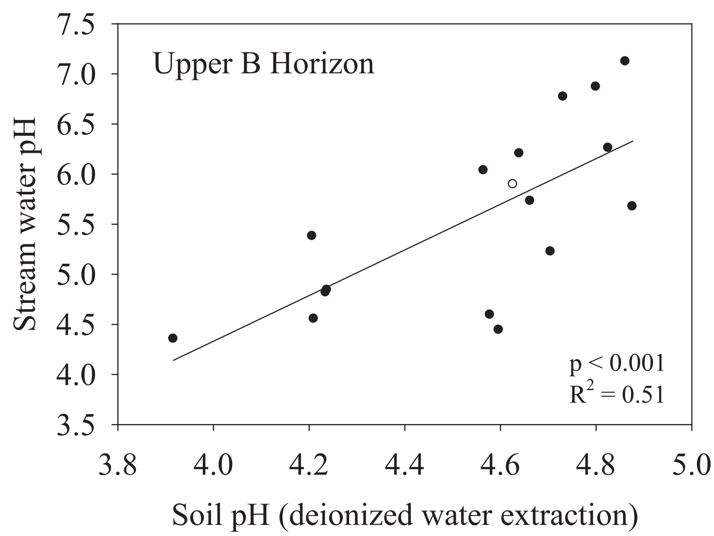


Figure 3-40. Stream water pH as a function of soil pH in the upper B horizon, averaged by watershed.

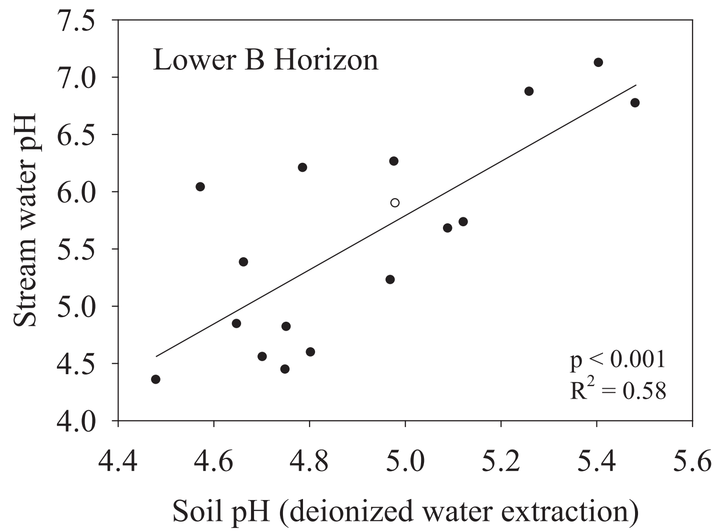


Figure 3-41. Stream water pH as a function of soil pH in the lower B horizon, averaged by watershed.

The lack of a significant relationship between Ca in stream water and Ca in upper B horizon soil is an indication that this upper mineral soil horizon has been more affected by acid anion leaching than either the Oa horizon, which maintains Ca through vegetative recycling, or the lower B horizon that has similar (or higher) exchangeable Ca to the upper B horizon due to its lower position. This occurs despite CECe values in the lower B horizon that are approximately half those of the upper B horizon. The profile position of the lower B horizon also provides an explanation for why the pH of this horizon is higher than that of the upper B horizon. The relationship between stream water pH and the pH of the Oa horizon is somewhat weaker than for the mineral soils because Oa horizon pH is highly dependent on organic matter, which tends to be removed from solution as drainage water percolates through the B horizon.

The model developed from the BCS-BS relationship in the Oa horizon in the earlier WASS study was very similar to that developed from the 20 watersheds sampled in this study (Table 3-7). Each model included nine of the same watersheds. Obtaining a new model that was approximately the same as the previous model, despite expanding the both the number of watersheds and the range of soil chemistry, indicates the robust nature of the relationship. Nevertheless, a significant model was not obtained for the upper B horizon with the 20 watersheds sampled in this study, in contrast to the WASS study in which a weakly significant relationship ($p < 0.05$; $R^2 = 0.39$) was obtained for the upper B horizon.

Table 3-7. Linear models that predict soil base saturation of the Oa horizon determined from 11 watersheds in the WASS study, and 20 watersheds in the Sugar Maple Assessment Study, from the base cation surplus measured in the streams of these watersheds during high flow stream sampling.

Base Saturation in the Oa Horizon				
Study	Number of Watersheds	Model	P	R^2
WASS	11	0.0012x + 0.39	< 0.01	0.68
This Study	20	0.0012x + 0.60	< 0.001	0.45

3.6.5 Response Summary

Results indicate that the lack of Adirondack SM regeneration is associated with low soil nutrient base cation status. A near absence of SM seedlings and saplings was observed on base-poor soils. This suggests that community composition of hardwood forests in acid-impacted areas of the Adirondacks may be in the process of shifting away from SM towards other species.

These results indicate that declines in regeneration and basal area growth, as well as low canopy vigor of SM, are common in the western Adirondack region, and that these conditions are associated with acidic deposition and low soil base cation status. Improved understanding of the relationships among soil acid-base chemical condition and the abundance, growth, health, and regeneration of SM is needed as a basis for evaluation of the critical load of acidic deposition that will be protective of this important tree species and to aid in forest management decisions.

An overall response score was generated for each of the 50 plots based on aspects of SM regeneration, growth response, and canopy condition. A plot was given a point if favorable conditions for SM were observed. Favorable conditions included presence of SM seedlings (Figure 3-42), absence of significant decline in growth between 1950 and 2005 (Figure 3-43), and moderate or high vigor (Figure 3-44). Coordinate locations of each plot are given in Appendix O. Points were summed to generate overall response scores that ranged between zero and three. Estimated levels of acidic deposition, upper B soil horizon acid- base chemistry (as represented by BS) and the overall SM response score all showed consistent spatial patterns, ranging from high impacts in the southwestern Adirondack region to low impacts in the northeastern Adirondacks (Figure 3-45). Two plots with high response scores are located in the southwestern region. It is expected that pockets of relatively insensitive areas will be found within acid sensitive regions. However, it should be noted that both of these plots contained only 2% and 11% of total seedlings as SM. Soil BS in the upper B was generally lower on plots with low overall response scores (Figure 3-46). The upper quartile of soil BS for response score groups 1 and 2 was consistently lower than 12% and the lower quartile of soil BS for response score groups 3 and 4 was higher than 12%.

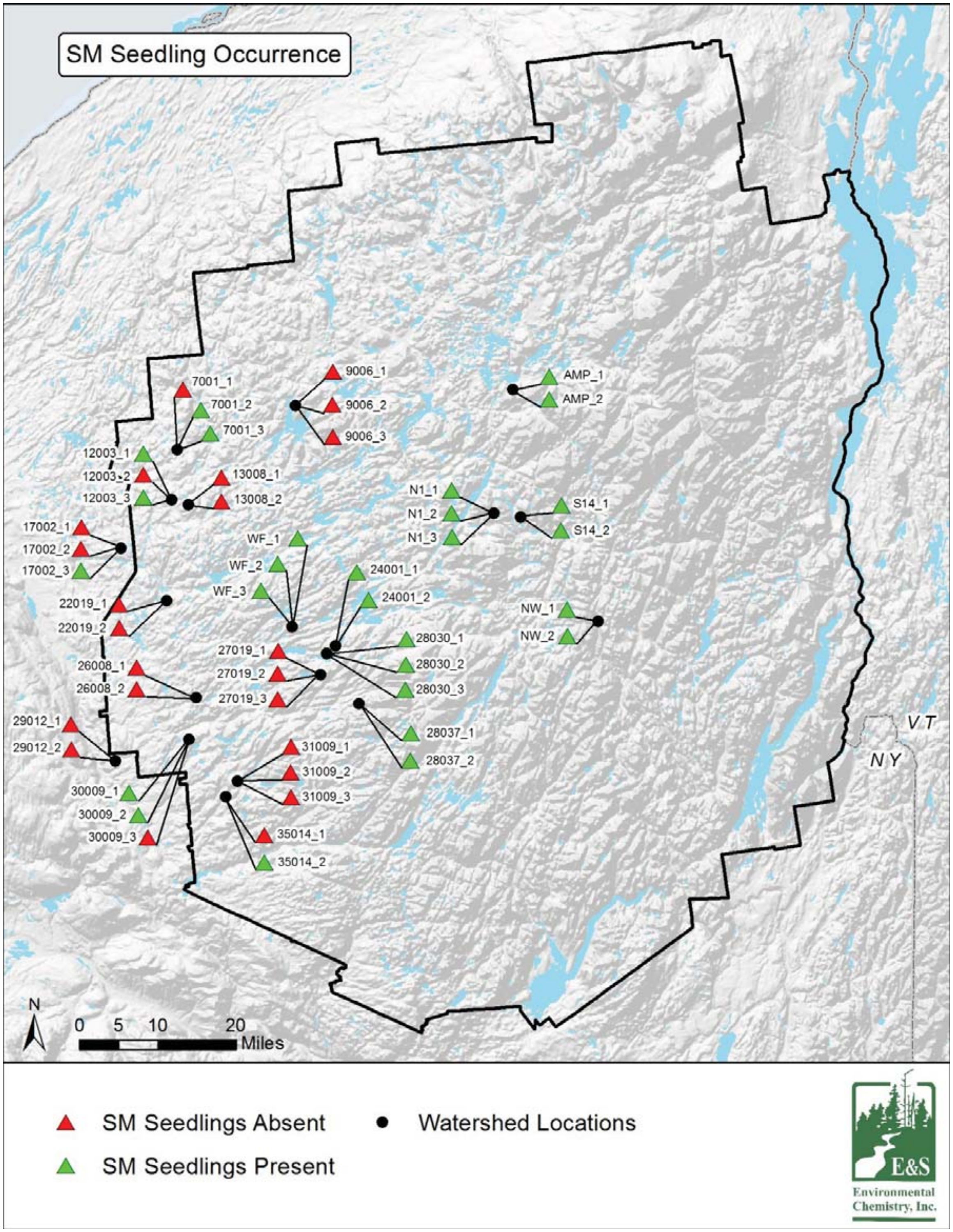


Figure 3-42. Sugar maple seedling presence/absence in study plots.

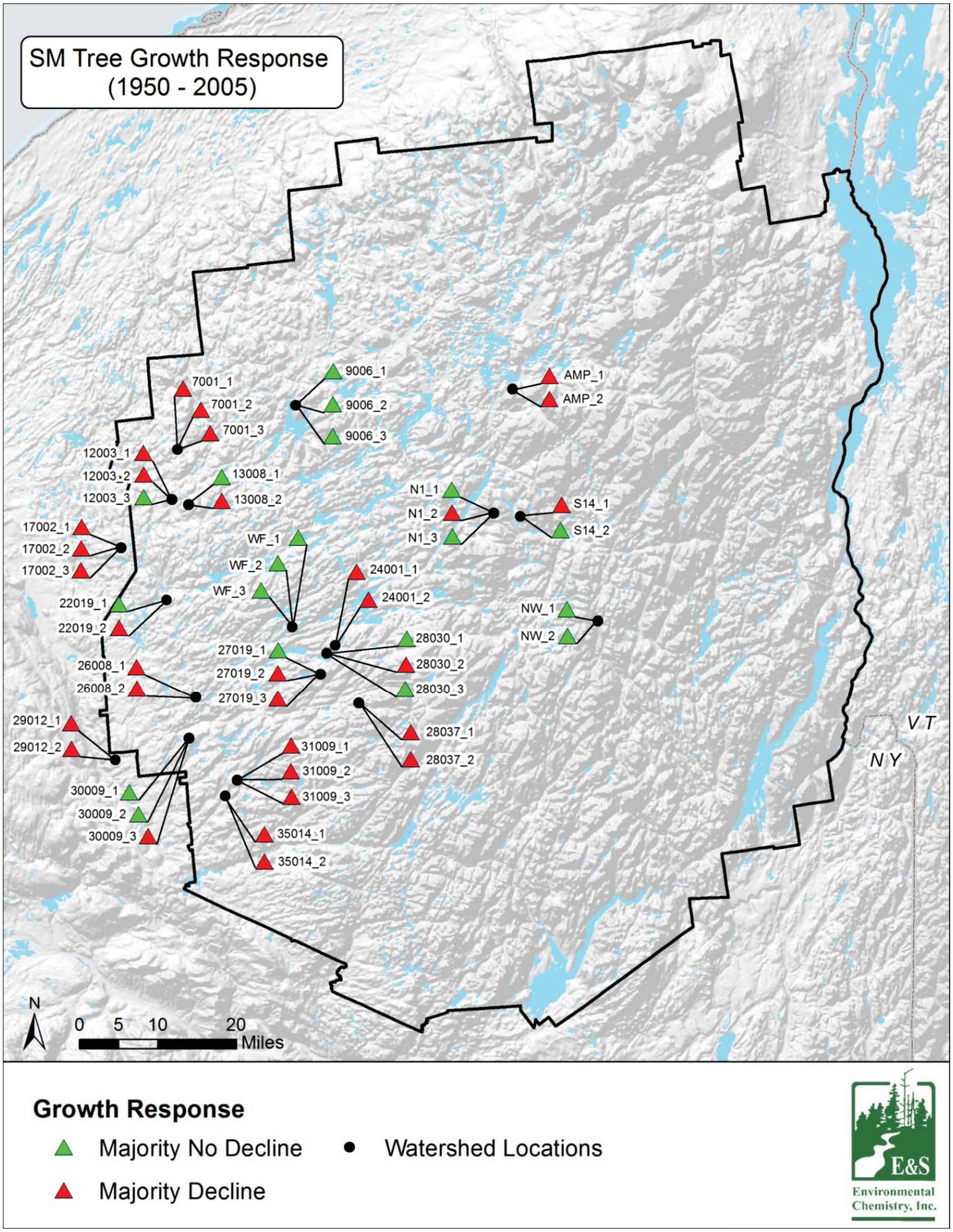


Figure 3-43. Sugar maple tree growth response by plot.

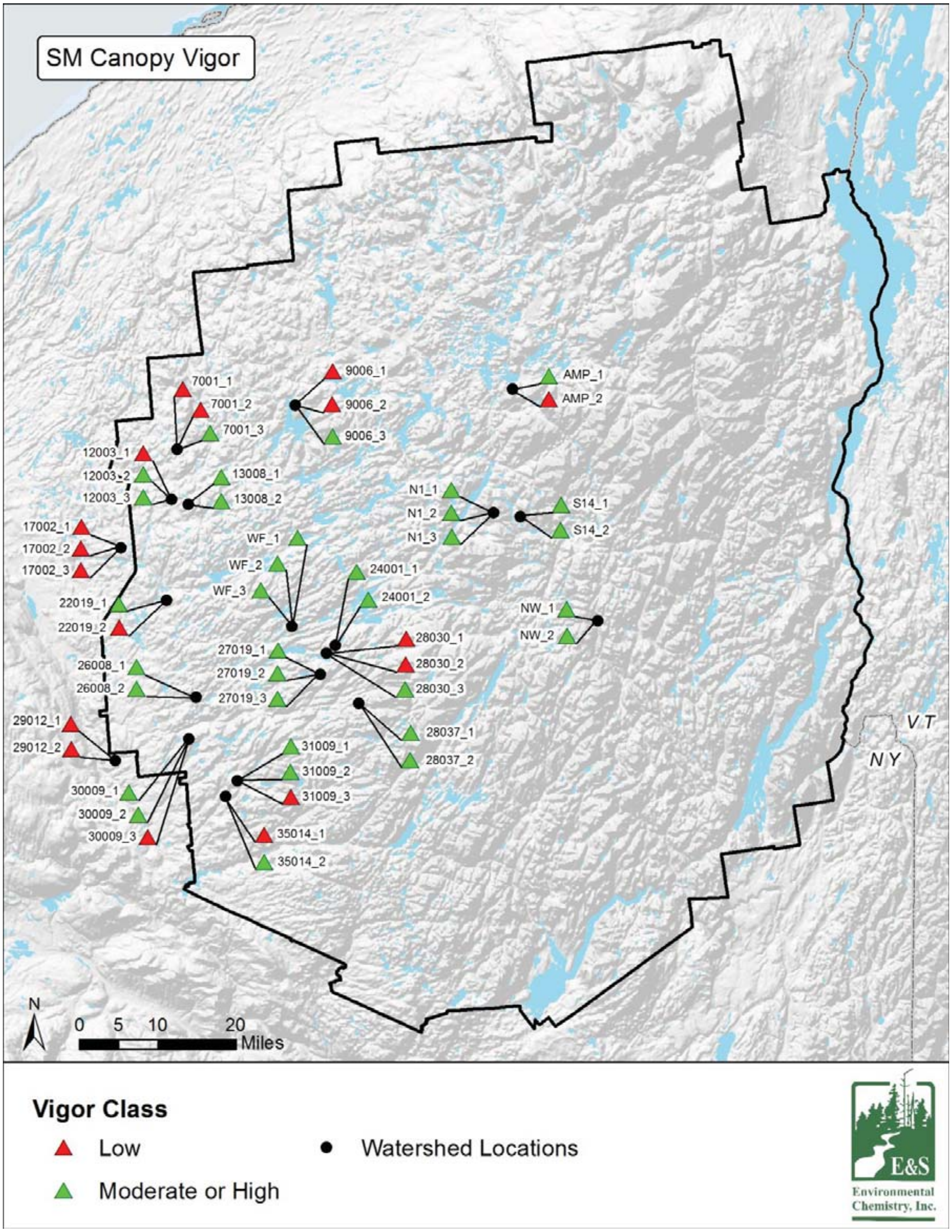


Figure 3-44. Plot averaged SM canopy vigor. Classes were established based on the 33rd and 66th percentiles of the range in average vigor by plot.

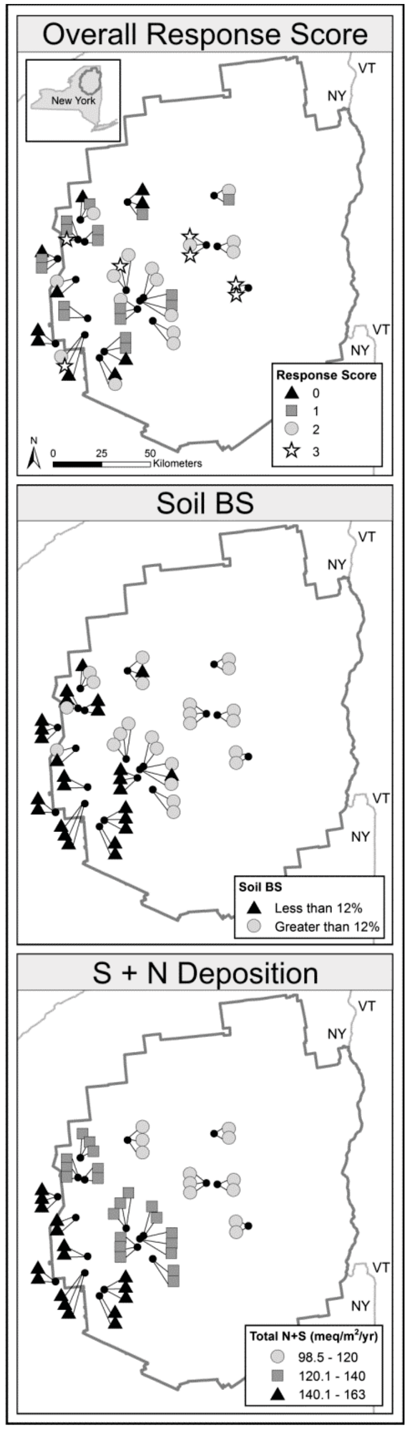


Figure 3-45. Maps showing the spatial distribution of sugar maple overall response score (as discussed in text; top panel), soil % BS of the upper B soil horizon (middle panel), and estimated total wet plus dry atmospheric S plus N) deposition (bottom panel) at each of 50 study plots. One plot (9006_1) did not contain sufficient data with which to characterize tree decline; therefore, this plot was scored on a scale from 0 – 2 for the overall response score.

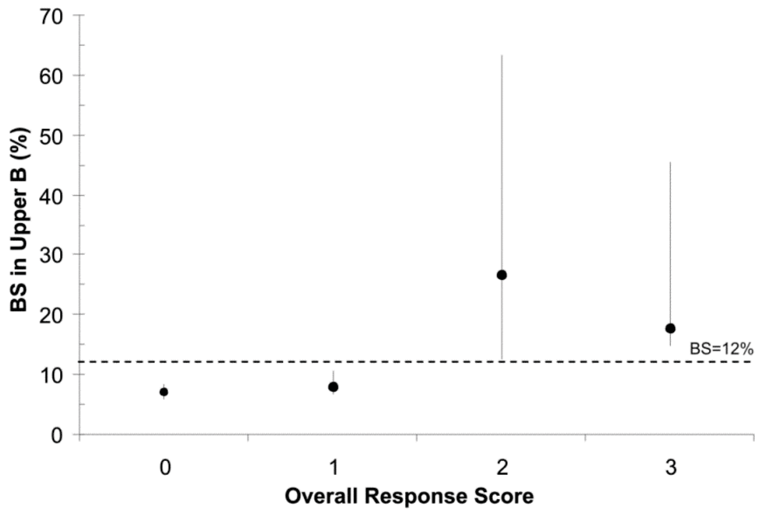


Figure 3-46. Median (dot) and quartile (bars) base saturation in the upper B soil horizon within each overall response score class. The numbers of plots in each response class (0 to 3) are 9, 15, 14, and 12, respectively.

3.7 Regional Representation

Through the plot selection process, we included the range of soil calcium availability for the Adirondack ecoregion (Sullivan *et al.* 2006a). We also encompassed much of the variation in elevation and longitude; both factors related to acidic deposition levels in this region. Therefore, the relationships developed between soil chemistry and vegetation measurements in this study can be considered relevant throughout the Adirondack region. Results also indicated that Ca depletion and negative measures of tree condition tended to decrease in a southwest to northeast direction. These spatial patterns coincided with spatial patterns in acidic deposition and soil acidity (Ito *et al.* 2002, Sullivan *et al.* 2011) and increased neutralization capacity of bedrock (http://pubs.usgs.gov/of/2005/1325/), although exceptions with regard to soil acidity were common.

Recent research in the upper Great Lakes forests has implicated N deposition as a contributor to reduced SM seedling establishment (Patterson *et al.* 2012). Field observations and experiments demonstrated that excess N deposition could decrease the rate of decomposition of organic matter, resulting in an increased thickness of organic soil horizons. Thicker organic soils can potentially establish a physical barrier for seedling roots, preventing them from extending into mineral soil horizons below. This issue was investigated using the Adirondack dataset compiled for this study. The relationship between SM seedling abundance and organic horizon thickness for the Adirondack dataset is shown in Figure 3-47. No relationships between organic horizon (Oi, Oe, Oa) thickness and SM seedling count were found.

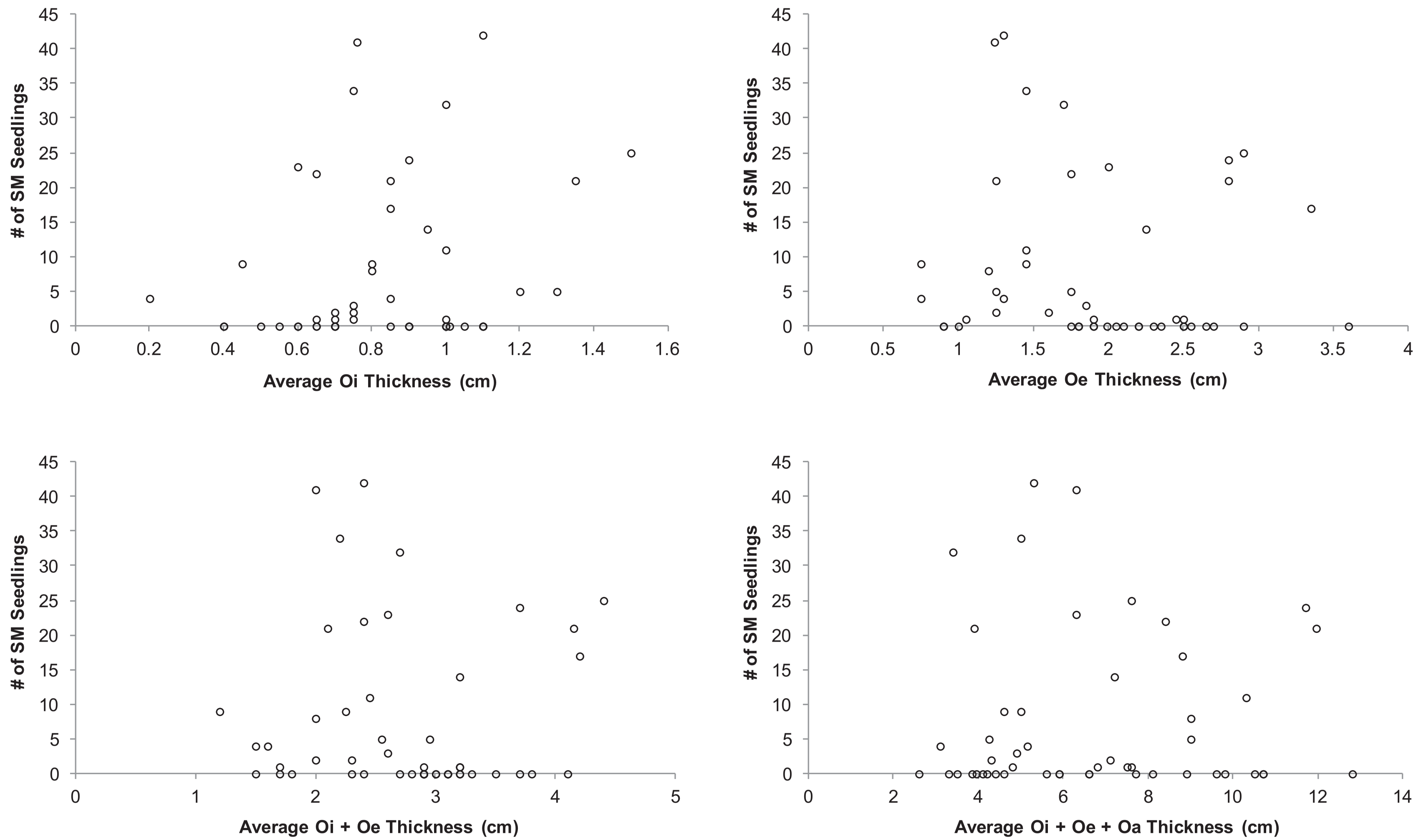


Figure 3-47. Relationship between sugar maple (SM) seedling count and horizon thickness for the a) Oi horizon, b) Oe horizon, c) Oi + Oe horizons, and d) Oi + Oe + Oa horizons.

Thresholds for SM response were identified for soil BS and exchangeable Ca. Sugar maple seedling proportion generally increased with increasing soil BS (Figure 3-19) and exchangeable Ca (Figure 3-20) in Oa, A, and upper B horizons. In the upper B horizon, which is often used as the basis for process model simulations (cf., Sullivan *et al.* 2011, 2012), thresholds were identified at BS = 12% and 20% and at exchangeable Ca of 1.3 $cmol_c\ kg^{-1}$. Above BS = 20% and exchangeable Ca = 1.3 $cmol_c\ kg^{-1}$, the SM seedling proportion was unrelated to upper B horizon acid-base chemistry. Sugar maple seedlings were generally absent at upper B horizon BS < 12%. We are not aware of a single factor other than soils that could explain our results for canopy condition, regeneration and long-term basal area growth. However, other factors may play a role in various individual responses. For example, deer browsing could result in poor regeneration, but wouldn't affect the condition of the canopy of dominant and co-dominant trees. However, a previous investigation throughout the Adirondack region was not able to identify a correlation between deer population size and regeneration success (Didier and Porter 2003). Sugar maple regneration could also be limited by expansive growth of beech saplings, which is related to beech bark disease (Griffin *et al.* 2003).

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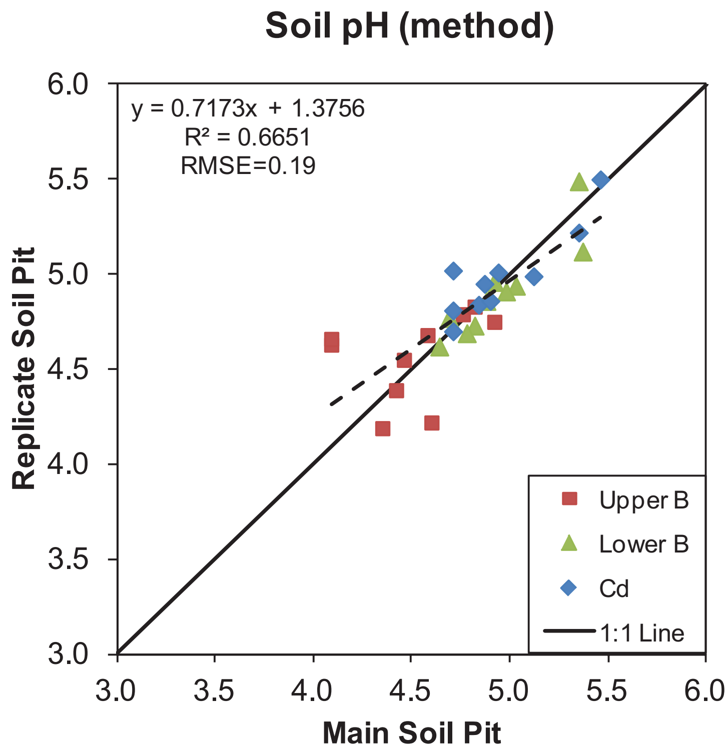
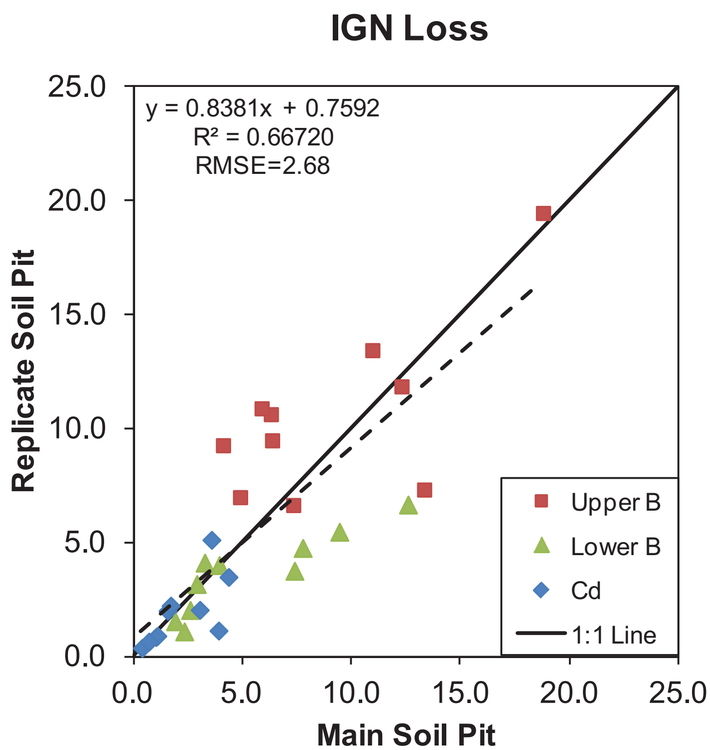
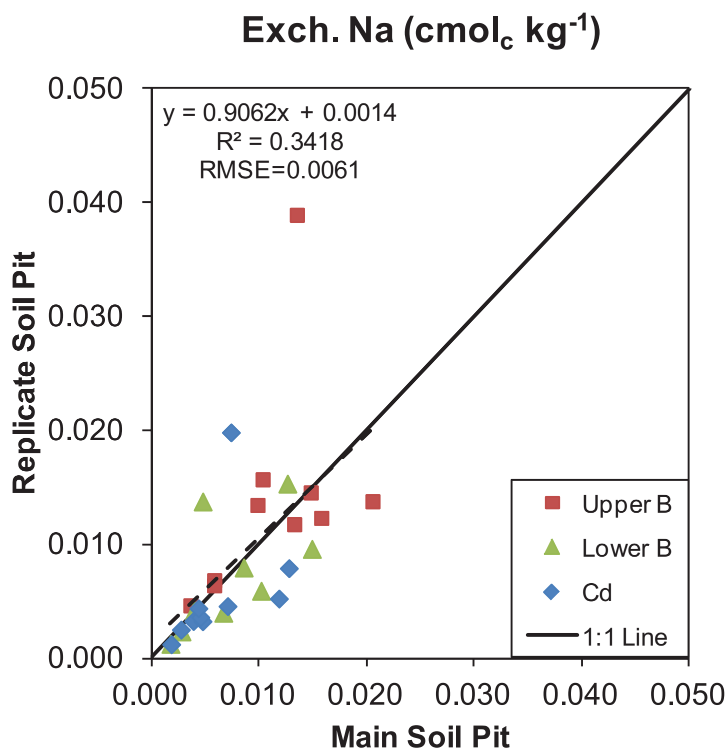
Appendix A

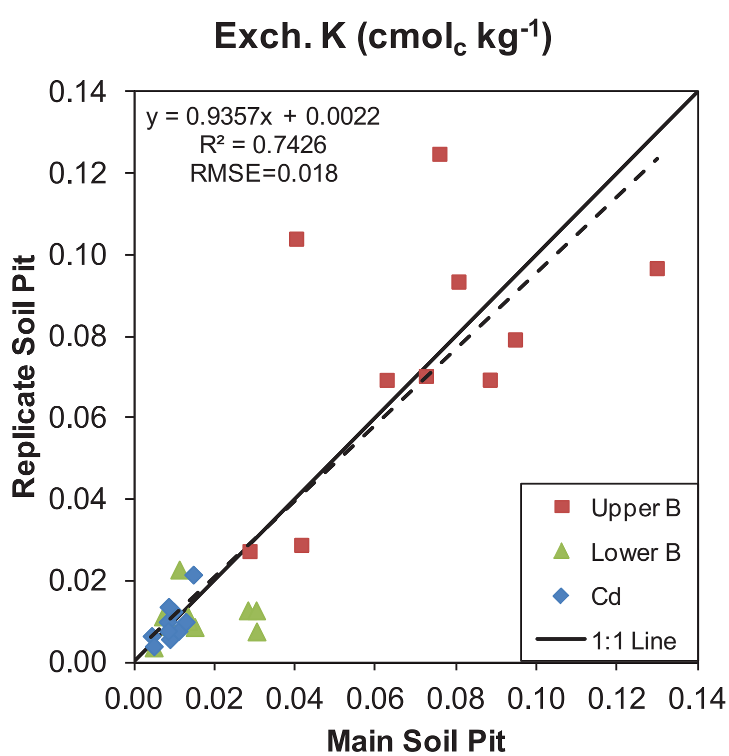
Charts showing the agreement between measured values from the main soil pit and measured values from replicated soil pits that were excavated and sampled for soil chemistry at ten plots.

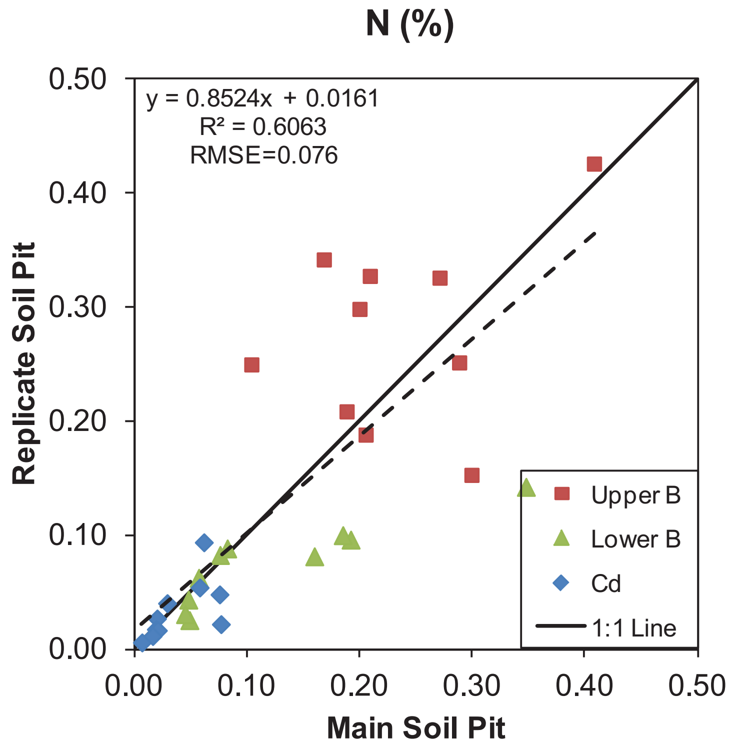
Replicate soil pits were excavated and sampled for soil chemistry at ten plots. These charts show the agreement between measured values from the main soil pit and measured values from the replicated pit. These comparisons illustrate the overall magnitude of differences in soil chemistry attributable to a combination of fine-scale spatial variability, sampling error, and measurement error.

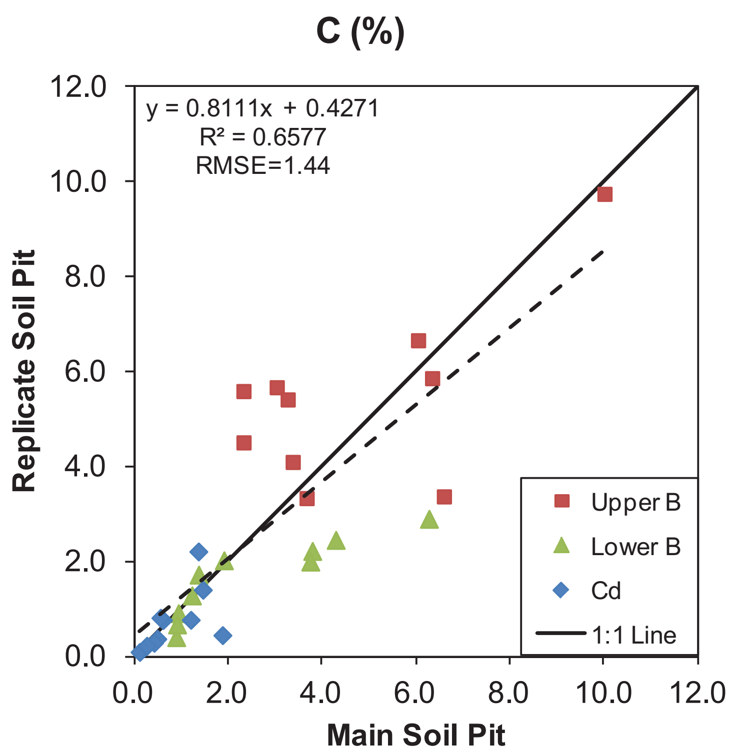

Soil pH (method)
y = 0.7173x + 1.3756
R² = 0.6651
RMSE=0.19
Replicate Soil Pit
Main Soil Pit
6.0
5.5
5.0
4.5
4.0
3.5
3.0
3.0
3.5
4.0
4.5
5.0
5.5
6.0
Upper B
Lower B
Cd
1:1 Line

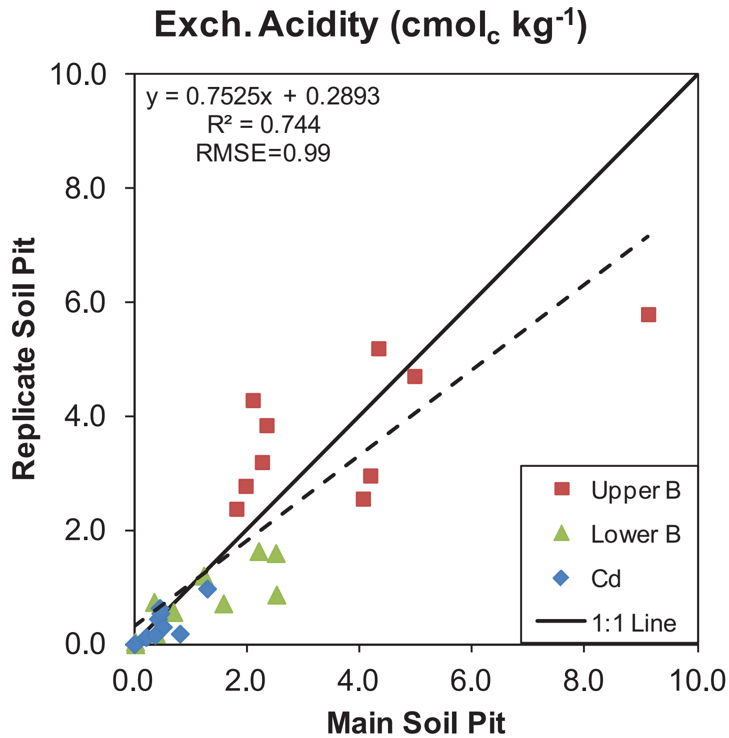

IGN Loss
y = 0.8381x + 0.7592
R² = 0.66720
RMSE=2.68
Replicate Soil Pit
Main Soil Pit
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
Upper B
Lower B
Cd
1:1 Line


Exch. Na (cmolc kg-1)
y = 0.9062x + 0.0014
R² = 0.3418
RMSE=0.0061
Upper B
Lower B
Cd
1:1 Line
Replicate Soil Pit
Main Soil Pit
0.000
0.010
0.020
0.030
0.040
0.050

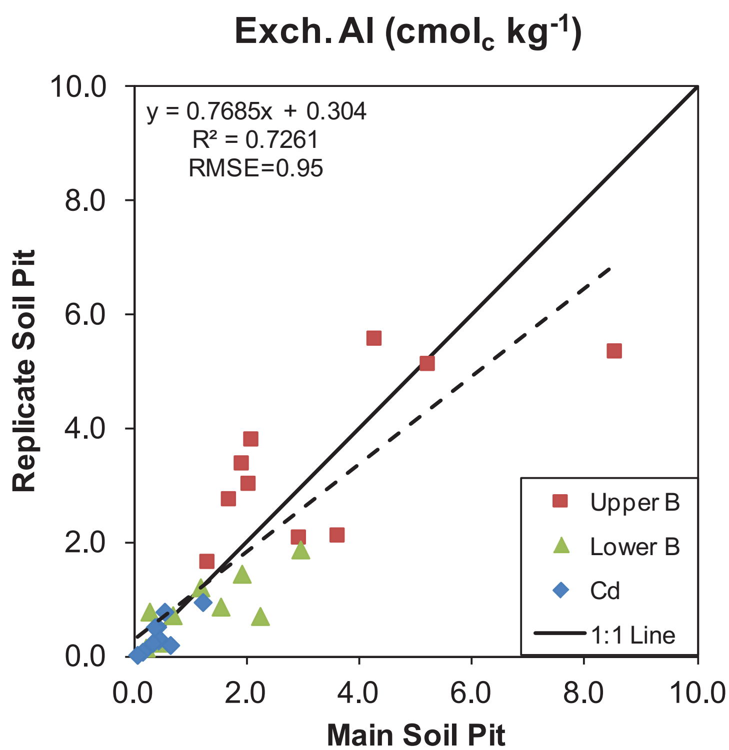

Exch. K (cmolc kg-1)
y = 0.9357x + 0.0022
R² = 0.7426
RMSE=0.018
Upper B
Lower B
Cd
1:1 Line
Replicate Soil Pit
Main Soil Pit
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14


N (%)
y = 0.8524x + 0.0161
R² = 0.6063
RMSE=0.076
0.50
0.40
0.30
0.20
0.10
0.00
Replicate Soil Pit
0.00
0.10
0.20
0.30
0.40
0.50
Main Soil Pit
Upper B
Lower B
Cd
1:1 Line

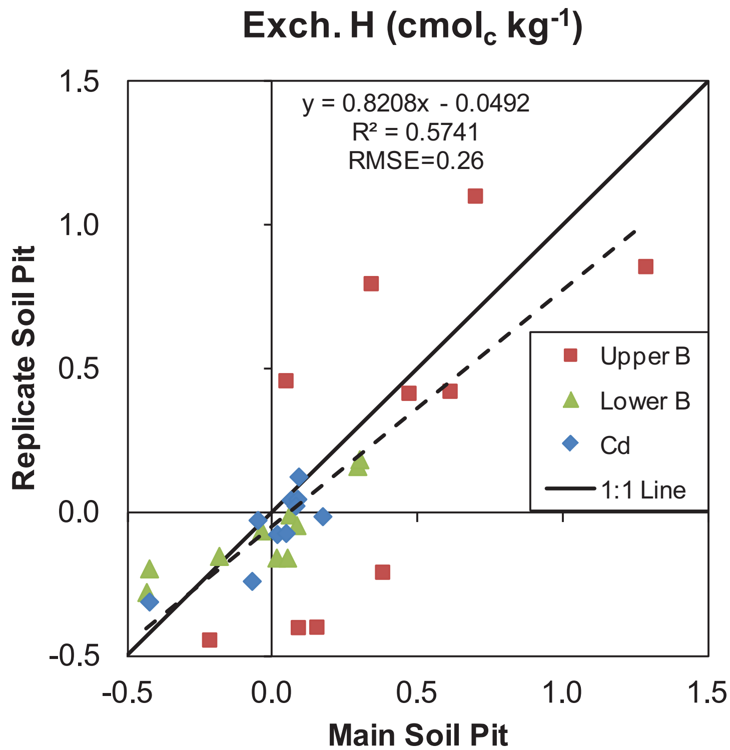

C (%)
y = 0.8111x + 0.4271
R² = 0.6577
RMSE=1.44
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Replicate Soil Pit
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Main Soil Pit
Upper B
Lower B
Cd
1:1 Line



Exch. Acidity (cmol$_c$ kg^{-1})
y = 0.7525x + 0.2893
R² = 0.744
RMSE=0.99
Replicate Soil Pit
Main Soil Pit
0.0
2.0
4.0
6.0
8.0
10.0
Upper B
Lower B
Cd
1:1 Line



Exch. Al (cmol$_c$ kg^{-1})
y = 0.7685x + 0.304
R² = 0.7261
RMSE=0.95
Replicate Soil Pit
Main Soil Pit
0.0
2.0
4.0
6.0
8.0
10.0
Upper B
Lower B
Cd
1:1 Line


Exch. H (cmol$_c$ kg^{-1})
y = 0.8208x - 0.0492
R² = 0.5741
RMSE=0.26
Upper B
Lower B
Cd
1:1 Line
Replicate Soil Pit
Main Soil Pit
1.5
1.0
0.5
0.0
-0.5
-0.5
0.0
0.5
1.0
1.5

Appendix B

Methods for calculating the percent of light penetration in the canopy using photographs taken at the study plot location.

Summary

Percent canopy cover was also estimated from the photographs taken at the time of sampling looking directly overhead. By using graphic software to systematically calculate the amount of light penetration in a forest canopy, individual pixels can be identified as either open canopy (light) or closed canopy (no light) based on the total number of pixels in the photograph. Once the user is familiar with this method, the light calculation for the same photograph can be repeated with near-duplicate results. This process is somewhat subjective, however, since the user needs to visually identify what is light and what is foliage or other matter. For instance, on a bright, sunny day there may be blue sky showing in parts of the photograph. This blue could vary from light to dark blue. By manually selecting which colors are considered light, both light and dark values can be subjectively recorded as open canopy. If this process were automated, the dark values of the blue sky would likely be recorded as dark. To simplify the process and minimize so many shades of color, the photograph is converted to a grayscale, bitmapped image, outputting fewer shades of gray. This will make it easier to group (merge) the light values as light, and the dark values as dark. The grayscale image should be visually checked against the original photograph to verify that the grayscale pixels of light accurately represent light in the photograph. Lights will be merged and darks will be merged so there are only two values remaining. By using a histogram, the number of light pixels will be counted and divided by the total number of pixels for the entire image to give a total percent of light for the photograph.

Process

In CorelDRAW, import a canopy cover photograph and resize it to 10.667 in. width and 8.0 in. height. This reduced size makes the image easier to work with. The photograph will need to be converted to a simplified image to distinguish the light versus dark values. Click the on the photo and go to “Bitmap” in the upper menu bar. From the drop down menu, select “Trace Bitmap”, and choose “Low Quality Image.” In the popup window, select the “Options” tab and choose the following settings:

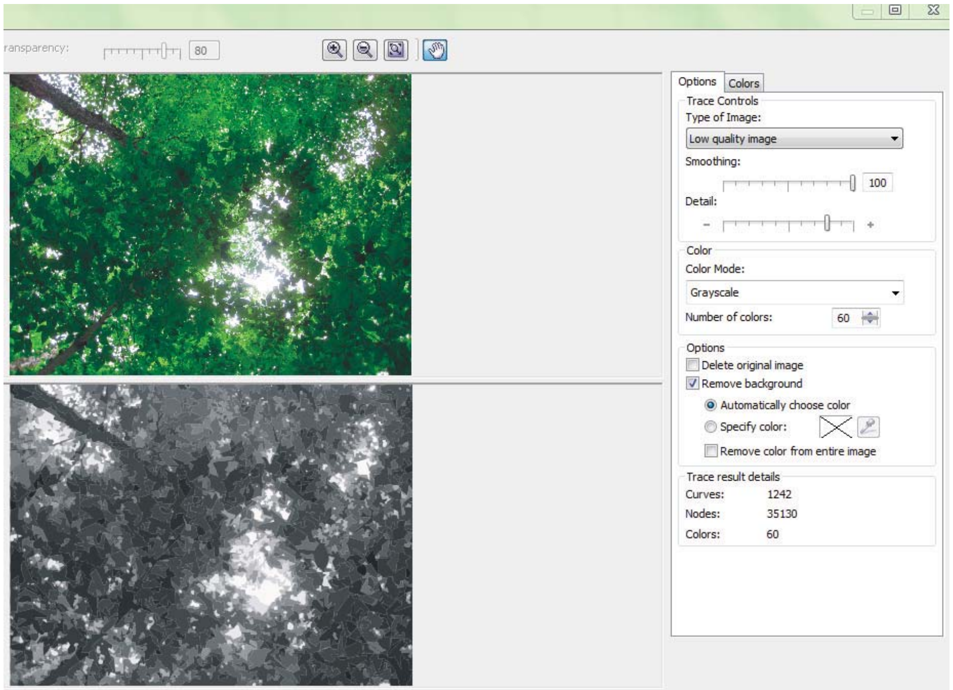
Type of Image*: Low Quality*
Smoothing: *100*
Detail: *80*
Color Mode: *Grayscale*
Deselect the options below this section.

In the same popup window, go to the “Colors” tab; there will be a variety of grayscale values. The lightest values need to represent light penetration in the forest canopy. This will involve some subjective merging of values, but can usually be replicated once the user is familiar with the process. The object during this process is to have only two grayscale values once finished; light and dark. To merge grayscale values, select the darkest values by holding down the “Cntl” key and picking the darkest values from the palate. This can also be done by holding down the “Shift” key, but all values must be lined in a row/column to use this feature. Click on “merge” and those values will merge into one value. After each merge, visually check the grayscale image against the original photograph to verify the dark values are closed canopy areas. You may need to repeat this several times before most of the darkest values are merged. Next, select a two or three of the lightest values and merge these values. Once these values are merged, the overall value will darken (similar to blending colors on a palate). To keep the light values light, or even white, click on “Edit” below click on the “Palettes” tab; select white or a very light color. The light will be easier to identify. Repeat the visual verification process to check that white accurately represent the light in the original photograph. After there are only two grayscale values remaining, click “OK” at the bottom of the popup window.

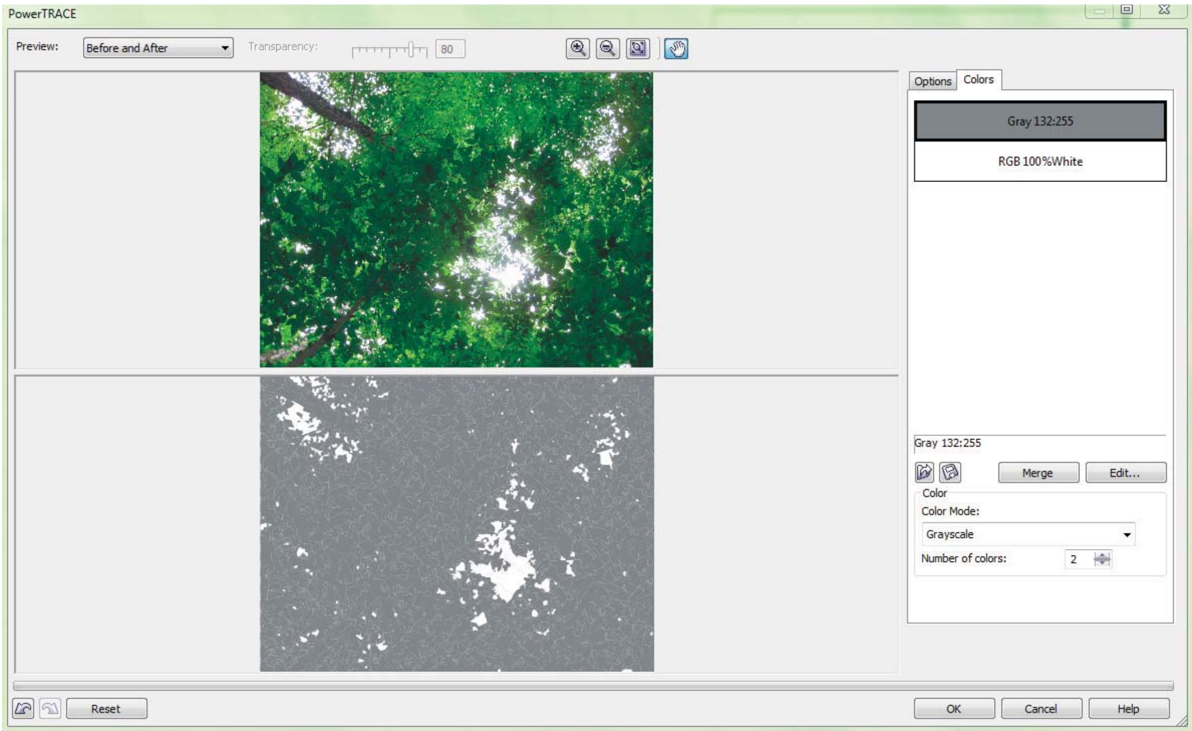
Click the grayscale image, go to “Bitmap” in the upper menu bar, click on “Convert to Bitmap”, and choose the following settings:

Resolution: *300dpi*
Color: *16 Colors (4-bit)*
Color Mode: *Apply ICC Profile*
Options: *Anti-aliasing*

Once converted to a bitmap, click on the image and select “Edit Bitmap” in the upper menu bar. Corel Paint will open in a separate window. Click on “Image” in the upper menu bar, and select “Histogram.” The pixels box will display the total number of pixels for the image. The number of pixels should be the same for every photograph, and this number be used to calculate the total light. Close this window. Click on “Mask” in the upper menu bar, and select “Color Mask.” Use the eyedropper tool to select the light or white color from the image. To the right of the selected color box, change the “n” to a value of “0.” Set “smooth” at the bottom of the window to “0” and click OK. In the upper menu bar click on “Image” and select “Histogram” to retrieve the total light pixels for the image. Divide this light pixel number by the total pixel number to get a percent of light for the photograph.



The photograph after conversion to a grayscale, low-quality image. The photograph is simplified into fewer groups of values.



The merged, two-value grayscale image. White represents light and grey represents no light.

Appendix C

Sugar maple seedling and sapling abundance on each of the sample plots.

Sugar maple seedling and sapling abundance on each of the sample plots is shown here. Values reported in these tables represent the sum of all observed seedlings and saplings across the five sub-plots in each plot. Abundance is reported in various forms including: total count (CT), basal area (BA), percentage of all observed species by CT (PctCT), percentage of all observed species by BA (PctBA), and density as count per square meter (DENS).

Saplings							Seedlings		
PLOT_I	CT	BA	PctCT	PctBA	DENS		CT	PctCT	DENS
12003_1	5	1.04	29.41	33.67	0.05		1	1.69	0.2
12003_2	3	0.65	17.65	44.69	0.03				
12003_3	4	0.78	16.67	45.64	0.04		9	60.00	1.8
13008_1									
13008_2									
17002_1									
17002_2	6	0.24	37.50	11.24	0.06				
17002_3	7	1.49	43.75	73.17	0.07		1	2.70	0.2
22019_1	4	0.83	15.38	23.74	0.04				
22019_2									
24001_1							25	89.29	5
24001_2	4	1.72	20.00	27.65	0.04		32	84.21	6.4
26008_1	3	1.24	13.04	19.76	0.03				
26008_2									
27019_1	2	0.44	15.38	28.96	0.02				
27019_2	2	1.05	8.33	25.80	0.02				
27019_3	1	0.62	4.00	15.53	0.01				
28030_1							8	53.33	1.6
28030_2							14	46.67	2.8
28030_3							5	35.71	1
28037_1	3	0.23	27.27	21.45	0.03		22	42.31	4.4
28037_2	11	2.69	68.75	67.46	0.11		17	39.53	3.4
29012_1									
29012_2	7	0.43	58.33	29.59	0.07				
30009_1							1	2.33	0.2
30009_2							3	11.11	0.6
30009_3	1	0.47	3.70	18.89	0.01				
31009_1									
31009_2	2	0.78	9.52	19.20	0.02				
31009_3									
35014_1									
35014_2							1	6.25	0.2
7001_1									
7001_2	11	2.69	50.00	62.58	0.11		2	50.00	0.4
7001_3	7	0.09	53.85	23.06	0.07		4	28.57	0.8
9006_1									
9006_2									
9006_3	2	0.10	16.67	3.95	0.02				
AMP_1							21	75.00	4.2
AMP_2							5	38.46	1
N1_1	1	0.31	3.57	8.13	0.01		2	28.57	0.4
N1_2	1	0.11	3.33	3.15	0.01		11	52.38	2.2
N1_3	4	0.73	15.38	22.50	0.04		189	99.47	37.8
NW_1							4	40.00	0.8
NW_2	1	0.30	3.23	7.07	0.01		9	64.29	1.8
S14_1	1	0.07	12.50	2.87	0.01		23	95.83	4.6
S14_2							21	87.50	4.2
WF_1							34	82.93	6.8
WF_2	1	0.53	14.29	66.73	0.01		41	70.69	8.2
WF_3	1	0.45	2.94	11.36	0.01		24	77.42	4.8

Appendix D

Distribution of sugar maple tree, sapling, and seedling abundance across the study plots.

The distribution of sugar maple (SM) tree, sapling, and seedling abundance across the study plots is shown in Table D-01. This table includes summary statistics across all study plots. Abundance values were calculated as percentages based on basal area (BA) for trees and saplings. Counts of seedlings are given for each plot in Table D-02. A graphical representation of median, 25th percentile, and 75th percentile for percent abundance by BA for SM trees and saplings, and percent abundance by count for SM seedlings is given in Figure D-01.

Table D-01. Distribution across all 50 plots of abundance values for SM trees, saplings, and seedlings.			
	Trees	**Saplings**	**Seedlings**
Max	95	73	99
75th	66	23	52
Median	57	3	3
25th	43	0	0
Min	18	0	0
Average	56	14	27

Table D-02. Abundance in each plot of SM trees and saplings by basal area and seedlings by count.			
PLOT_ID	**Percent Abundance by Basal Area Tree**	**Percent Abundance by Basal Area Sapling**	**Percent Count Seedling**
7001_1	53.64	0.00	0.00
7001_2	84.16	62.58	50.00
7001_3	40.67	23.06	28.57
9006_1	37.98	0.00	0.00
9006_2	32.22	0.00	0.00
9006_3	47.14	3.95	0.00
12003_1	31.98	33.67	1.69
12003_2	66.17	44.69	0.00
12003_3	84.90	45.64	60.00
13008_1	42.49	0.00	0.00
13008_2	63.65	0.00	0.00
17002_1	64.34	0.00	0.00
17002_2	62.50	11.24	0.00
17002_3	85.98	73.17	2.70
22019_1	31.48	23.74	0.00
22019_2	56.43	0.00	0.00
24001_1	85.28	0.00	89.29
24001_2	95.19	27.65	84.21
26008_1	65.36	19.76	0.00

PLOT_ID	Percent Abundance by Basal Area Tree	Percent Abundance by Basal Area Sapling	Percent Count Seedling
26008_2	46.29	0.00	0.00
27019_1	24.47	28.96	0.00
27019_2	21.38	25.80	0.00
27019_3	72.51	15.53	0.00
28030_1	57.94	0.00	53.33
28030_2	58.71	0.00	46.67
28030_3	66.48	0.00	35.71
28037_1	45.27	21.45	42.31
28037_2	53.85	67.46	39.53
29012_1	66.48	0.00	0.00
29012_2	84.75	29.59	0.00
30009_1	24.56	0.00	2.33
30009_2	58.46	0.00	11.11
30009_3	46.42	18.89	0.00
31009_1	17.73	0.00	0.00
31009_2	35.29	19.20	0.00
31009_3	42.32	0.00	0.00
35014_1	29.83	0.00	0.00
35014_2	46.51	0.00	6.25
AMP_1	43.45	0.00	75.00
AMP_2	56.47	0.00	38.46
N1_1	72.44	8.13	28.57
N1_2	59.74	3.15	52.38
N1_3	74.91	22.50	99.47
NW_1	50.57	0.00	40.00
NW_2	79.19	7.07	64.29
S14_1	62.68	2.87	95.83
S14_2	69.30	0.00	87.50
WF_1	80.19	0.00	82.93
WF_2	53.45	66.73	70.69
WF_3	63.68	11.36	77.42

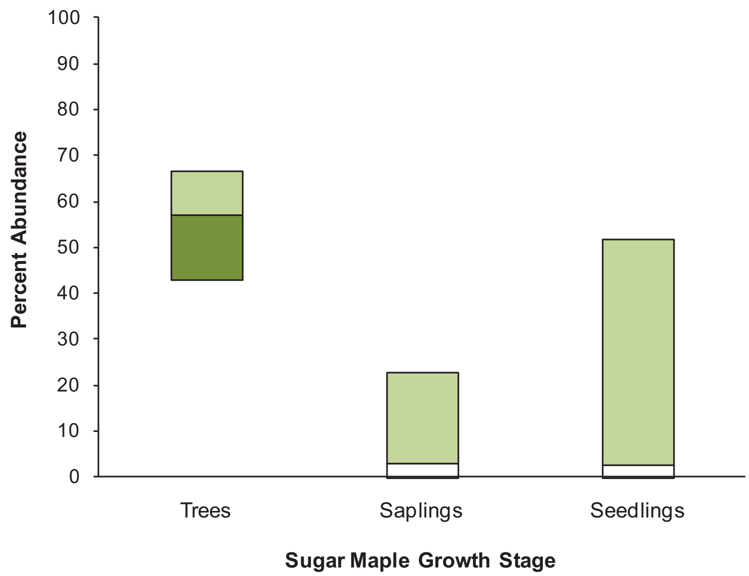


Figure D-01. Median, 25th, and 75th percentile of the percent abundance by basal area for SM trees and saplings, along with the distribution of the percent abundance by count for seedlings.

Appendix E

Plot averages of sugar maple canopy condition ratings for each plot.

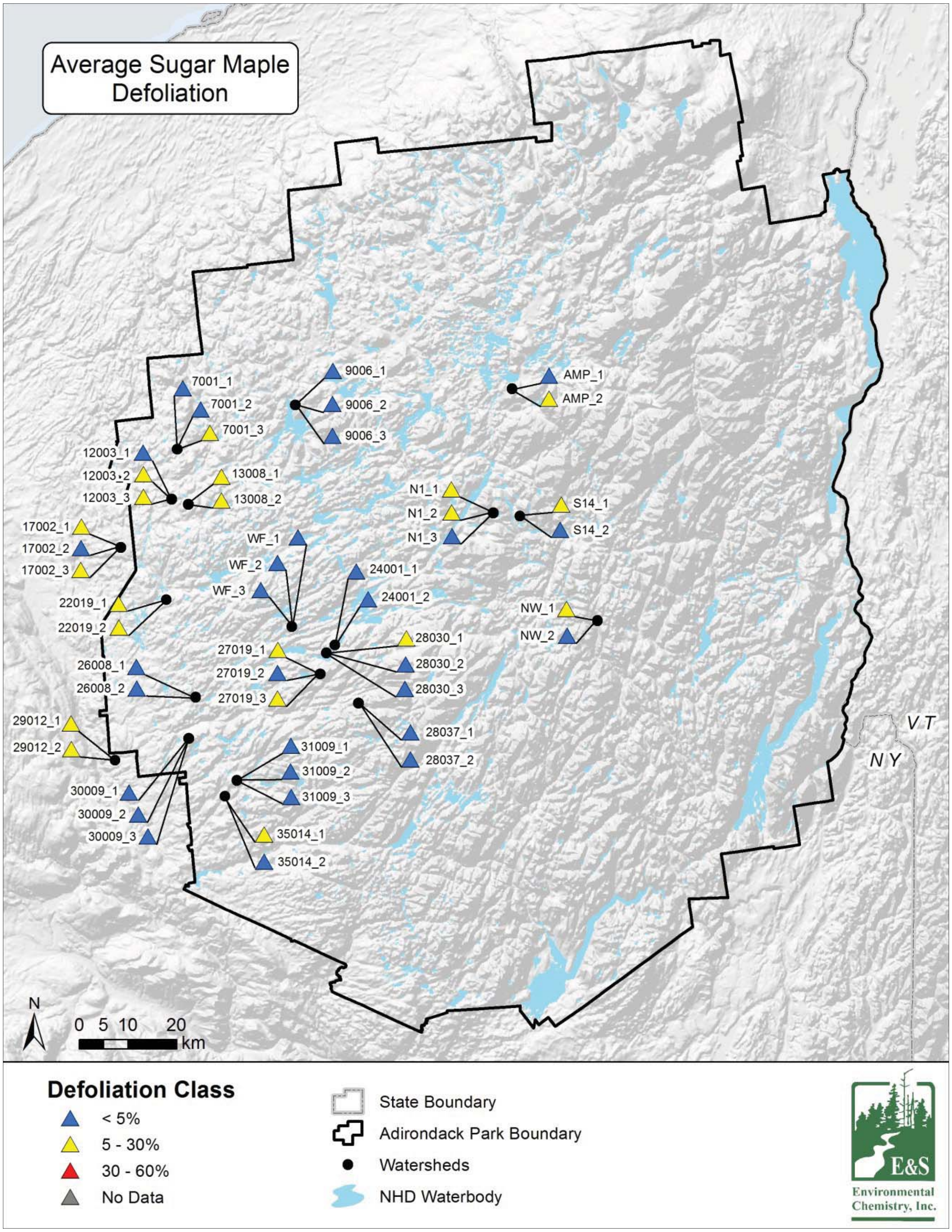
Each observed sugar maple (SM) tree was given a rating for defoliation, dieback, discoloration, transparency and vigor to represent canopy condition. Plot averages for each plot of these canopy condition ratings for SM are provided in this appendix.

PLOT_ID	Defoliation	Dieback	Discoloration	Transparency	Vigor
12003_1	0.4	31.0	11.4	36.2	3.0
12003_2	0.3	25.7	11.4	34.6	2.9
12003_3	0.8	22.4	8.2	30.0	2.4
13008_1	0.1	32.4	11.2	35.9	3.3
13008_2	0.5	25.4	6.9	37.7	3.5
17002_1	0.2	30.5	9.3	30.0	2.9
17002_2	0.4	31.0	11.7	32.9	3.2
17002_3	0.9	23.6	10.0	26.4	2.5
22019_1	0.6	23.1	5.2	26.4	2.4
22019_2	0.7	31.6	2.4	33.2	2.7
24001_1	0.8	22.5	6.8	16.1	2.6
24001_2	1.0	30.7	8.9	32.6	3.0
26008_1	0.3	28.8	13.6	40.0	3.1
26008_2	1.3	26.7	5.7	28.1	3.0
27019_1	0.5	26.4	3.2	27.1	2.9
27019_2	1.0	32.6	19.8	33.3	3.1
27019_3	0.2	21.6	5.6	26.0	2.7
28030_1	0.0	11.6	0.9	19.3	1.5
28030_2	0.1	11.8	2.4	20.8	2.4
28030_3	0.3	22.9	1.5	21.8	2.8
28037_1	0.5	25.8	10.0	30.0	2.5
28037_2	0.4	20.0	8.3	28.9	2.7
29012_1	0.6	24.1	9.3	22.2	2.4
29012_2	0.5	26.2	11.5	28.5	3.0
30009_1	0.3	26.7	10.0	27.8	3.2
30009_2	0.1	21.9	10.0	25.0	2.4
30009_3	0.3	19.3	4.0	20.5	2.6
31009_1	0.4	24.2	4.8	24.9	2.3
31009_2	1.3	27.2	11.9	28.9	3.3
31009_3	1.0	25.5	4.7	30.7	3.1
35014_1	0.0	15.0	1.9	25.0	2.5
35014_2	0.0	20.9	3.9	26.4	2.8
7001_1	0.0	23.9	5.9	33.5	3.3
7001_2	0.1	19.1	0.5	27.3	2.4
7001_3	0.2	21.5	5.4	24.6	2.8
9006_1	0.0	26.0	2.3	30.7	3.1
9006_2	1.0	26.7	1.3	30.8	3.1
9006_3	0.5	27.1	4.5	26.1	2.9
AMP_1	0.0	24.4	6.1	27.8	2.3
AMP_2	0.8	30.0	23.3	35.6	3.0
N1_1	0.5	23.8	2.2	20.3	2.4
N1_2	0.6	23.8	3.8	22.5	2.6
N1_3	0.2	18.6	1.7	29.5	2.1
NW_1	0.6	24.5	1.0	31.4	2.8
NW_2	0.4	25.2	0.7	27.6	2.7
S14_1	0.6	24.4	7.8	24.4	2.7
S14_2	0.1	19.3	3.3	24.0	2.7
WF_1	0.3	19.1	2.0	29.1	2.2
WF_2	0.2	18.3	3.3	24.2	2.4
WF_3	0.2	21.7	3.0	24.1	2.4

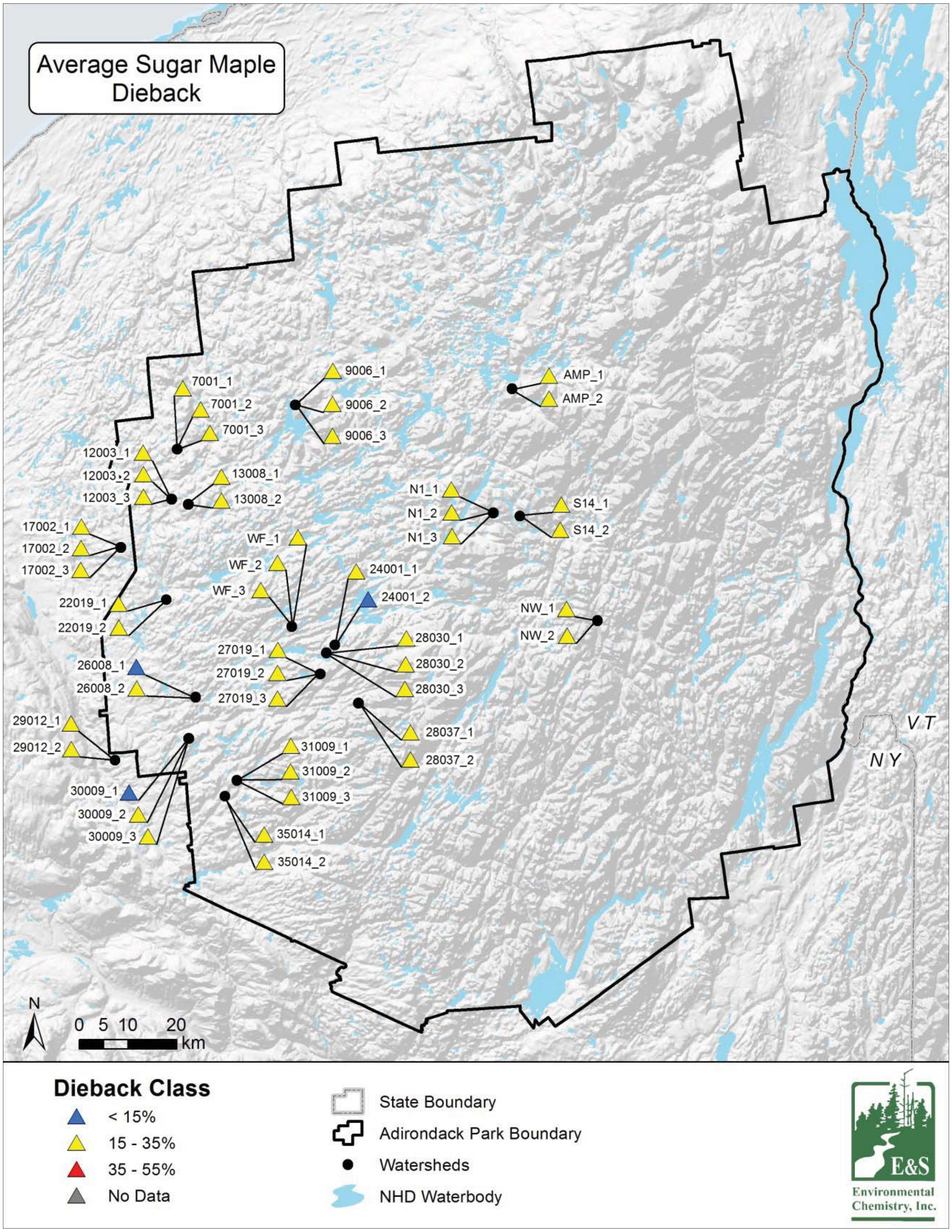
Appendix F

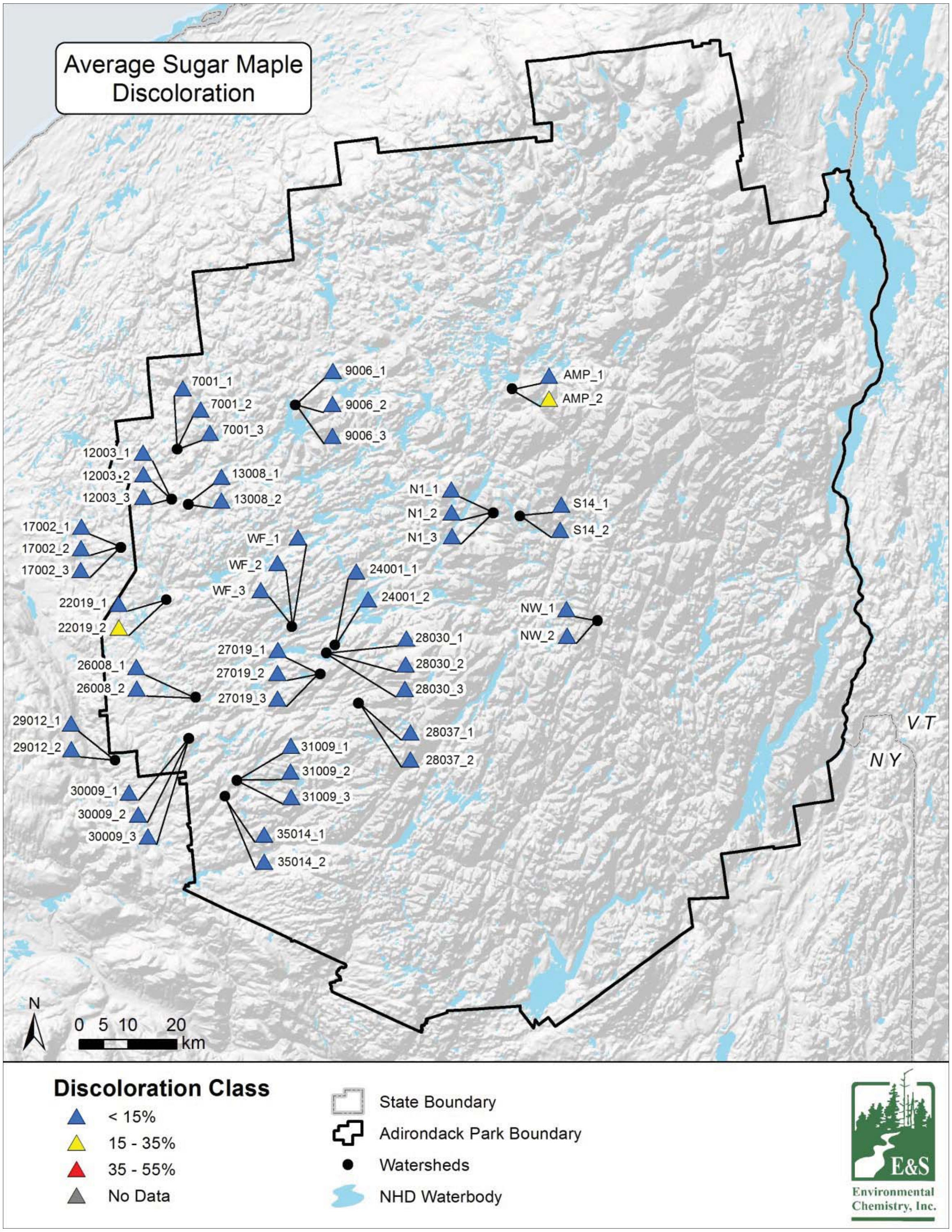
Maps showing plot averages of canopy condition ratings for Sugar maple (SM).

Each observed SM tree was given a rating for defoliation, dieback, discoloration, transparency and vigor to represent canopy condition. Plot averages of these canopy condition ratings for SM are shown on these maps.

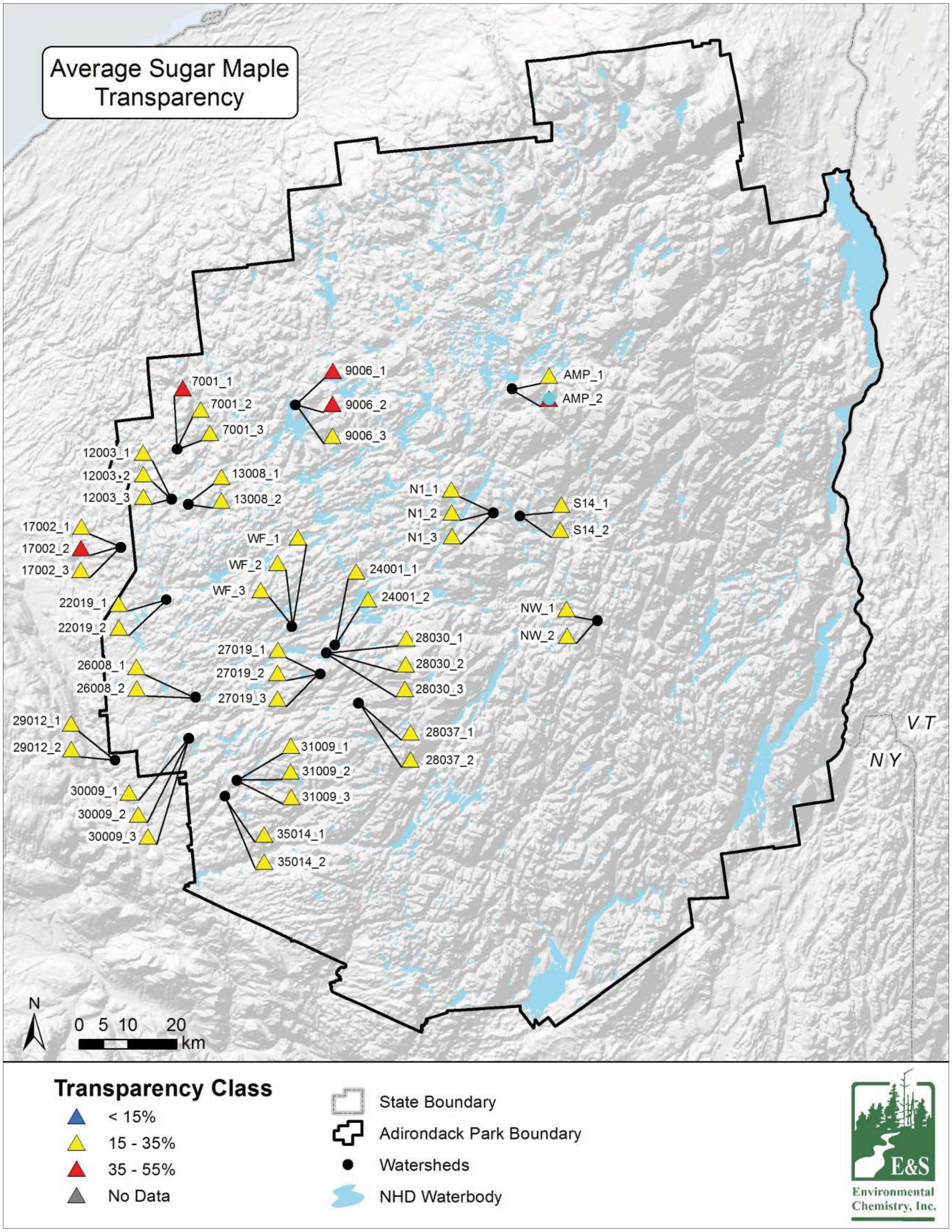


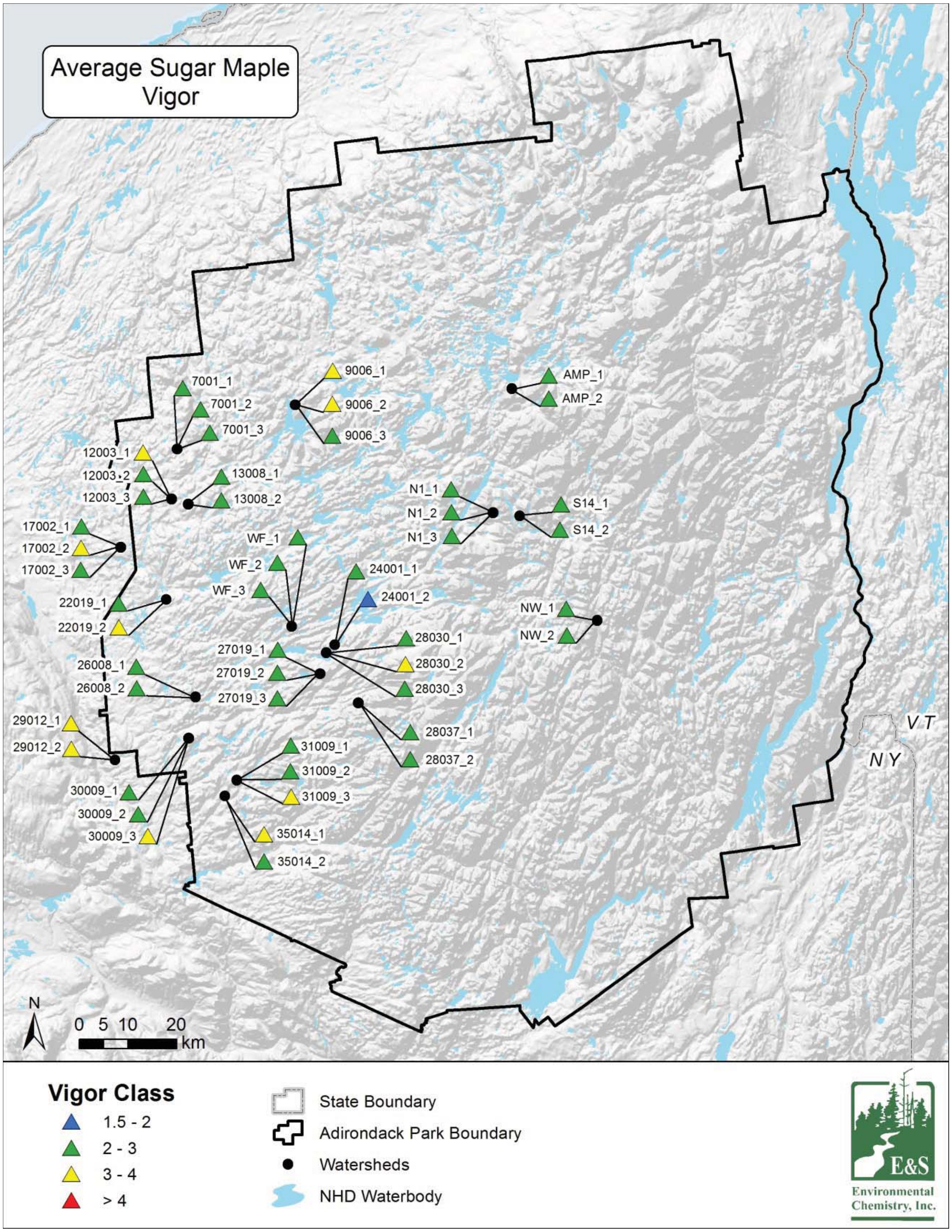
Average Sugar Maple Defoliation
7001_1
7001_2
7001_3
9006_1
9006_2
9006_3
AMP_1
AMP_2
12003_1
12003_2
12003_3
13008_1
13008_2
N1_1
N1_2
N1_3
S14_1
S14_2
17002_1
17002_2
17002_3
WF_1
WF_2
WF_3
24001_1
24001_2
22019_1
22019_2
NW_1
NW_2
28030_1
28030_2
28030_3
27019_1
27019_2
27019_3
26008_1
26008_2
29012_1
29012_2
28037_1
28037_2
31009_1
31009_2
31009_3
30009_1
30009_2
30009_3
35014_1
35014_2
VT
NY
N
0 5 10 20
km
Defoliation Class
< 5%
5 - 30%
30 - 60%
No Data
State Boundary
Adirondack Park Boundary
Watersheds
NHD Waterbody
E&S
Environmental Chemistry, Inc.


Average Sugar Maple Dieback
7001_1
7001_2
7001_3
9006_1
9006_2
9006_3
AMP_1
AMP_2
12003_1
12003_2
12003_3
13008_1
13008_2
N1_1
N1_2
N1_3
S14_1
S14_2
17002_1
17002_2
17002_3
WF_1
WF_2
WF_3
24001_1
24001_2
22019_1
22019_2
NW_1
NW_2
28030_1
28030_2
28030_3
27019_1
27019_2
27019_3
26008_1
26008_2
29012_1
29012_2
28037_1
28037_2
31009_1
31009_2
31009_3
30009_1
30009_2
30009_3
35014_1
35014_2
VT
NY
N
0 5 10 20
km
Dieback Class
< 15%
15 - 35%
35 - 55%
No Data
State Boundary
Adirondack Park Boundary
Watersheds
NHD Waterbody
E&S
Environmental Chemistry, Inc.



Average Sugar Maple Discoloration
7001_1
7001_2
7001_3
9006_1
9006_2
9006_3
AMP_1
AMP_2
12003_1
12003_2
12003_3
13008_1
13008_2
N1_1
N1_2
N1_3
S14_1
S14_2
17002_1
17002_2
17002_3
WF_1
WF_2
WF_3
24001_1
24001_2
22019_1
22019_2
NW_1
NW_2
28030_1
28030_2
28030_3
27019_1
27019_2
27019_3
26008_1
26008_2
29012_1
29012_2
28037_1
28037_2
31009_1
31009_2
31009_3
30009_1
30009_2
30009_3
35014_1
35014_2
VT
NY
N
0 5 10 20
km
Discoloration Class
< 15%
15 - 35%
35 - 55%
No Data
State Boundary
Adirondack Park Boundary
Watersheds
NHD Waterbody
E&S Environmental Chemistry, Inc.


Average Sugar Maple Transparency
7001_1
7001_2
7001_3
9006_1
9006_2
9006_3
AMP_1
AMP_2
12003_1
12003_2
12003_3
13008_1
13008_2
N1_1
N1_2
N1_3
S14_1
S14_2
17002_1
17002_2
17002_3
WF_1
WF_2
WF_3
24001_1
24001_2
22019_1
22019_2
NW_1
NW_2
28030_1
28030_2
28030_3
26008_1
26008_2
27019_1
27019_2
27019_3
29012_1
29012_2
28037_1
28037_2
31009_1
31009_2
31009_3
30009_1
30009_2
30009_3
35014_1
35014_2
VT
NY
N
0 5 10 20
km
Transparency Class
< 15%
15 - 35%
35 - 55%
No Data
State Boundary
Adirondack Park Boundary
Watersheds
NHD Waterbody
E&S Environmental Chemistry, Inc.

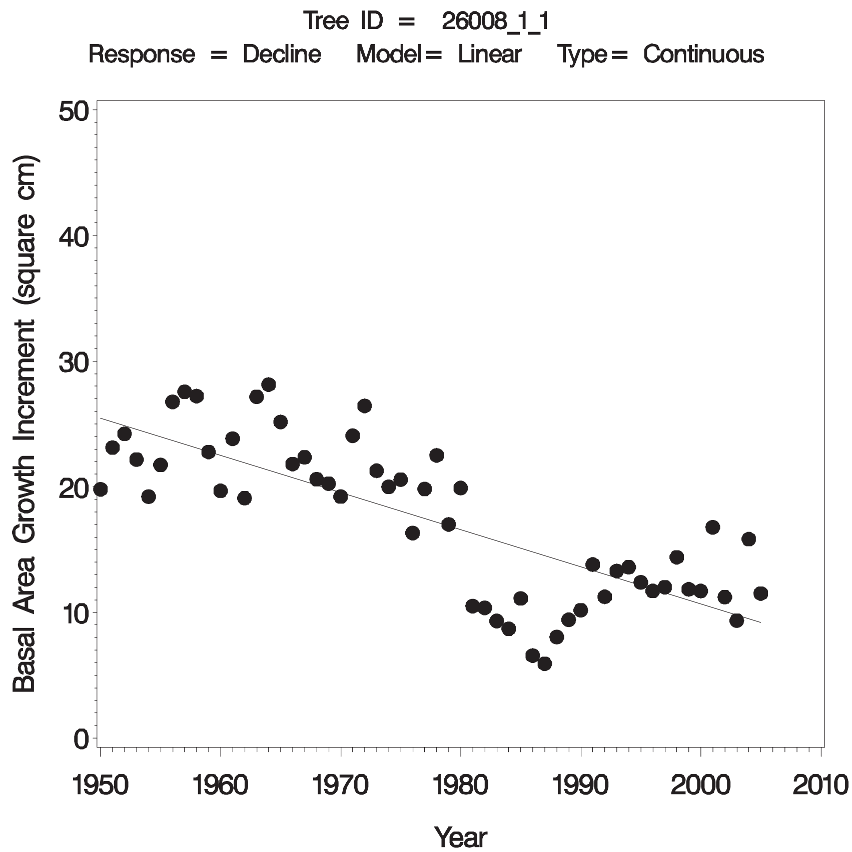


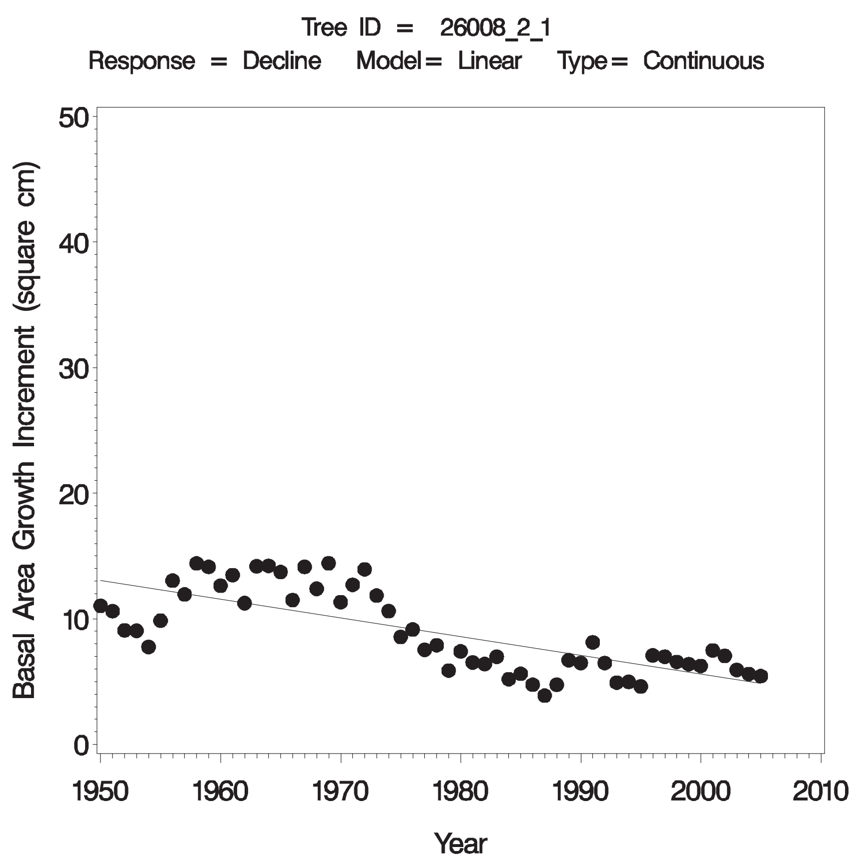
Average Sugar Maple Vigor
7001_1
7001_2
7001_3
9006_1
9006_2
9006_3
AMP_1
AMP_2
12003_1
12003_2
12003_3
13008_1
13008_2
N1_1
N1_2
N1_3
S14_1
S14_2
17002_1
17002_2
17002_3
WF_1
WF_2
WF_3
24001_1
24001_2
22019_1
22019_2
NW_1
NW_2
28030_1
28030_2
28030_3
27019_1
27019_2
27019_3
26008_1
26008_2
29012_1
29012_2
28037_1
28037_2
31009_1
31009_2
31009_3
30009_1
30009_2
30009_3
35014_1
35014_2
VT
NY
N
0 5 10 20 km
Vigor Class
1.5 - 2
2 - 3
3 - 4
> 4
State Boundary
Adirondack Park Boundary
Watersheds
NHD Waterbody
E&S Environmental Chemistry, Inc.

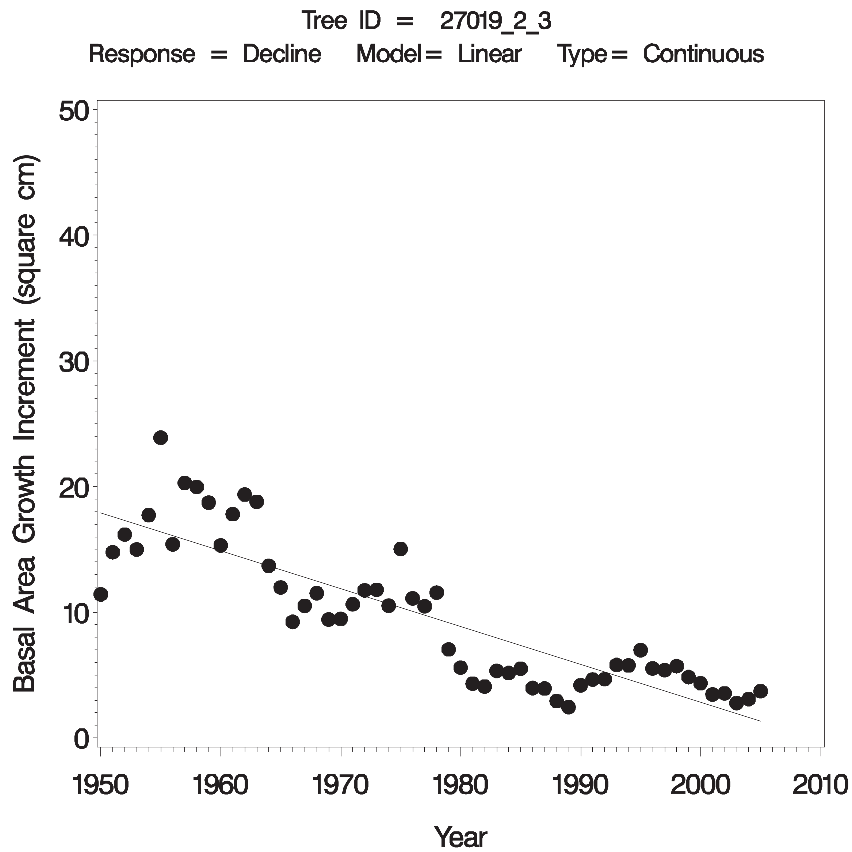
Appendix G

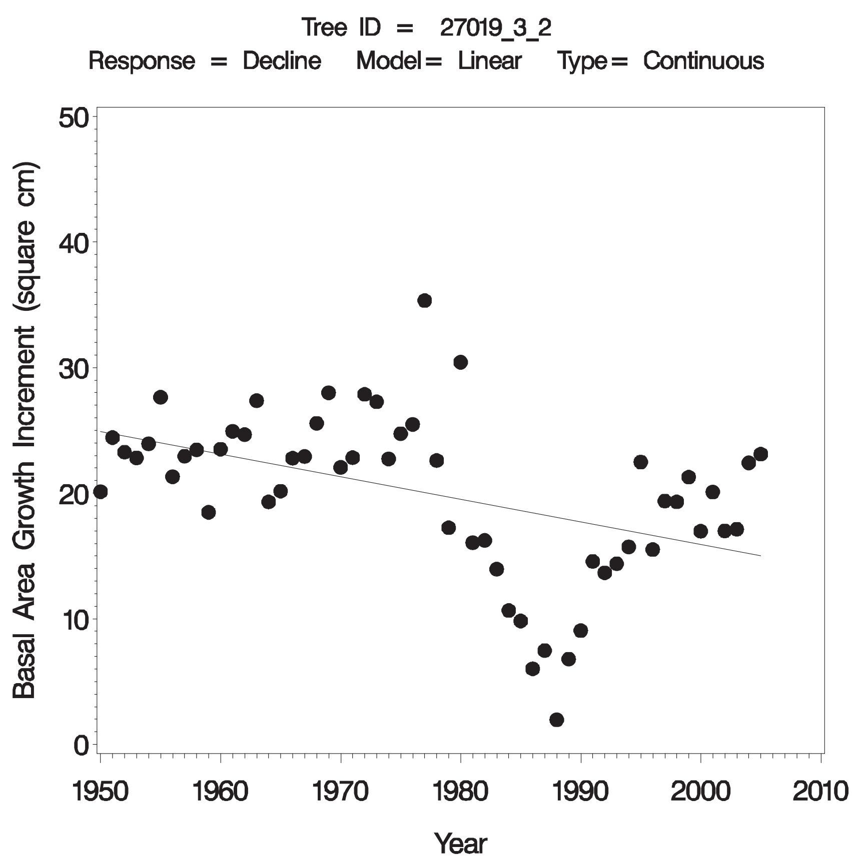
Data used to identify cored trees showing evidence of growth declines, typically expressed as the average results of two cores collected from each tree.

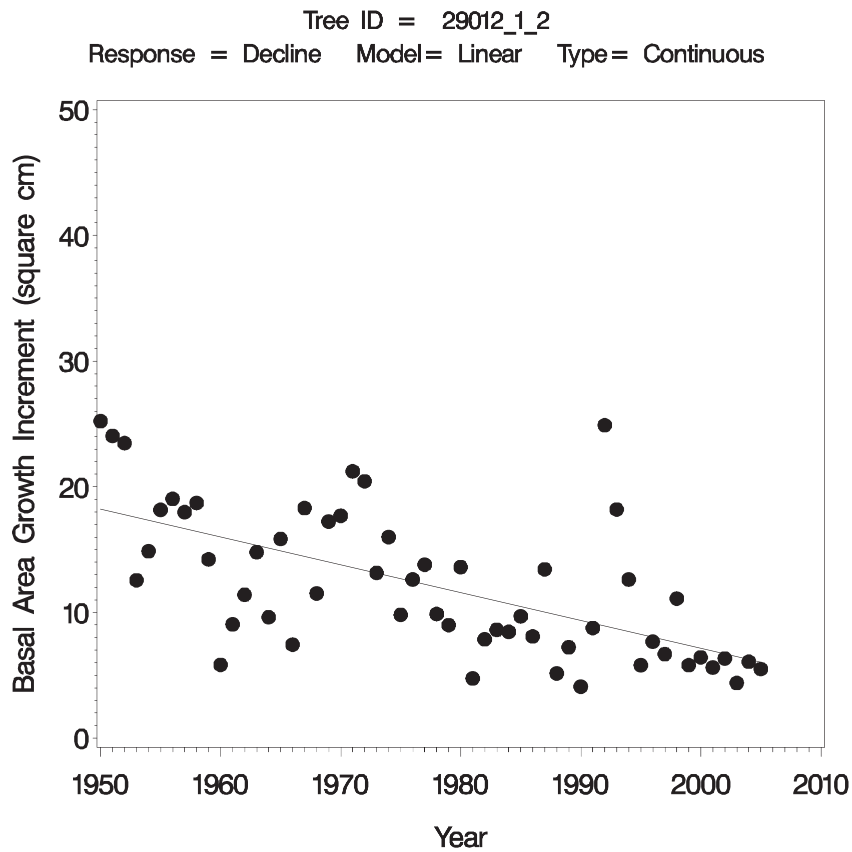
Sugar maple (SM) tree growth data from 1950 to 2005 were fit with either a linear or piecewise regression model to identify cored trees showing evidence of growth decline. The data used in this analysis are shown here for each cored tree, expressed as the average results of two cores collected from each tree. Growth *response* was determined as either "Decline" or "No Decline" based on either a "Linear" or "Piecewise" *model*. The *type* of response was classified as "Continuous", "Initial" or "Recent" depending on the time period over which the response occurred.


Tree ID = 26008_1_1
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year

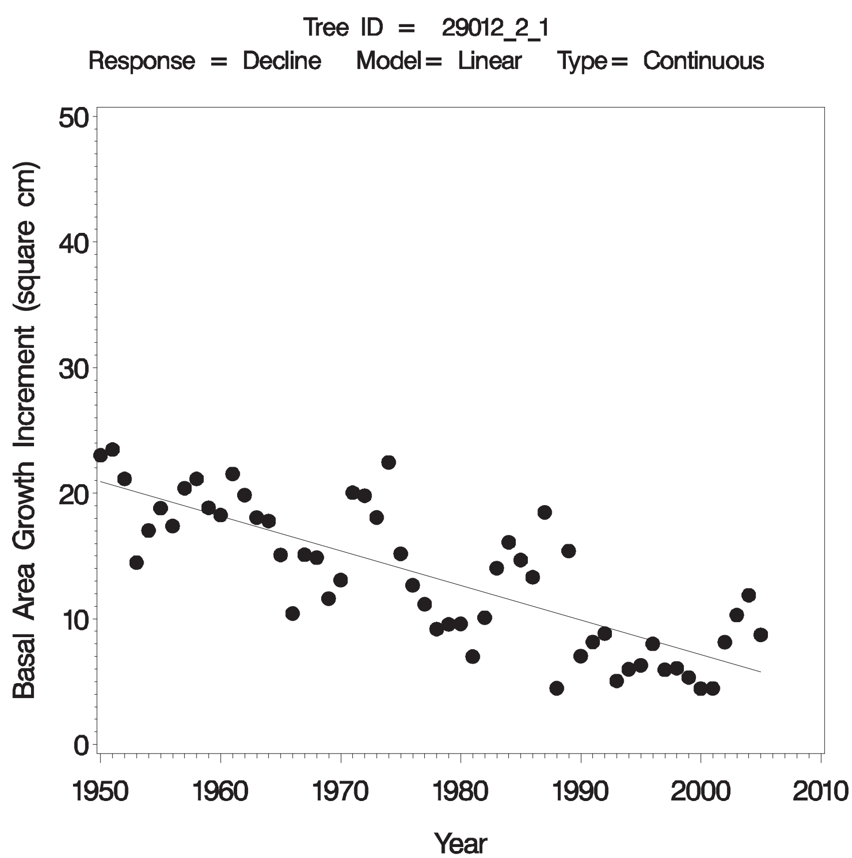

Tree ID = 26008_2_1
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 27019_2_3
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 27019_3_2
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

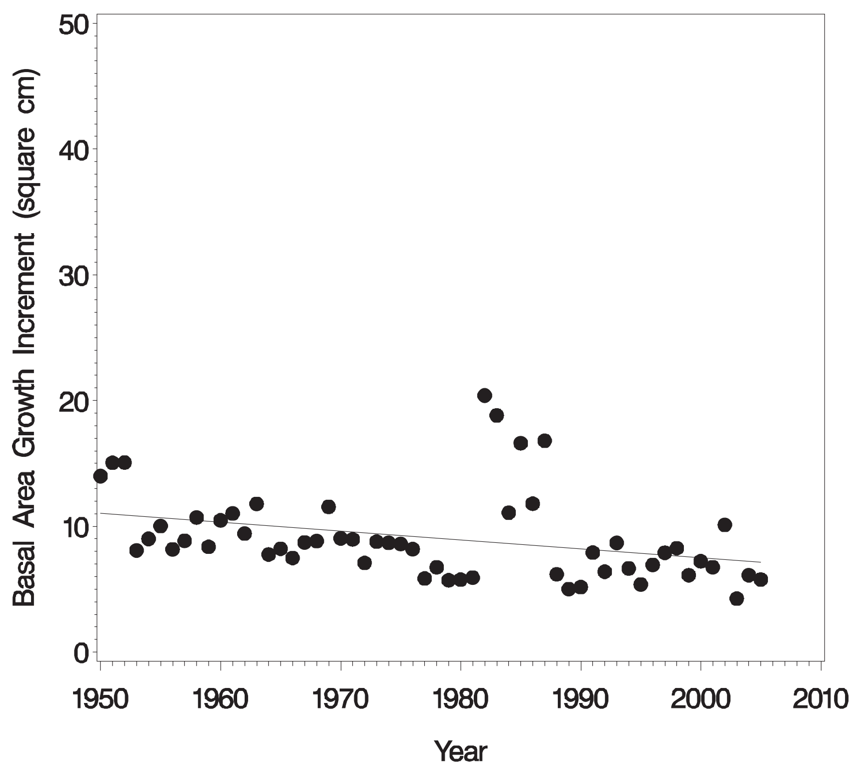


Tree ID = 29012_1_2
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

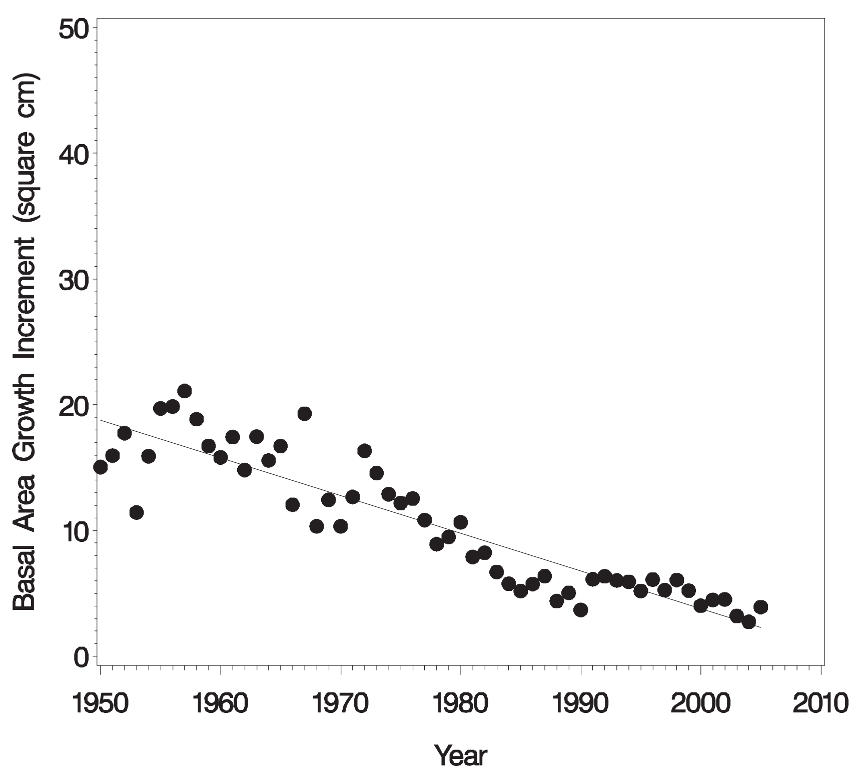


Tree ID = 29012_2_1
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

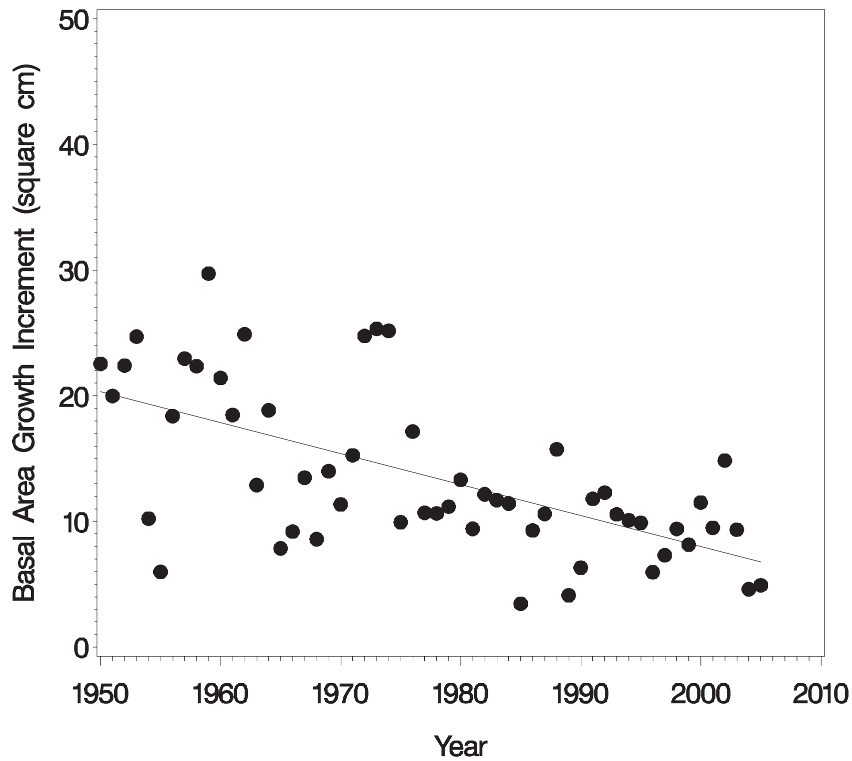
Tree ID = 29012_2_3
Response = Decline Model= Linear Type= Continuous



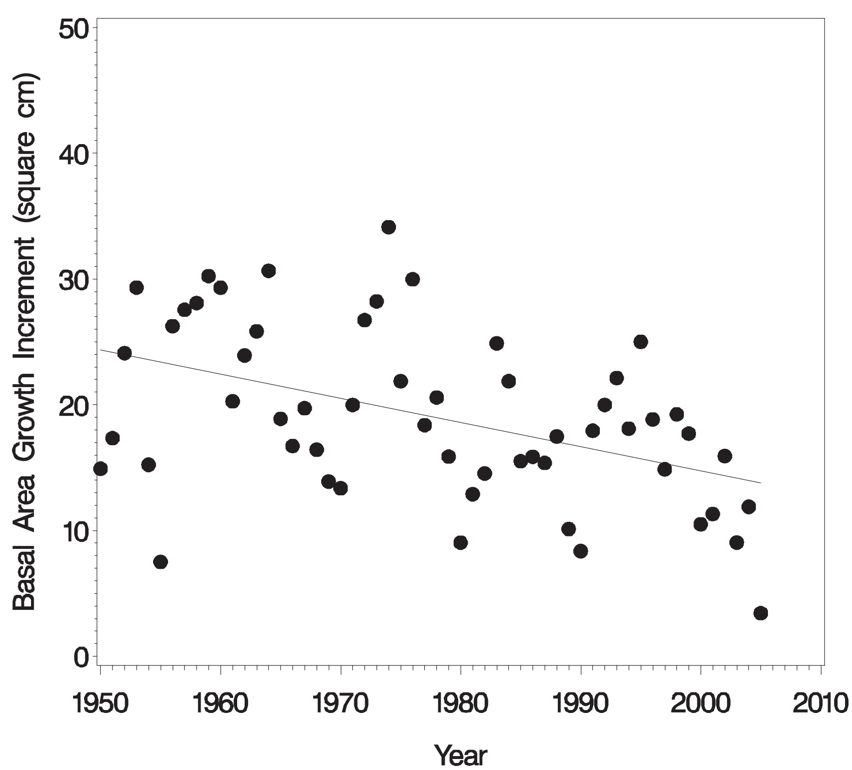
Tree ID = 30009_3_1
Response = Decline Model= Linear Type= Continuous

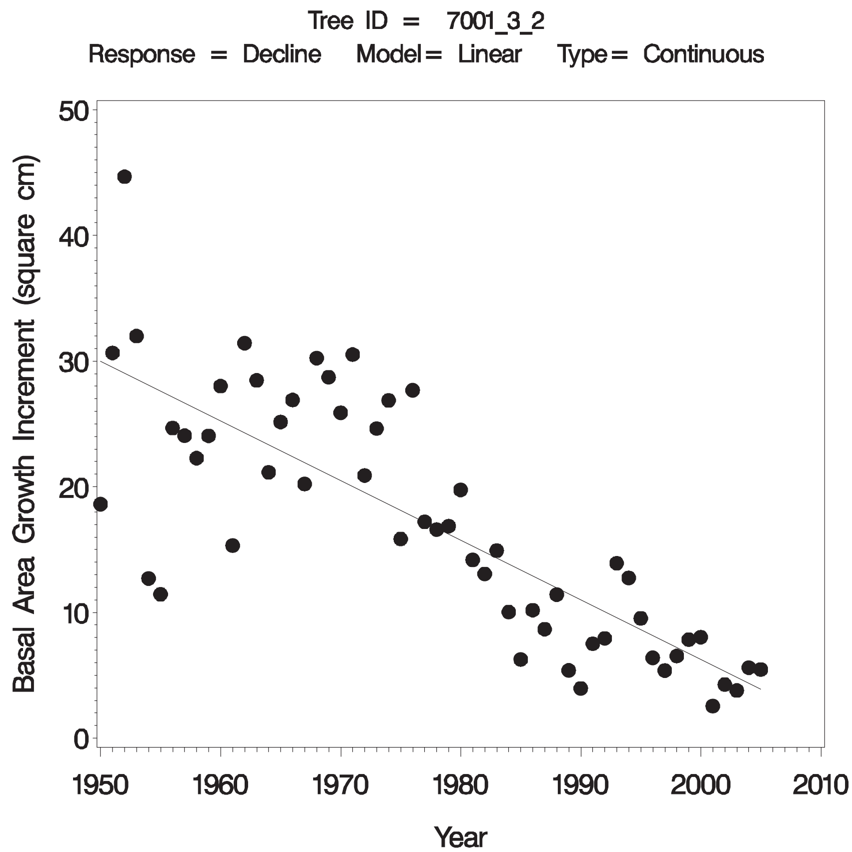


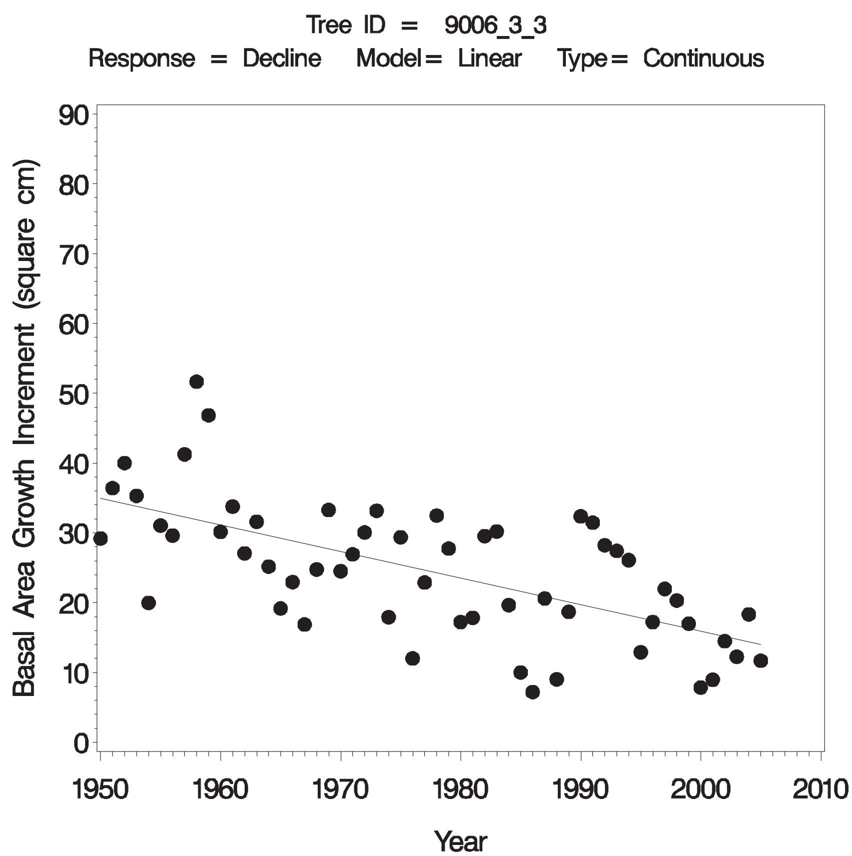
Tree ID = 7001_1_1
Response = Decline Model= Linear Type= Continuous

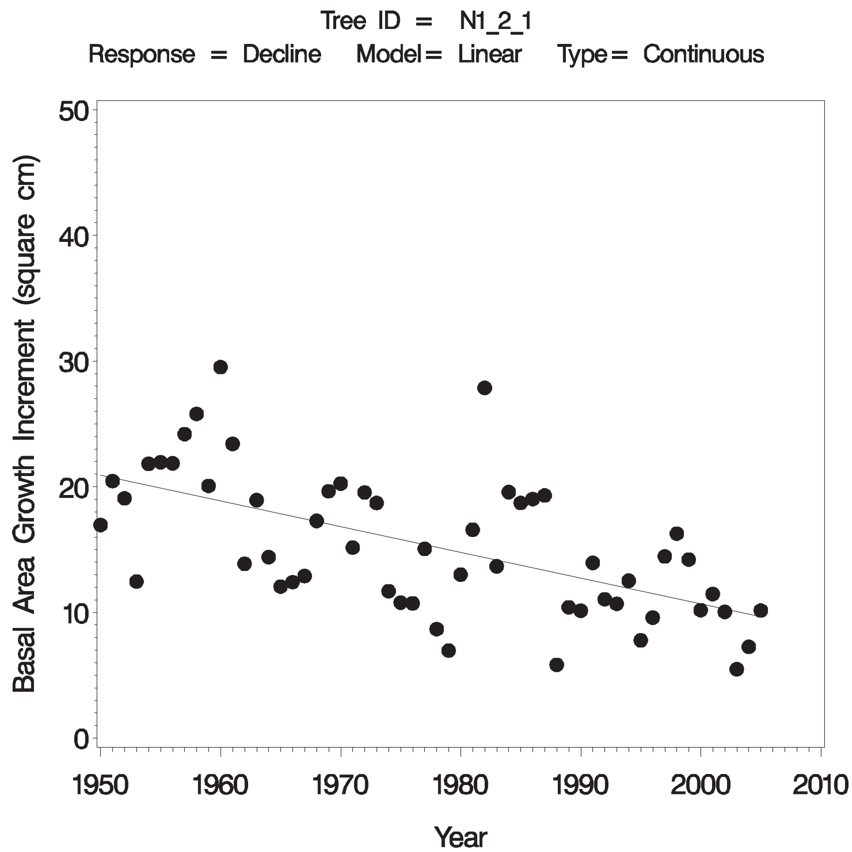


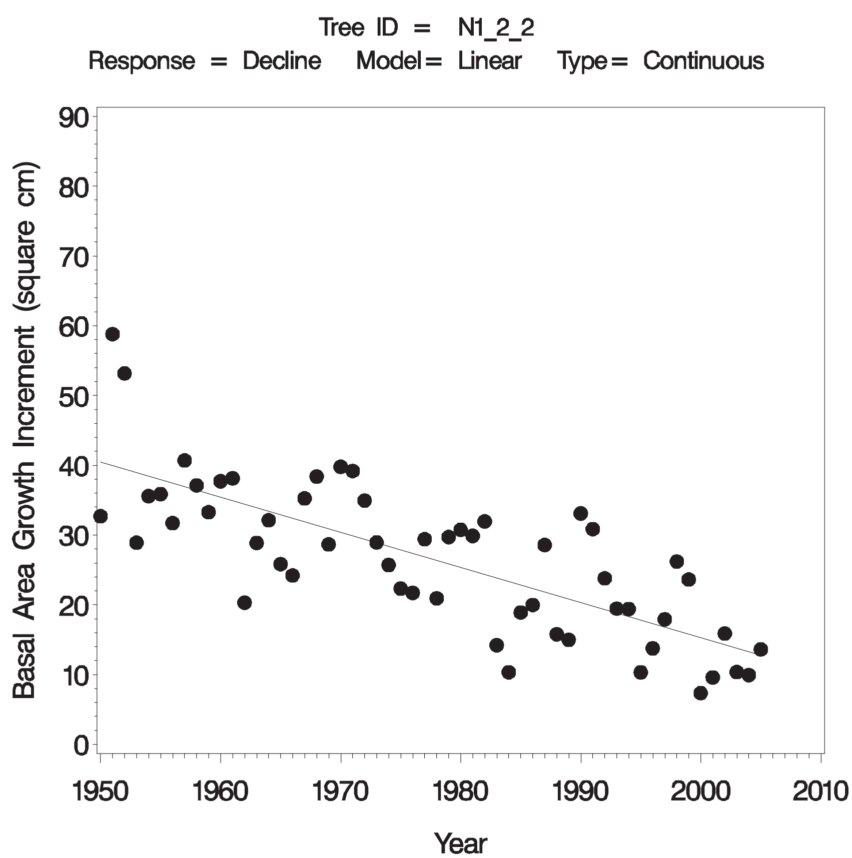
Tree ID = 7001_1_2
Response = Decline Model= Linear Type= Continuous

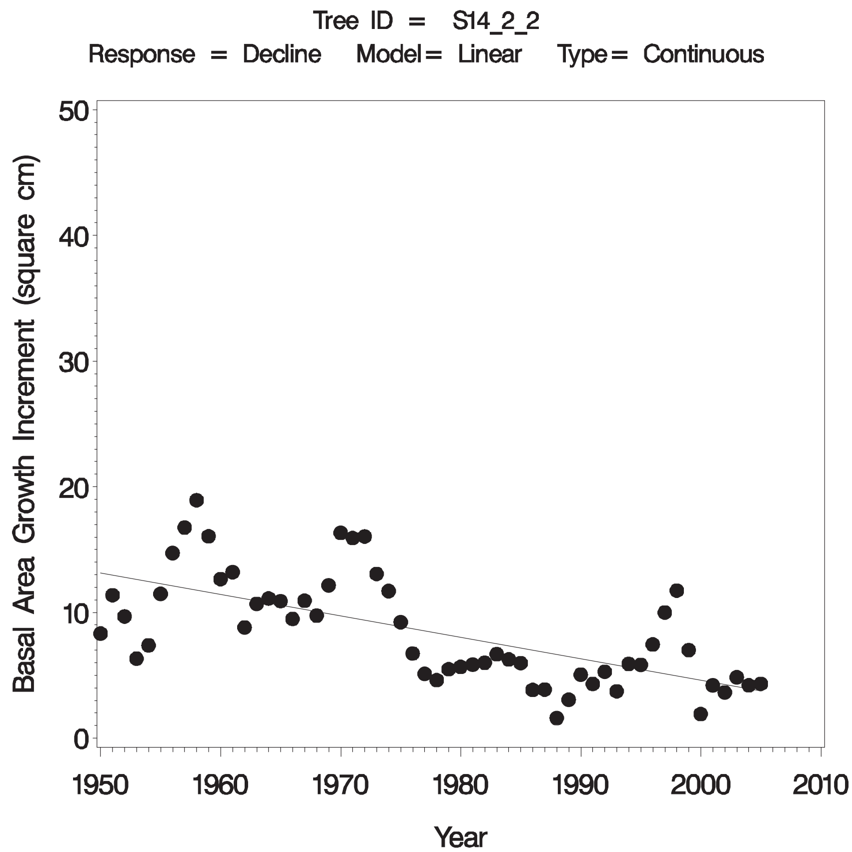


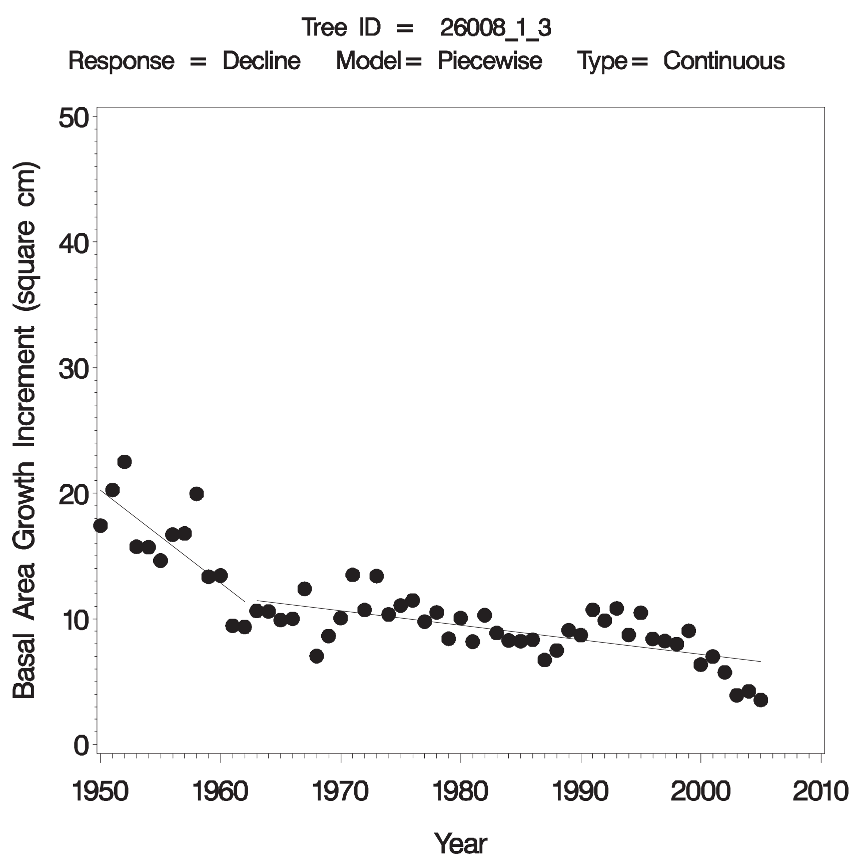

Tree ID = 7001_3_2
Response = Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

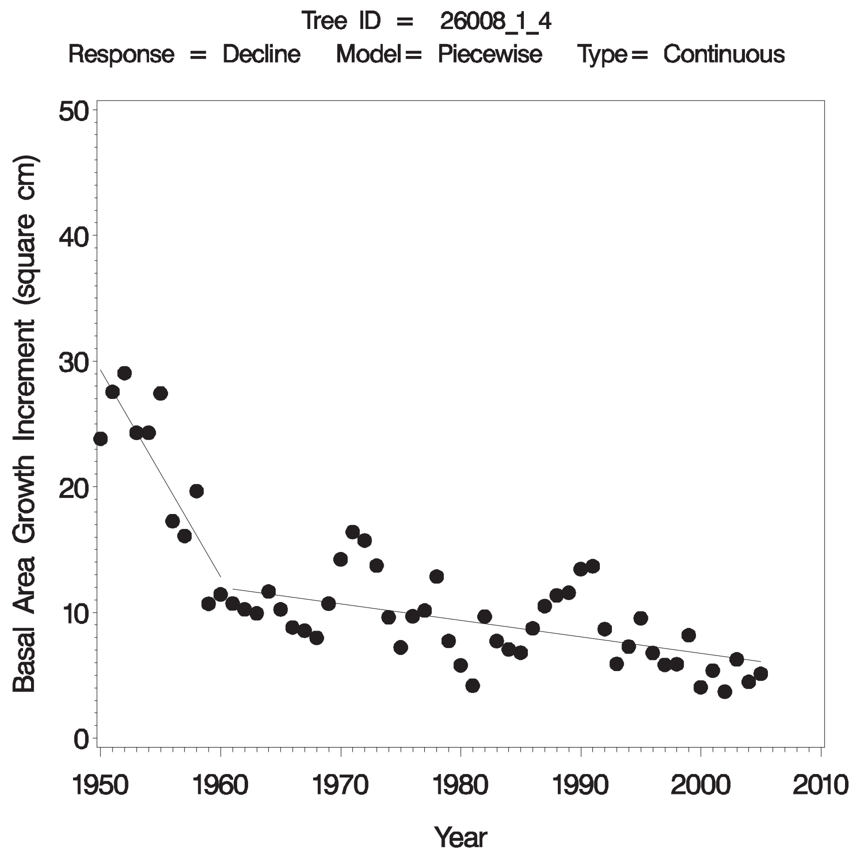

Tree ID = 9006_3_3
Response = Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010

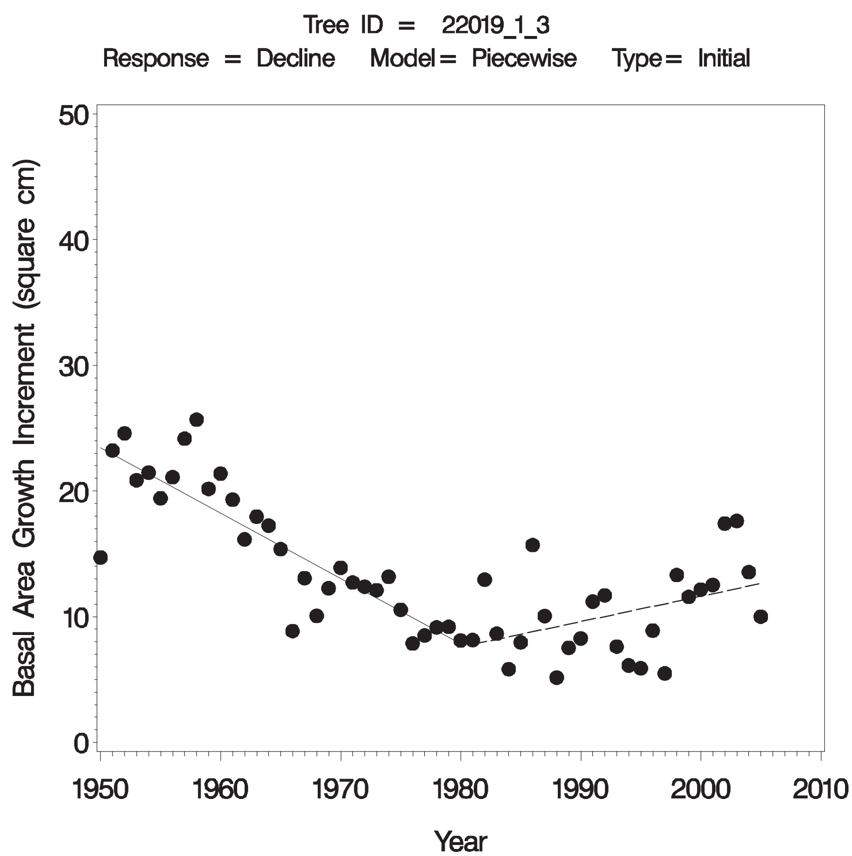

Tree ID = N1_2_1
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

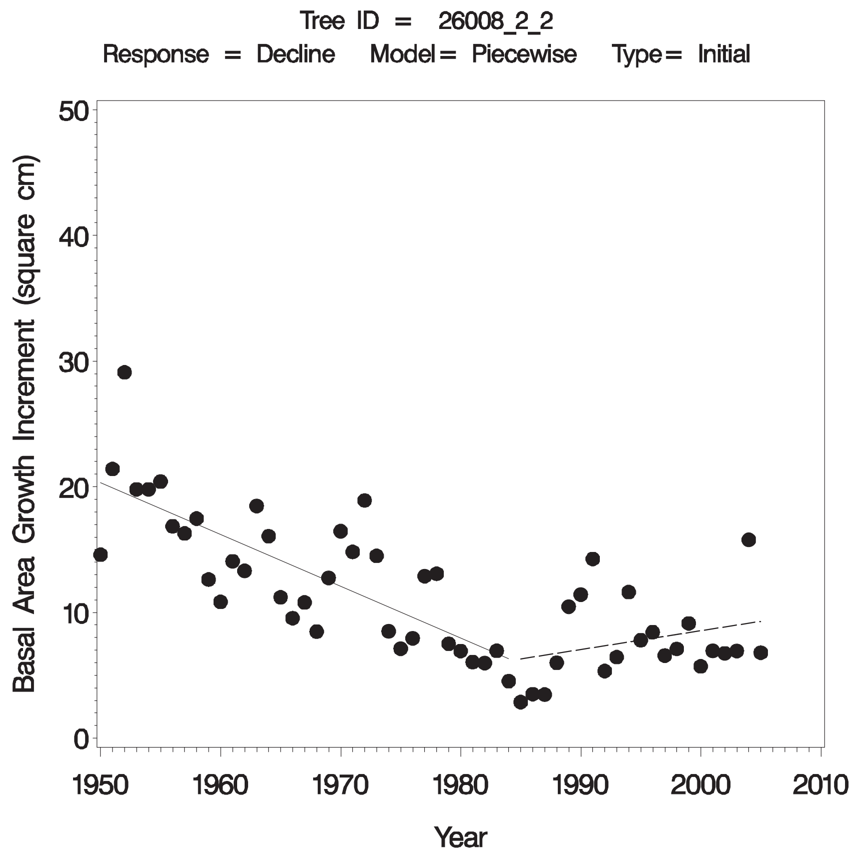

Tree ID = N1_2_2
Response = Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010
Year

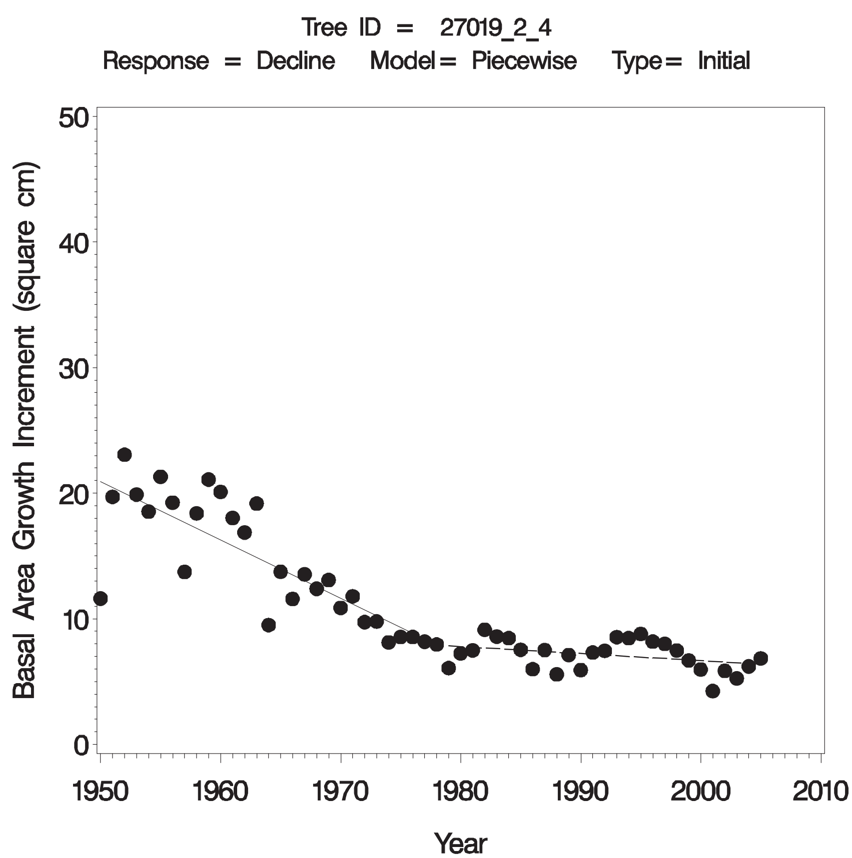

Tree ID = S14_2_2
Response = Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year

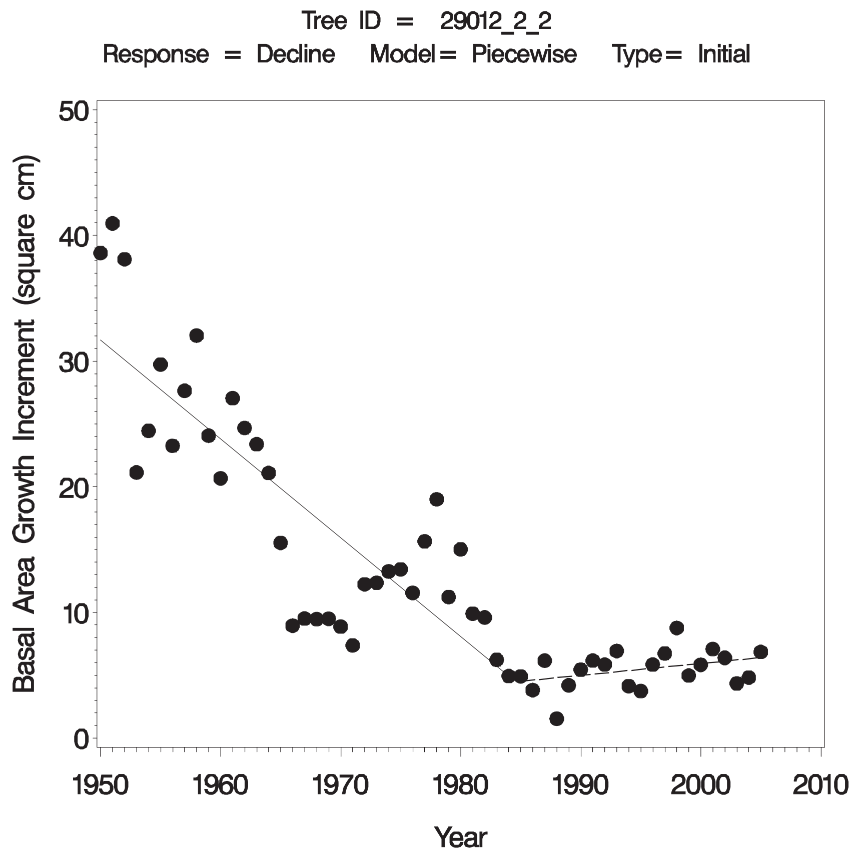

Tree ID = 26008_1_3
Response = Decline Model= Piecewise Type= Continuous
Basal Area Growth Increment (square cm)
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year

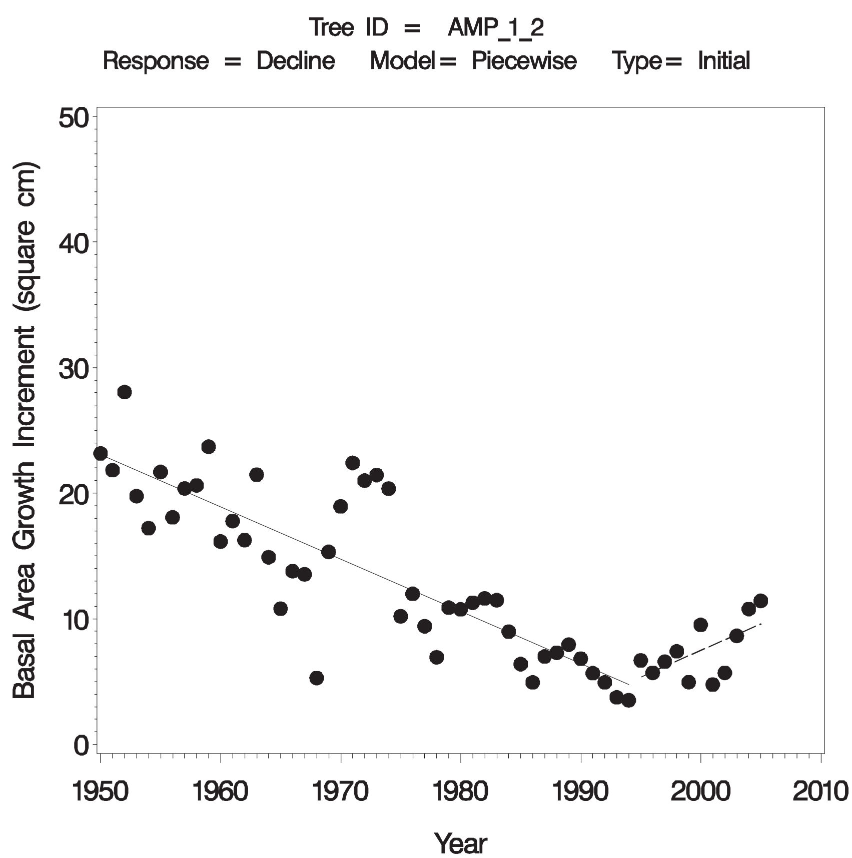

Tree ID = 26008_1_4
Response = Decline Model= Piecewise Type= Continuous
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

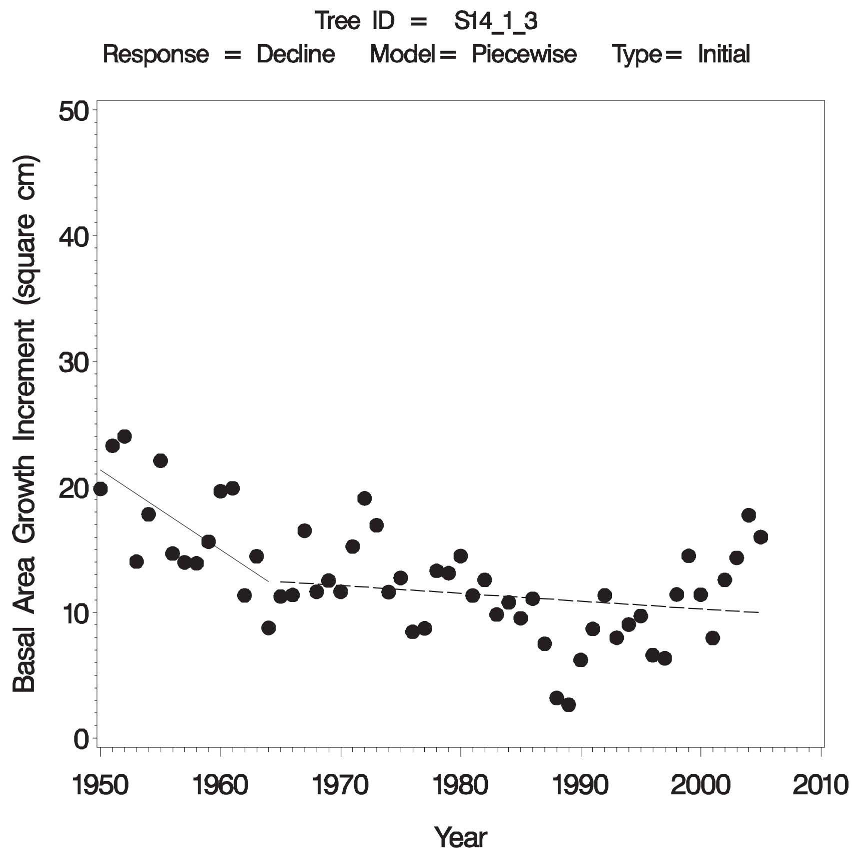

Tree ID = 22019_1_3
Response = Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010


Tree ID = 26008_2_2
Response = Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
Year

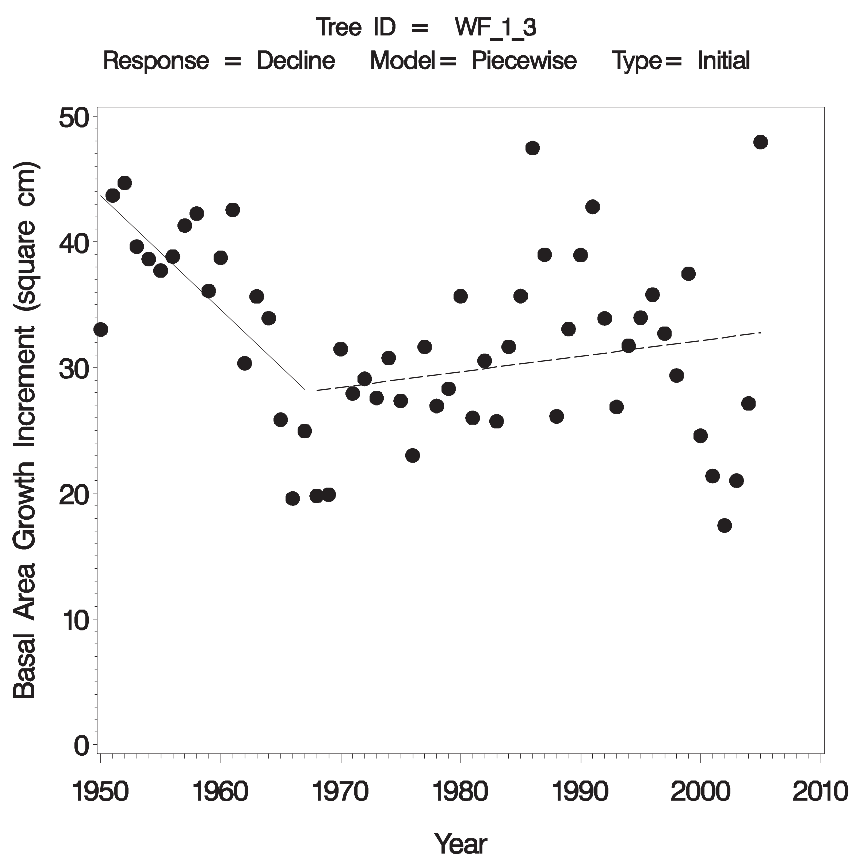

Tree ID = 27019_2_4
Response = Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
Year


Tree ID = 29012_2_2
Response = Decline Model = Piecewise Type = Initial
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

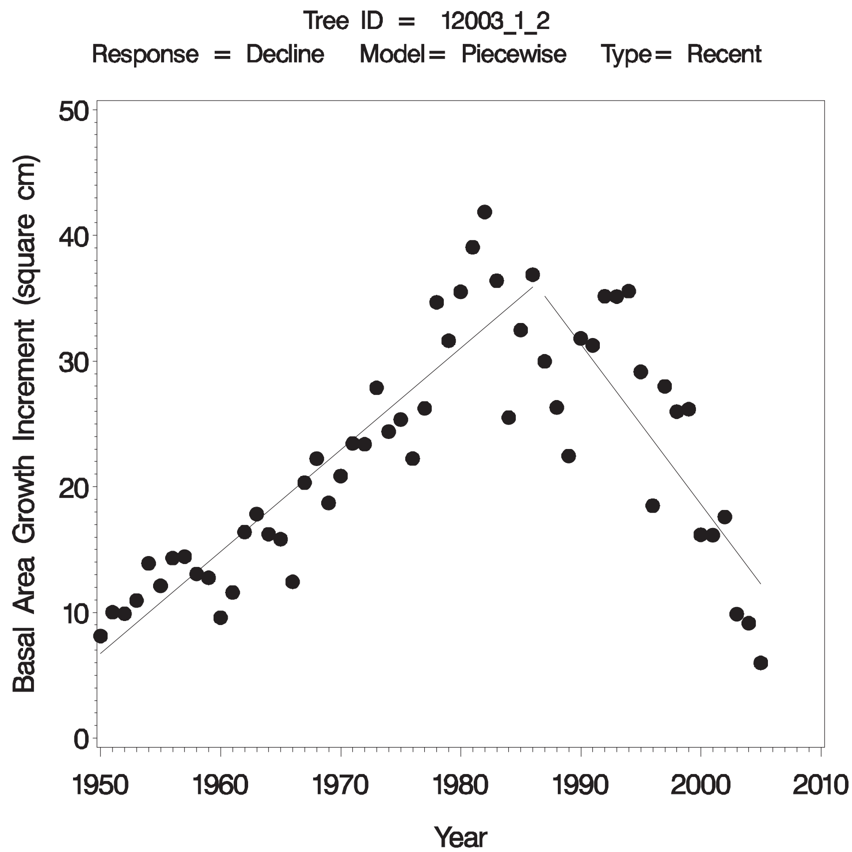

Tree ID = AMP_1_2
Response = Decline Model = Piecewise Type = Initial
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

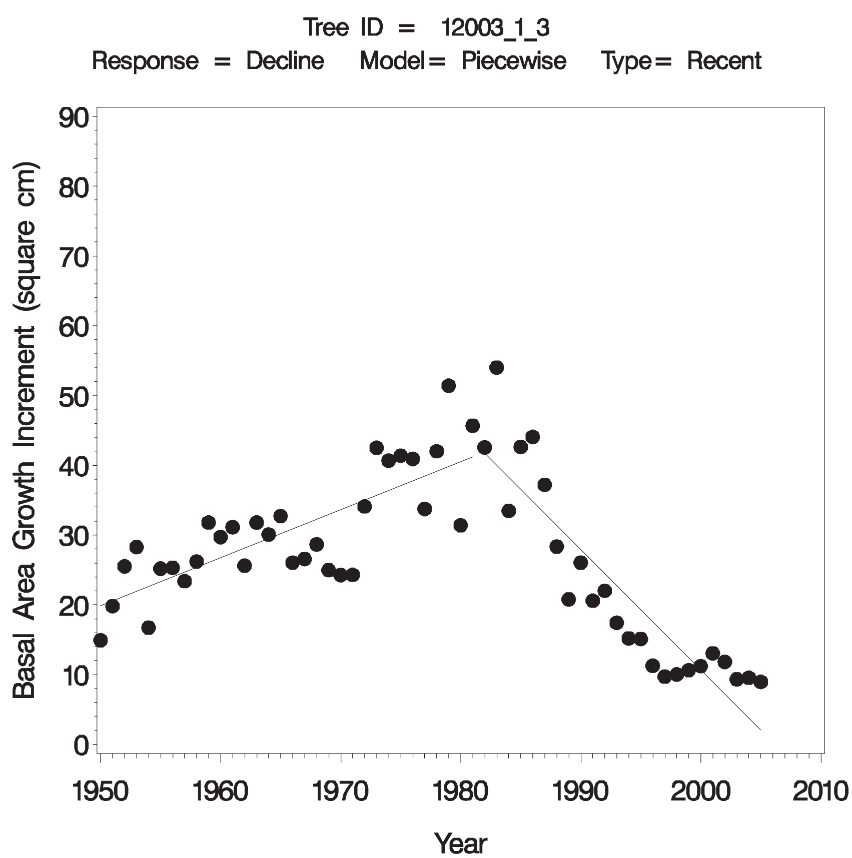


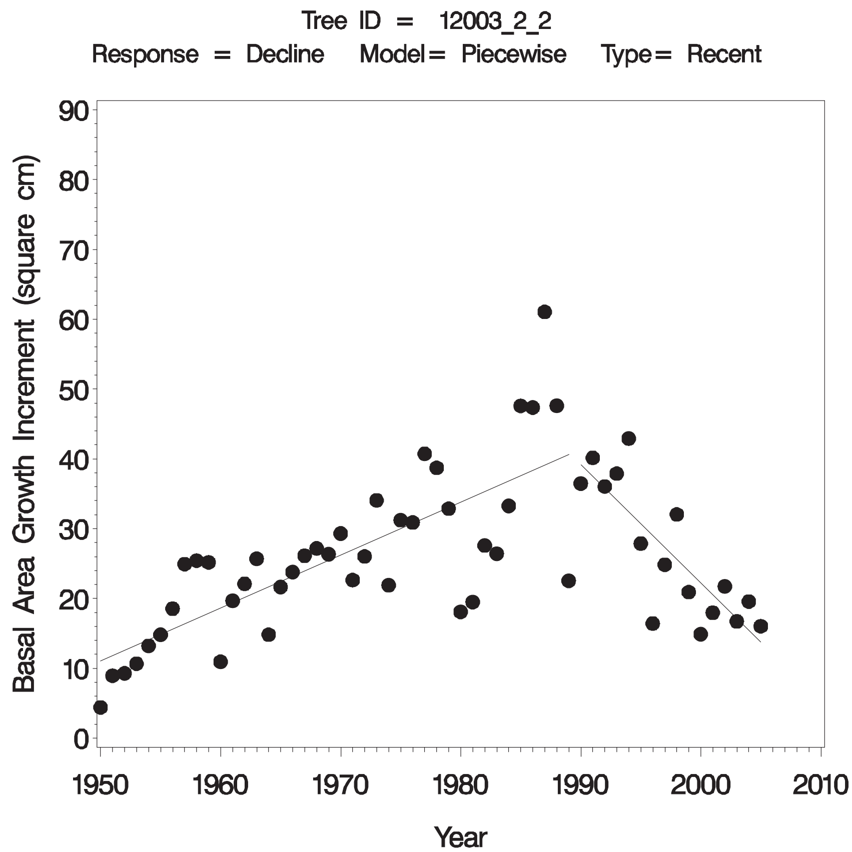
Tree ID = S14_1_3
Response = Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
Year

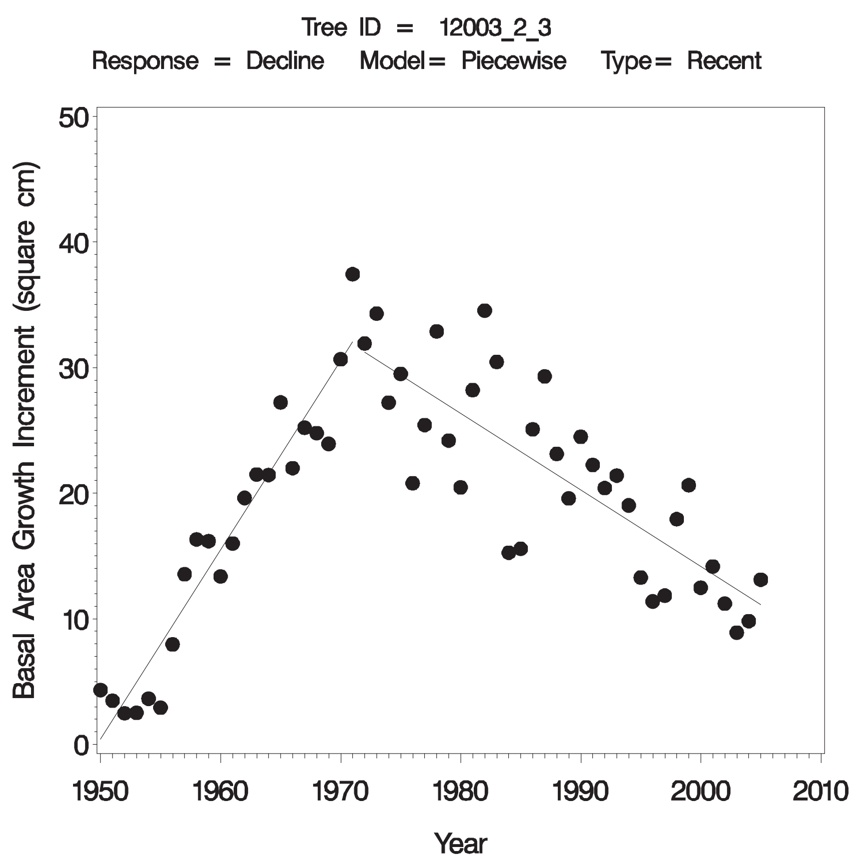


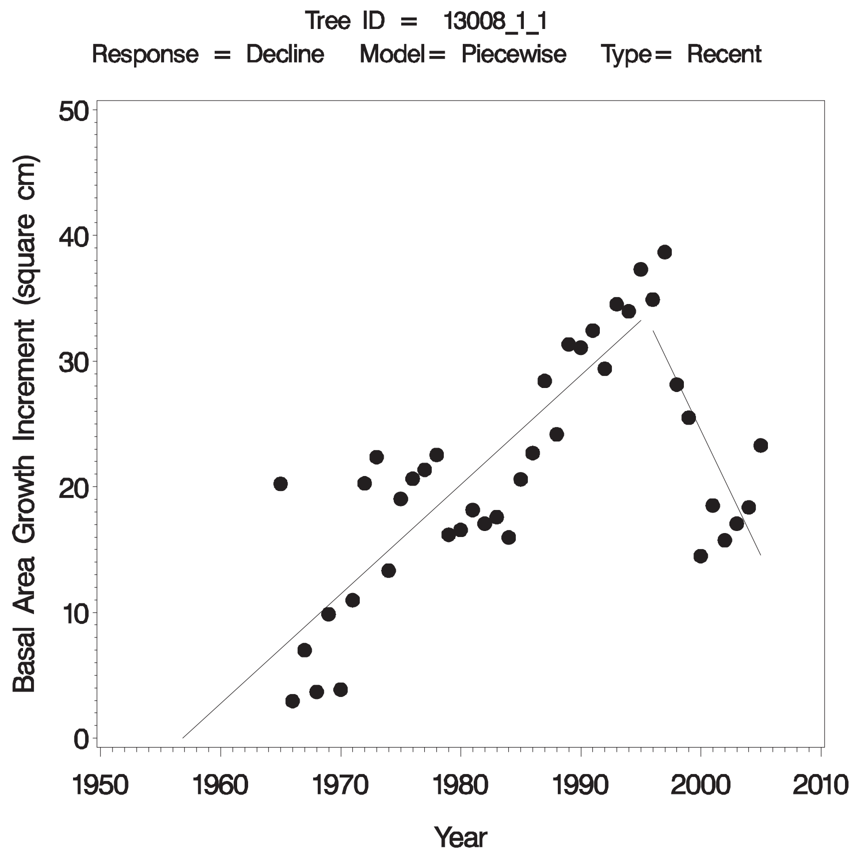
Tree ID = WF_1_3
Response = Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
Year

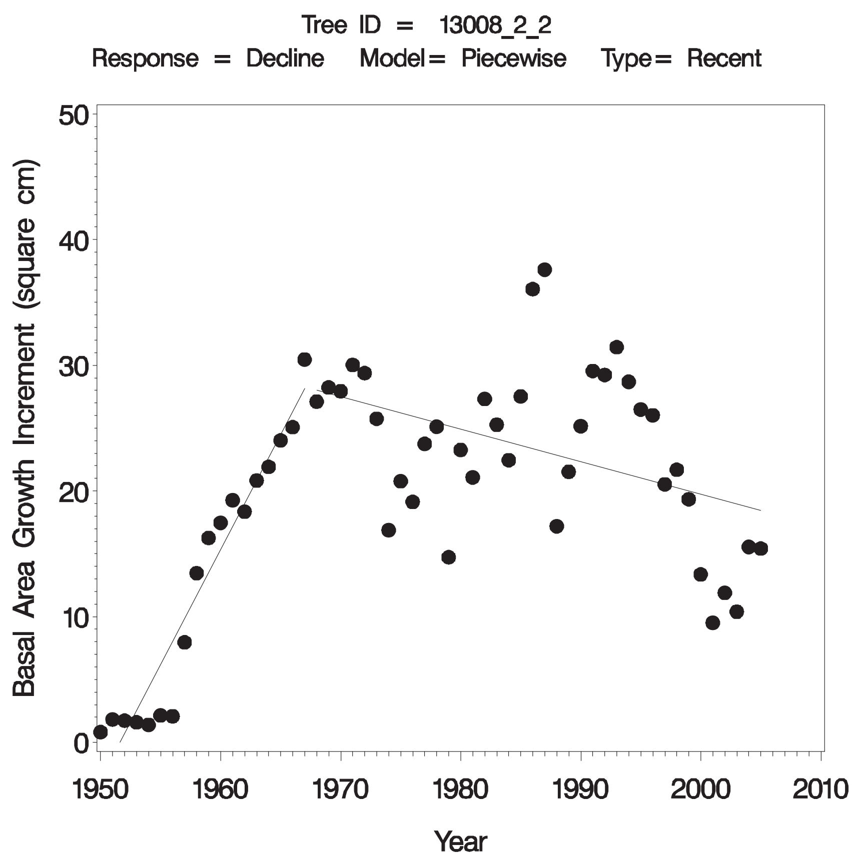

Tree ID = 12003_1_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

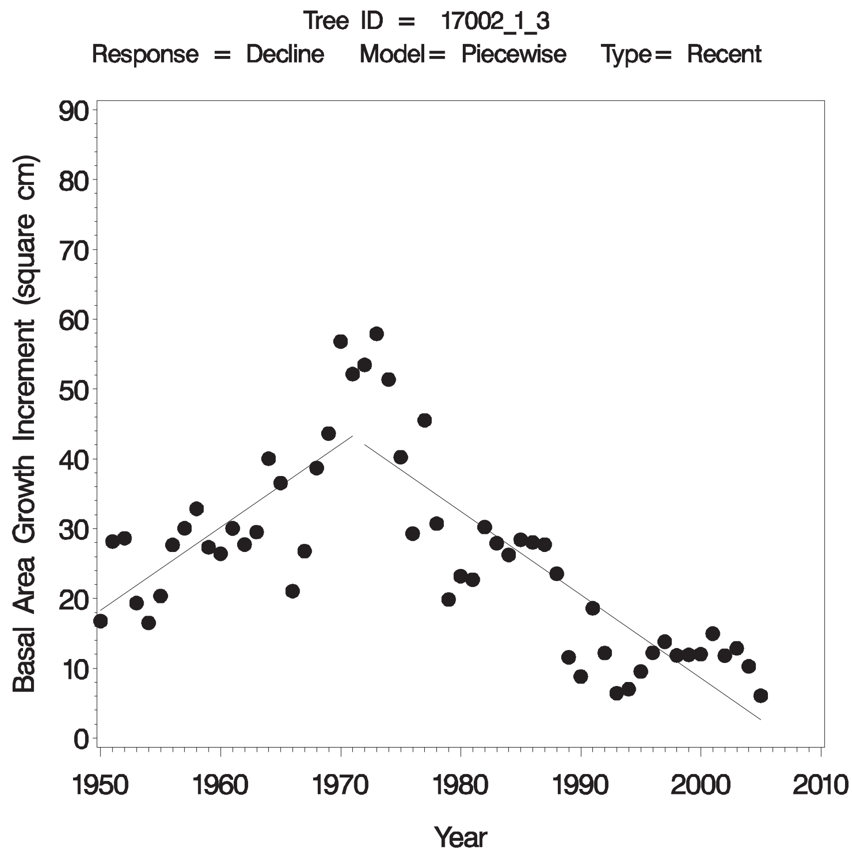

Tree ID = 12003_1_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010
Year

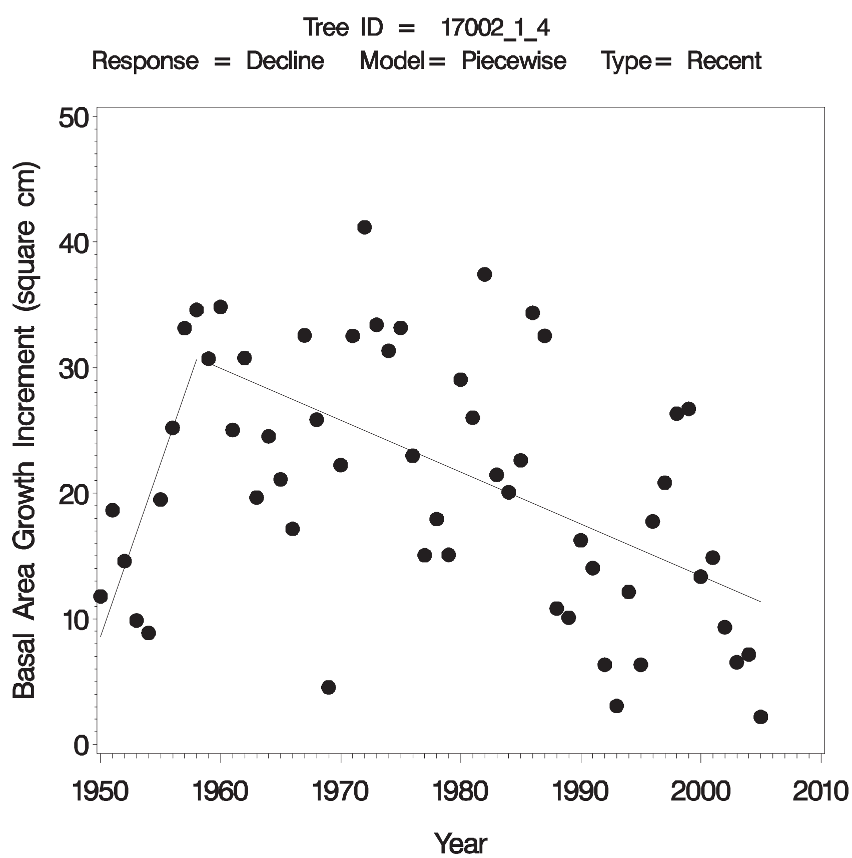

Tree ID = 12003_2_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010


Tree ID = 12003_2_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

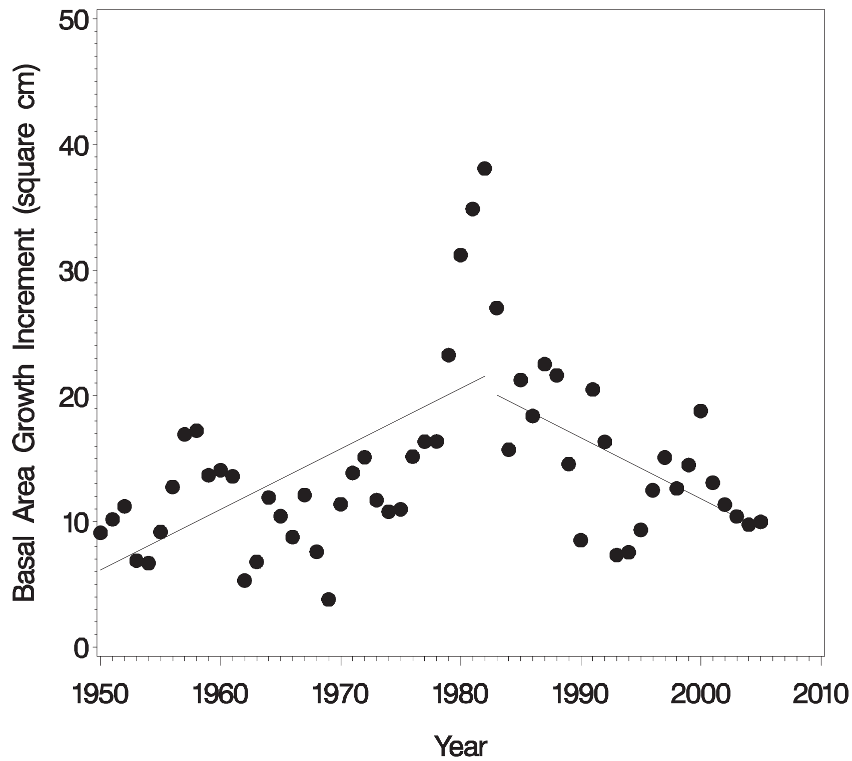

Tree ID = 13008_1_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010


Tree ID = 13008_2_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

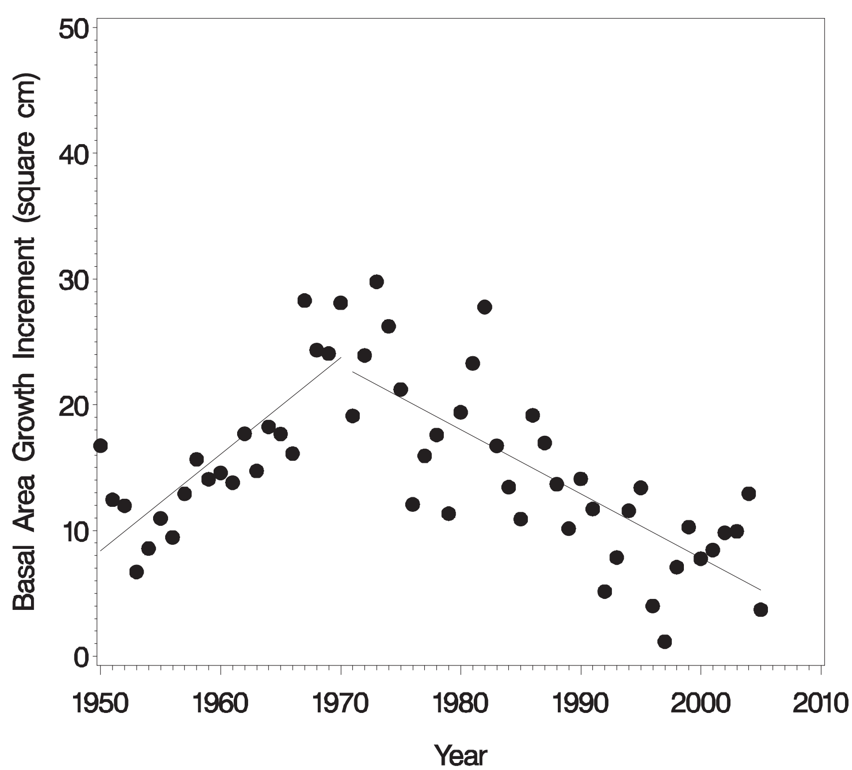

Tree ID = 17002_1_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010

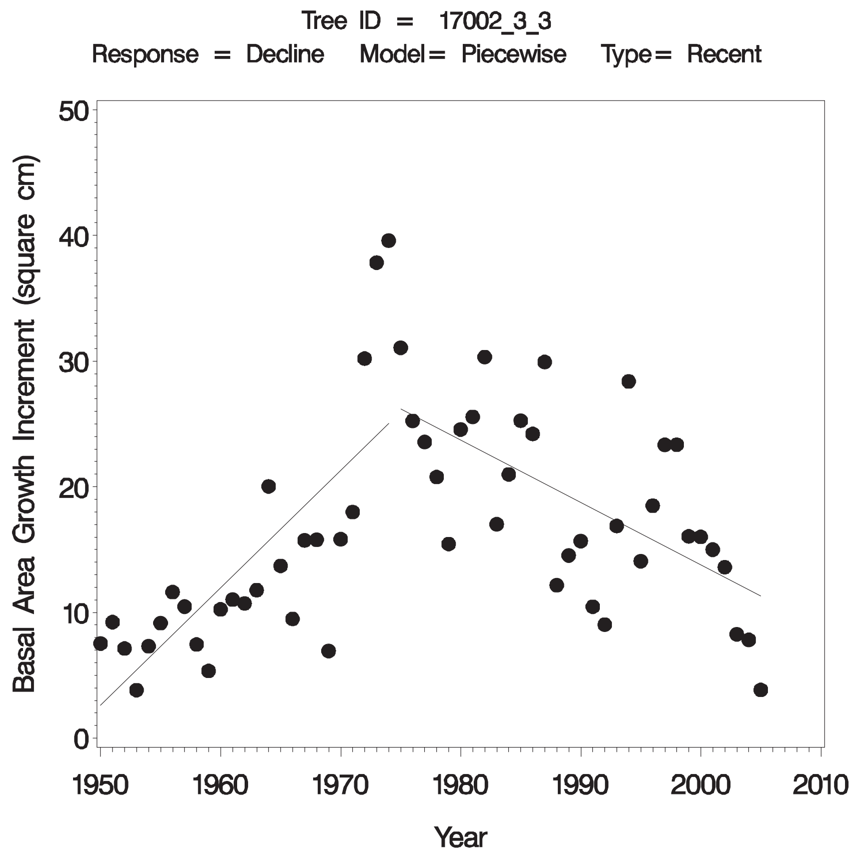

Tree ID = 17002_1_4
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

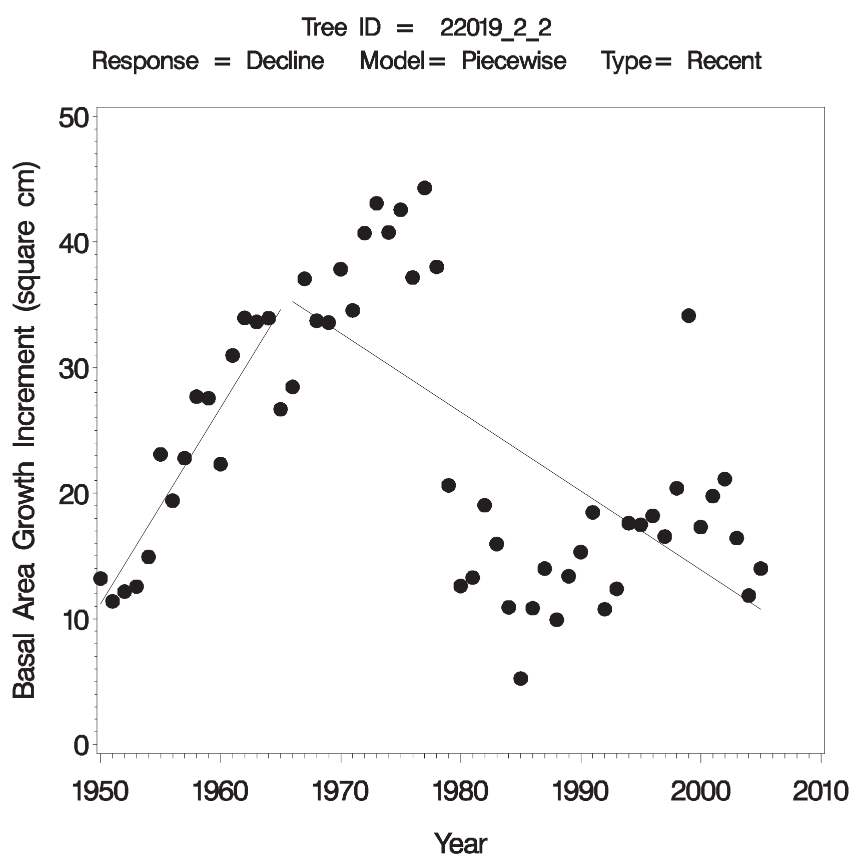
Tree ID = 17002_2_3
Response = Decline Model= Piecewise Type= Recent

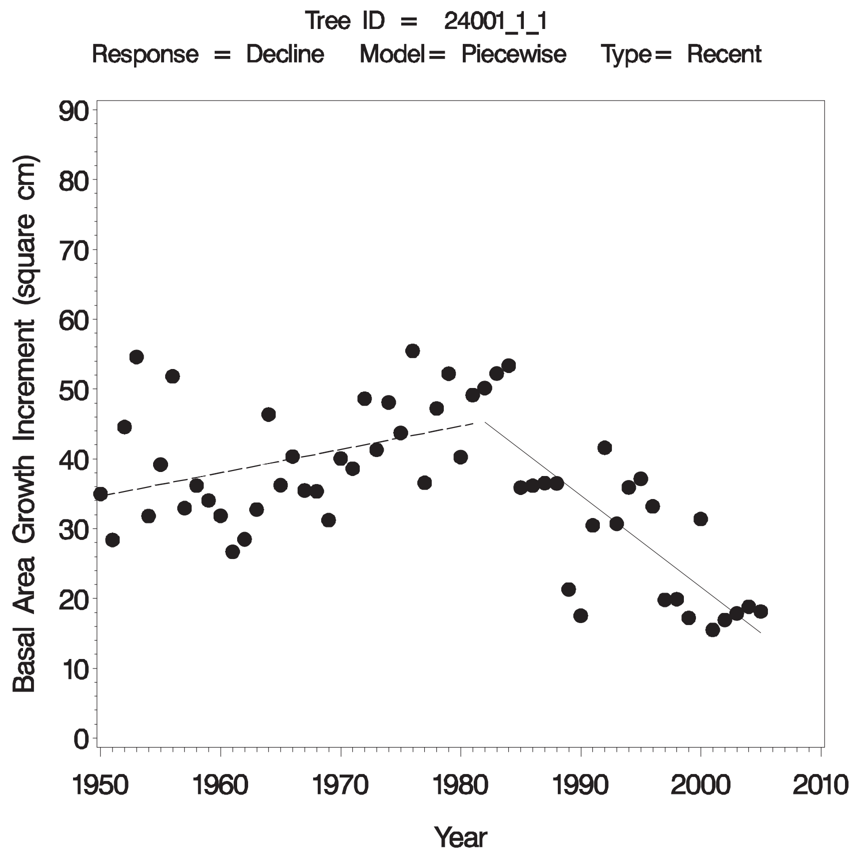


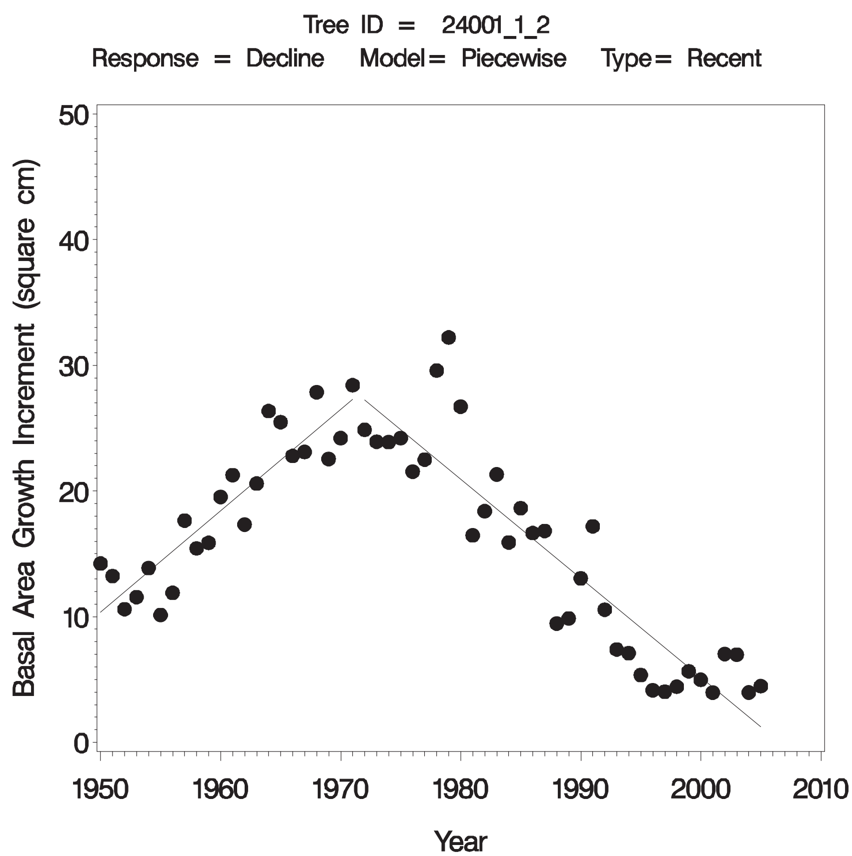
Tree ID = 17002_3_2
Response = Decline Model= Piecewise Type= Recent



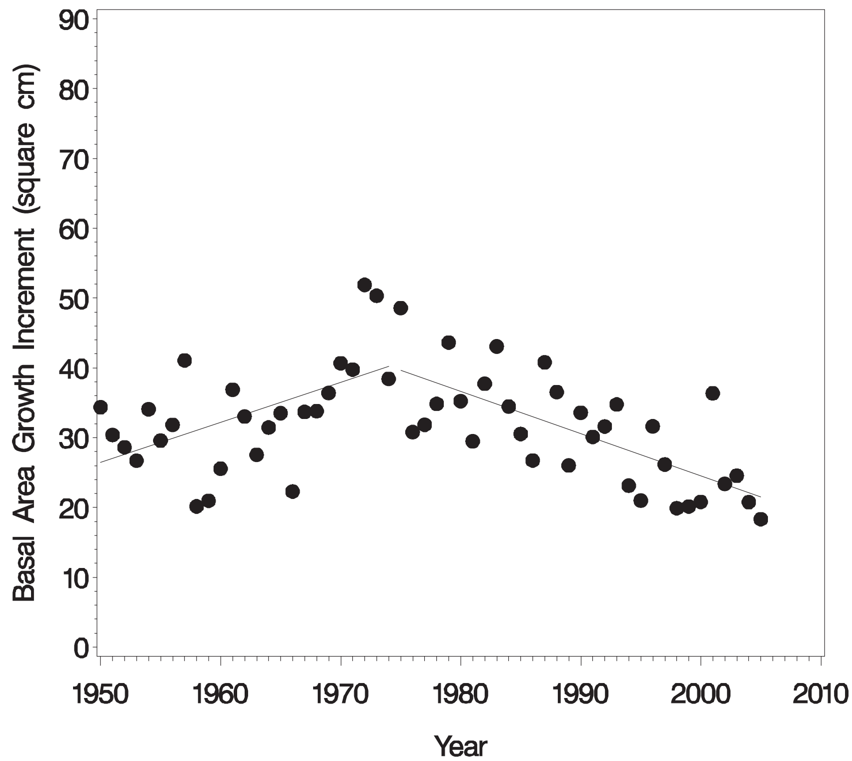

Tree ID = 17002_3_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 22019_2_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

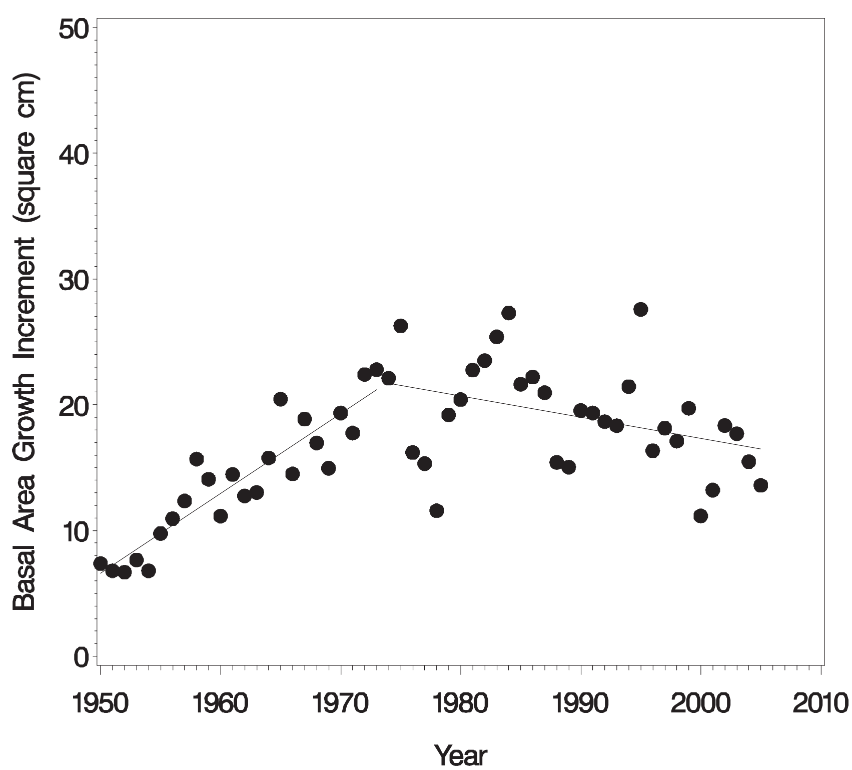

Tree ID = 24001_1_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010
Year

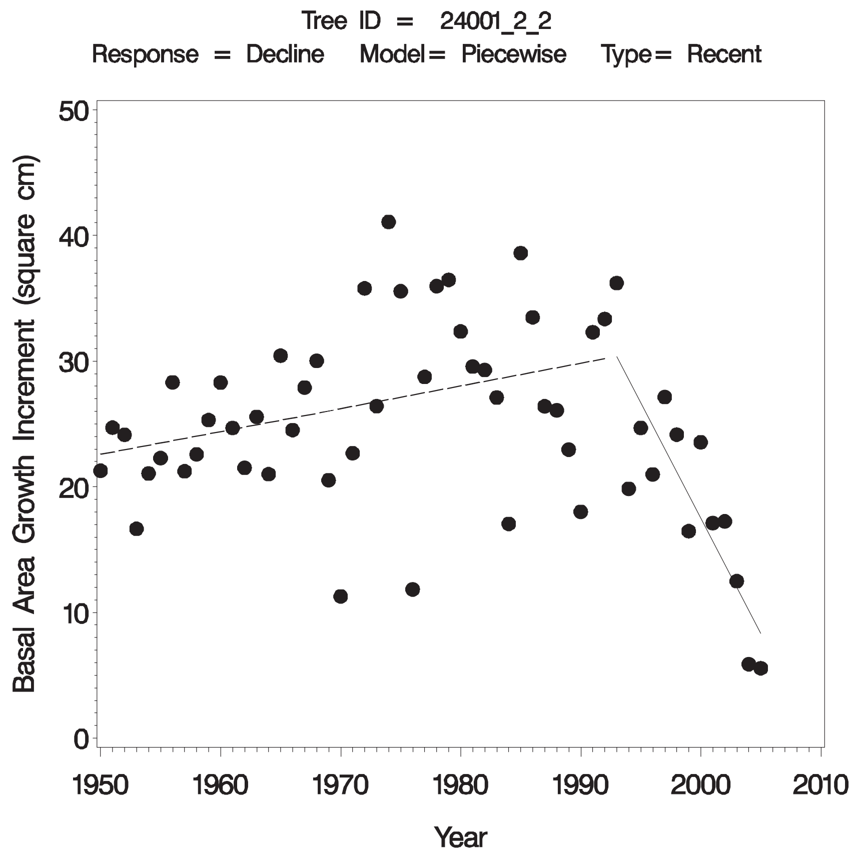

Tree ID = 24001_1_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

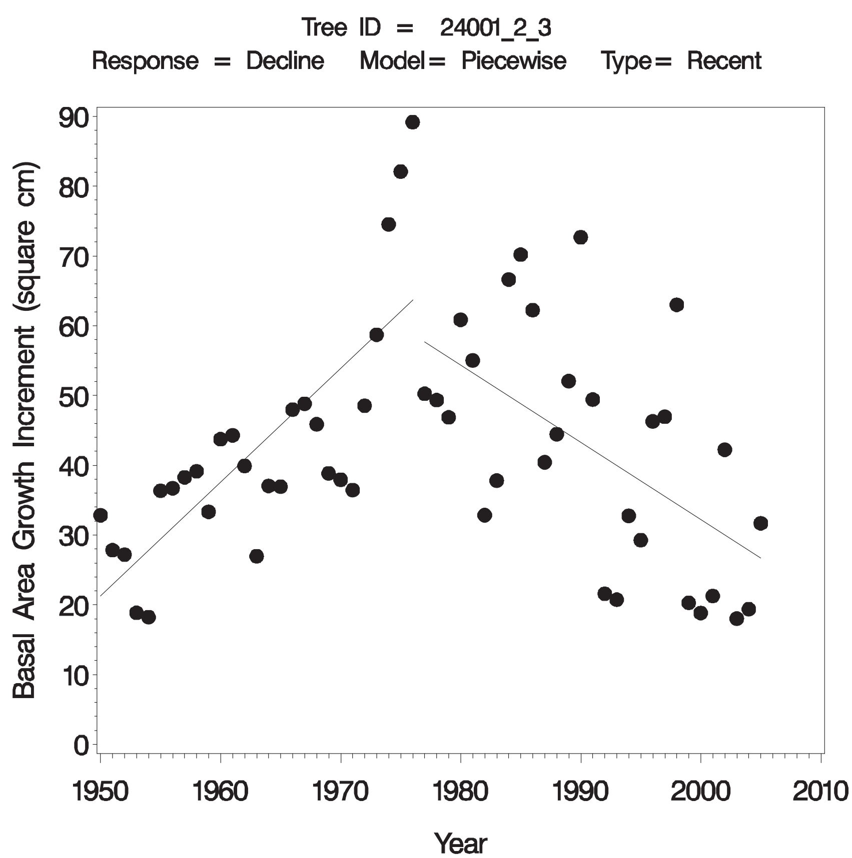
Tree ID = 24001_1_3
Response = Decline Model= Piecewise Type= Recent

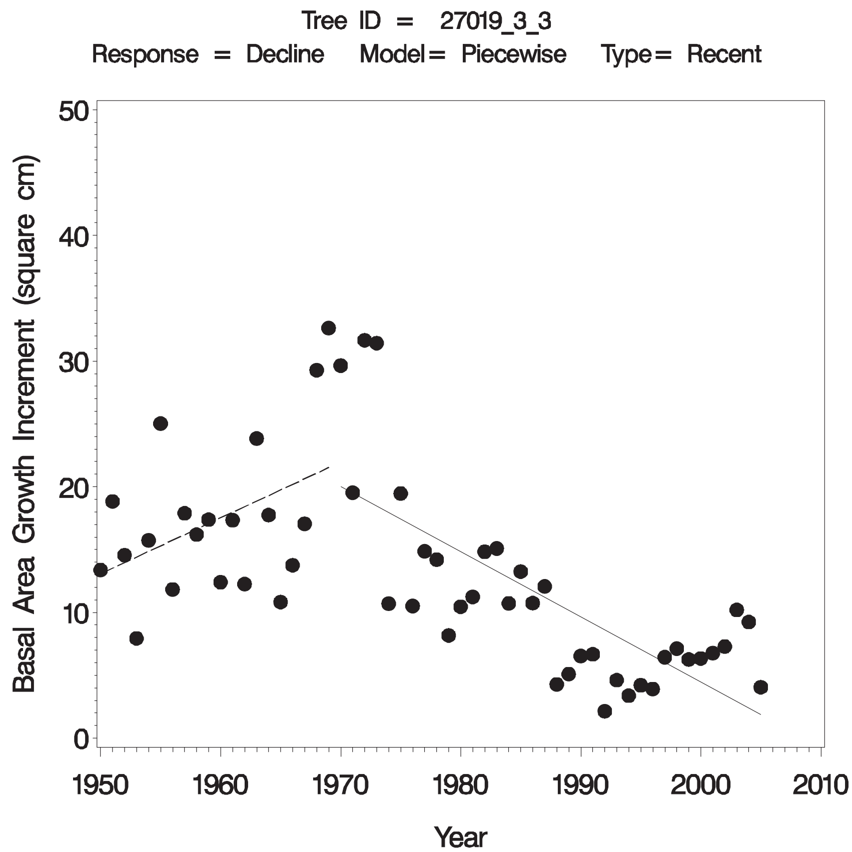


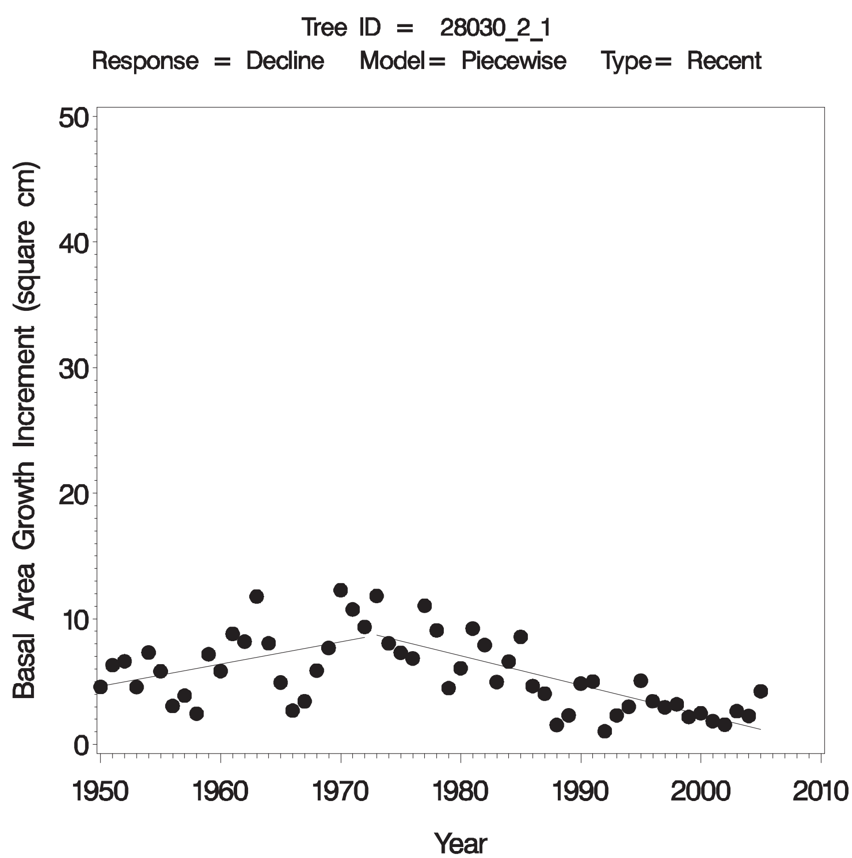
Tree ID = 24001_2_1
Response = Decline Model= Piecewise Type= Recent




Tree ID = 24001_2_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 24001_2_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 27019_3_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 28030_2_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
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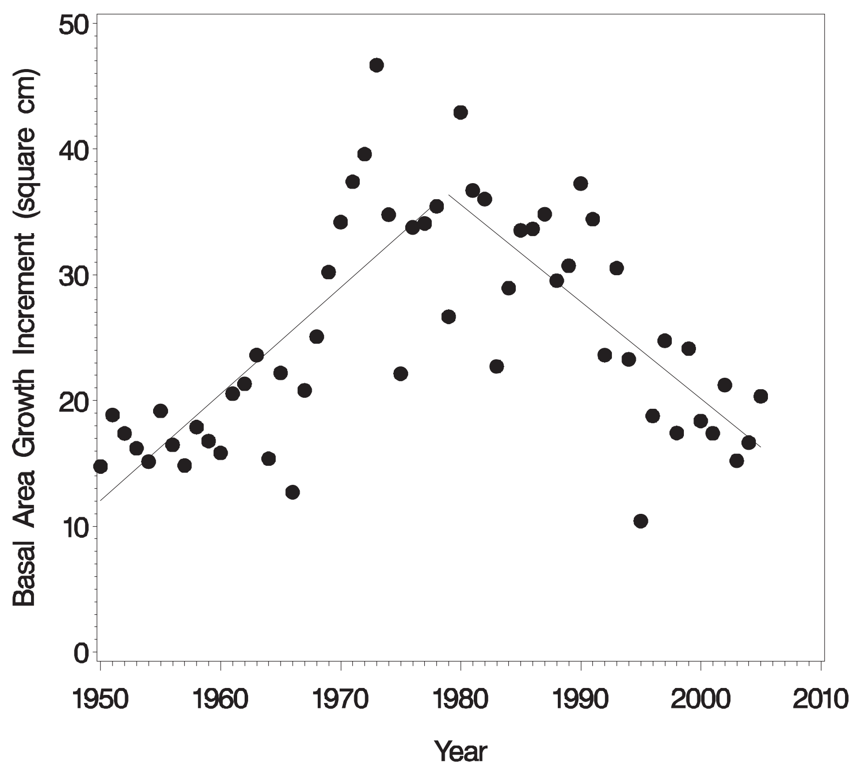
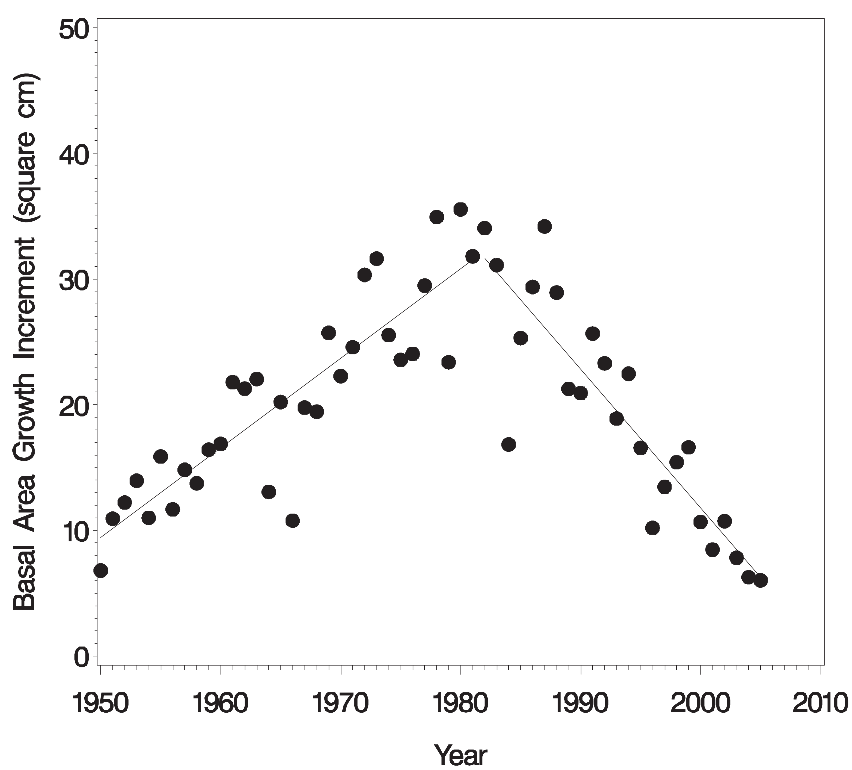
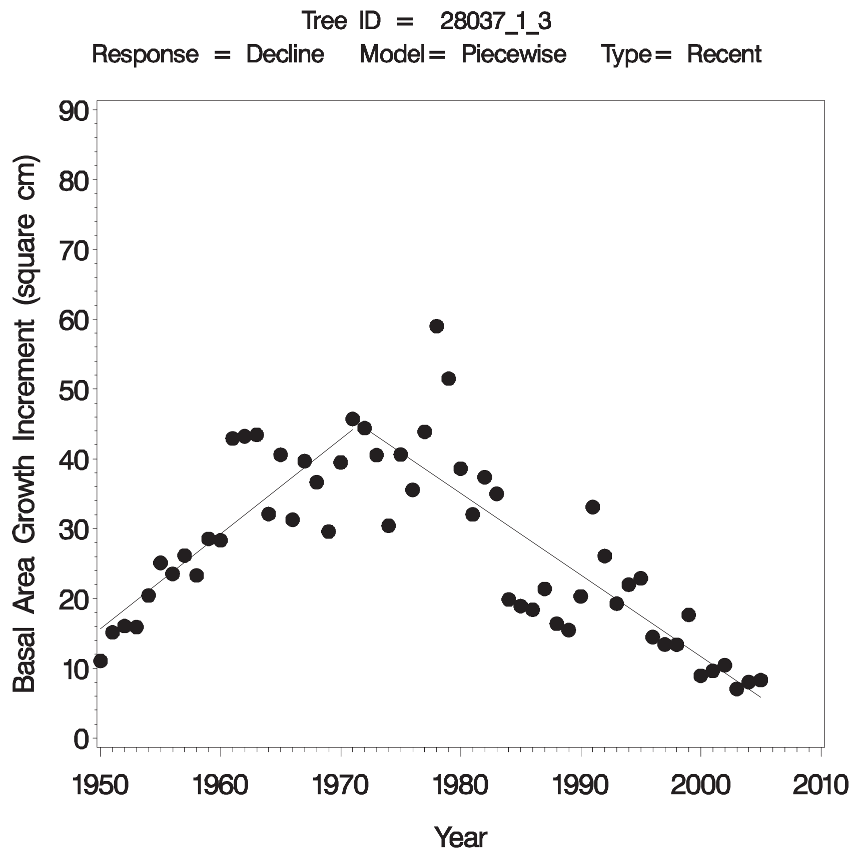
1950
1960
1970
1980
1990
2000
2010
Year

Tree ID = 28037_1_1
Response = Decline Model= Piecewise Type= Recent



Tree ID = 28037_1_2
Response = Decline Model= Piecewise Type= Recent




Tree ID = 28037_1_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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60
70
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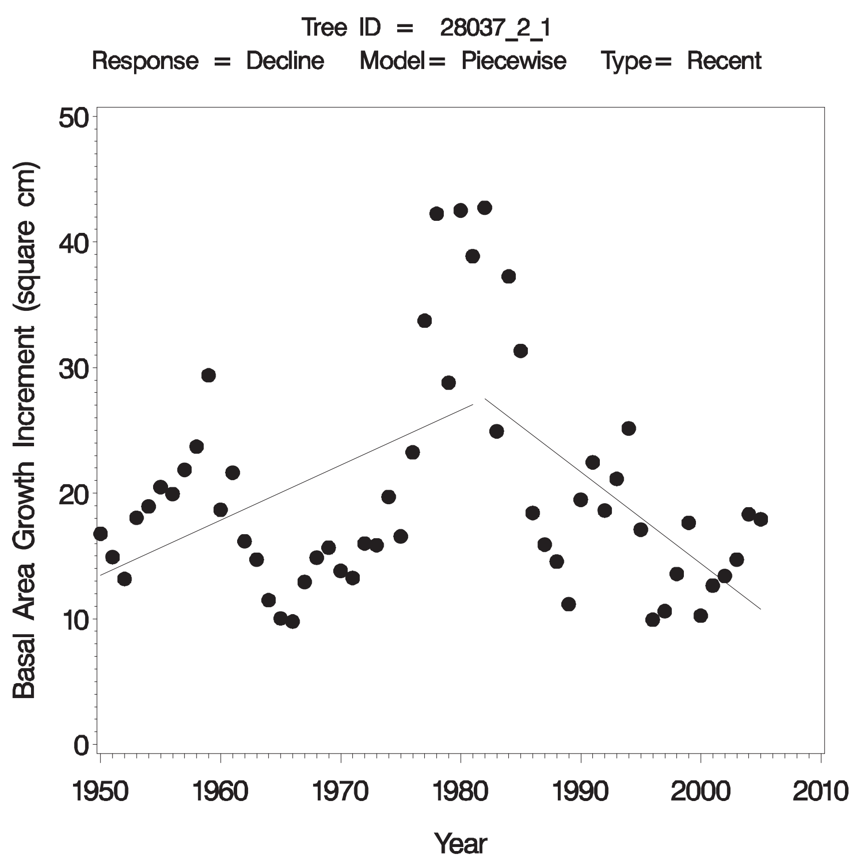
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 28037_2_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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1950
1960
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1990
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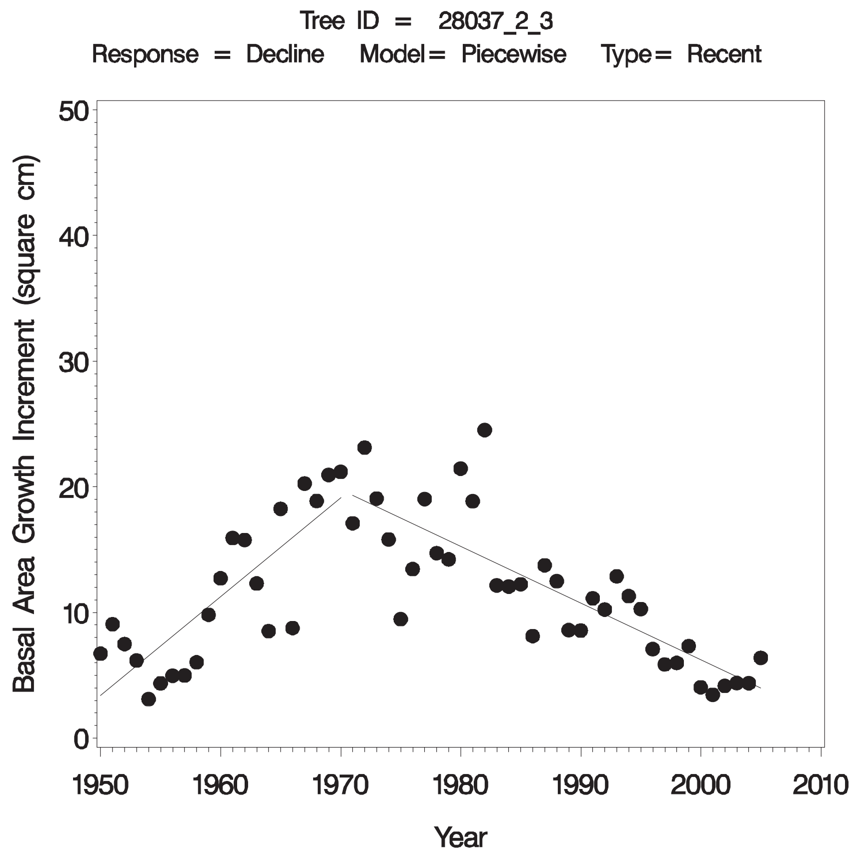
2010
Year


Tree ID = 28037_2_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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1950
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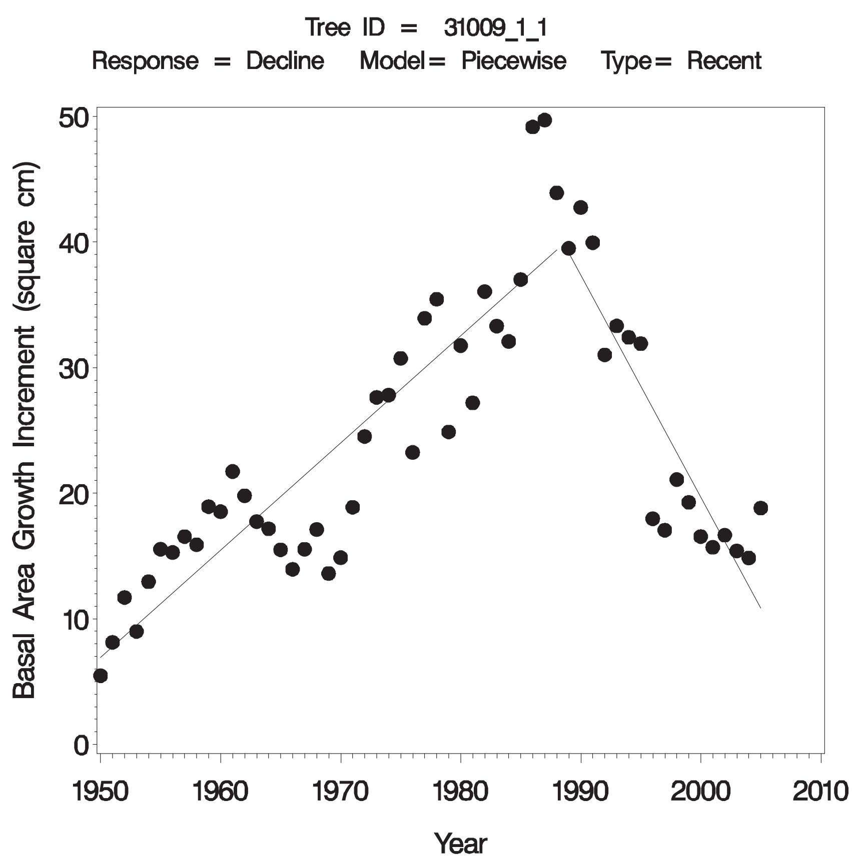
2010
Year


Tree ID = 31009_1_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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1950
1960
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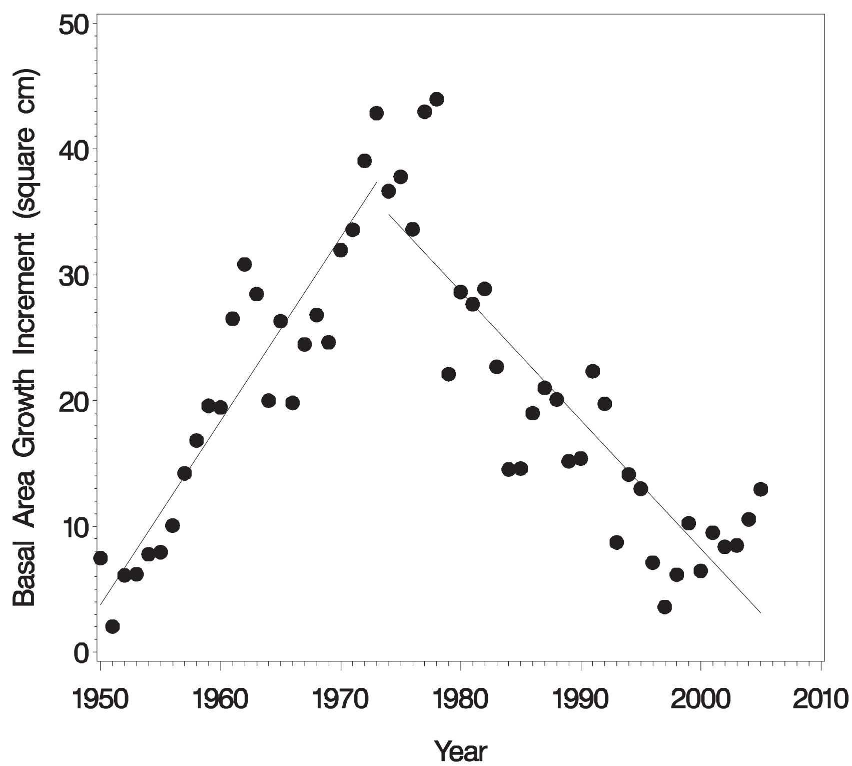
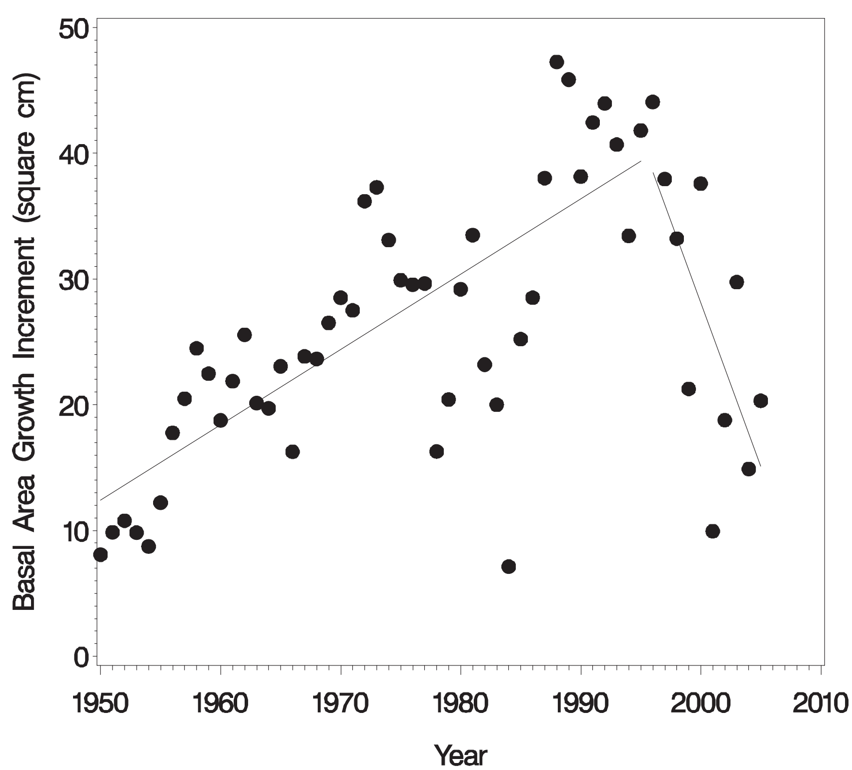
1990
2000
2010
Year

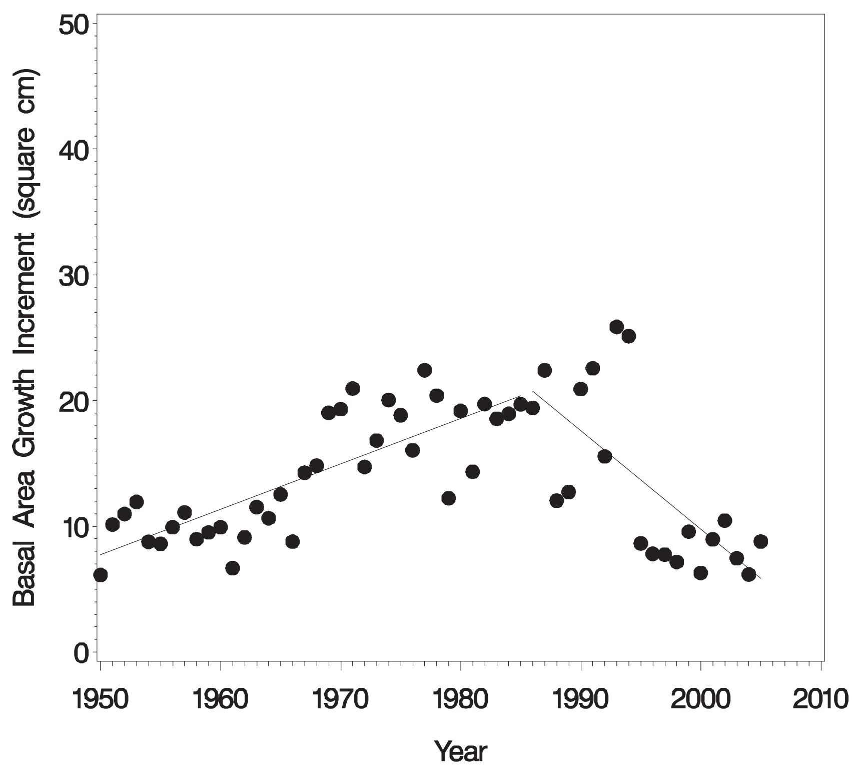
Tree ID = 31009_2_1
Response = Decline Model= Piecewise Type= Recent



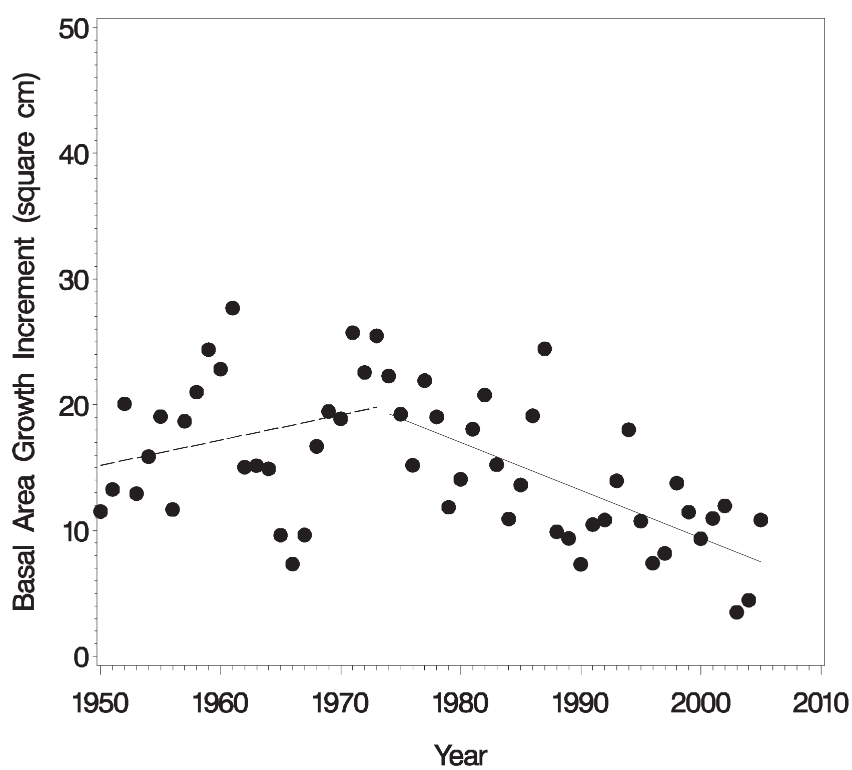
Tree ID = 31009_2_2
Response = Decline Model= Piecewise Type= Recent

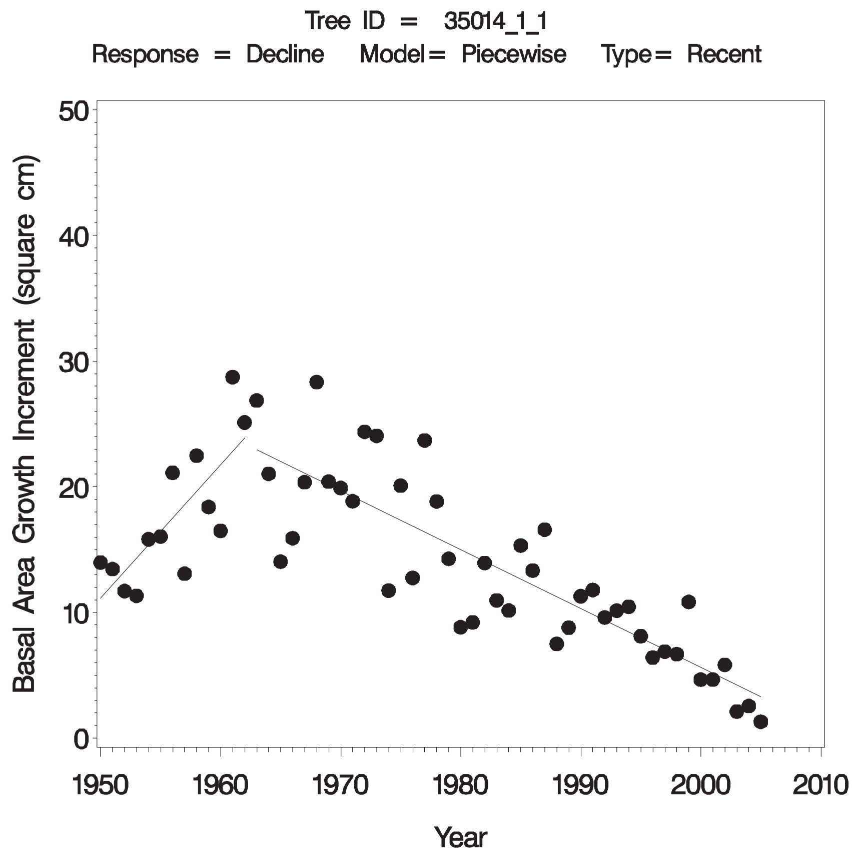


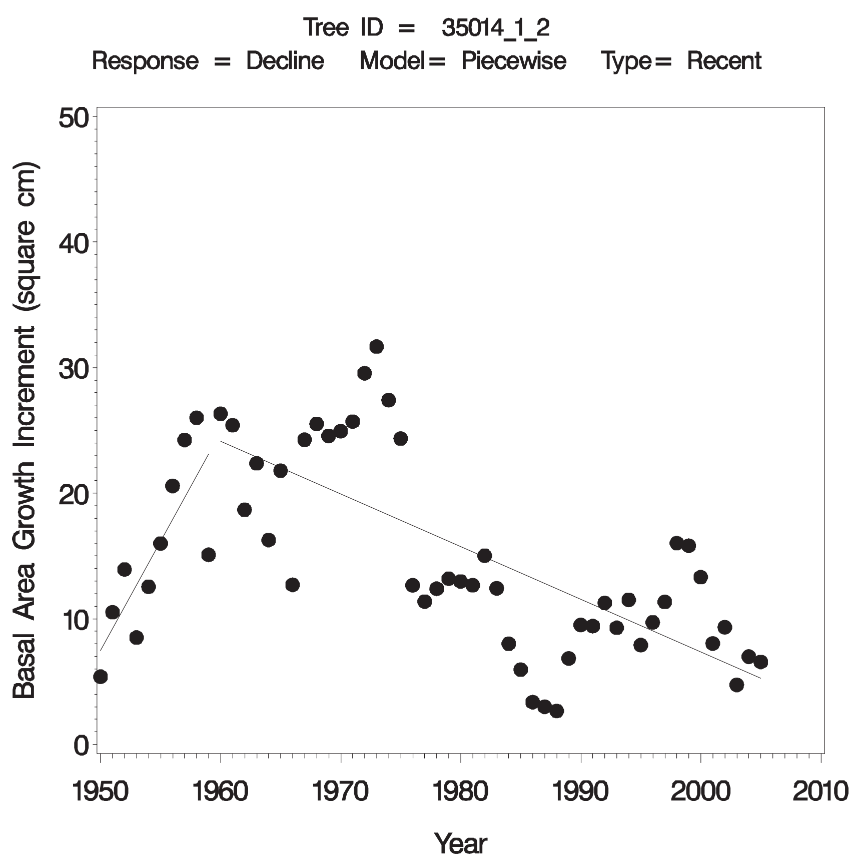
Tree ID = 31009_3_1
Response = Decline Model= Piecewise Type= Recent

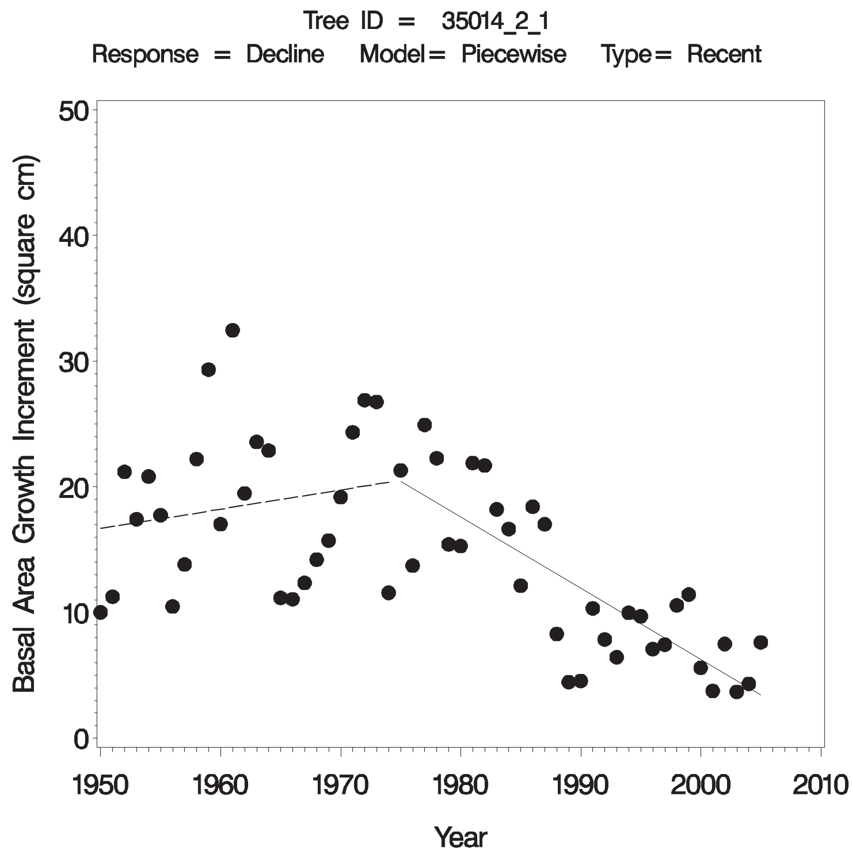


Tree ID = 31009_3_3
Response = Decline Model= Piecewise Type= Recent




Tree ID = 35014_1_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year


Tree ID = 35014_1_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year


Tree ID = 35014_2_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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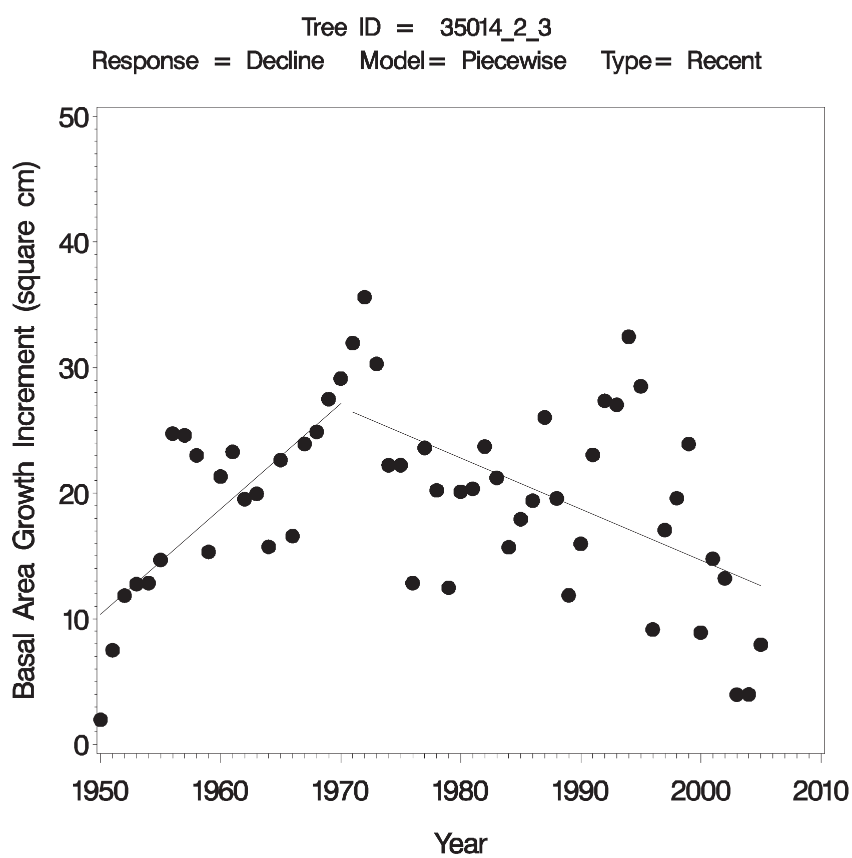
1960
1970
1980
1990
2000
2010
Year


Tree ID = 35014_2_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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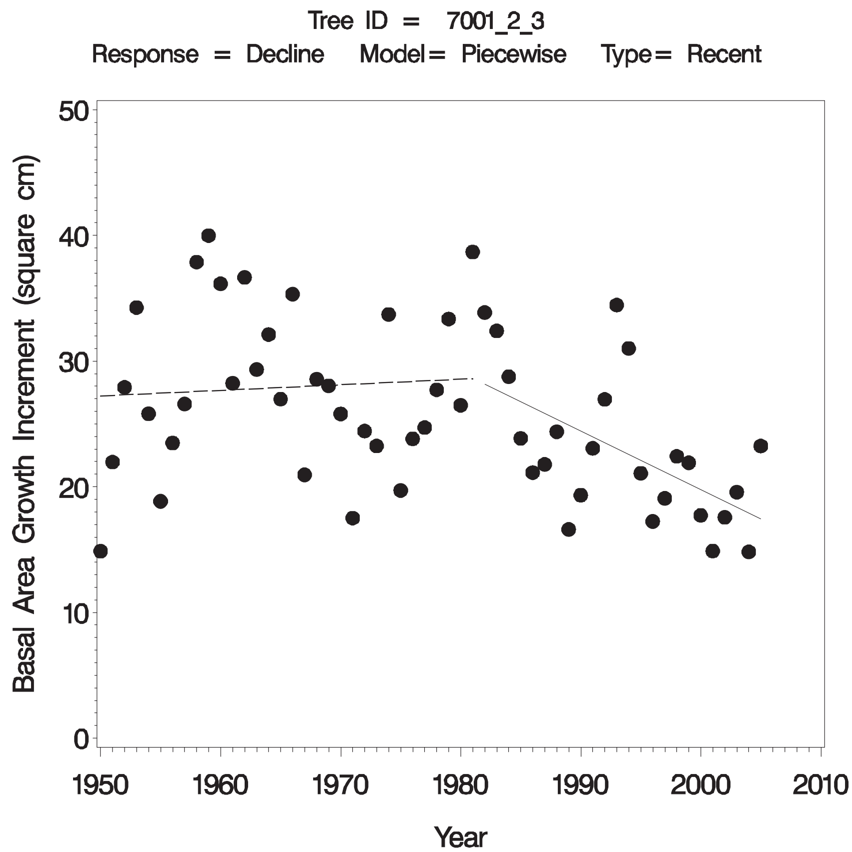
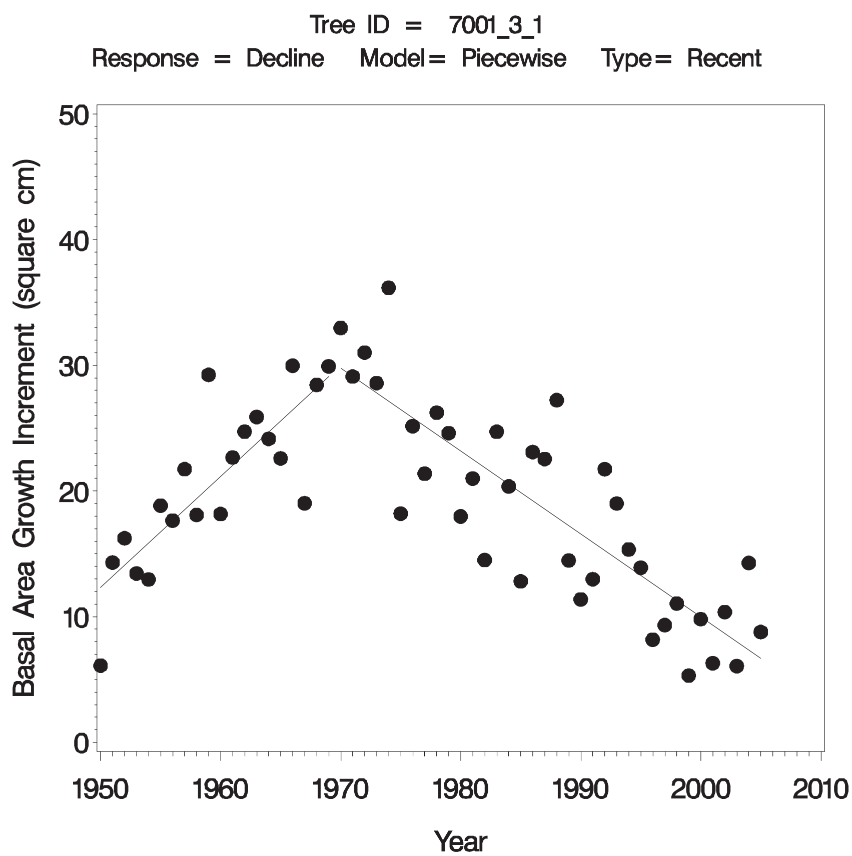
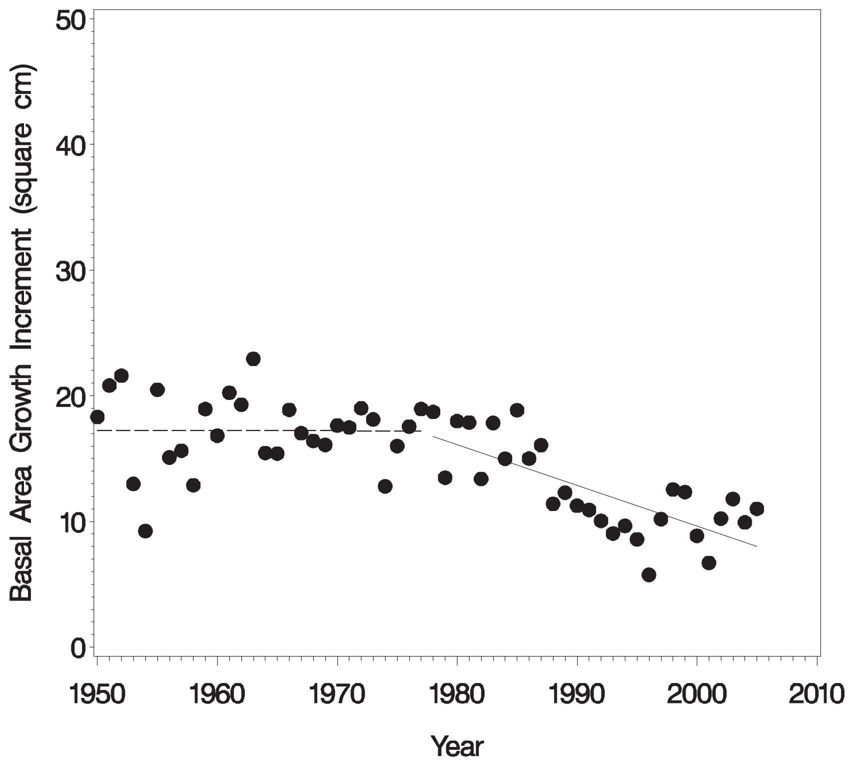
2000
2010
Year

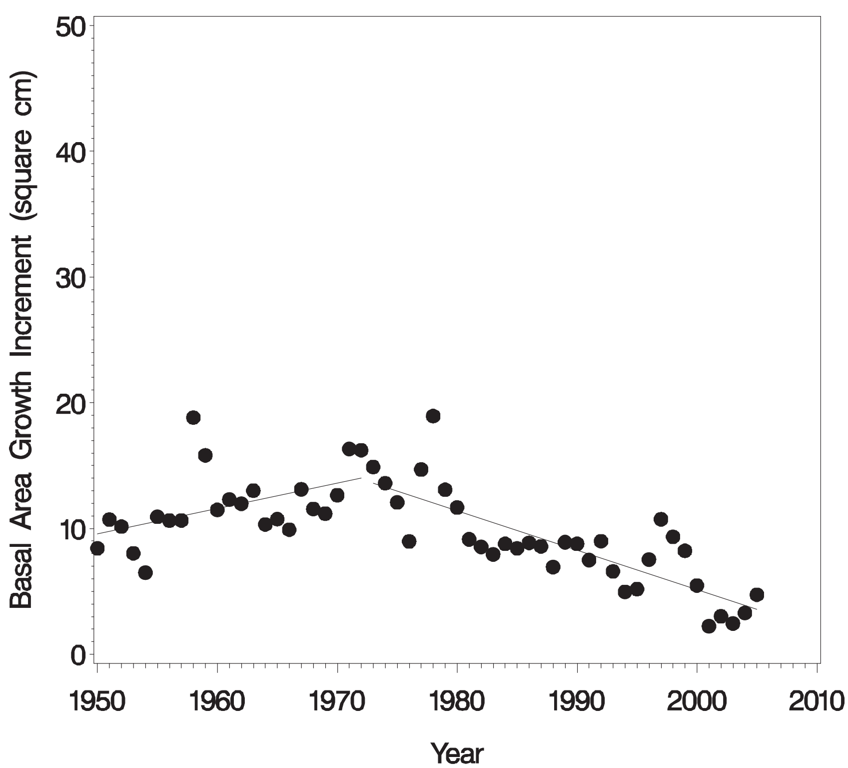

Tree ID = 7001_2_3
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year

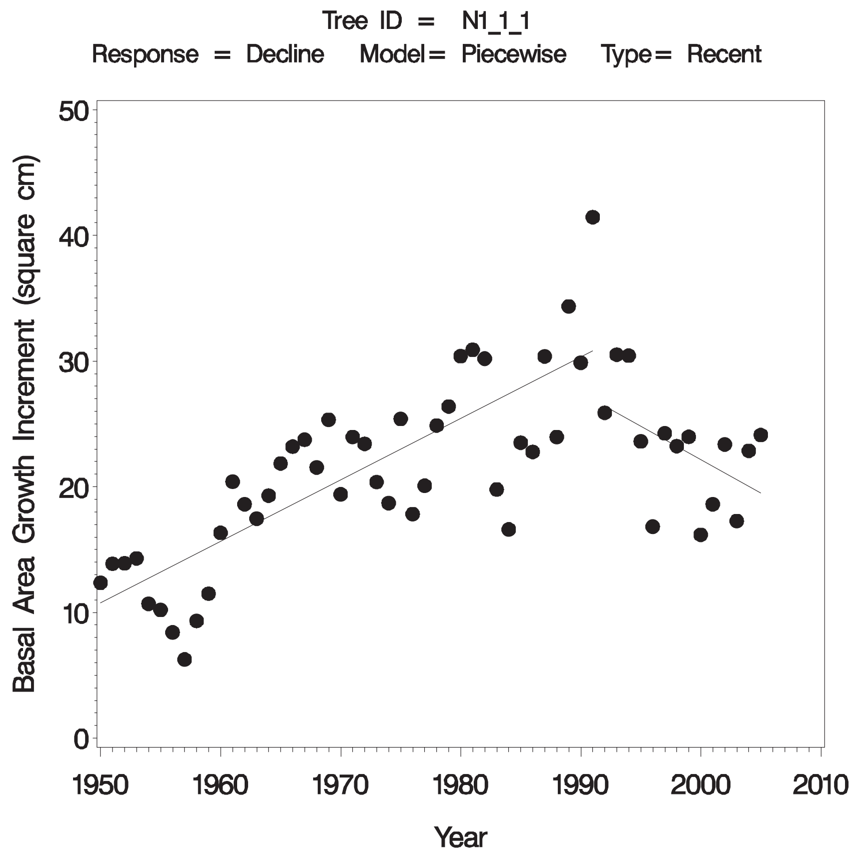

Tree ID = 7001_3_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year

Tree ID = AMP_1_3
Response = Decline Model= Piecewise Type= Recent



Tree ID = AMP_2_2
Response = Decline Model= Piecewise Type= Recent





Tree ID = N1_1_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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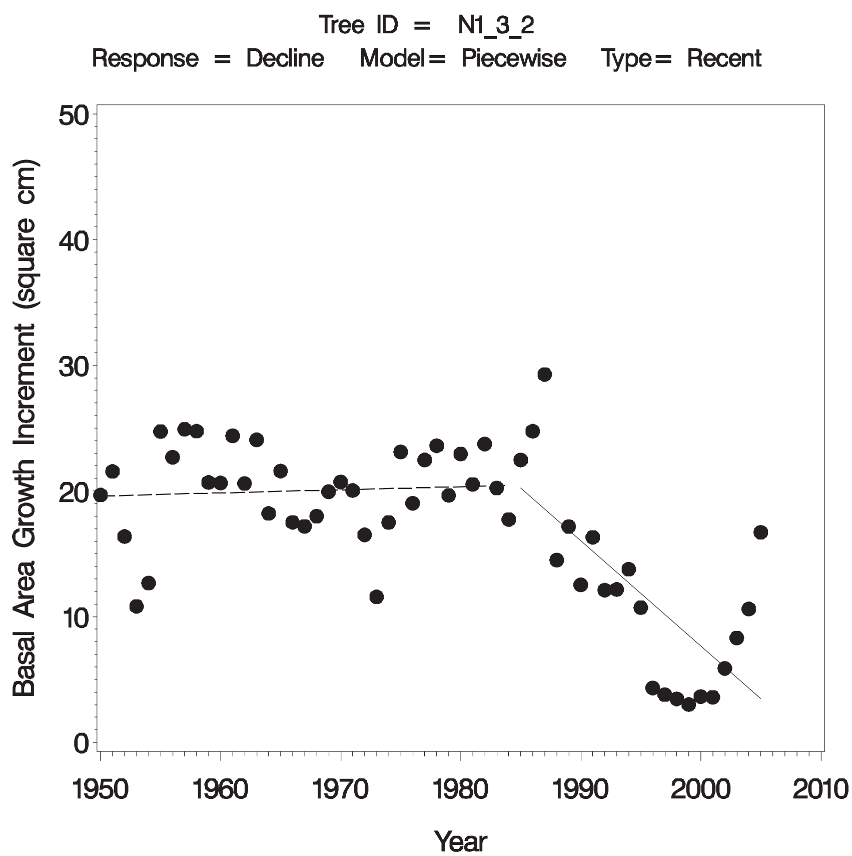
2010
Year



Tree ID = N1_3_2
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
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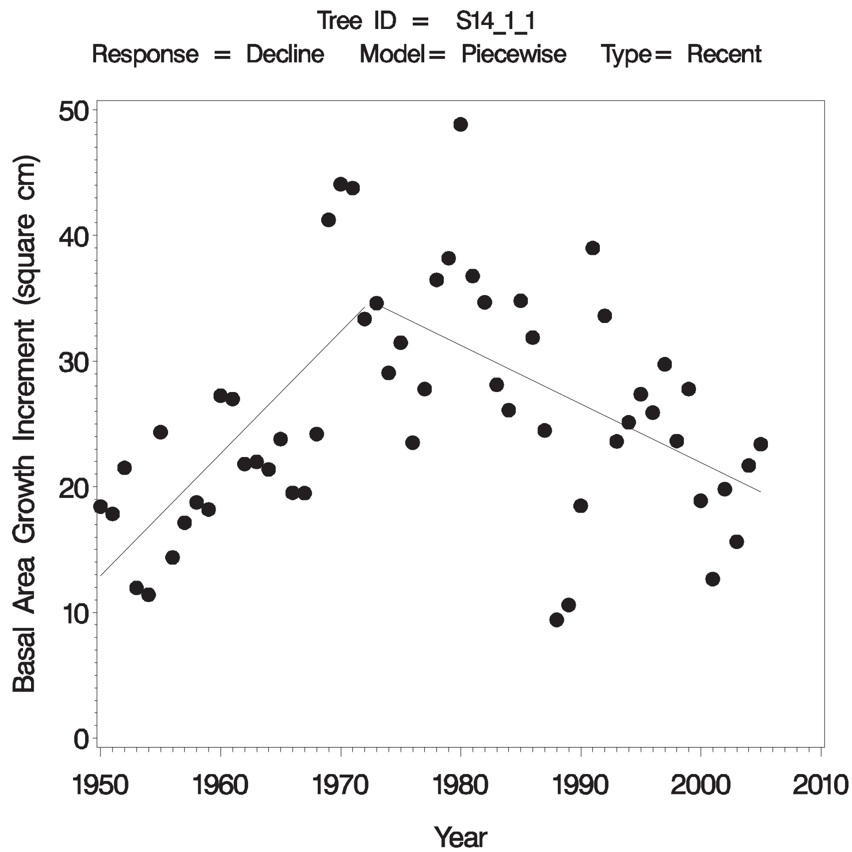
2010
Year


Tree ID = S14_1_1
Response = Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
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1950
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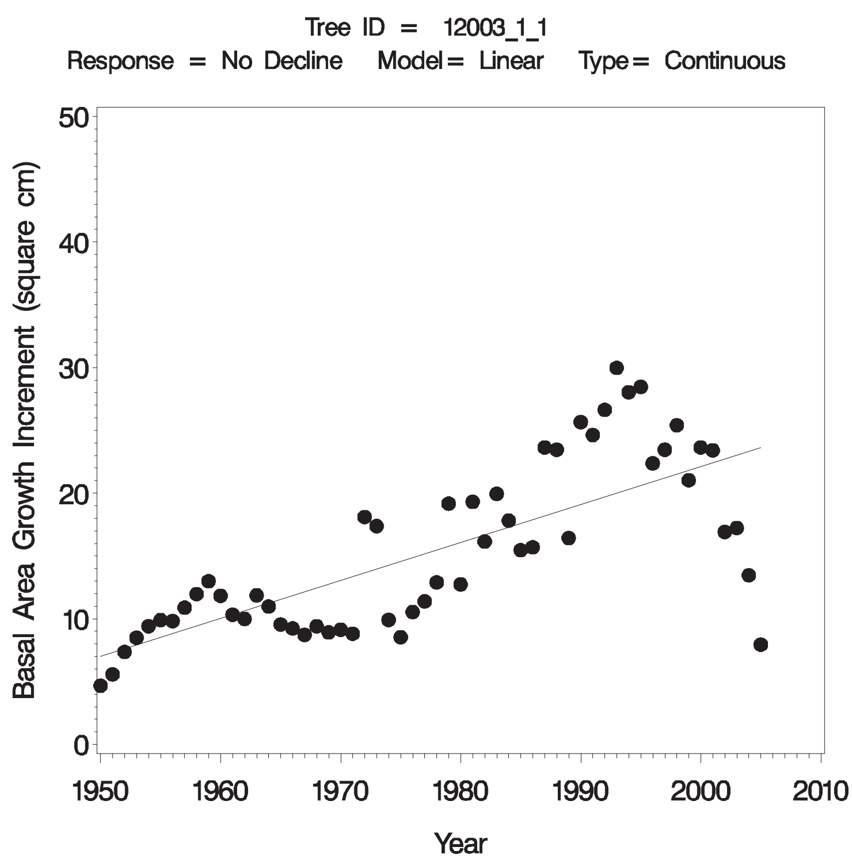
1990
2000
2010


Tree ID = 12003_1_1
Response = No Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
Year
0
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1950
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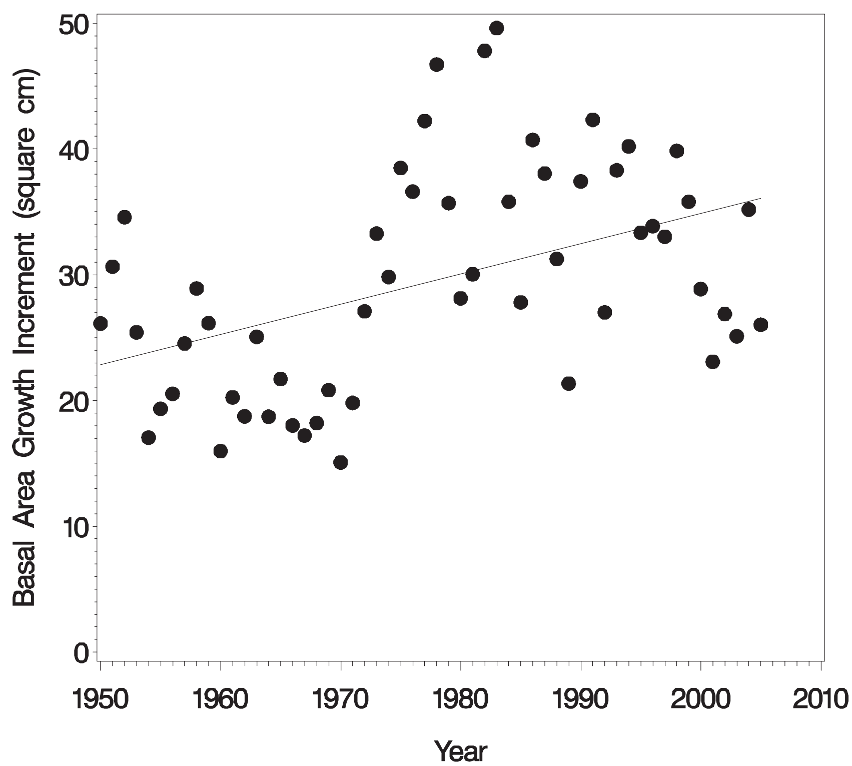
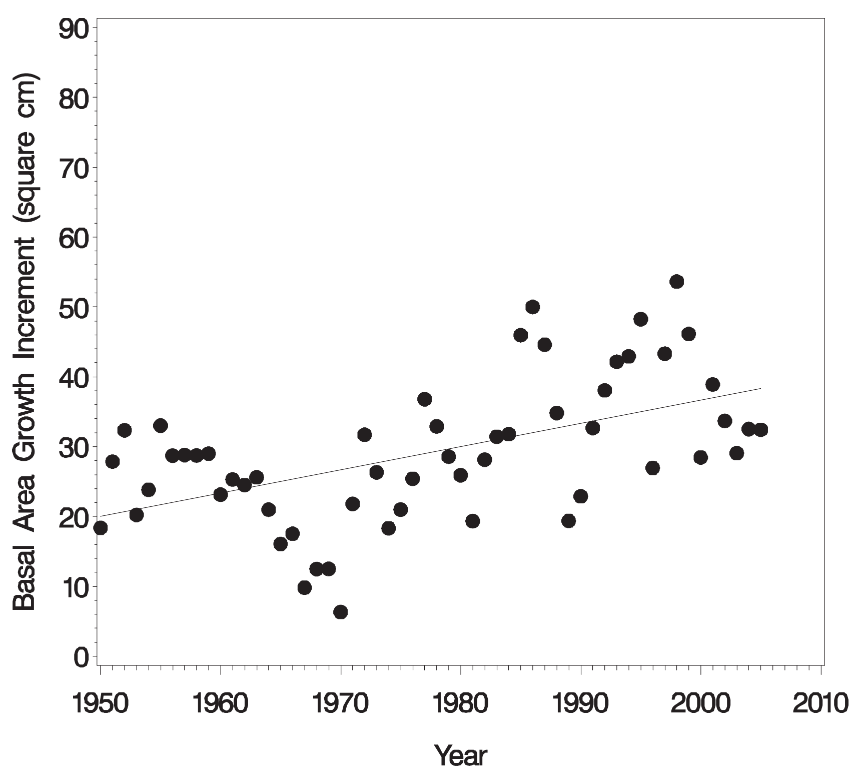
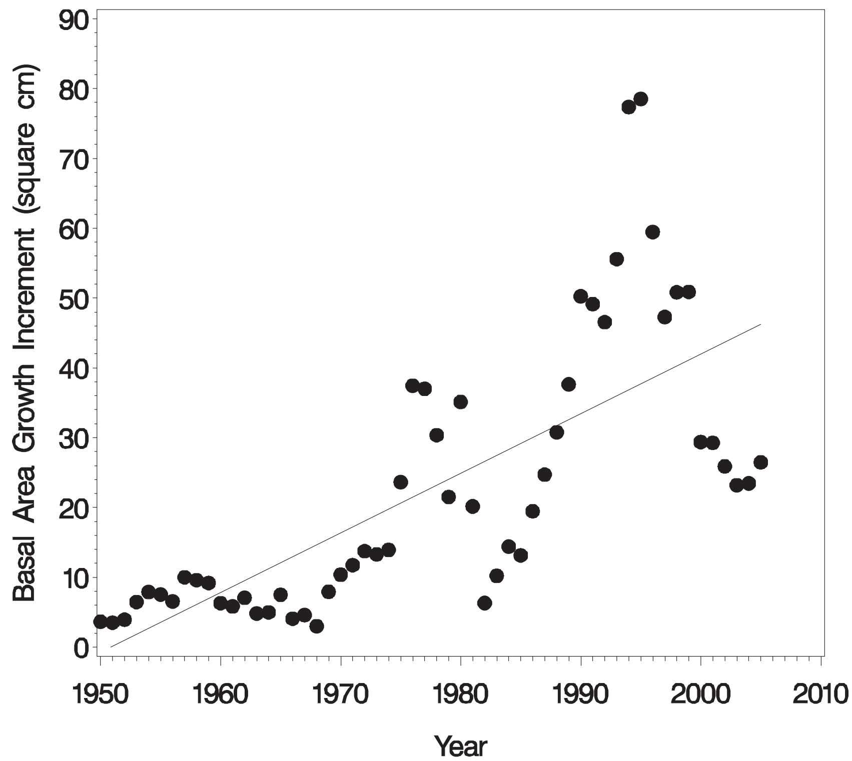
Tree ID = 12003_3_1
Response = No Decline Model= Linear Type= Continuous



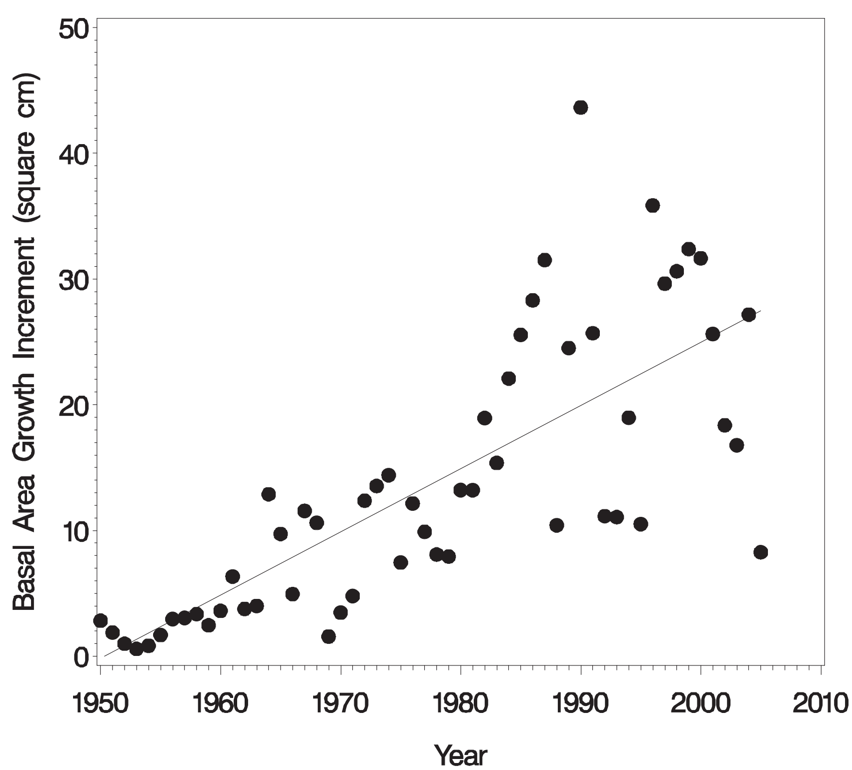
Tree ID = 12003_3_2
Response = No Decline Model= Linear Type= Continuous



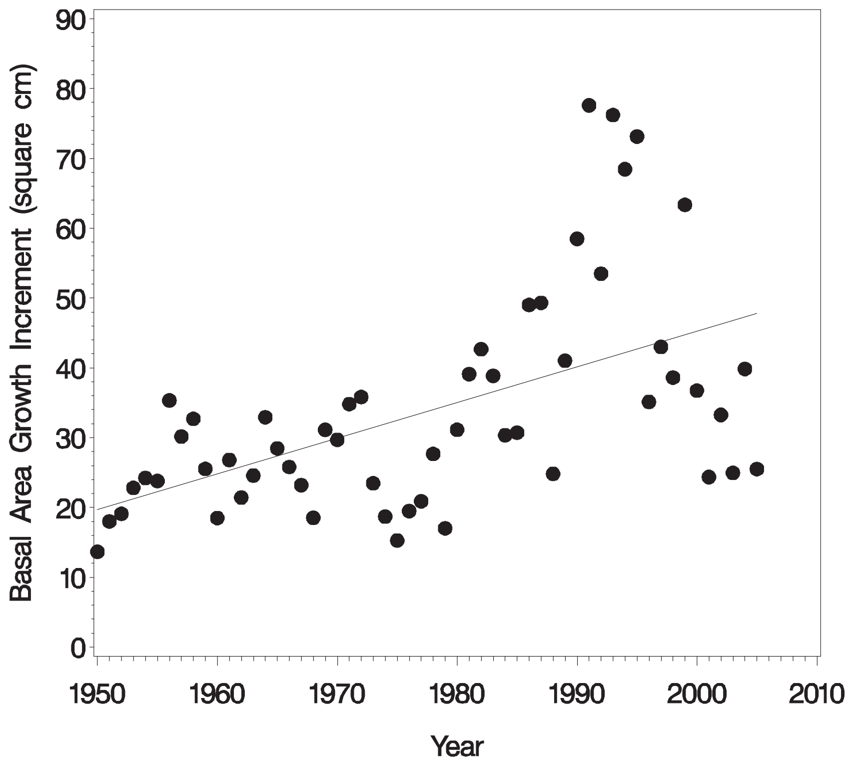
Tree ID = 13008_1_3
Response = No Decline Model= Linear Type= Continuous



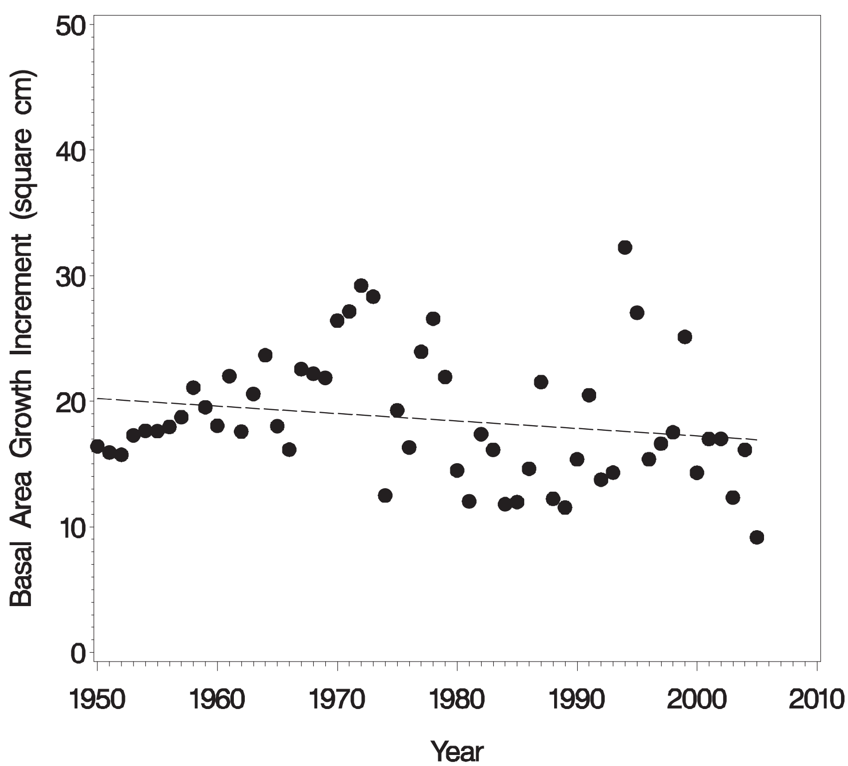
Tree ID = 17002_1_1
Response = No Decline Model= Linear Type= Continuous

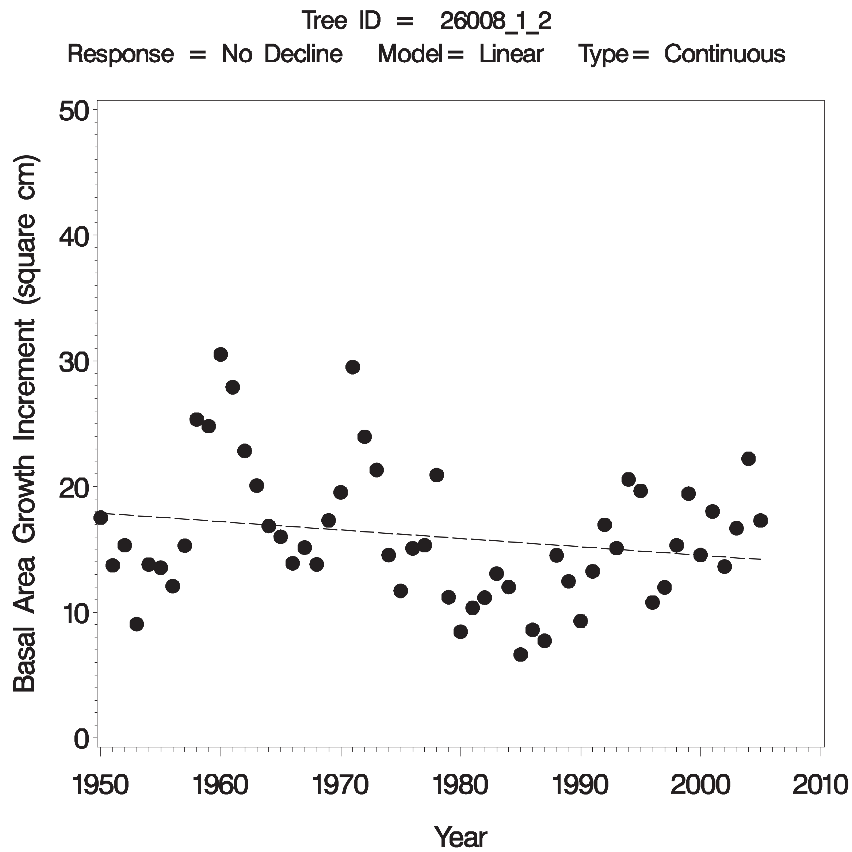


Tree ID = 22019_1_1
Response = No Decline Model = Linear Type = Continuous



Tree ID = 22019_2_1
Response = No Decline Model = Linear Type = Continuous




Tree ID = 26008_1_2
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
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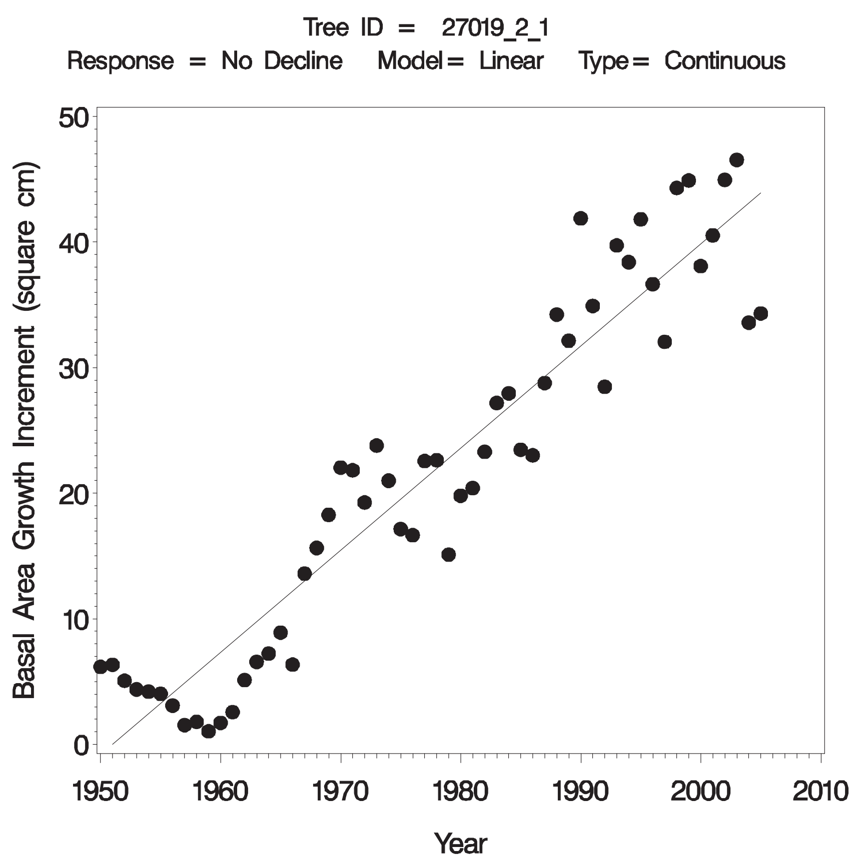
2010
Year


Tree ID = 27019_2_1
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
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1970
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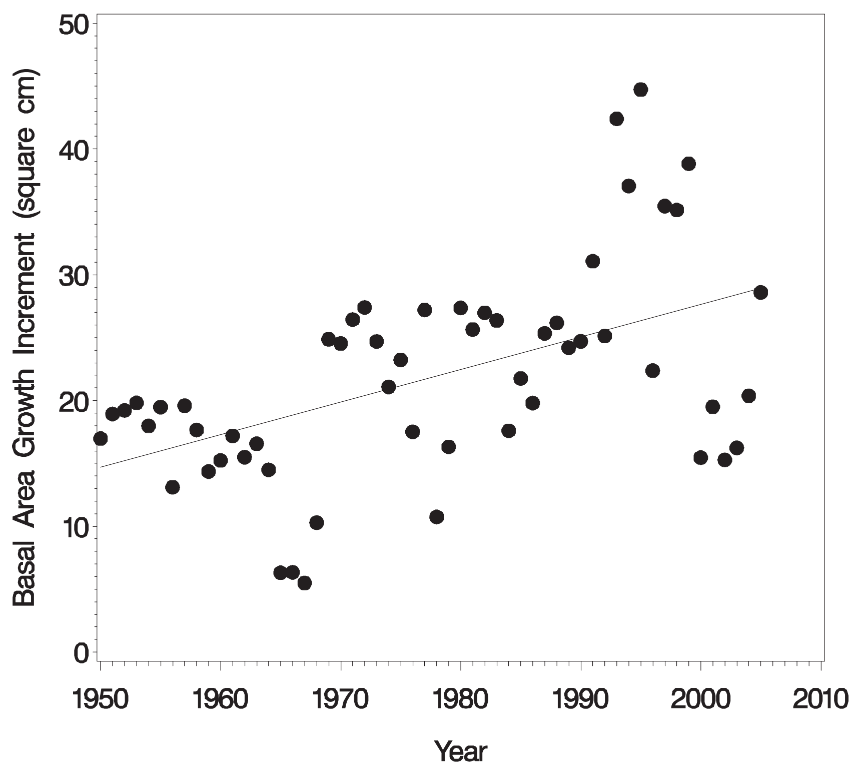
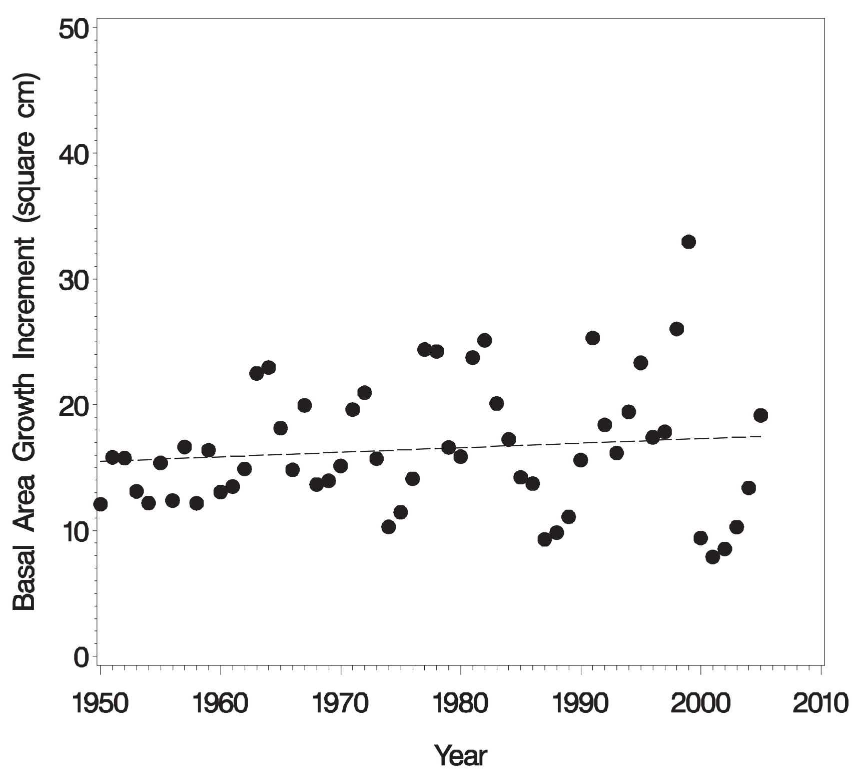
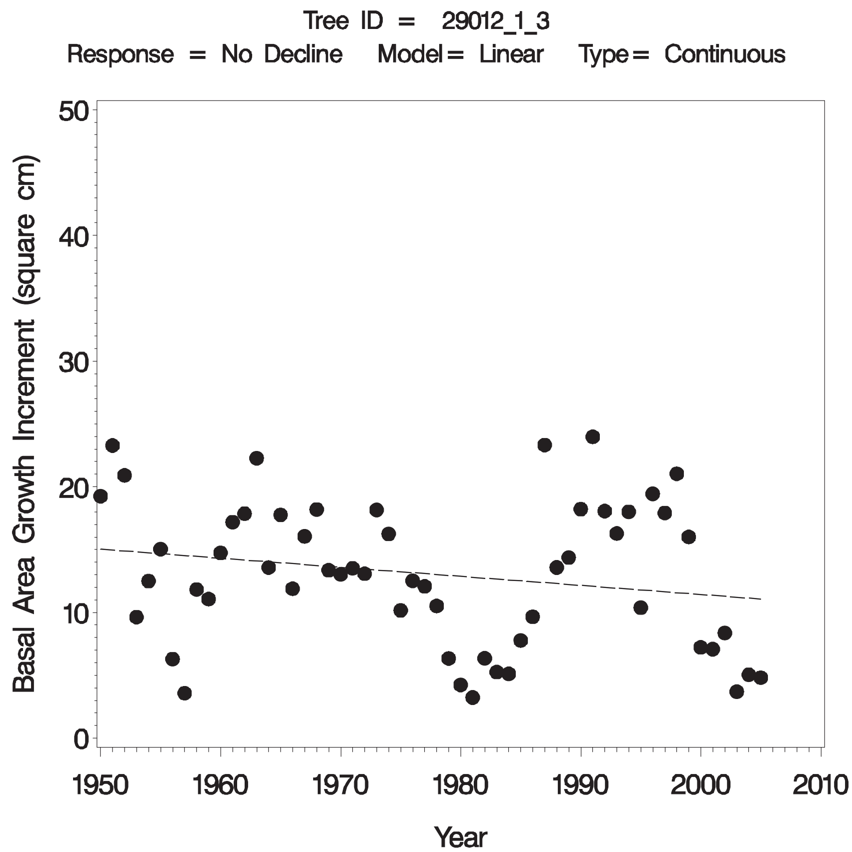
1990
2000
2010
Year

Tree ID = 27019_3_1
Response = No Decline Model = Linear Type = Continuous



Tree ID = 28030_3_3
Response = No Decline Model = Linear Type = Continuous




Tree ID = 29012_1_3
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
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1960
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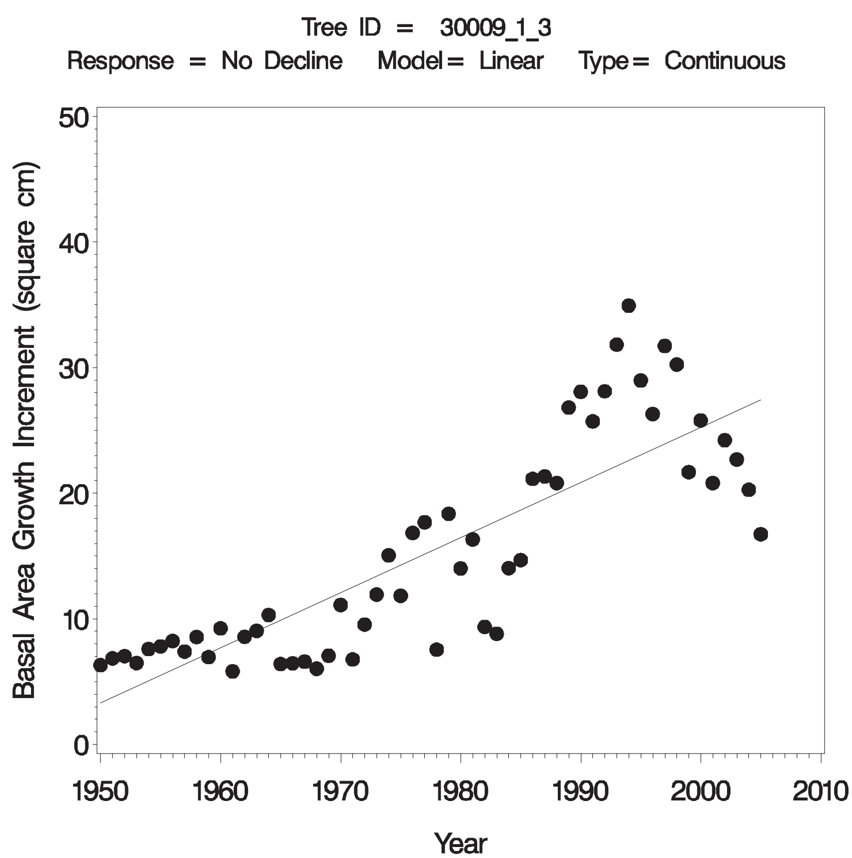
2000
2010
Year


Tree ID = 30009_1_3
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
10
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1950
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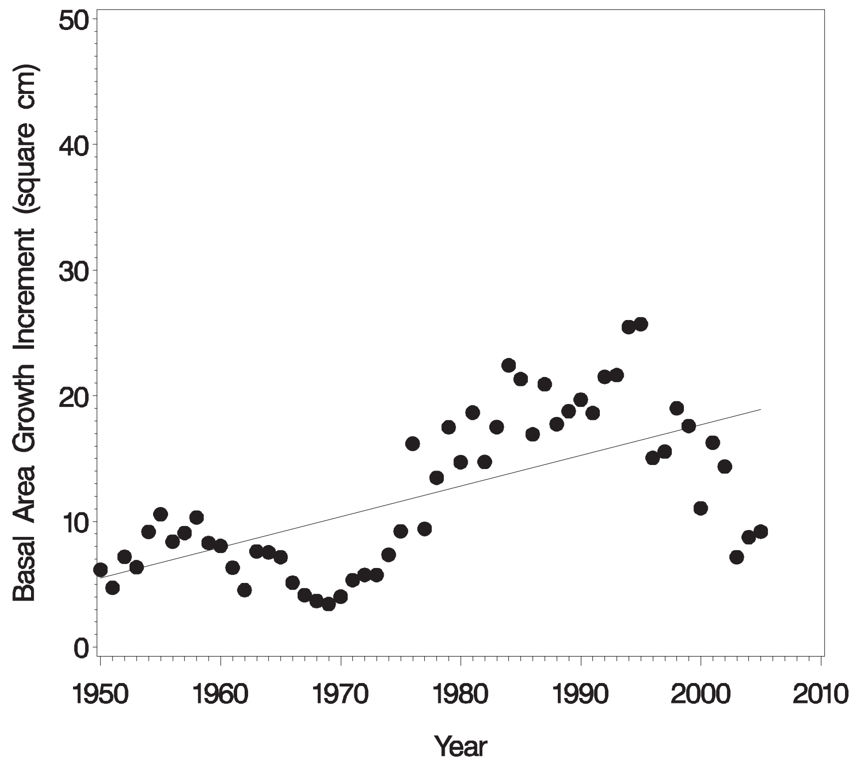
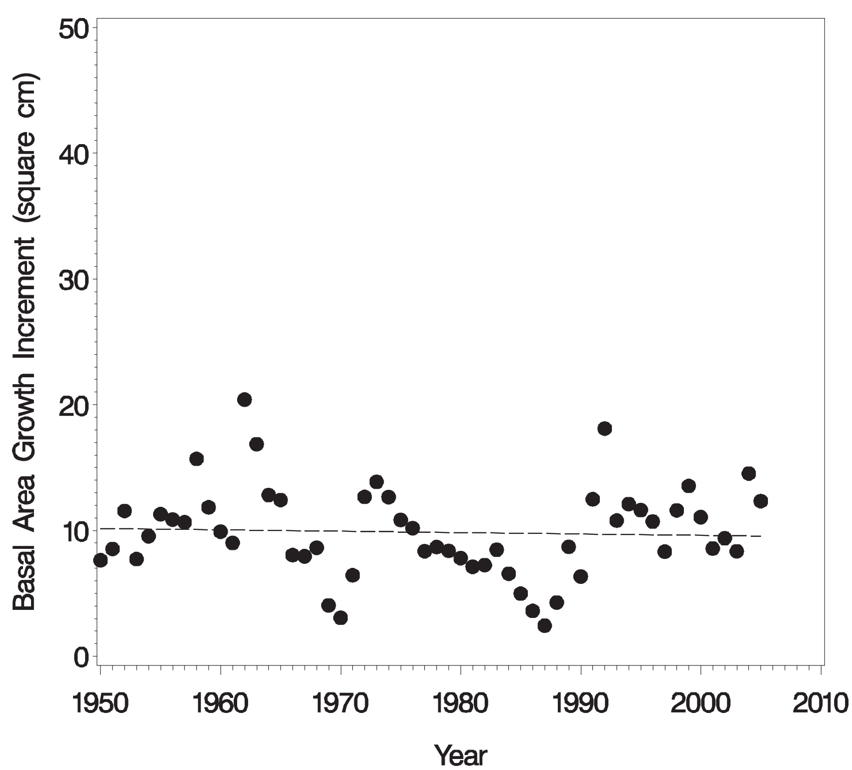
1990
2000
2010
Year

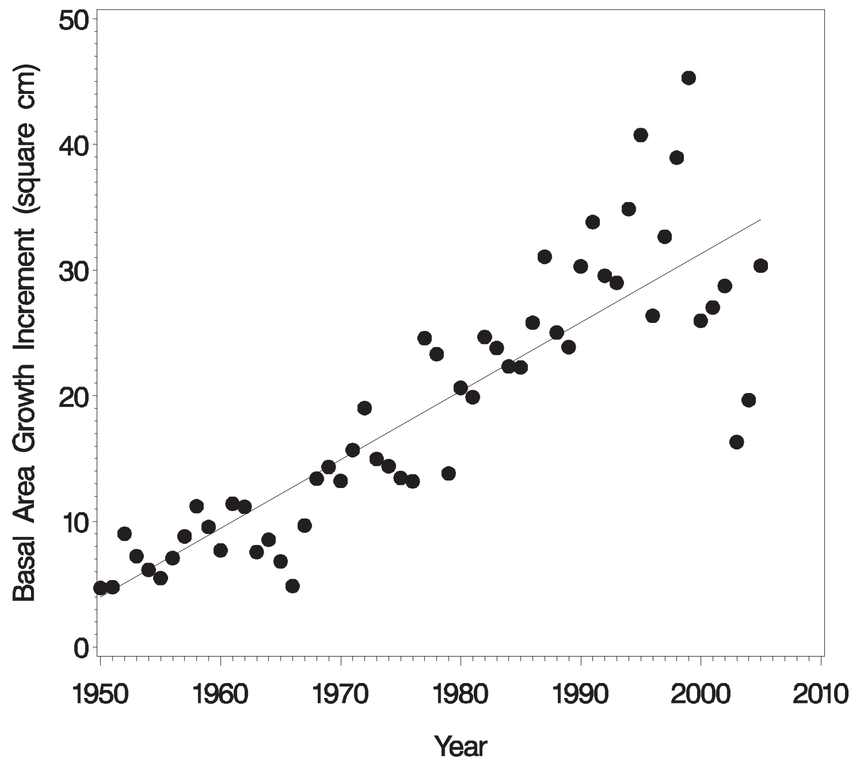
Tree ID = 30009_2_2
Response = No Decline Model= Linear Type= Continuous



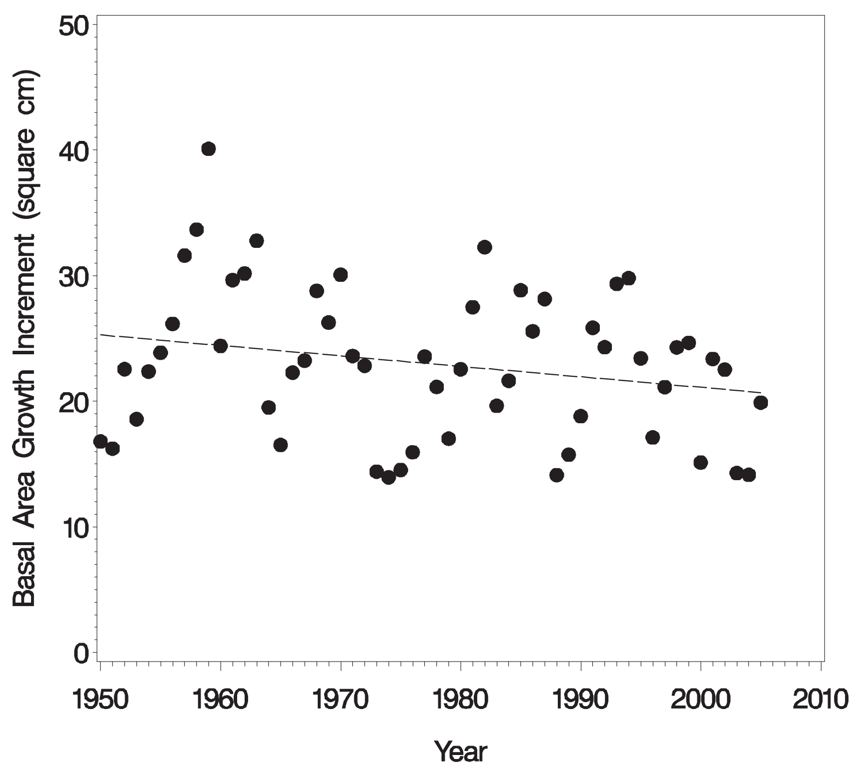
Tree ID = 30009_2_3
Response = No Decline Model= Linear Type= Continuous



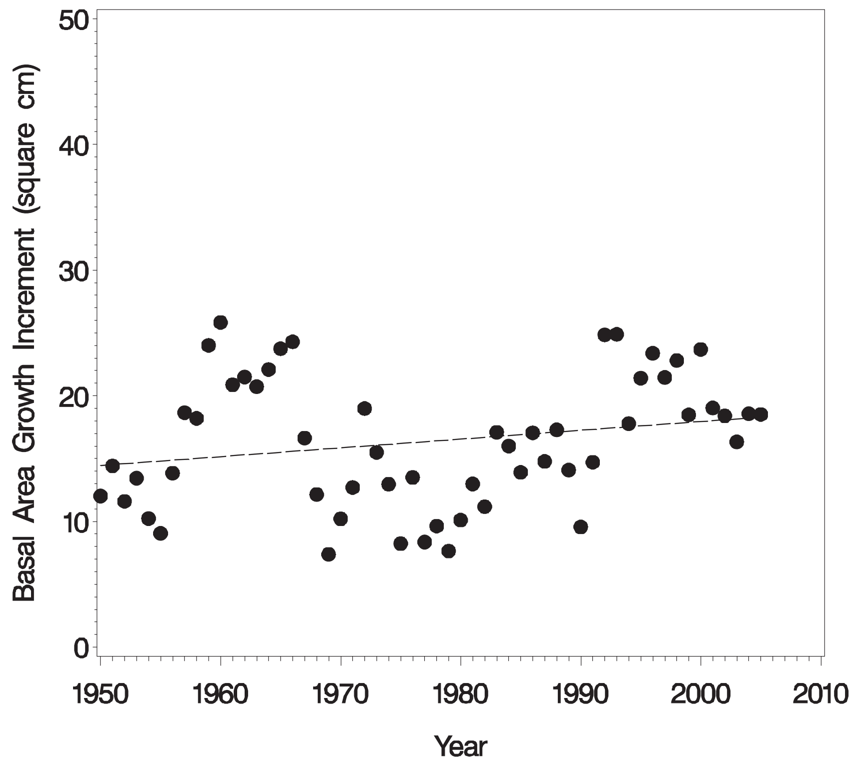
Tree ID = 31009_1_2
Response = No Decline Model= Linear Type= Continuous



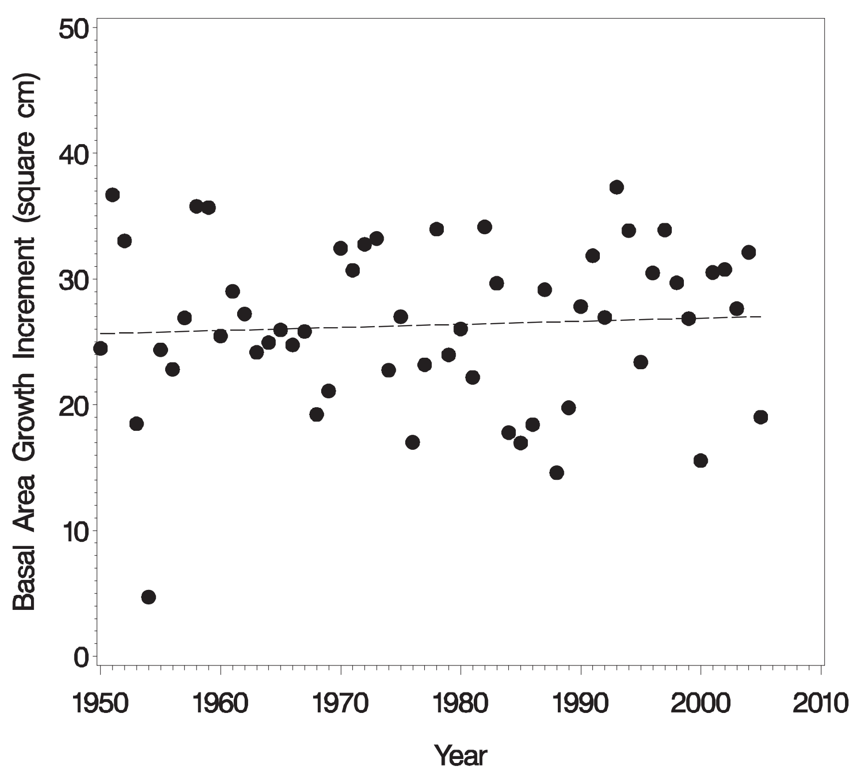
Tree ID = 35014_2_2
Response = No Decline Model= Linear Type= Continuous



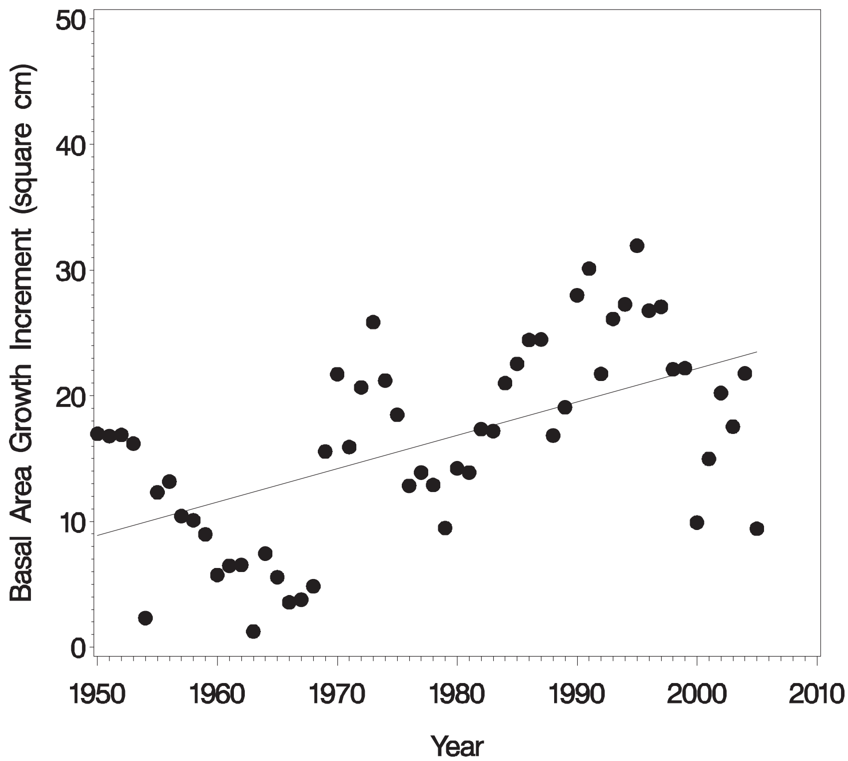
Tree ID = 7001_1_3
Response = No Decline Model= Linear Type= Continuous



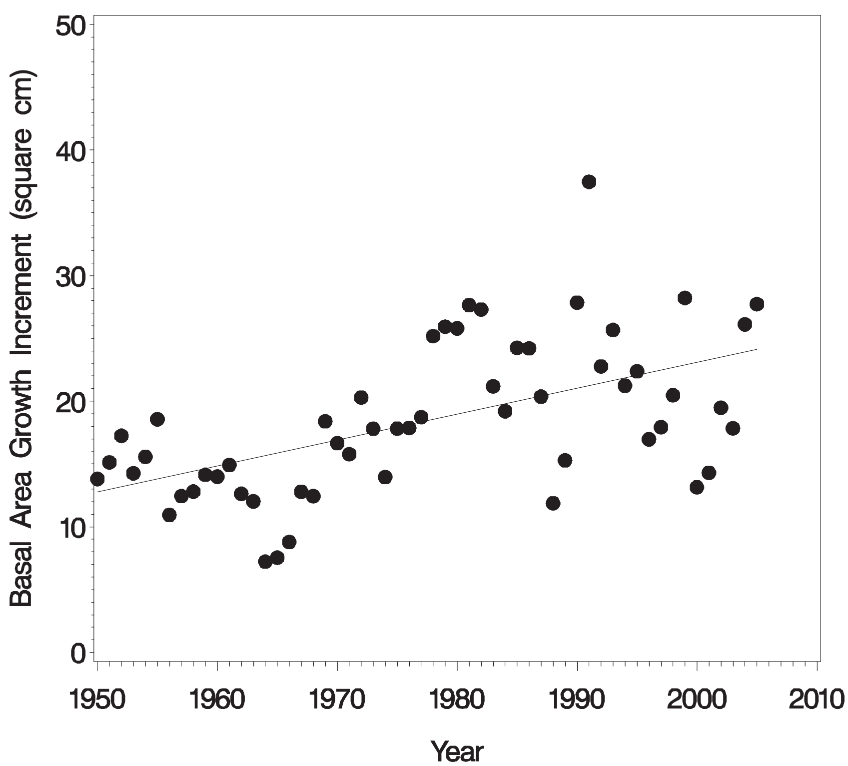
Tree ID = 9006_2_1
Response = No Decline Model= Linear Type= Continuous



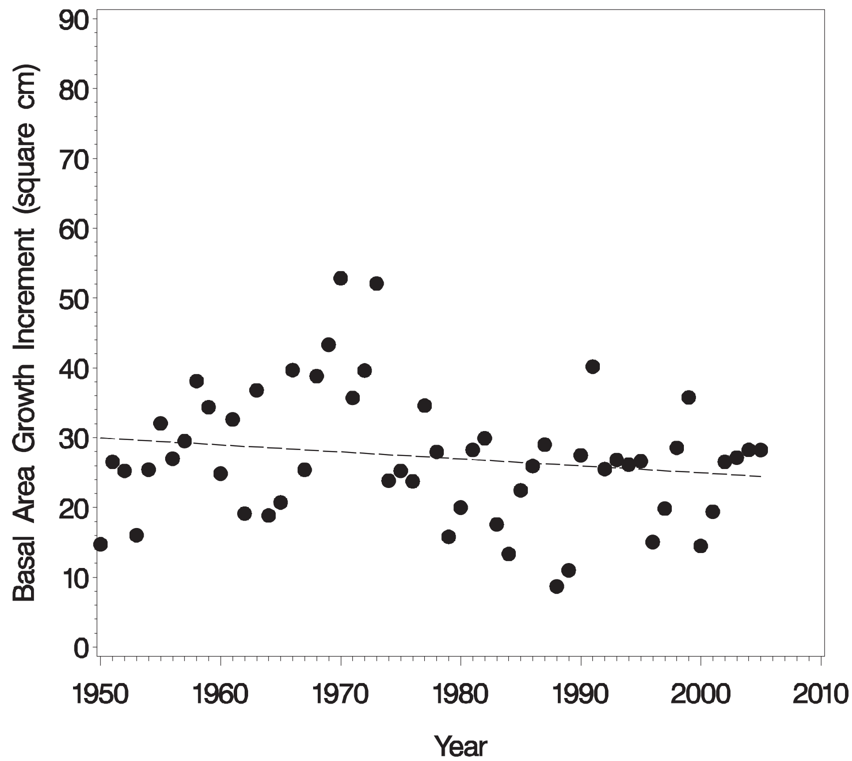
Tree ID = 9006_3_1
Response = No Decline Model = Linear Type = Continuous



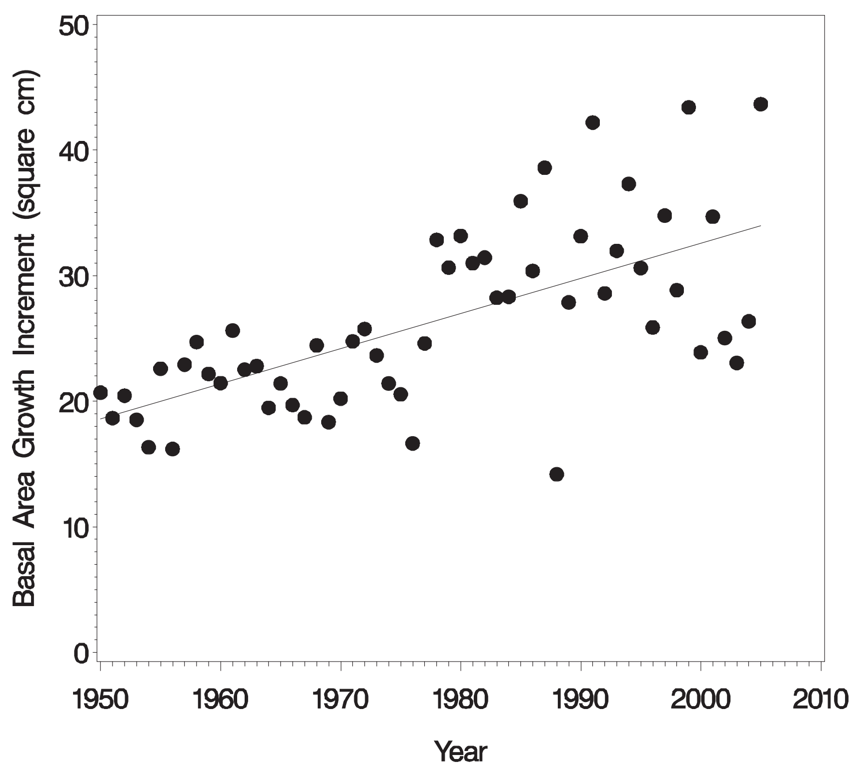
Tree ID = N1_1_2
Response = No Decline Model = Linear Type = Continuous

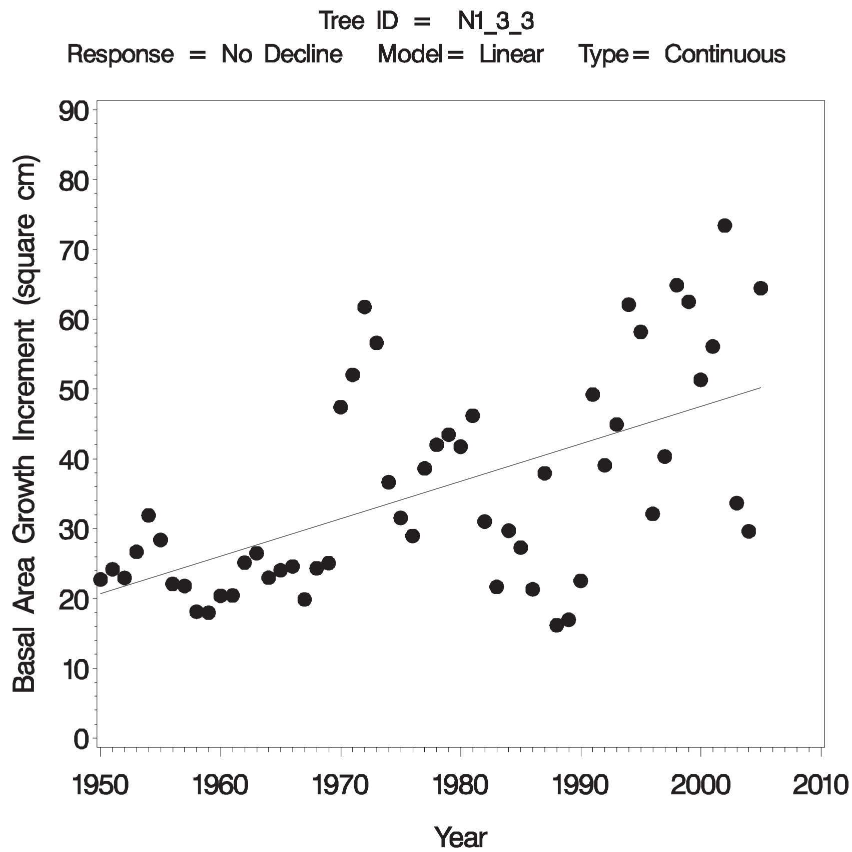


Tree ID = N1_2_3
Response = No Decline Model = Linear Type = Continuous



Tree ID = N1_3_1
Response = No Decline Model = Linear Type = Continuous




Tree ID = N1_3_3
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
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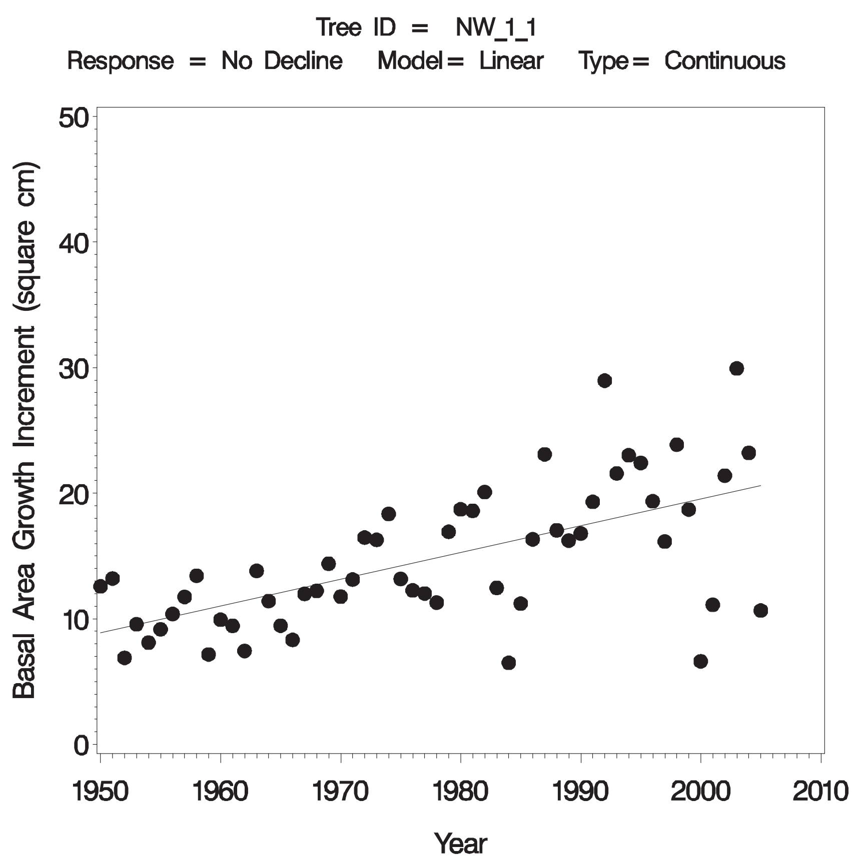
2000
2010
Year


Tree ID = NW_1_1
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
0
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1950
1960
1970
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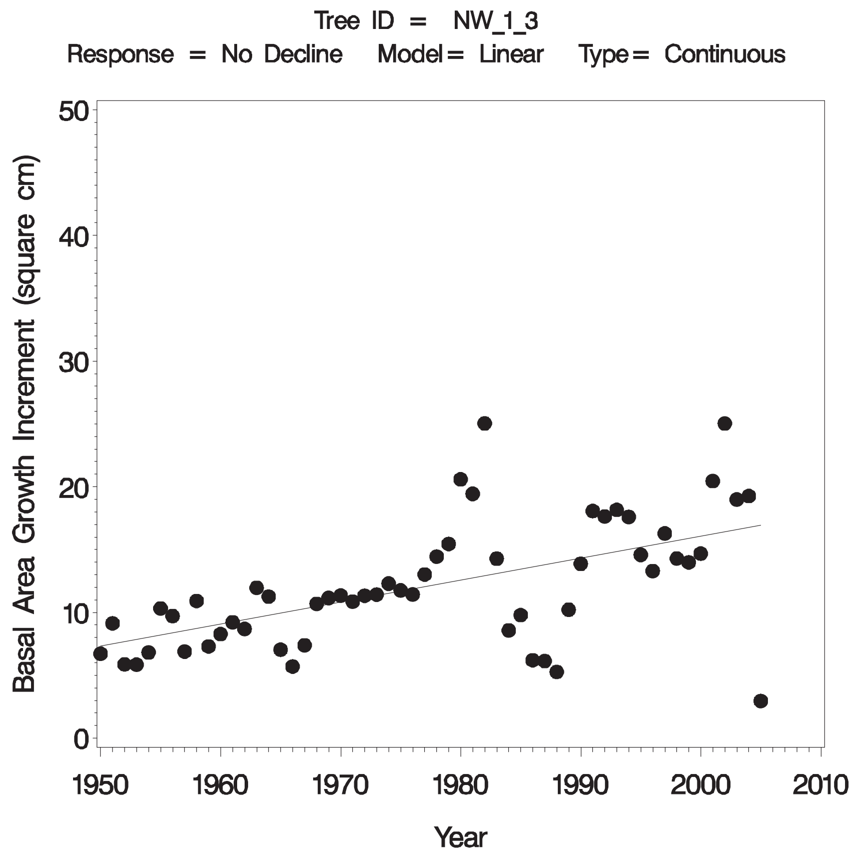
1990
2000
2010
Year


Tree ID = NW_1_3
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
Year
0
10
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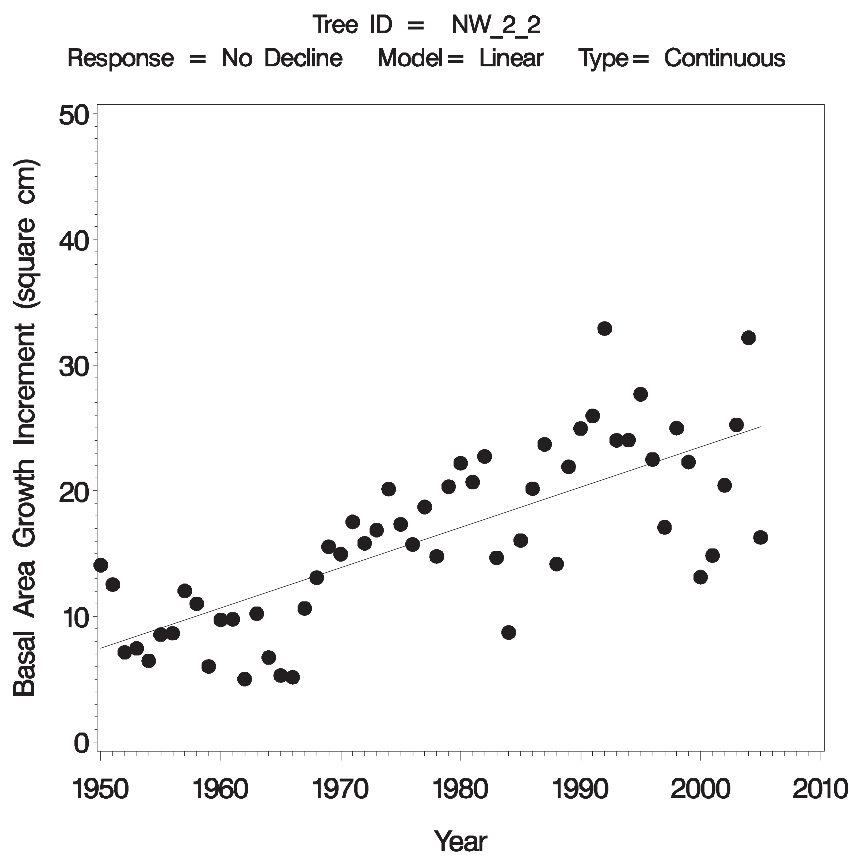
1950
1960
1970
1980
1990
2000
2010


Tree ID = NW_2_2
Response = No Decline Model = Linear Type = Continuous
Basal Area Growth Increment (square cm)
Year
0
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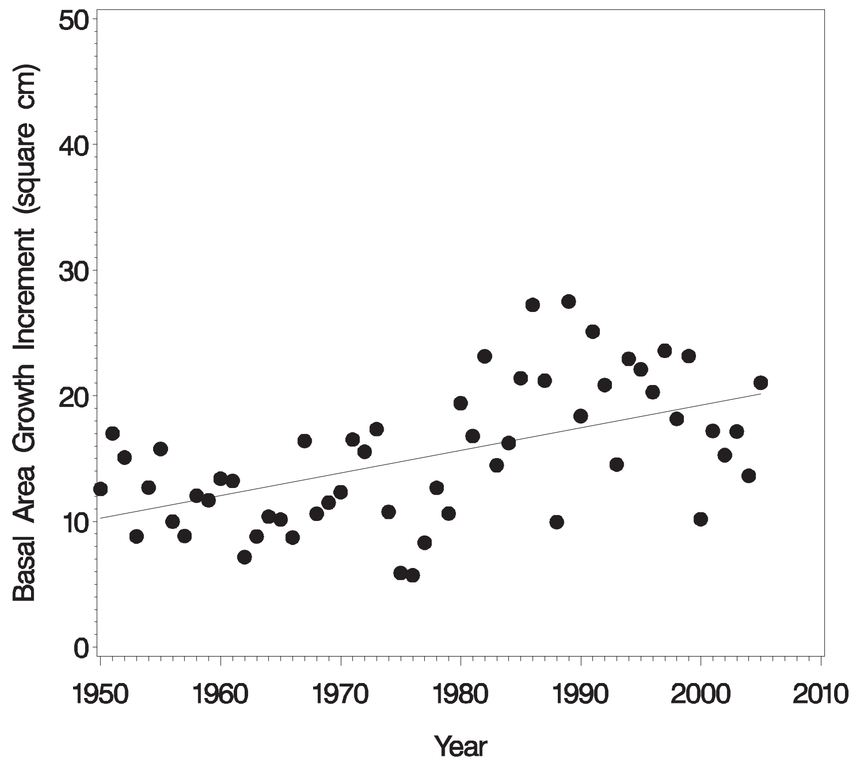
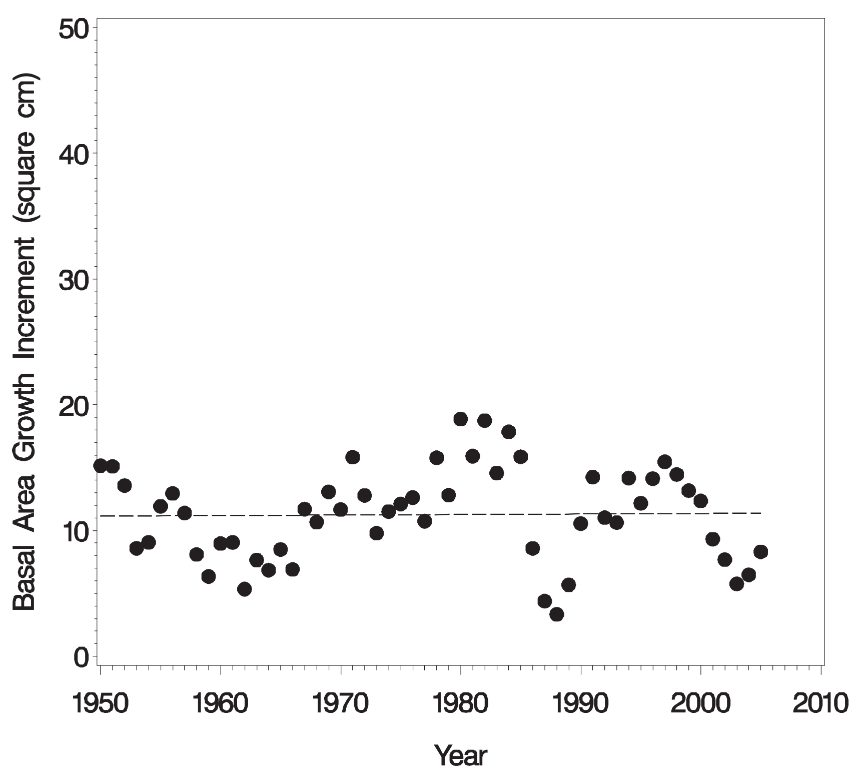
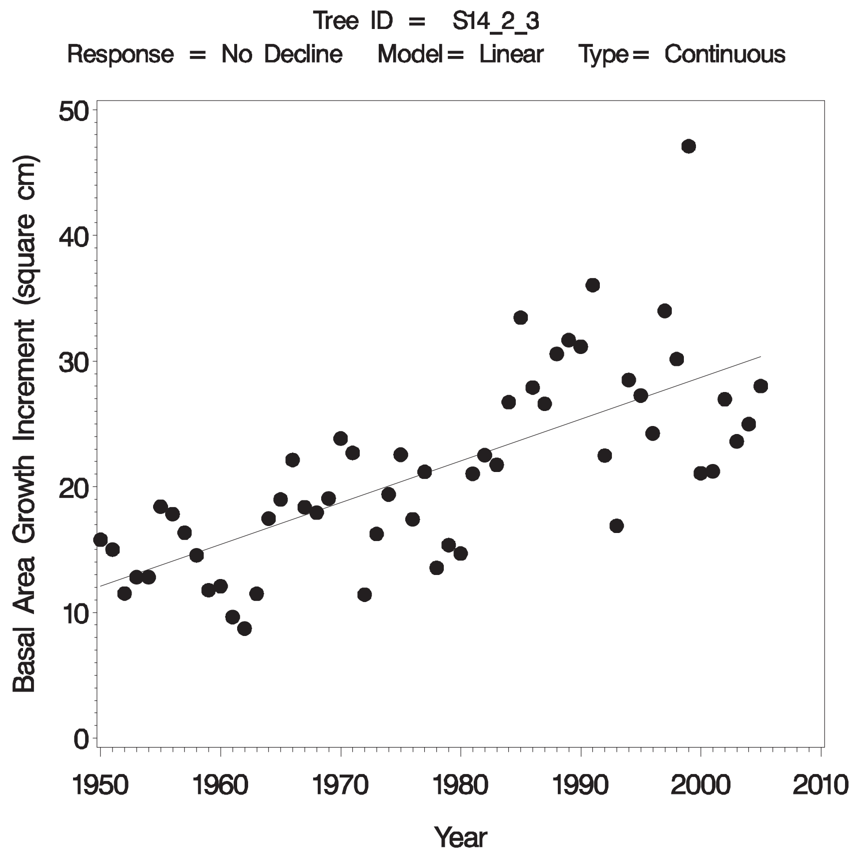
2010

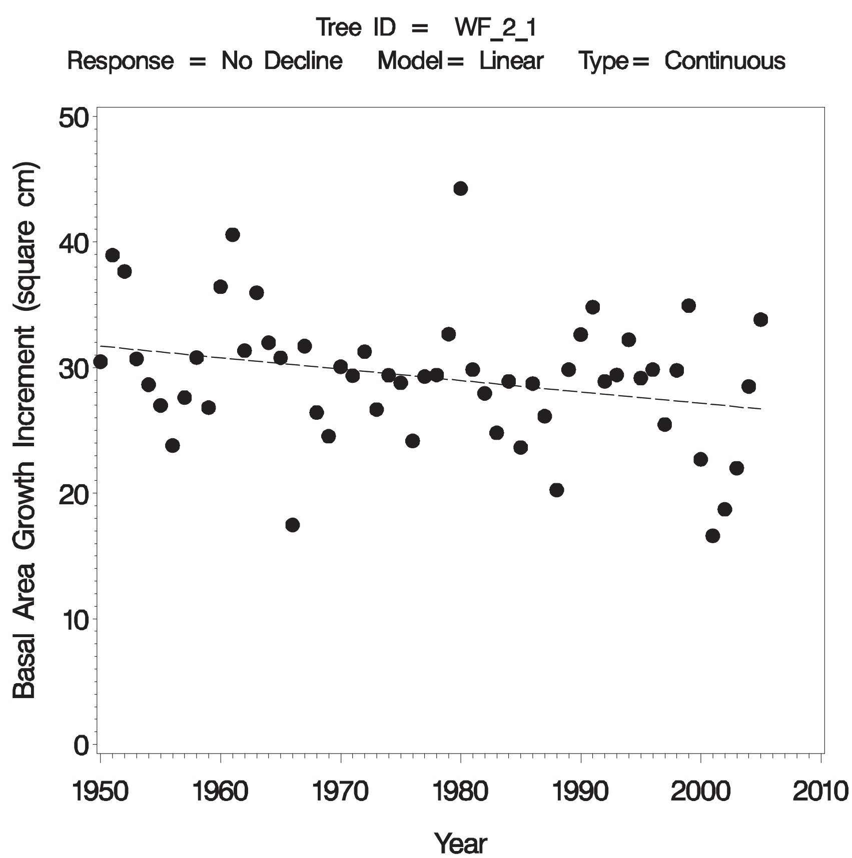
Tree ID = S14_1_2
Response = No Decline Model= Linear Type= Continuous

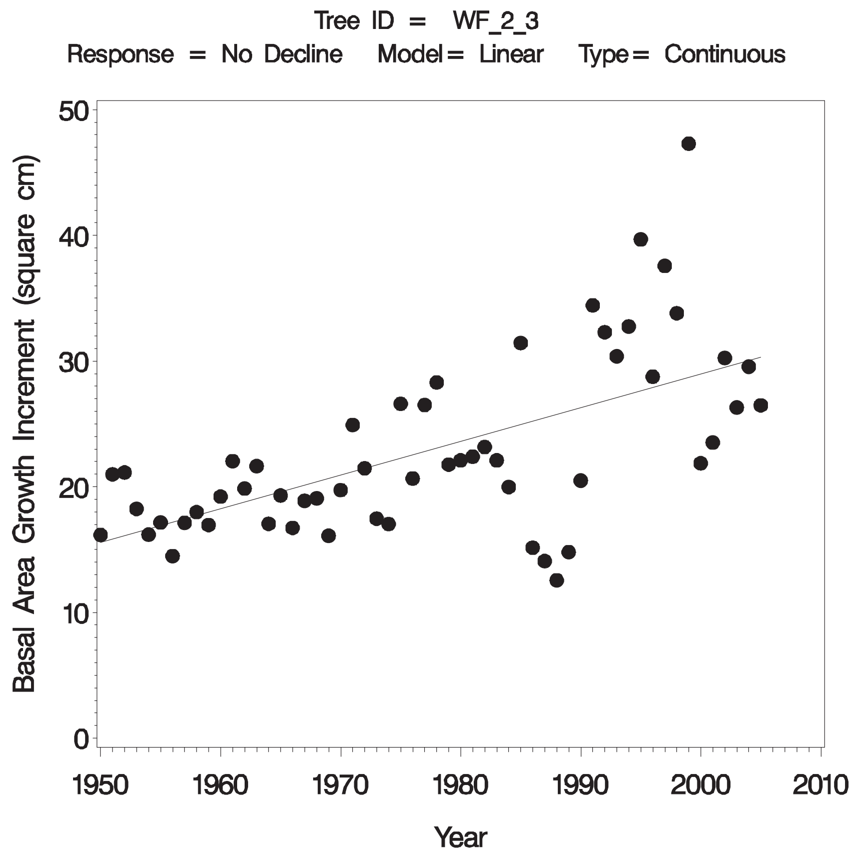


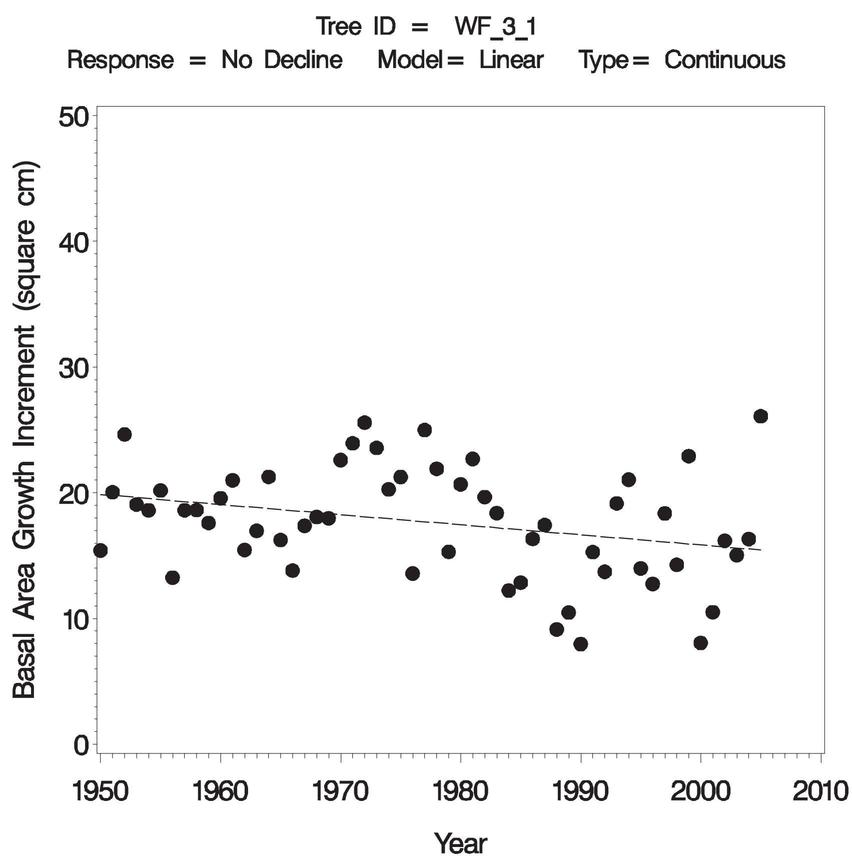
Tree ID = S14_2_1
Response = No Decline Model= Linear Type= Continuous



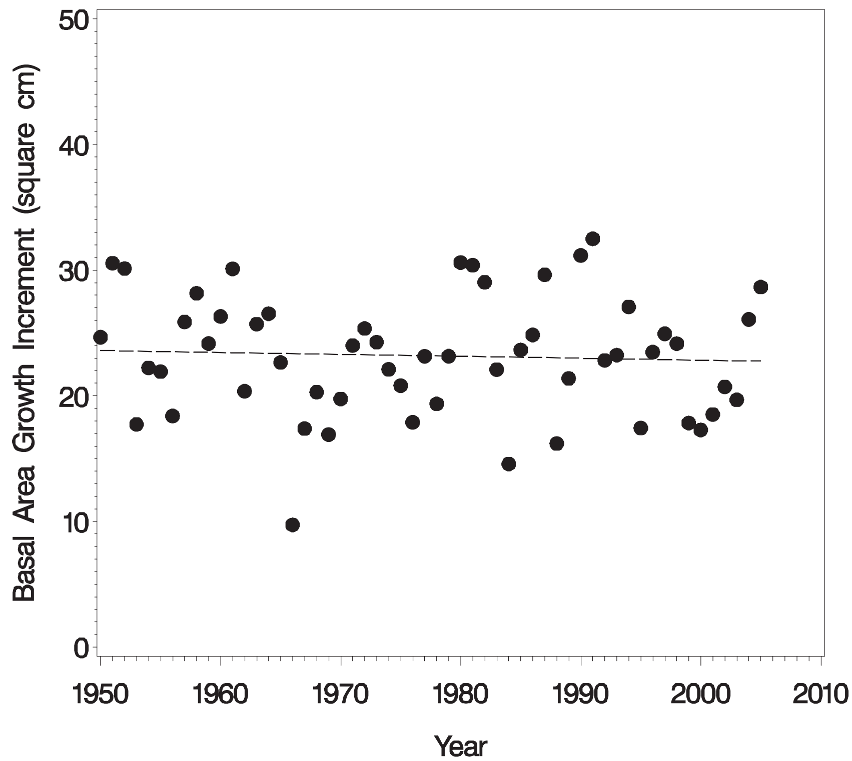

Tree ID = S14_2_3
Response = No Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = WF_2_1
Response = No Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

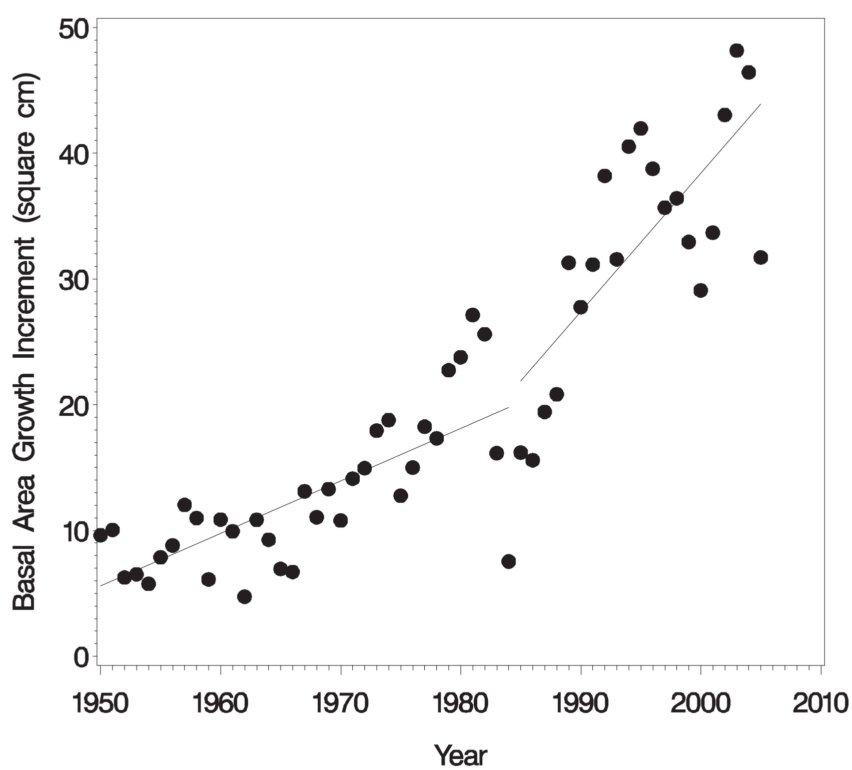

Tree ID = WF_2_3
Response = No Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = WF_3_1
Response = No Decline Model= Linear Type= Continuous
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

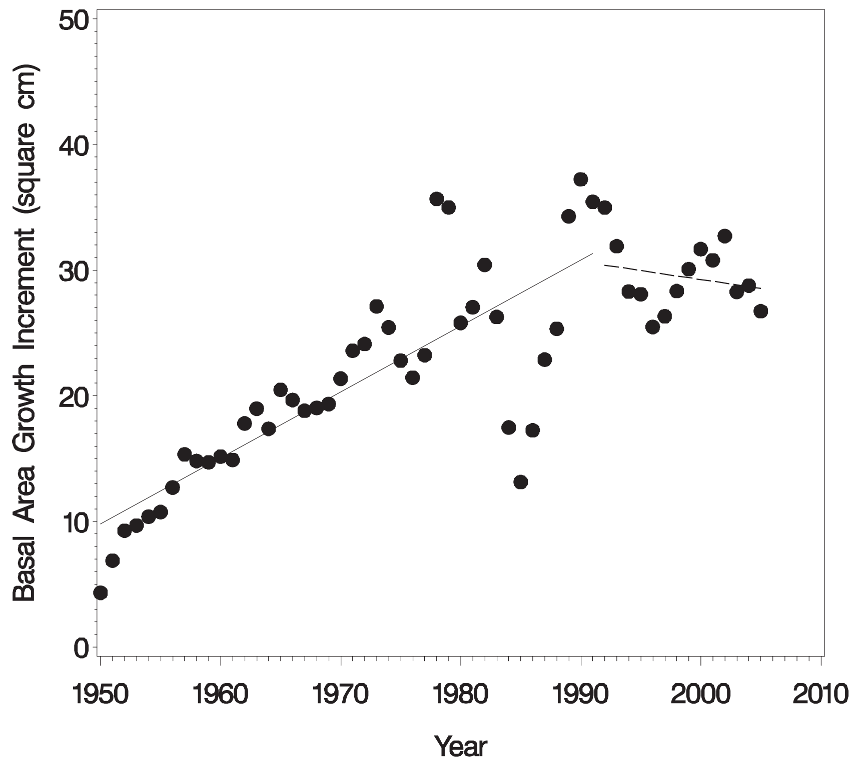
Tree ID = WF_3_3
Response = No Decline Model= Linear Type= Continuous



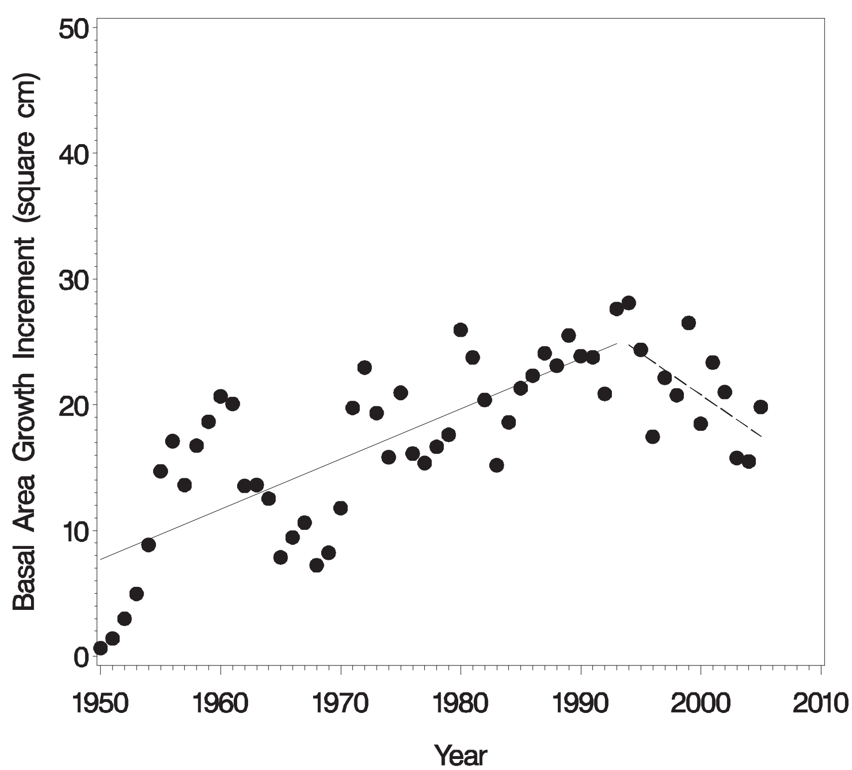
Tree ID = NW_2_1
Response = No Decline Model= Piecewise Type= Continuous

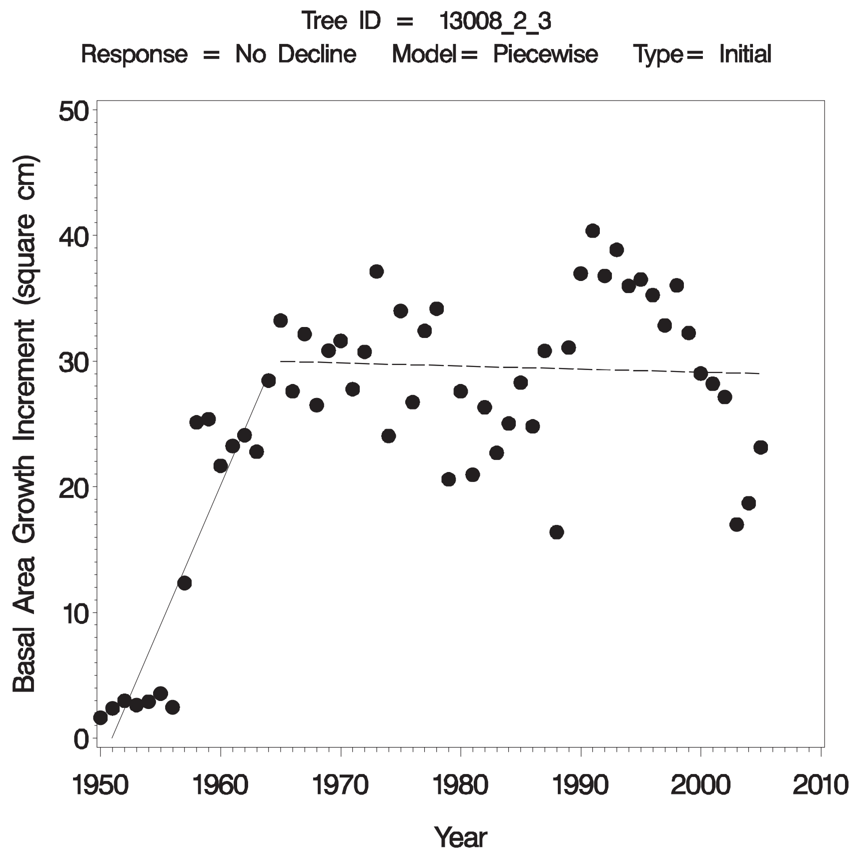


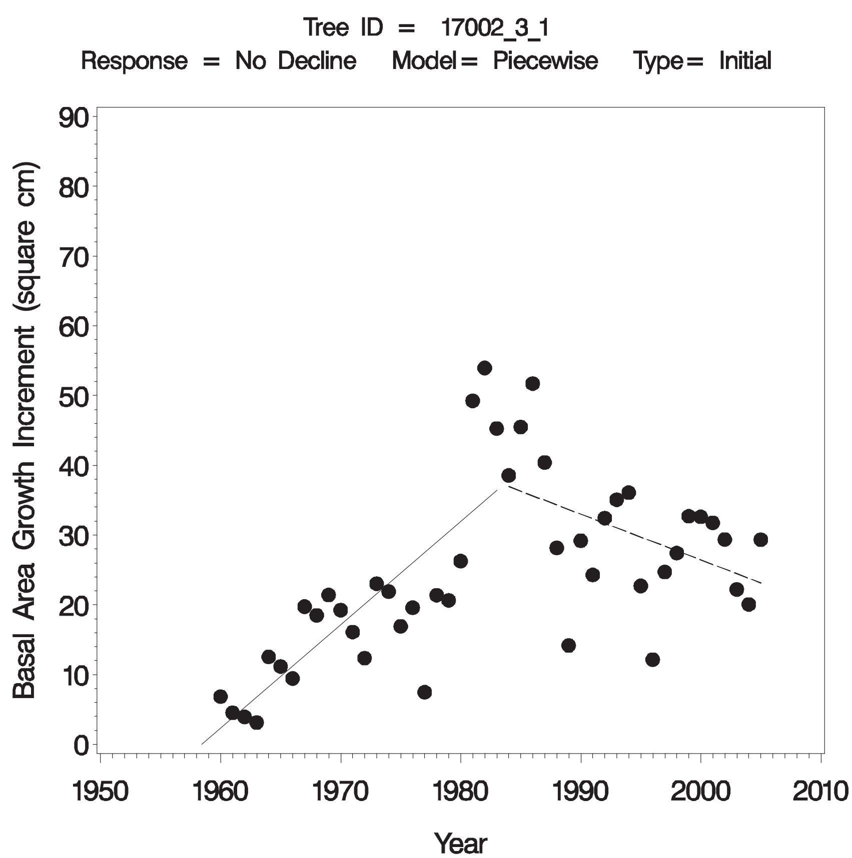
Tree ID = 12003_3_3
Response = No Decline Model= Piecewise Type= Initial

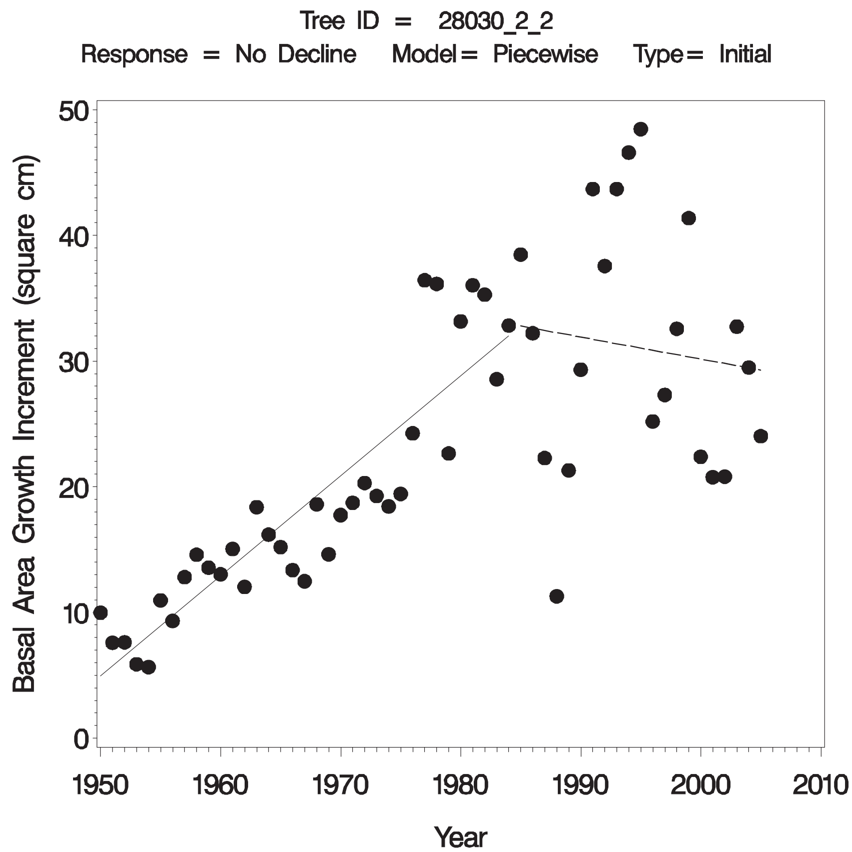


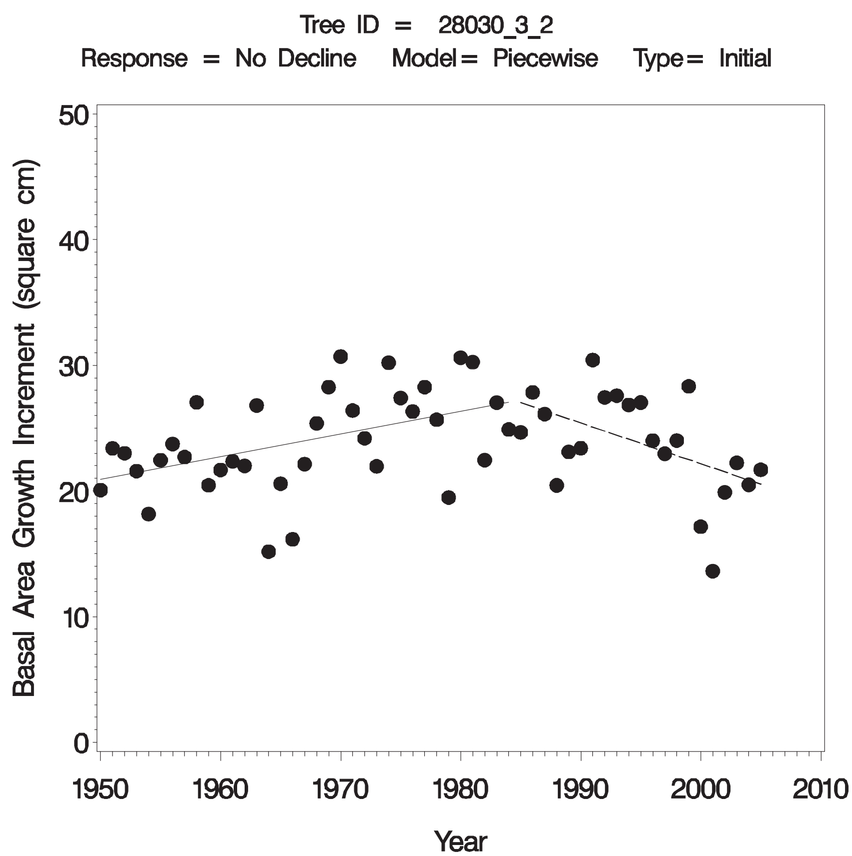
Tree ID = 13008_1_2
Response = No Decline Model= Piecewise Type= Initial



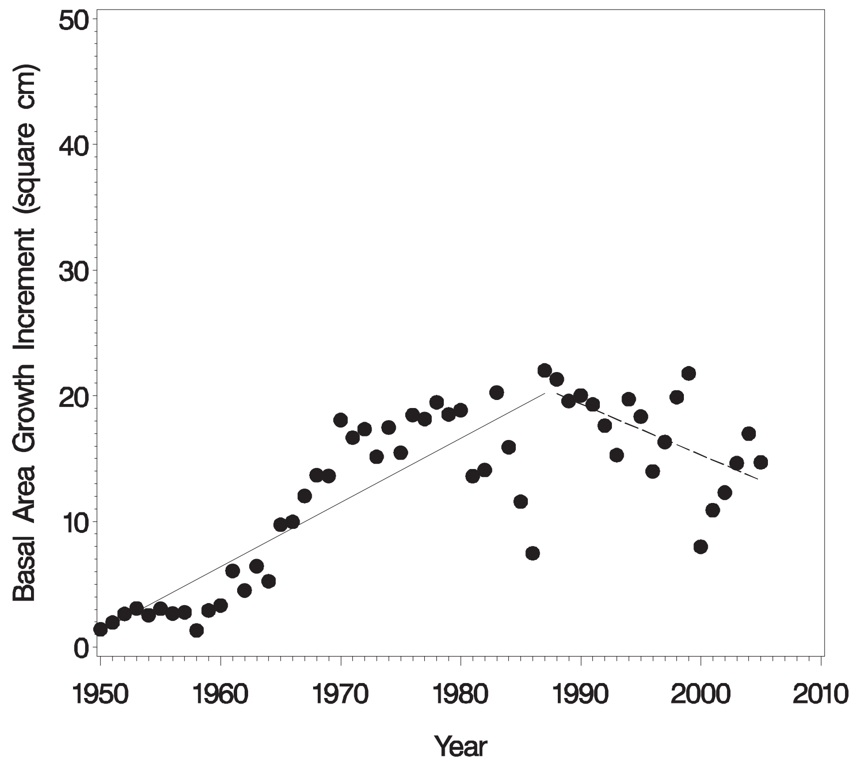

Tree ID = 13008_2_3
Response = No Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 17002_3_1
Response = No Decline Model= Piecewise Type= Initial
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010
Year

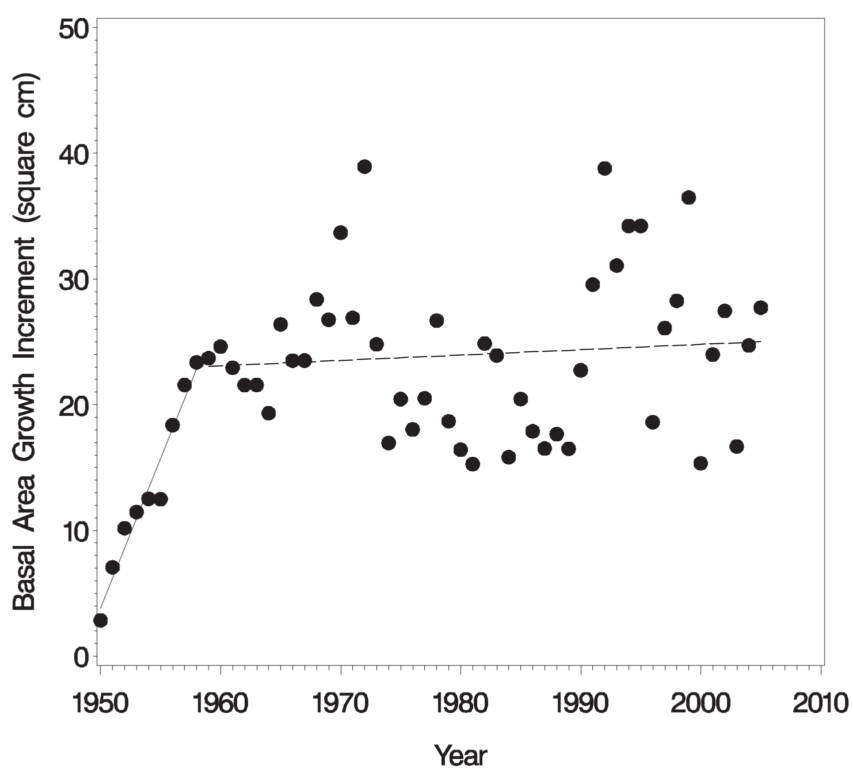

Tree ID = 28030_2_2
Response = No Decline Model = Piecewise Type = Initial
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = 28030_3_2
Response = No Decline Model = Piecewise Type = Initial
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

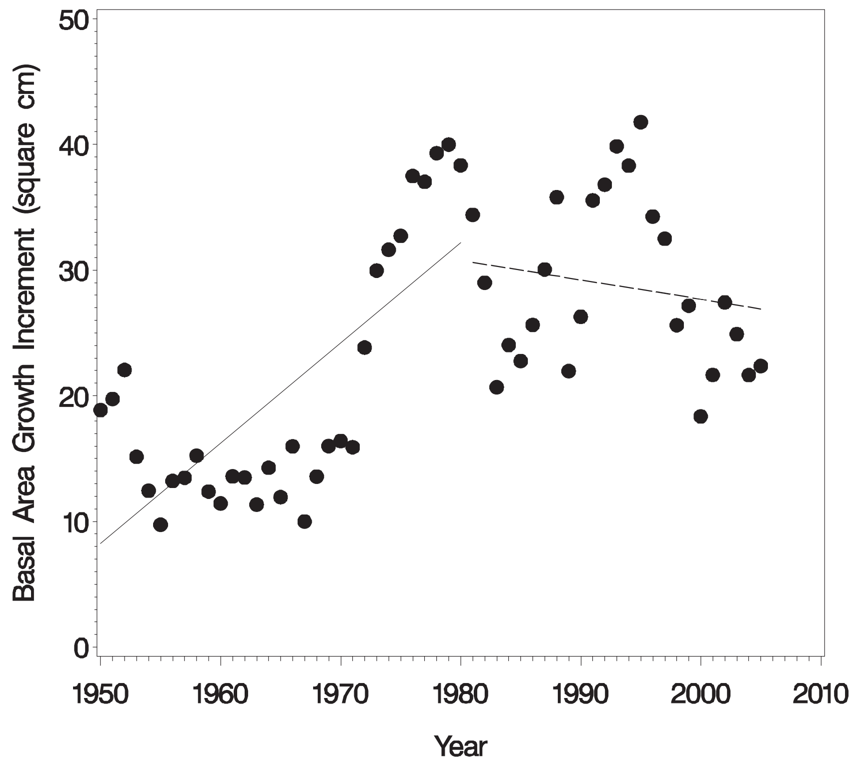
Tree ID = 28037_2_2
Response = No Decline Model= Piecewise Type= Initial



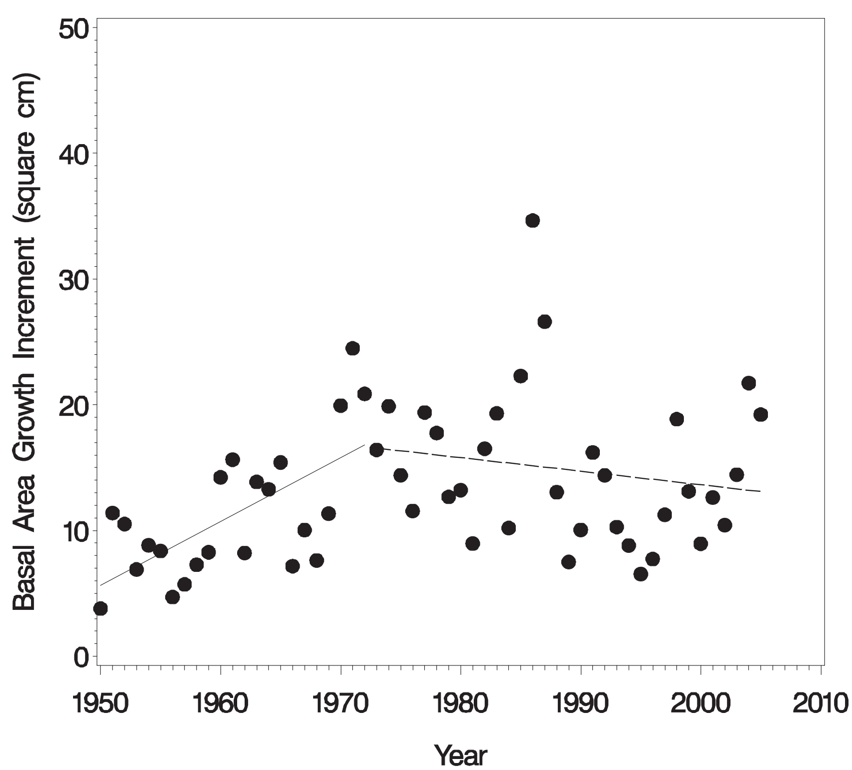
Tree ID = 35014_2_4
Response = No Decline Model= Piecewise Type= Initial

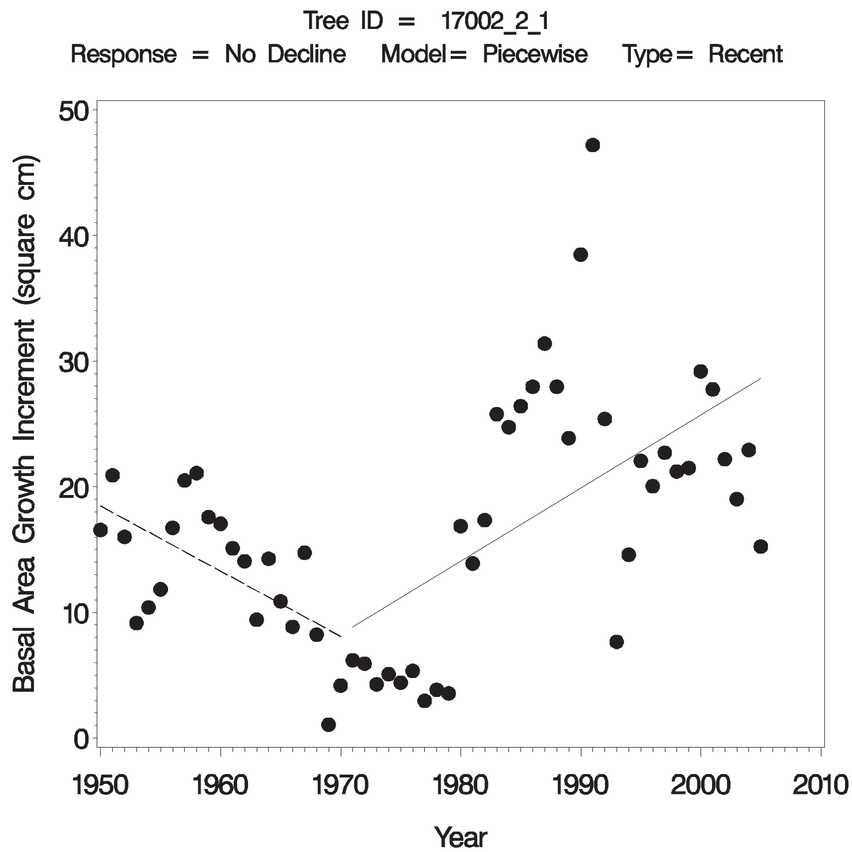


Tree ID = 7001_2_2
Response = No Decline Model= Piecewise Type= Initial

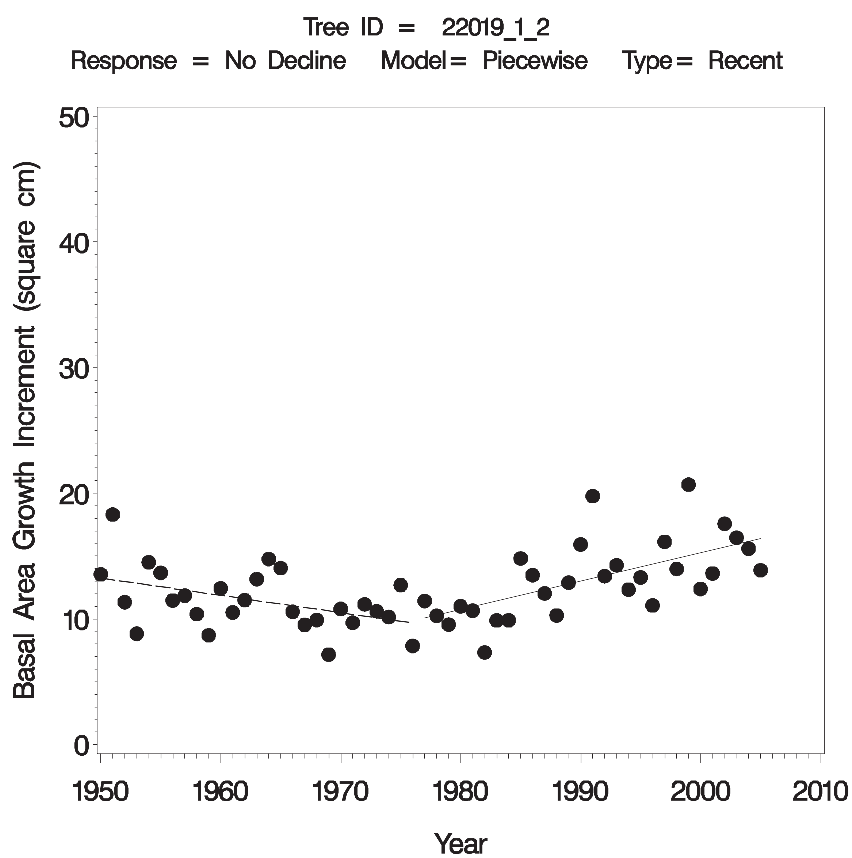


Tree ID = WF_2_2
Response = No Decline Model= Piecewise Type= Initial

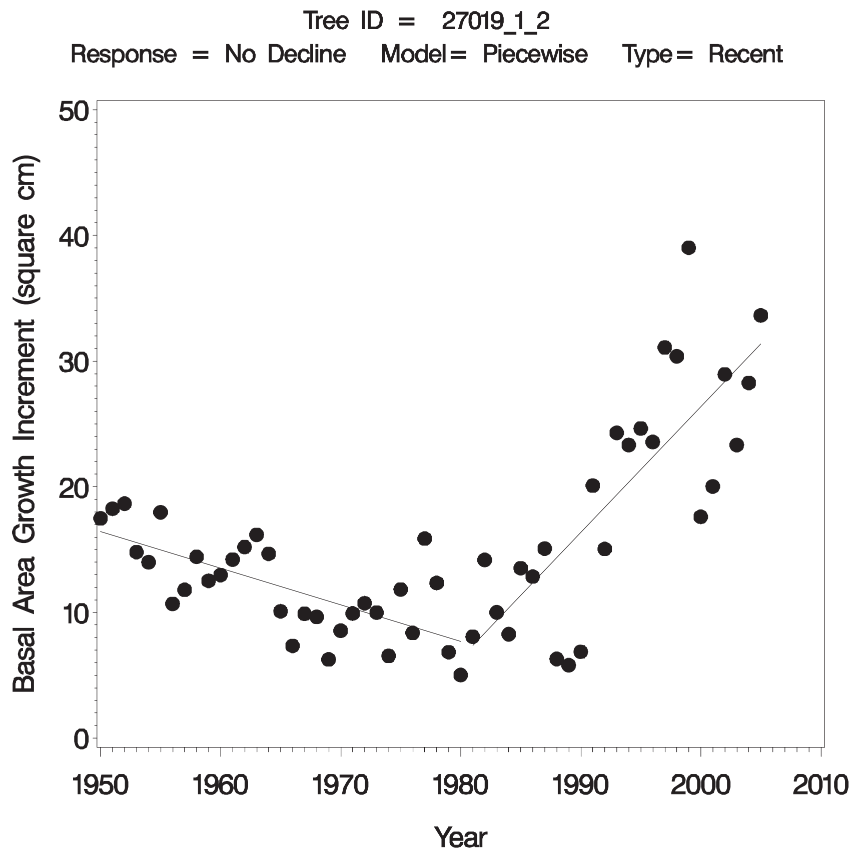


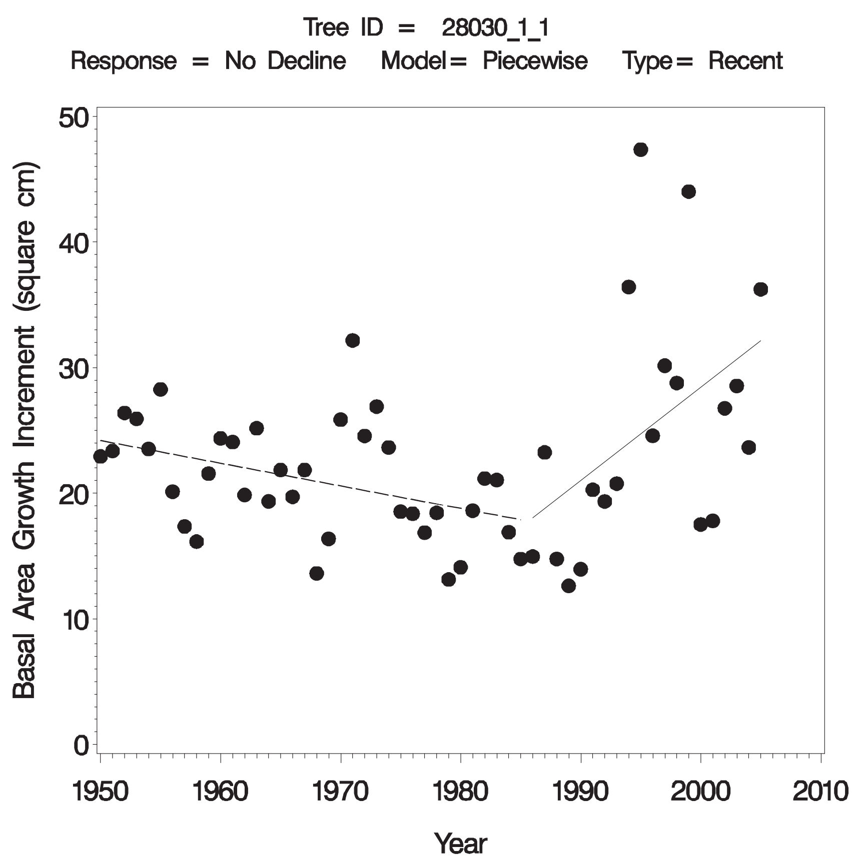


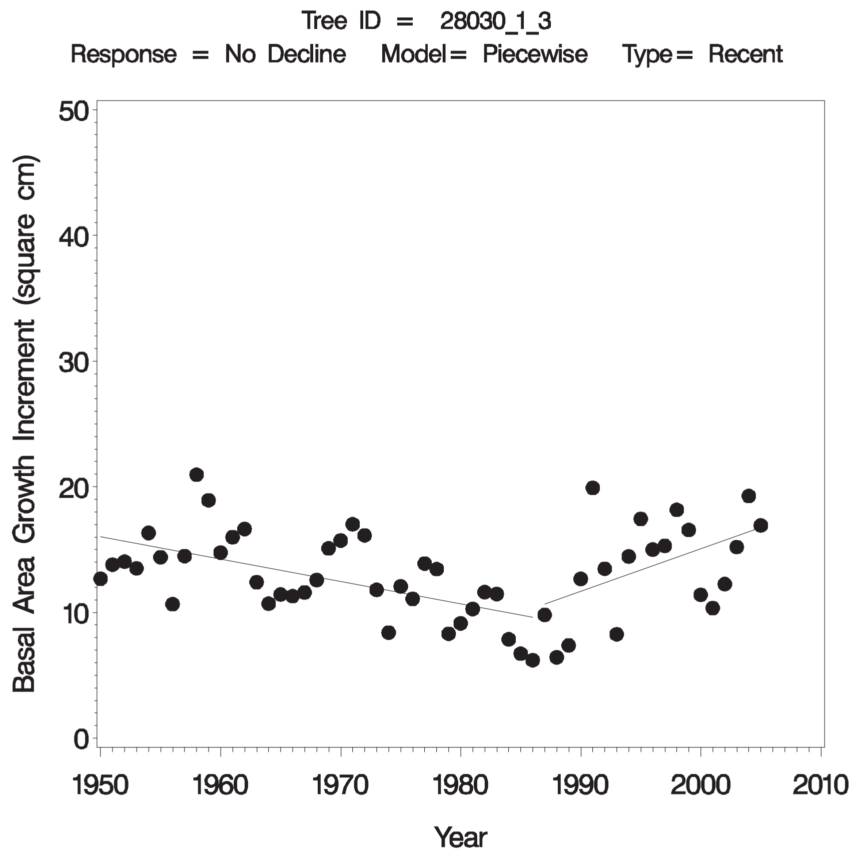
Tree ID = 17002_2_1
Response = No Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

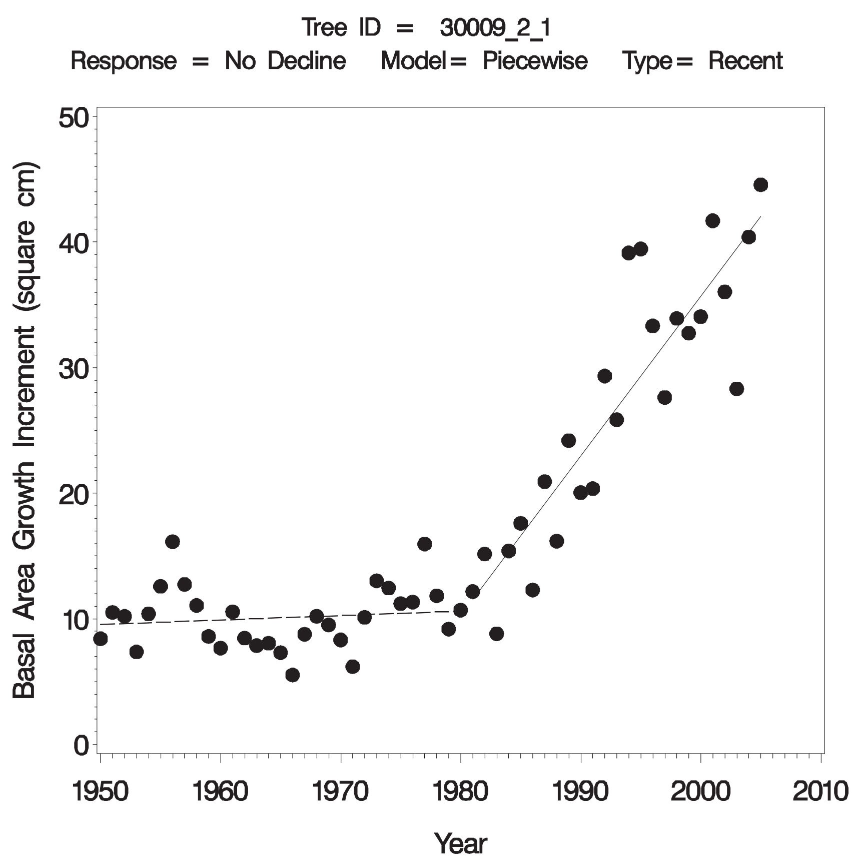


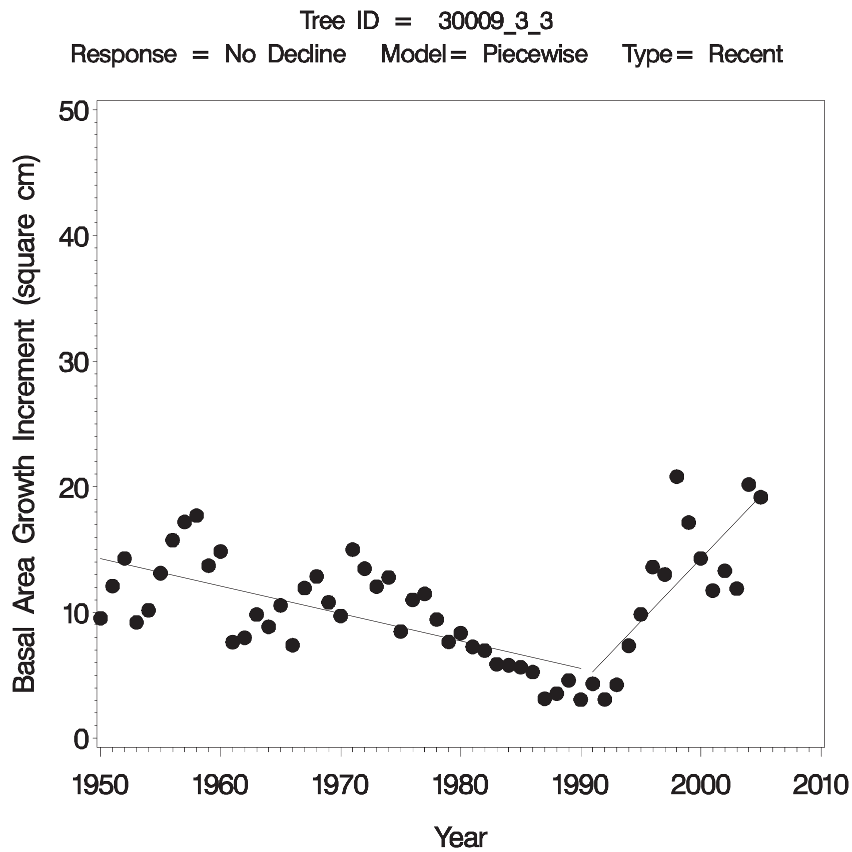
Tree ID = 22019_1_2
Response = No Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

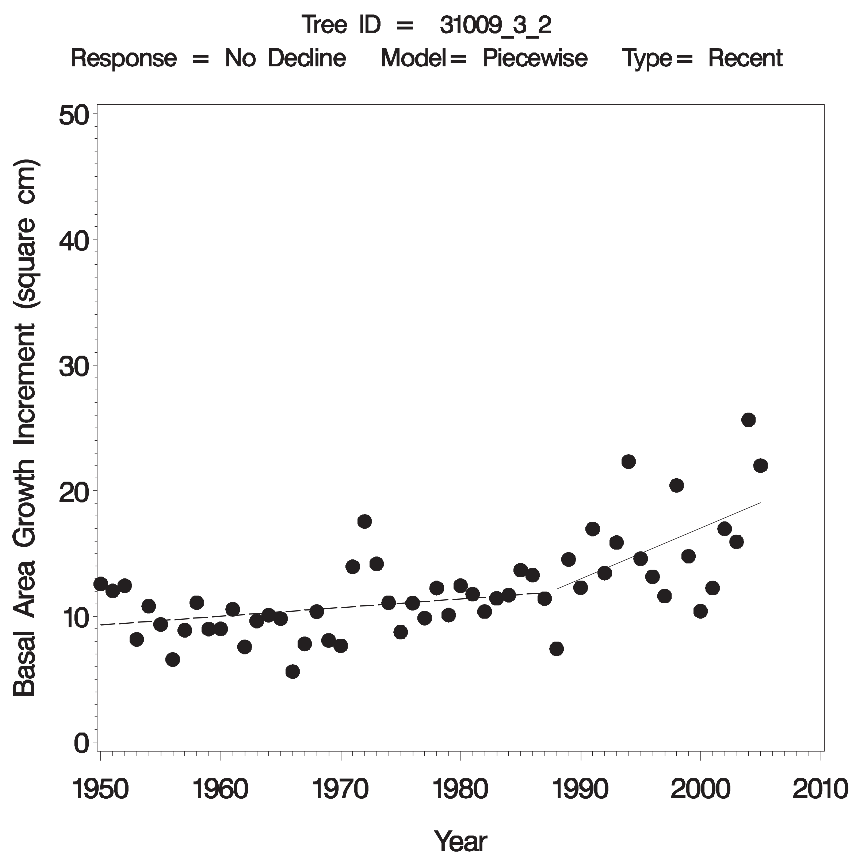

Tree ID = 27019_1_2
Response = No Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

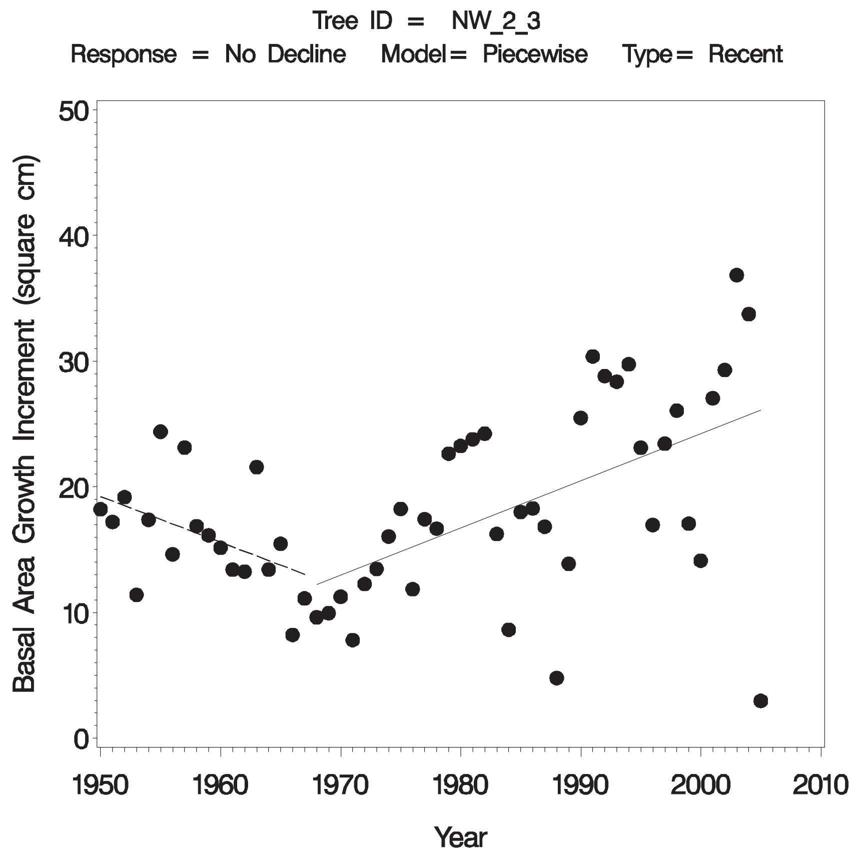

Tree ID = 28030_1_1
Response = No Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010

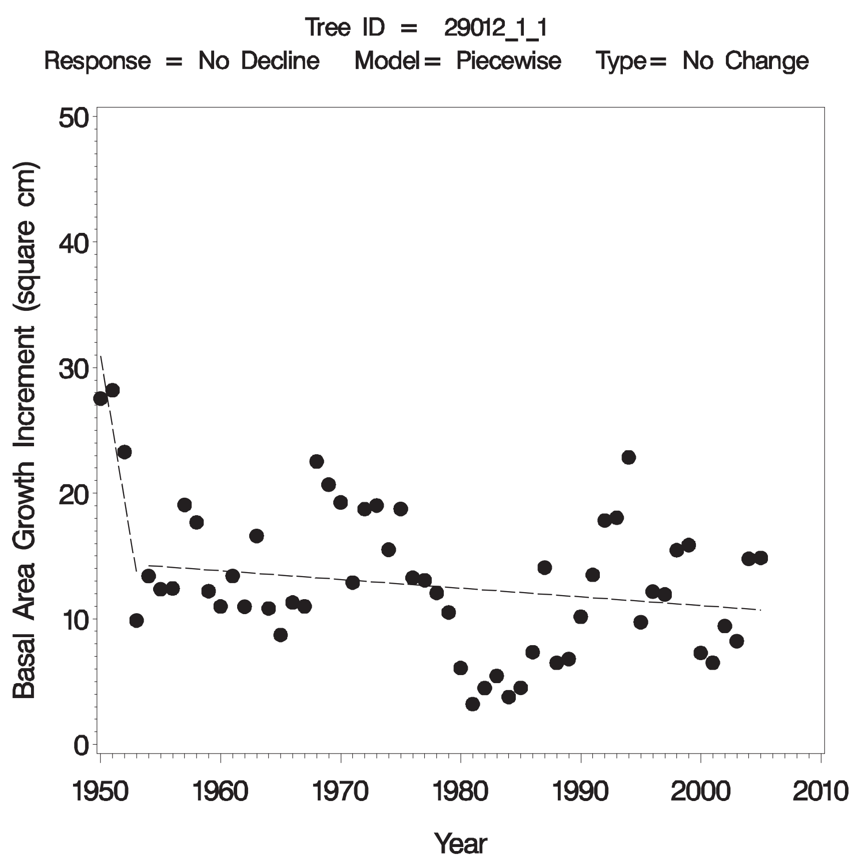

Tree ID = 28030_1_3
Response = No Decline Model = Piecewise Type = Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

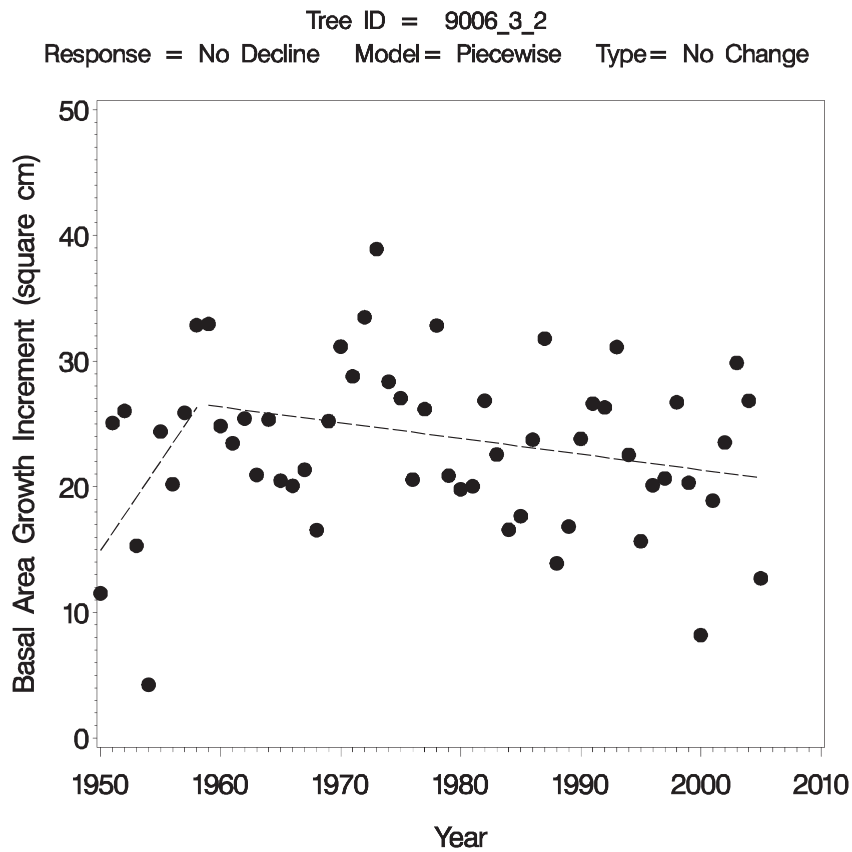

Tree ID = 30009_2_1
Response = No Decline Model = Piecewise Type = Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

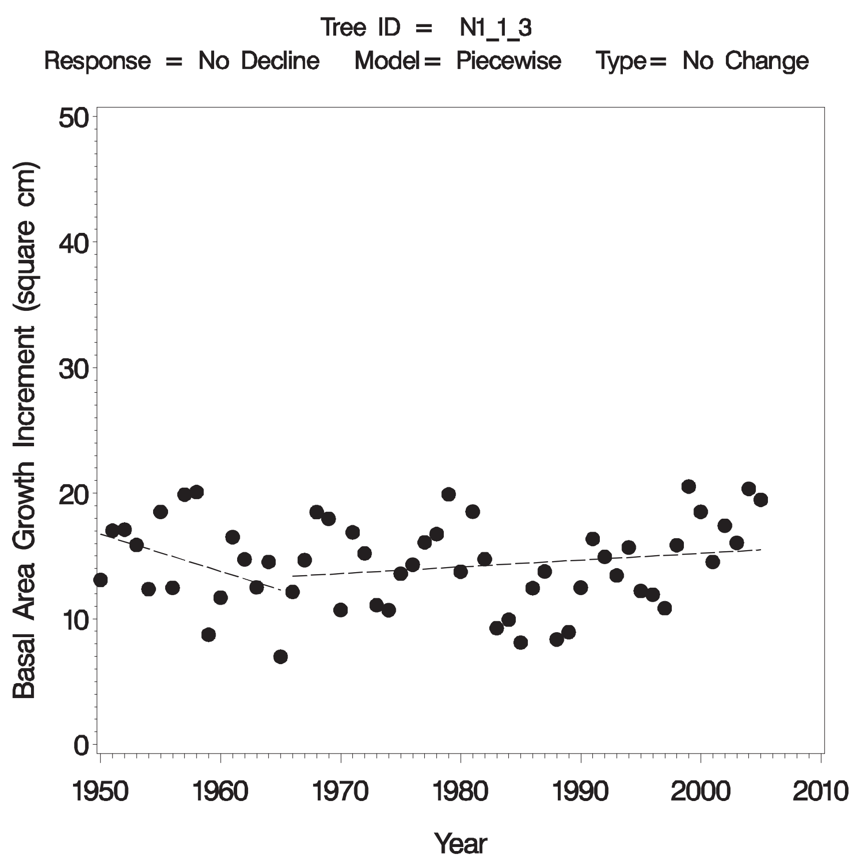

Tree ID = 30009_3_3
Response = No Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

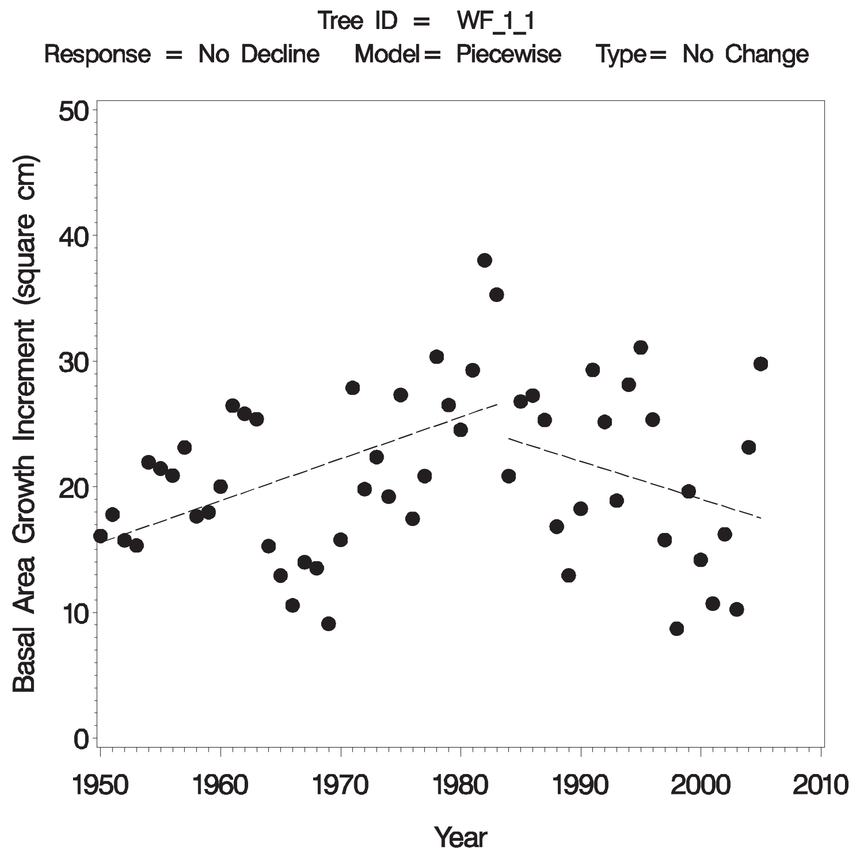

Tree ID = 31009_3_2
Response = No Decline Model= Piecewise Type= Recent
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

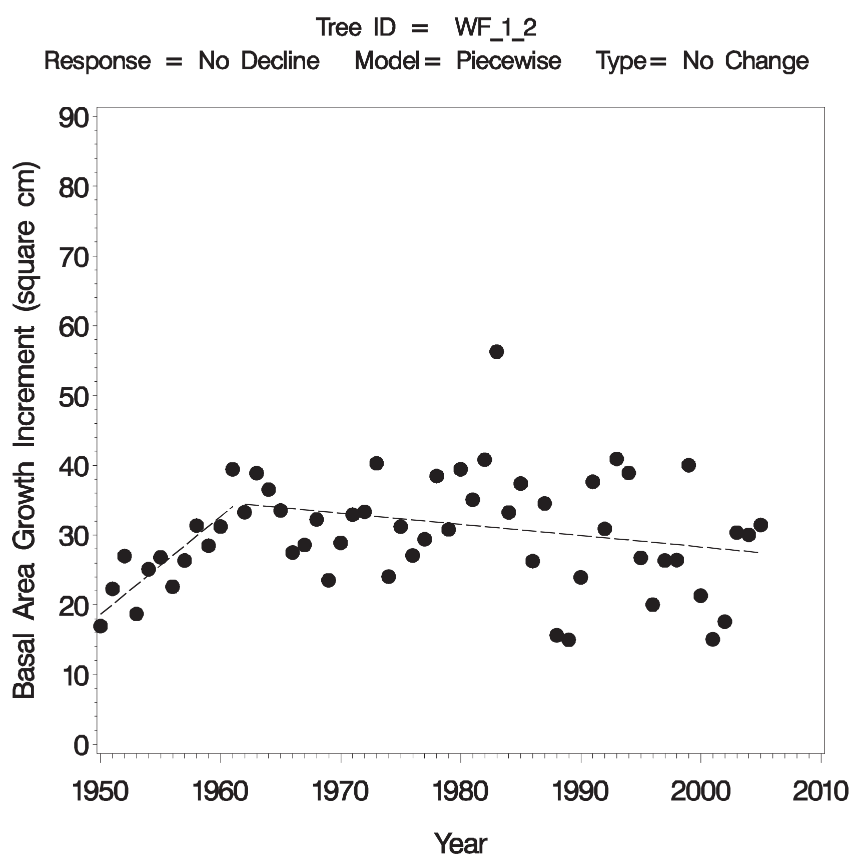

Tree ID = NW_2_3
Response = No Decline Model = Piecewise Type = Recent
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010


Tree ID = 29012_1_1
Response = No Decline Model = Piecewise Type = No Change
Basal Area Growth Increment (square cm)
Year
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010


Tree ID = 9006_3_2
Response = No Decline Model= Piecewise Type= No Change
Basal Area Growth Increment (square cm)
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year


Tree ID = N1_1_3
Response = No Decline Model= Piecewise Type= No Change
Basal Area Growth Increment (square cm)
50
40
30
20
10
0
1950
1960
1970
1980
1990
2000
2010
Year

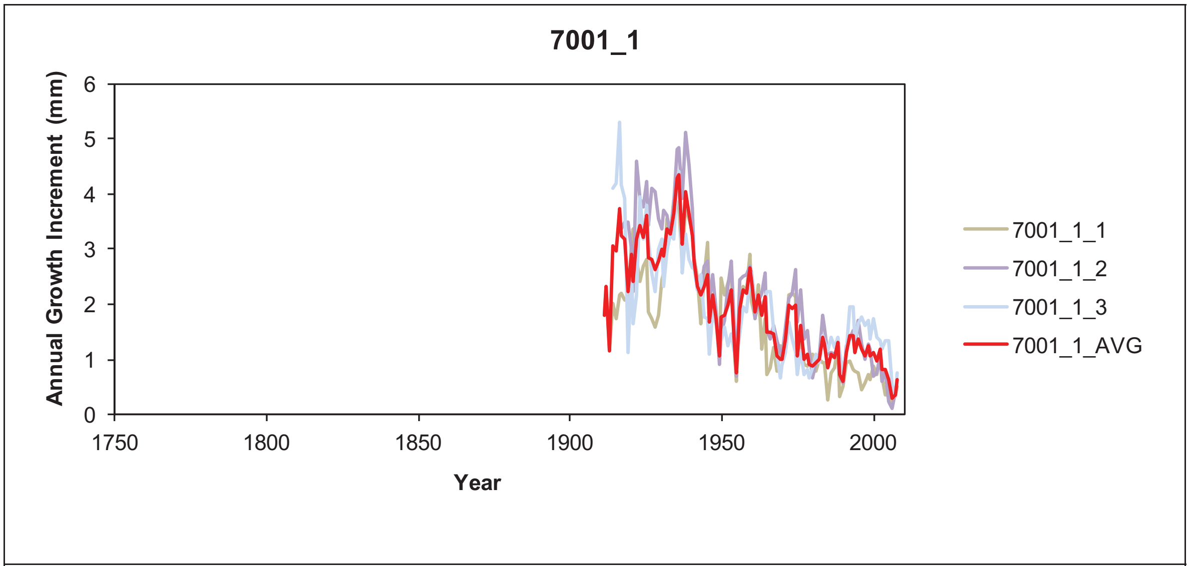

Tree ID = WF_1_1
Response = No Decline Model= Piecewise Type= No Change
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
1950
1960
1970
1980
1990
2000
2010
Year

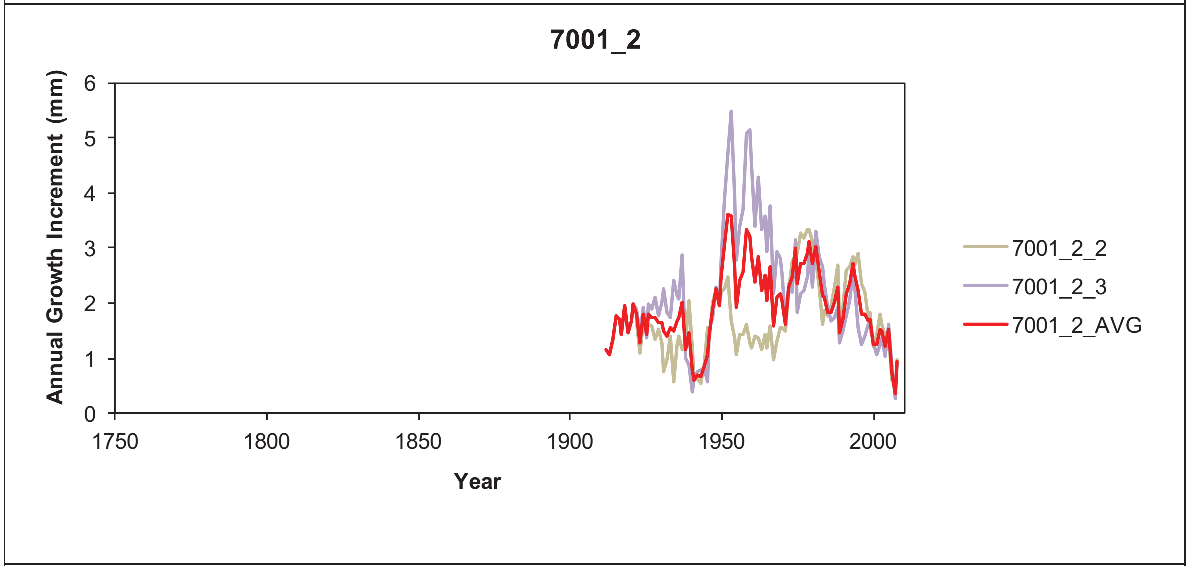

Tree ID = WF_1_2
Response = No Decline Model= Piecewise Type= No Change
Basal Area Growth Increment (square cm)
0
10
20
30
40
50
60
70
80
90
1950
1960
1970
1980
1990
2000
2010
Year

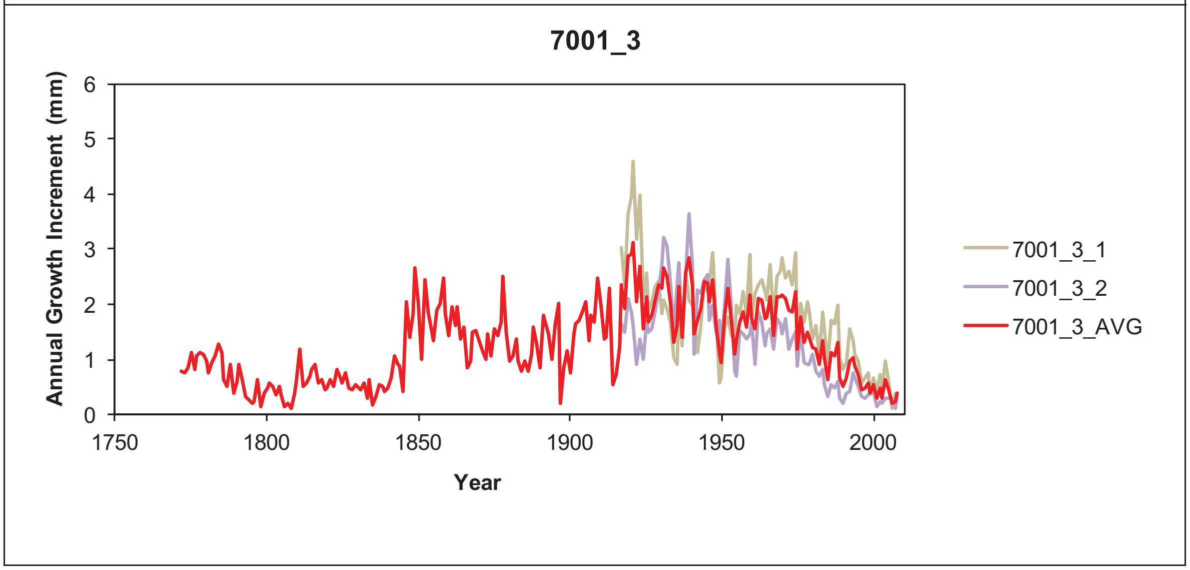
Appendix H

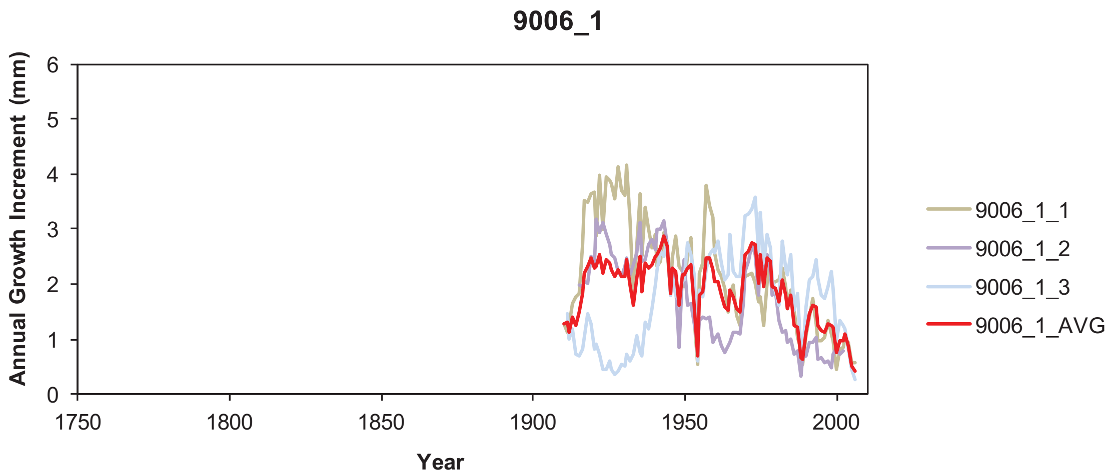
Charts showing the full set of dendrochronology for each cored tree on a given plot.

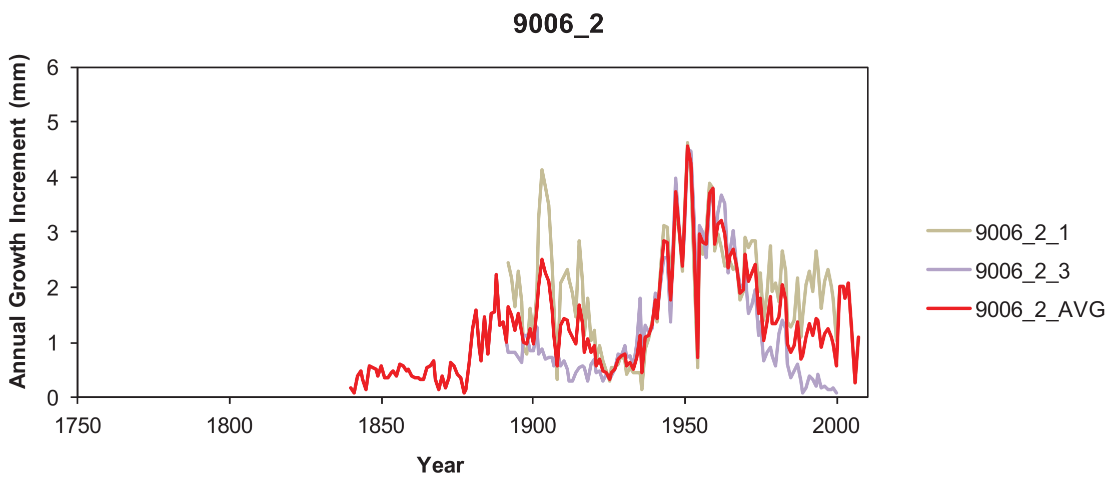
These charts show the full set of dendrochronology for each cored tree on a given plot. Most cored trees had data from two cores, which were averaged. Growth data from individual trees are shown as annual increments (mm). The average of all trees on a plot is shown (red line).

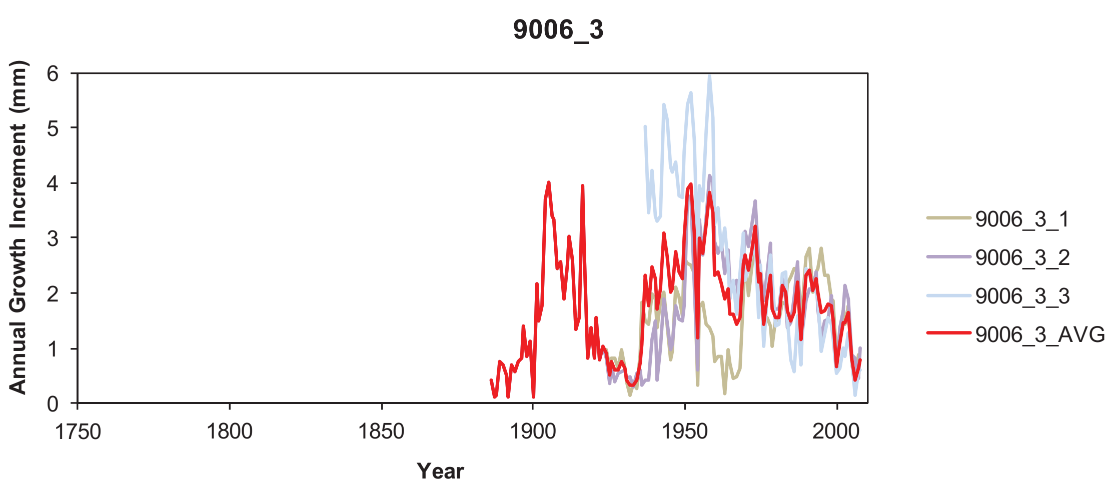

7001_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
7001_1_1
7001_1_2
7001_1_3
7001_1_AVG

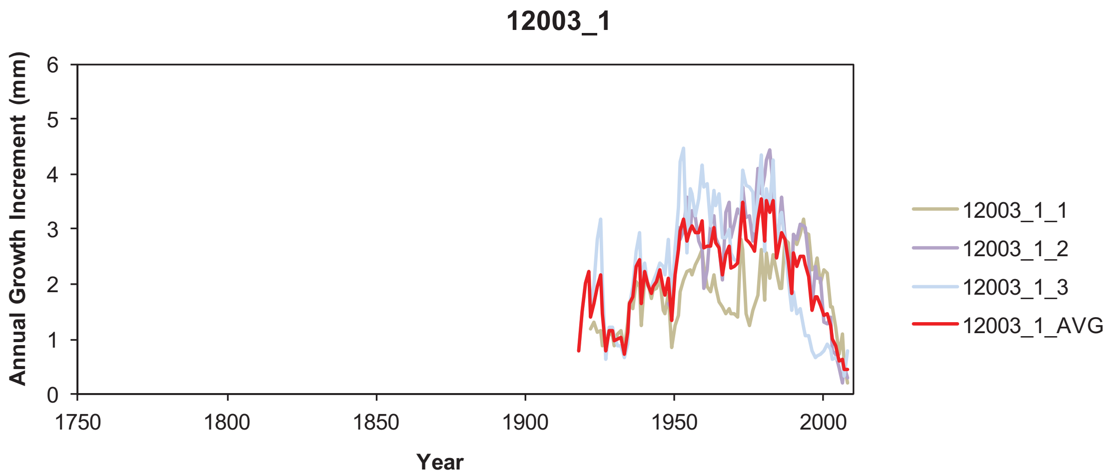

7001_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
7001_2_2
7001_2_3
7001_2_AVG

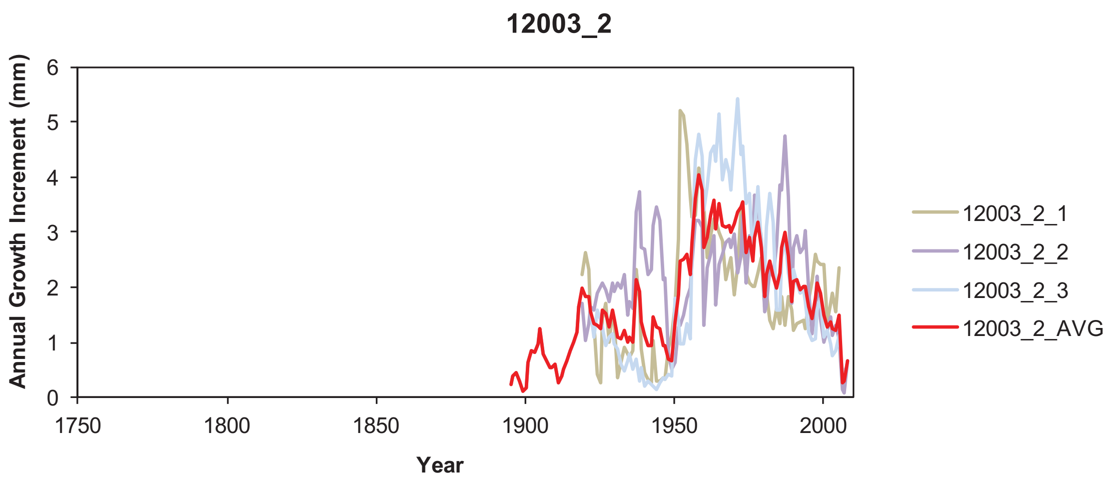

7001_3
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
7001_3_1
7001_3_2
7001_3_AVG

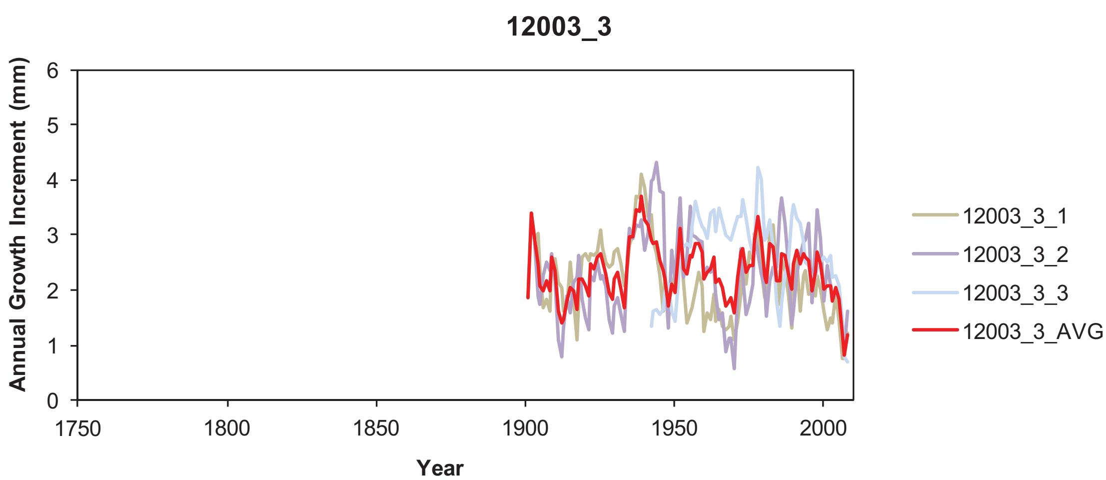

9006_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
9006_1_1
9006_1_2
9006_1_3
9006_1_AVG

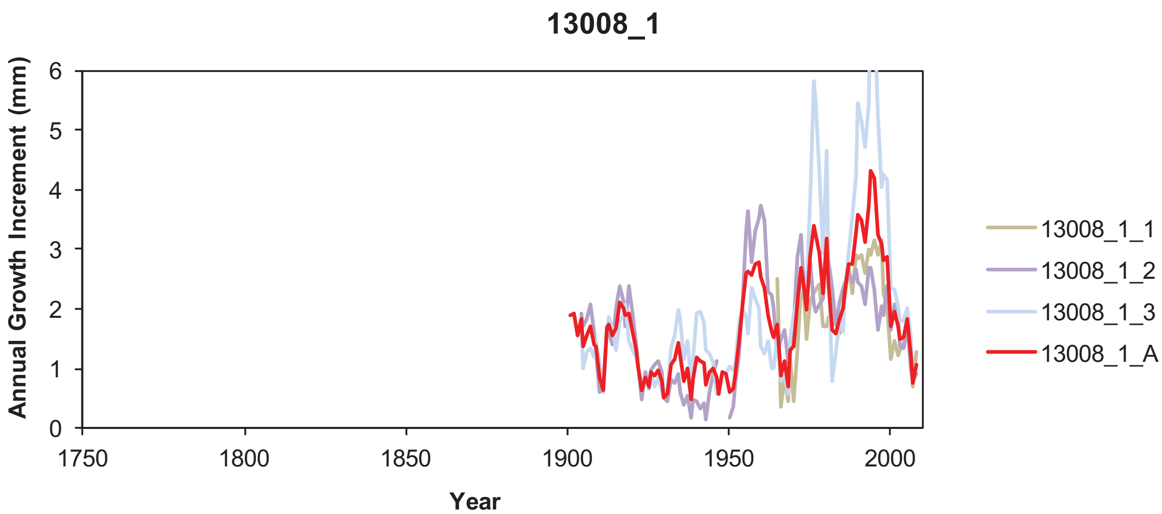

9006_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
9006_2_1
9006_2_3
9006_2_AVG

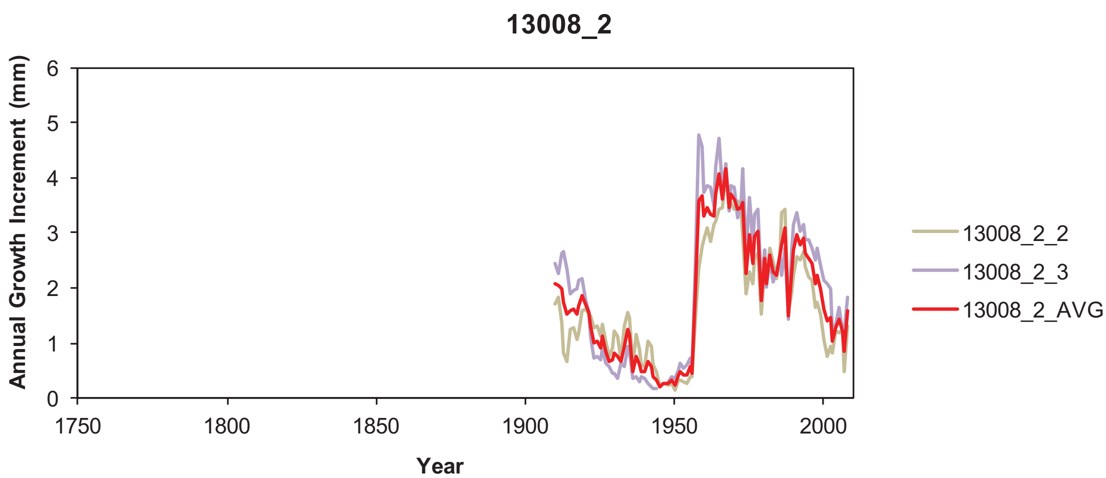

9006_3
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
9006_3_1
9006_3_2
9006_3_3
9006_3_AVG

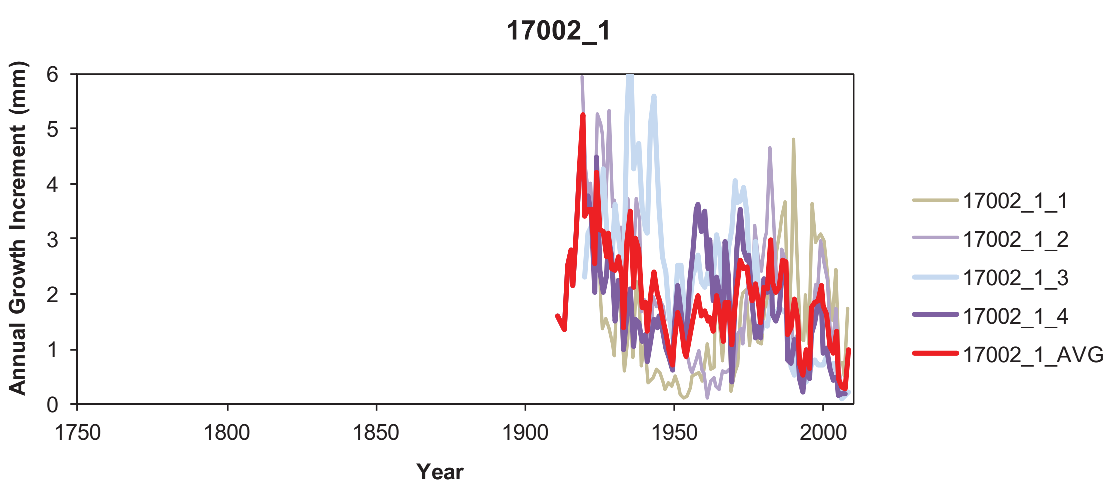

12003_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
12003_1_1
12003_1_2
12003_1_3
12003_1_AVG

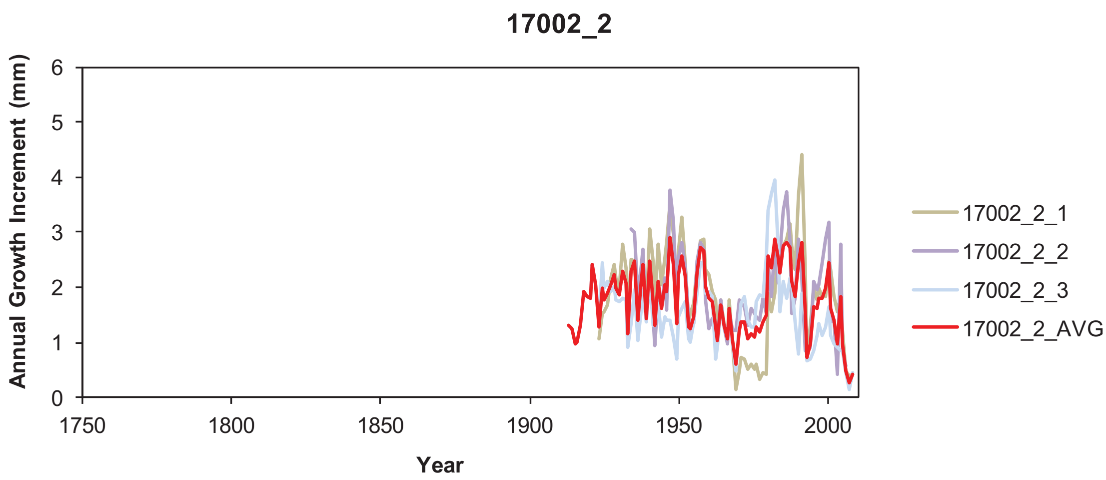

12003_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
12003_2_1
12003_2_2
12003_2_3
12003_2_AVG

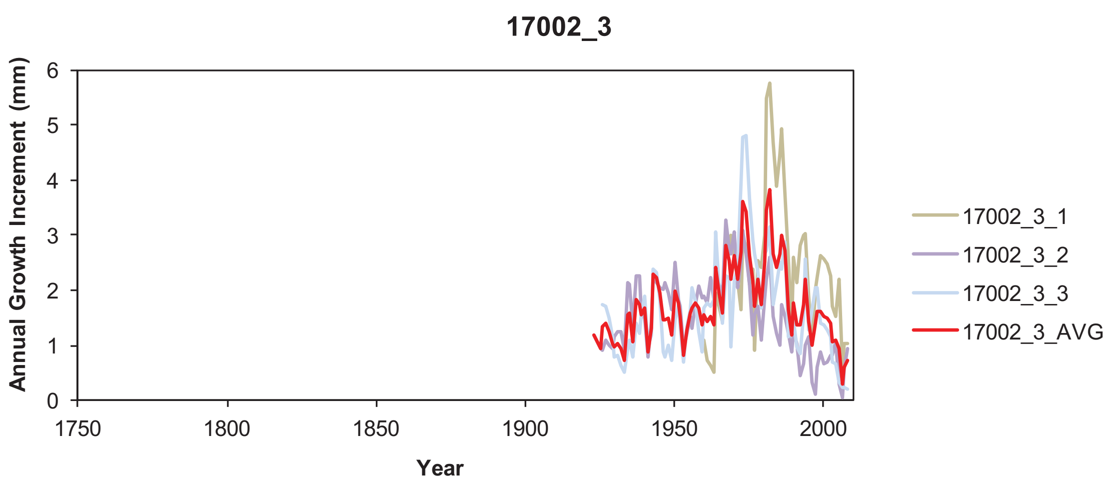

12003_3
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
12003_3_1
12003_3_2
12003_3_3
12003_3_AVG

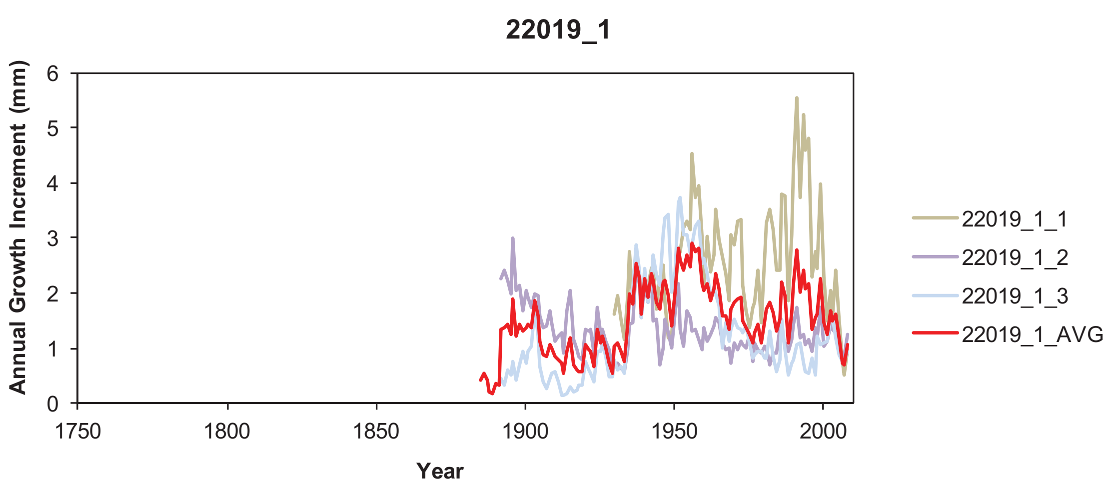

13008_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
13008_1_1
13008_1_2
13008_1_3
13008_1_A

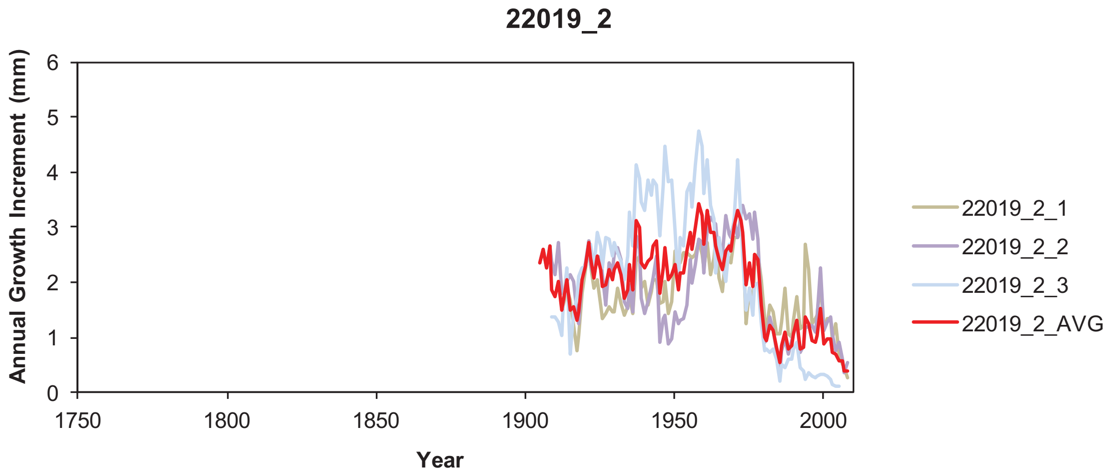

13008_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
13008_2_2
13008_2_3
13008_2_AVG

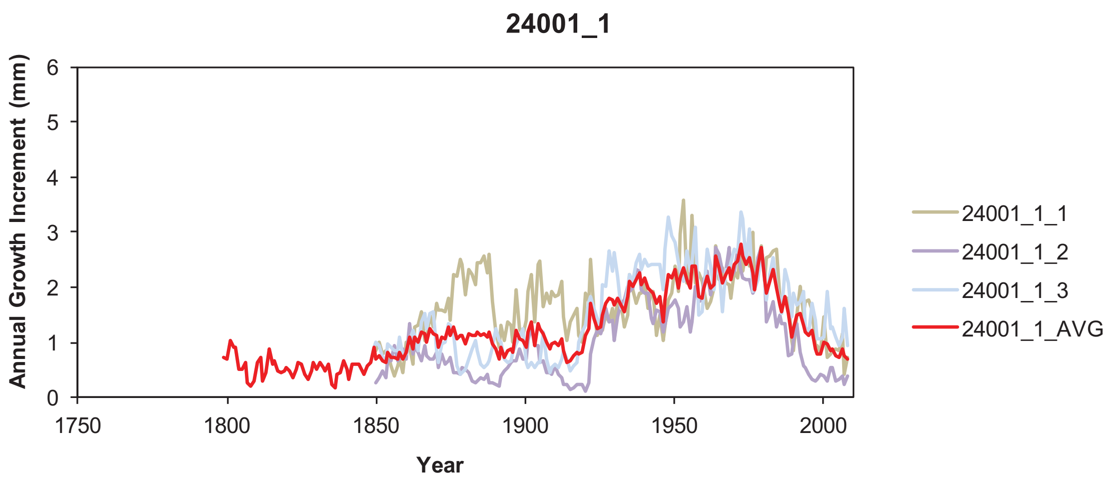

17002_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
17002_1_1
17002_1_2
17002_1_3
17002_1_4
17002_1_AVG

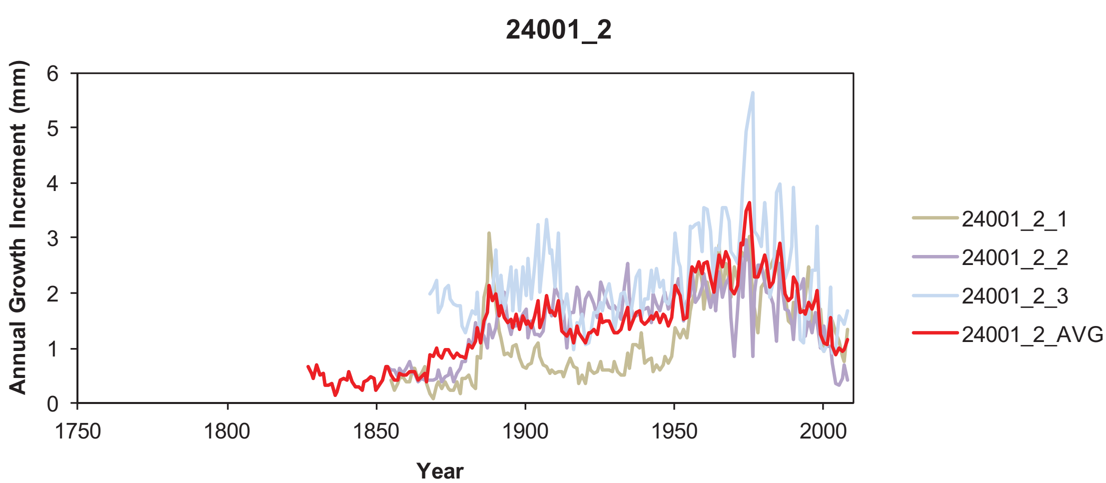

17002_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
17002_2_1
17002_2_2
17002_2_3
17002_2_AVG

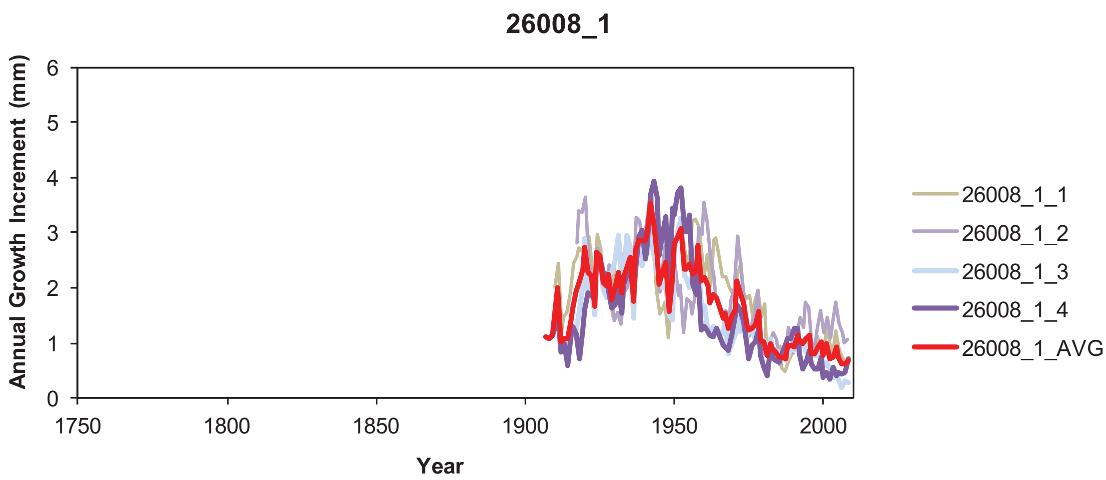

17002_3
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
17002_3_1
17002_3_2
17002_3_3
17002_3_AVG

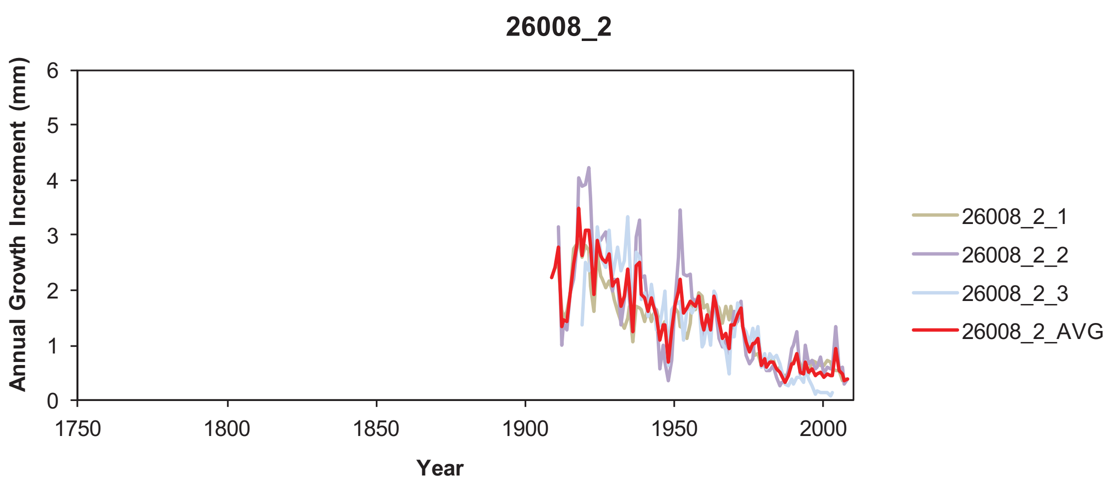

22019_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
22019_1_1
22019_1_2
22019_1_3
22019_1_AVG

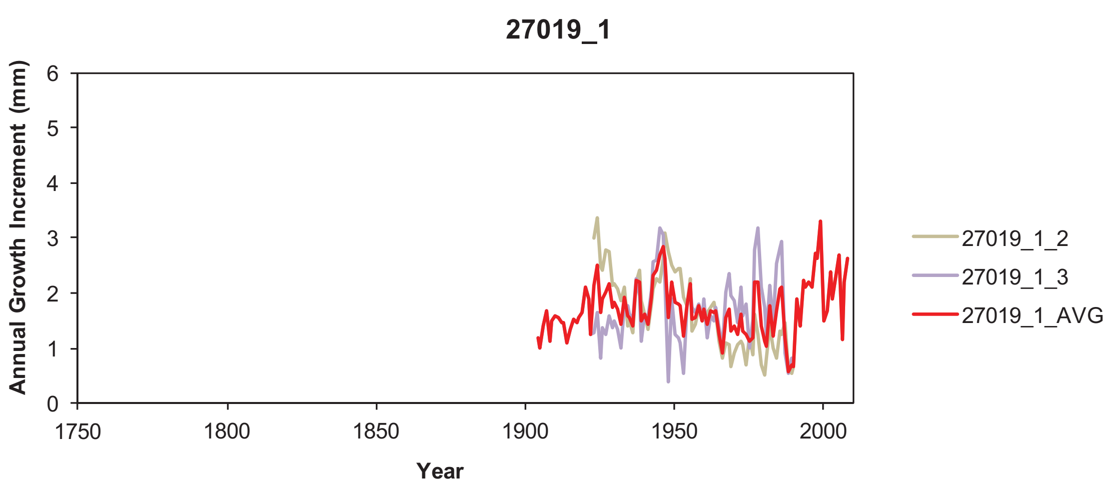

22019_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
22019_2_1
22019_2_2
22019_2_3
22019_2_AVG

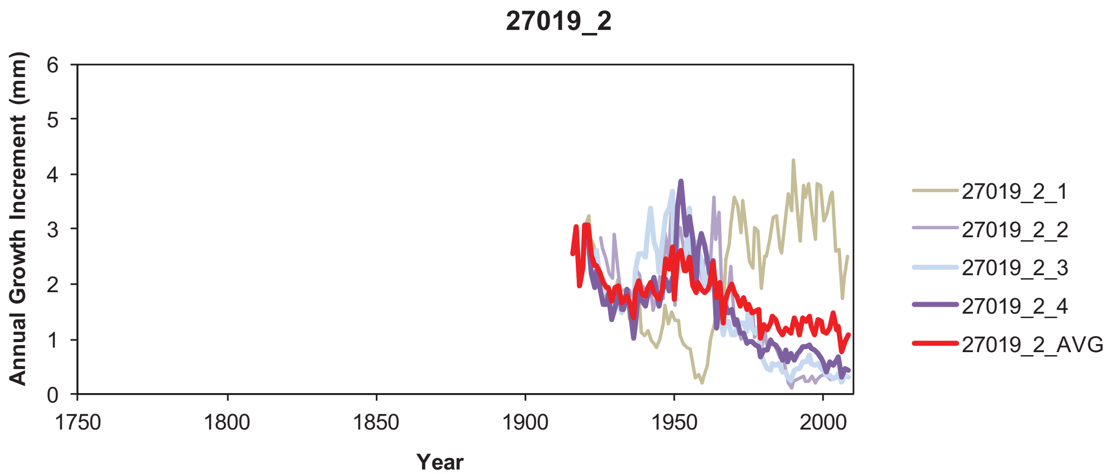

24001_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
24001_1_1
24001_1_2
24001_1_3
24001_1_AVG

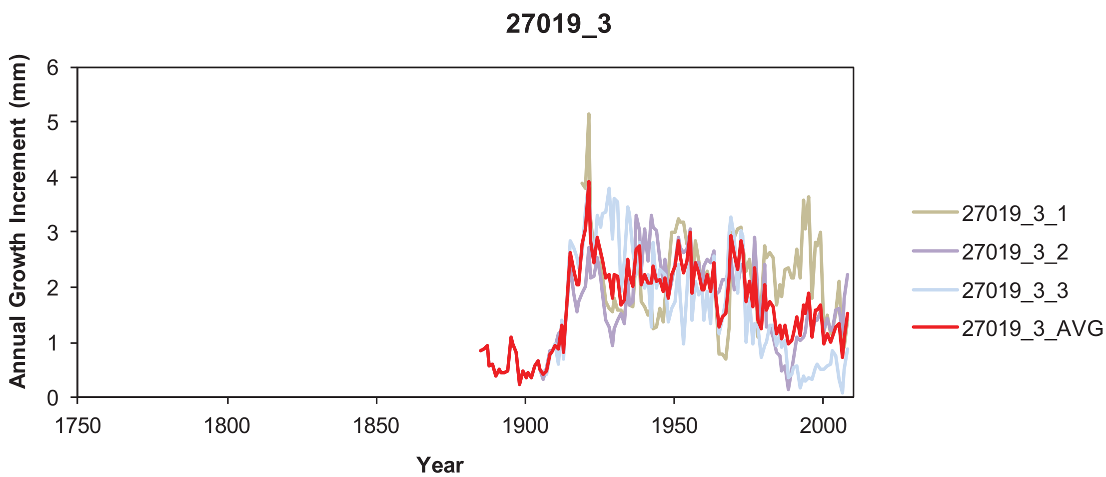

24001_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
24001_2_1
24001_2_2
24001_2_3
24001_2_AVG

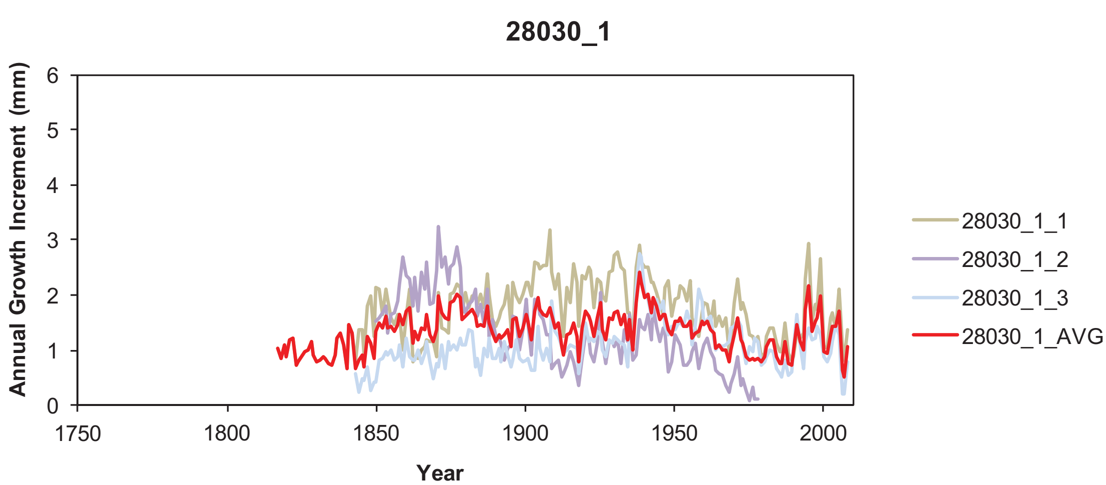

26008_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
26008_1_1
26008_1_2
26008_1_3
26008_1_4
26008_1_AVG

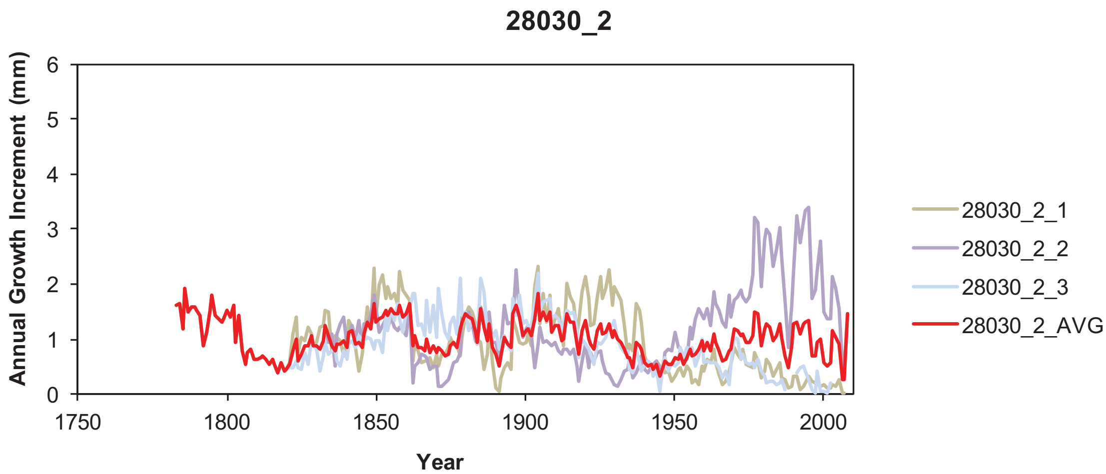

26008_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
26008_2_1
26008_2_2
26008_2_3
26008_2_AVG

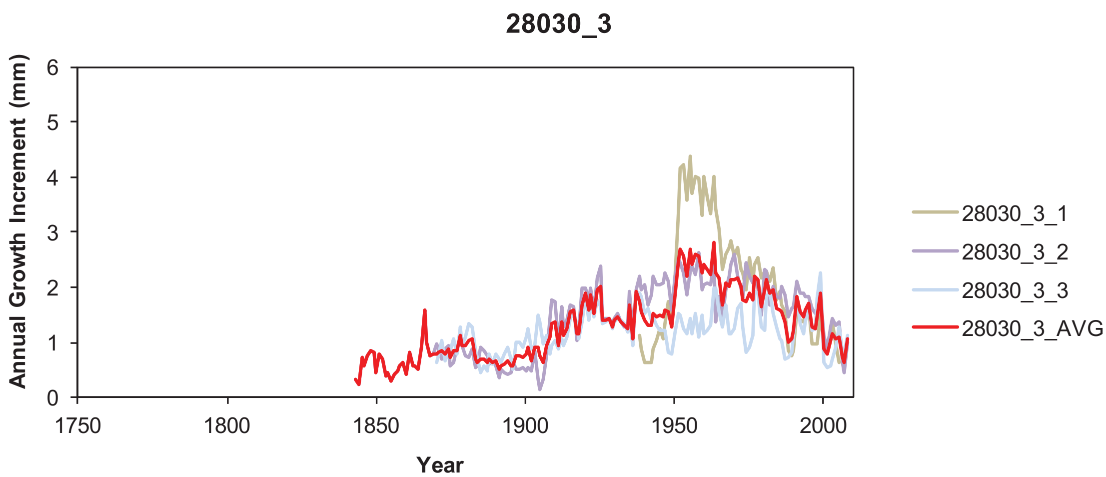

27019_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
27019_1_2
27019_1_3
27019_1_AVG

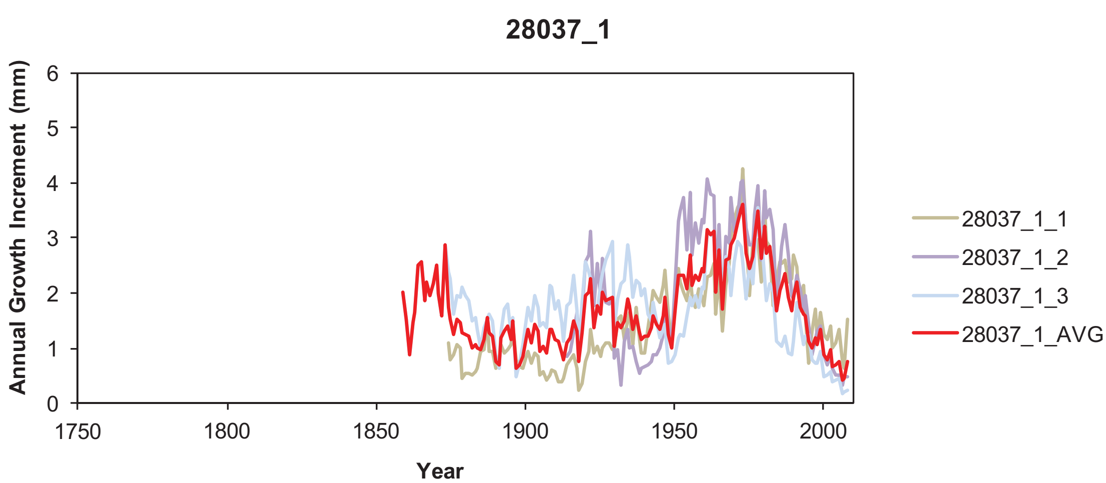

27019_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
27019_2_1
27019_2_2
27019_2_3
27019_2_4
27019_2_AVG

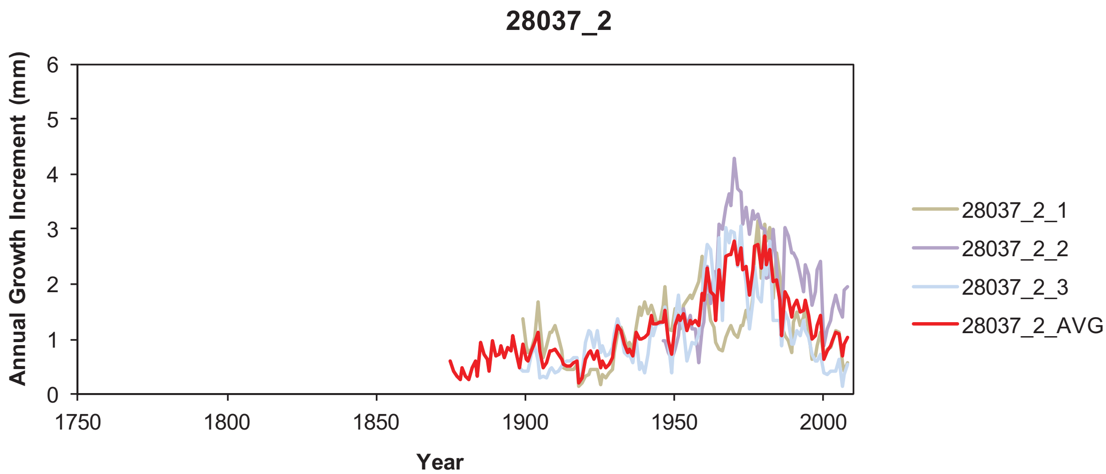

27019_3
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
27019_3_1
27019_3_2
27019_3_3
27019_3_AVG

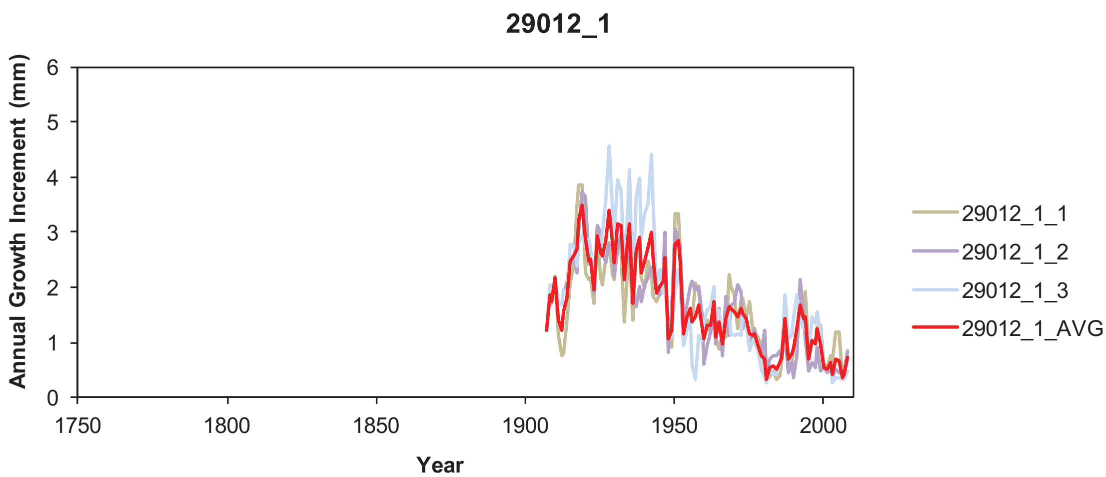

28030_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
28030_1_1
28030_1_2
28030_1_3
28030_1_AVG

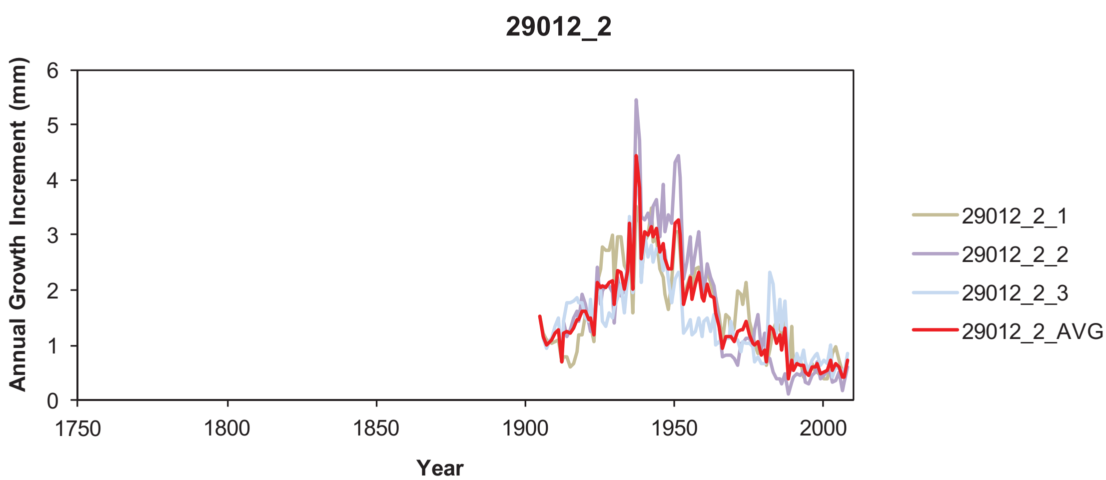

28030_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
28030_2_1
28030_2_2
28030_2_3
28030_2_AVG

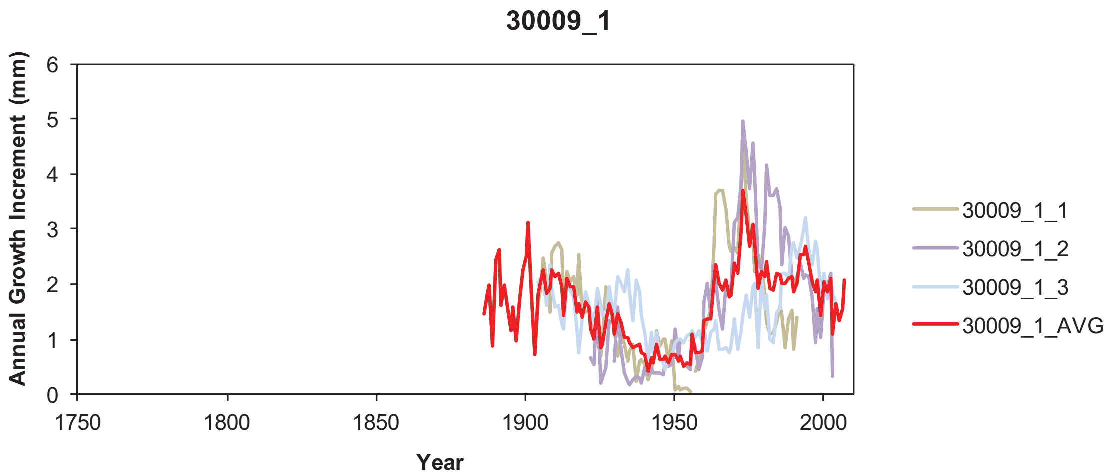

28030_3
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
28030_3_1
28030_3_2
28030_3_3
28030_3_AVG

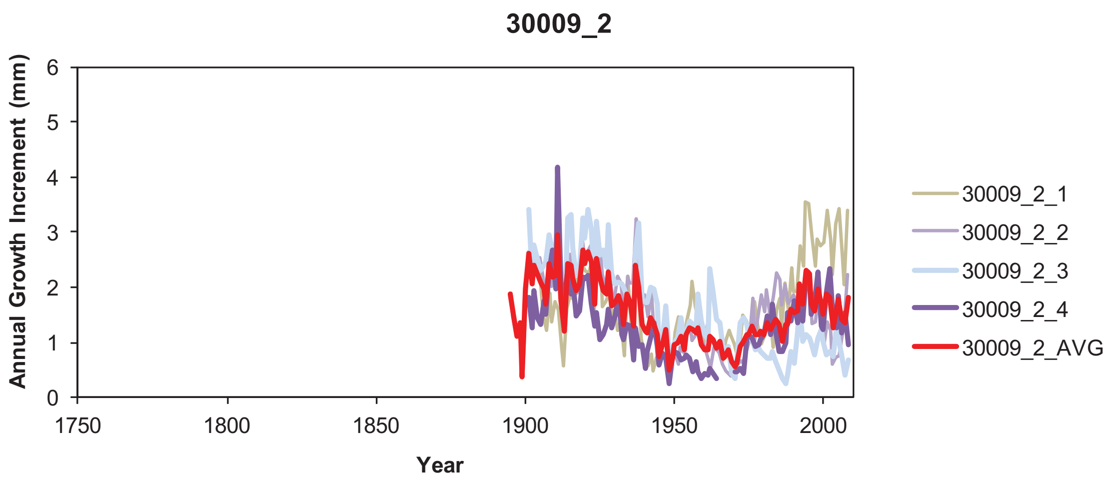

28037_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
28037_1_1
28037_1_2
28037_1_3
28037_1_AVG

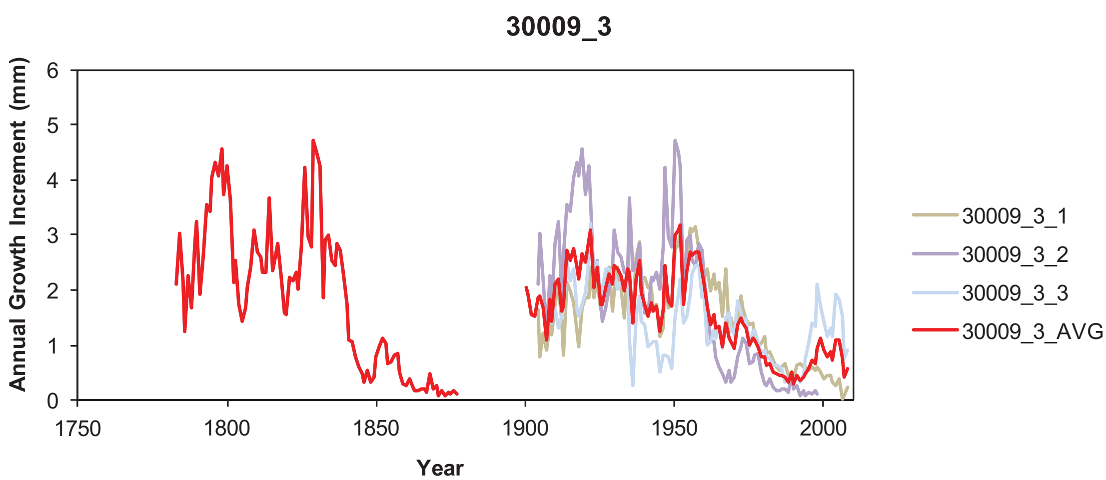

28037_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
28037_2_1
28037_2_2
28037_2_3
28037_2_AVG

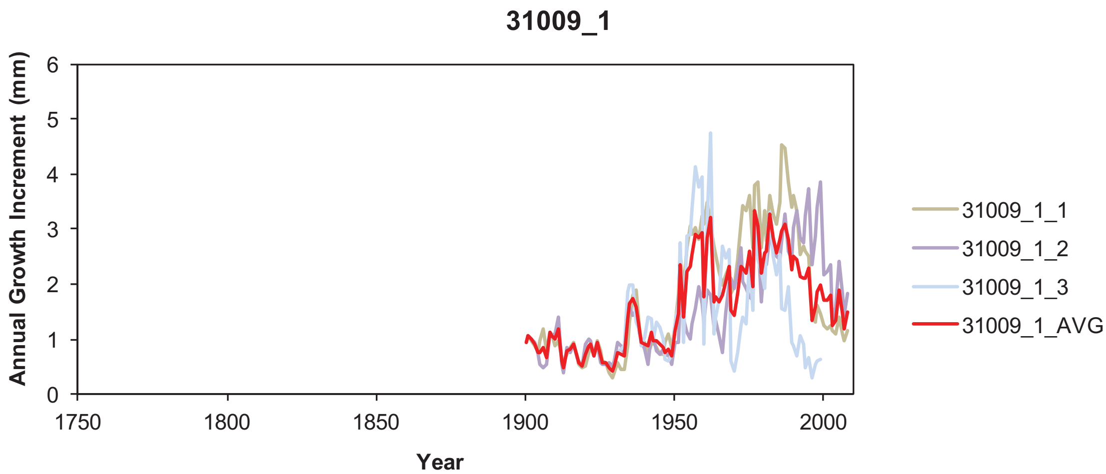

29012_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
29012_1_1
29012_1_2
29012_1_3
29012_1_AVG

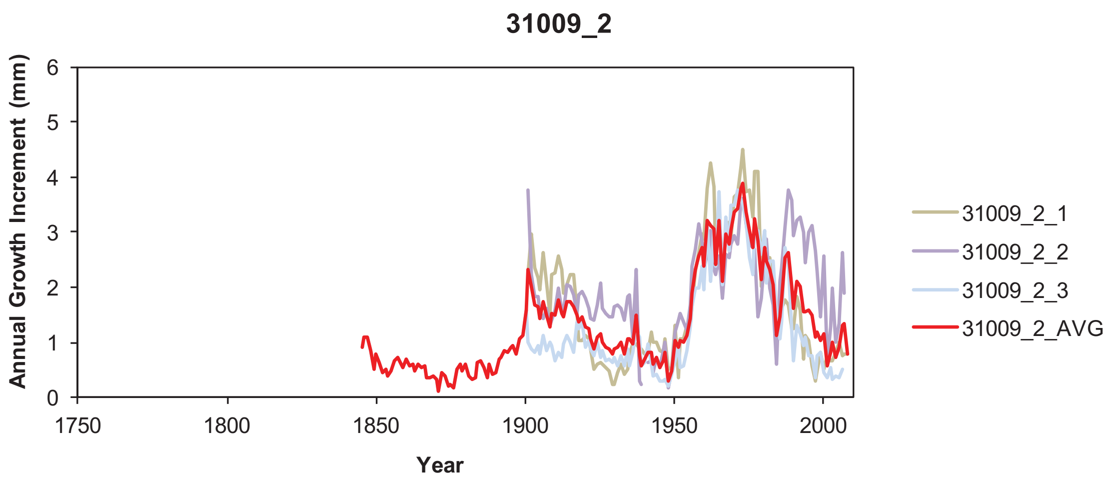

29012_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
29012_2_1
29012_2_2
29012_2_3
29012_2_AVG

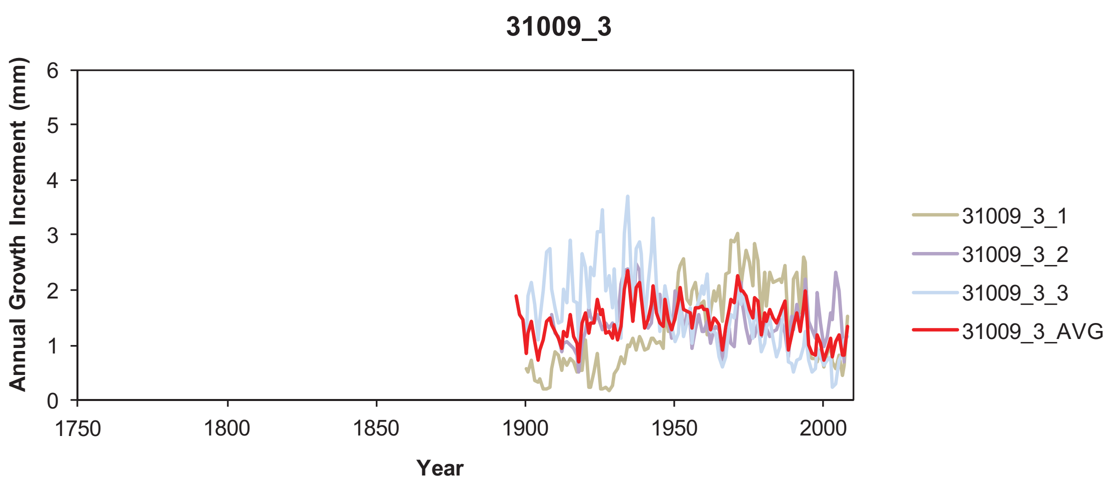

30009_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
30009_1_1
30009_1_2
30009_1_3
30009_1_AVG

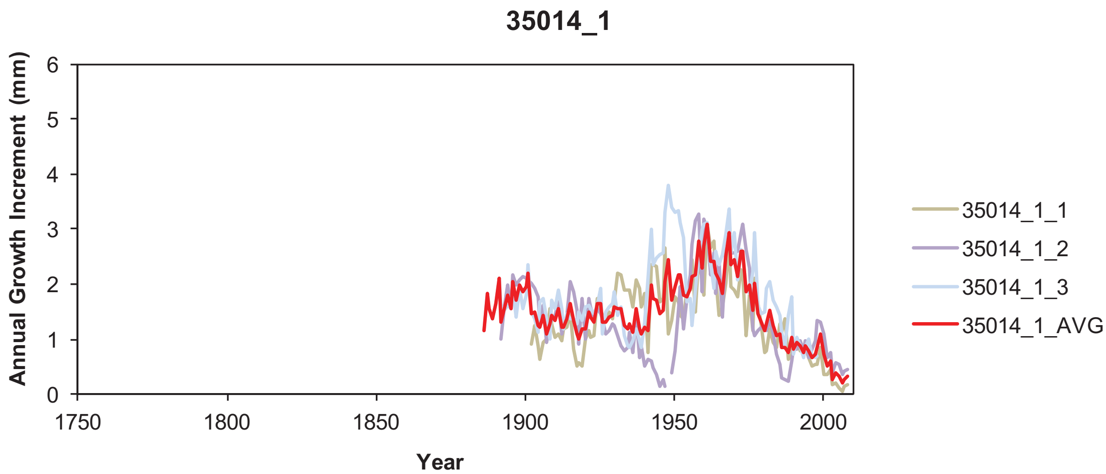

30009_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
30009_2_1
30009_2_2
30009_2_3
30009_2_4
30009_2_AVG


30009_3
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
30009_3_1
30009_3_2
30009_3_3
30009_3_AVG

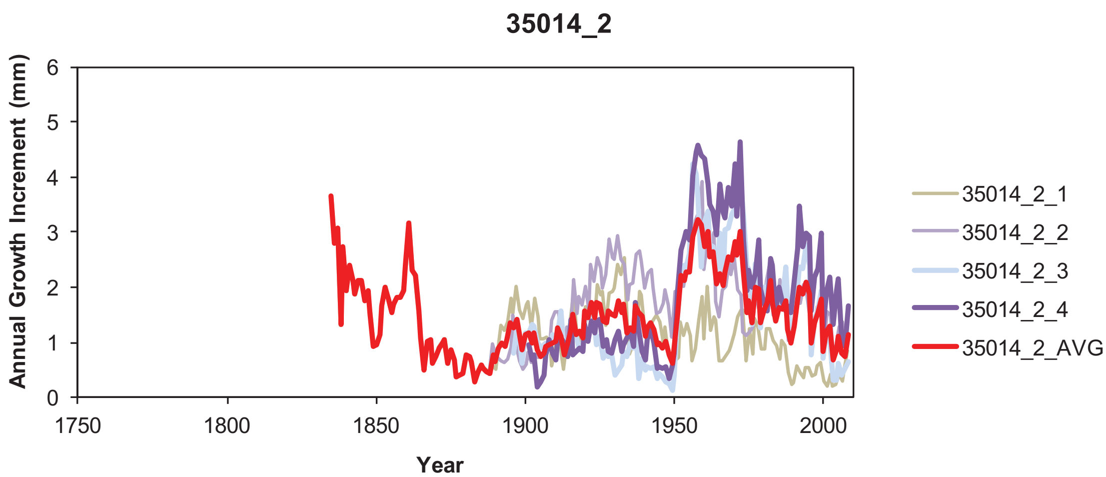

31009_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
31009_1_1
31009_1_2
31009_1_3
31009_1_AVG


31009_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
31009_2_1
31009_2_2
31009_2_3
31009_2_AVG

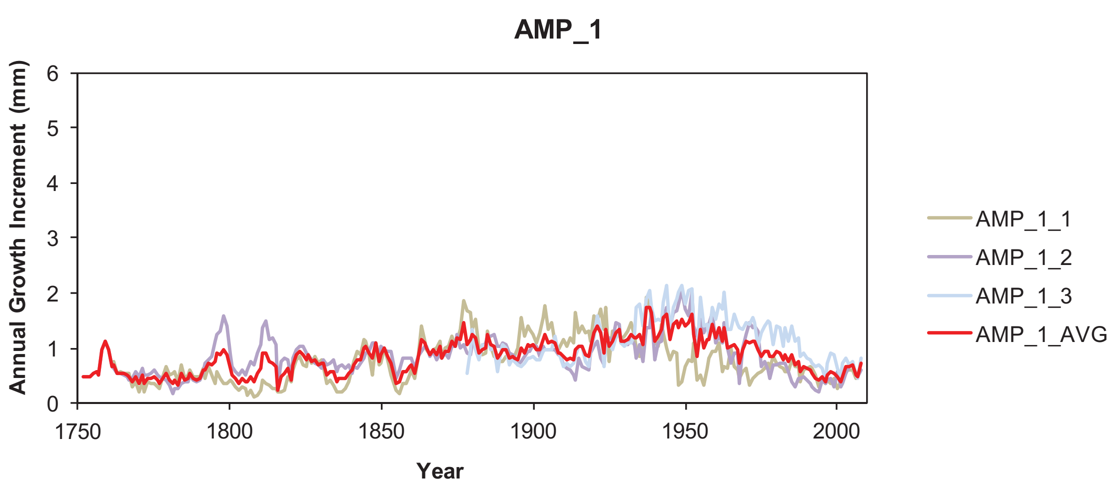

31009_3
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
31009_3_1
31009_3_2
31009_3_3
31009_3_AVG



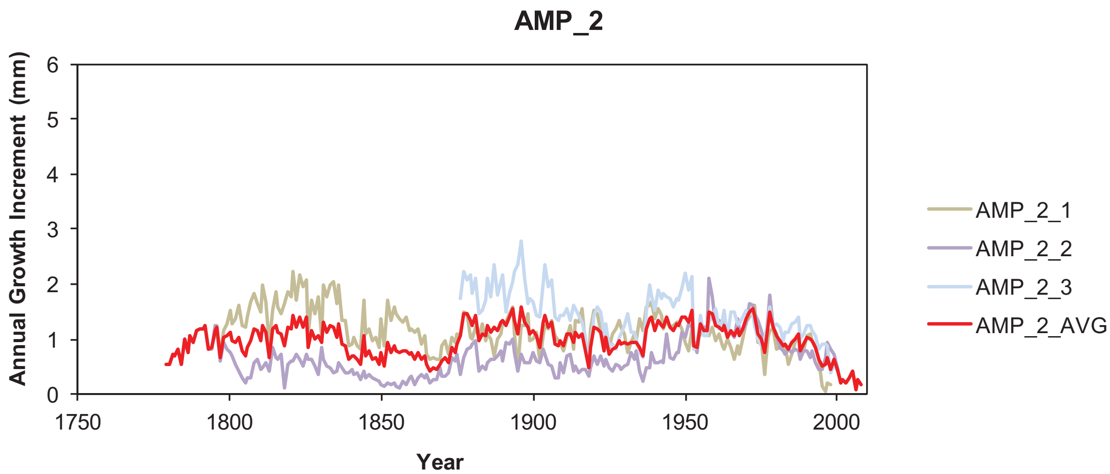
35014_1
Annual Growth Increment (mm)
Year
35014_1_1
35014_1_2
35014_1_3
35014_1_AVG

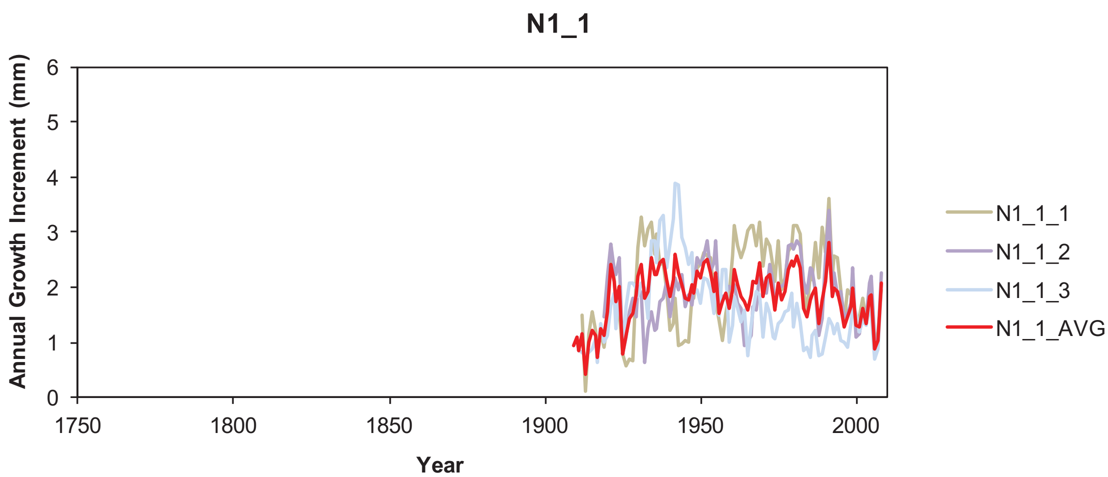


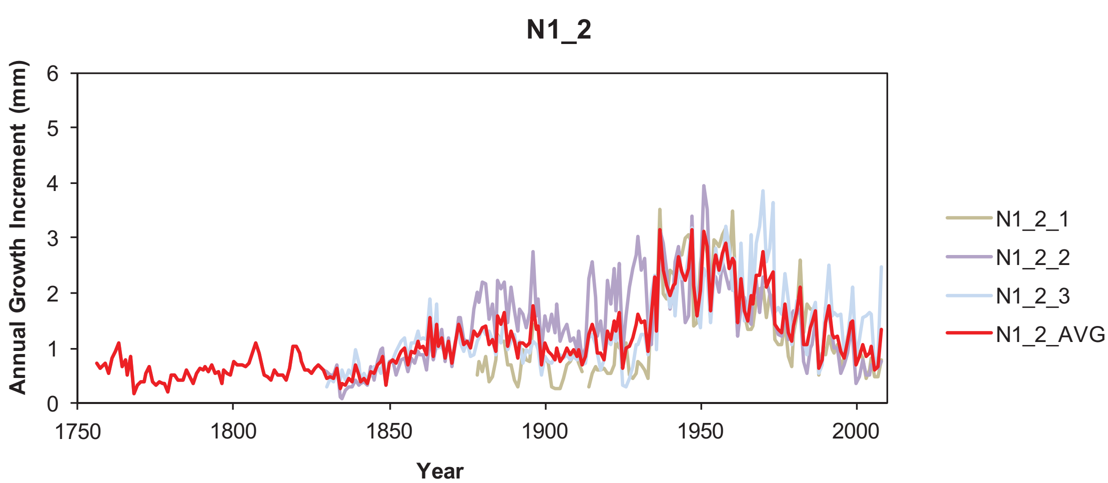
35014_2
Annual Growth Increment (mm)
Year
35014_2_1
35014_2_2
35014_2_3
35014_2_4
35014_2_AVG

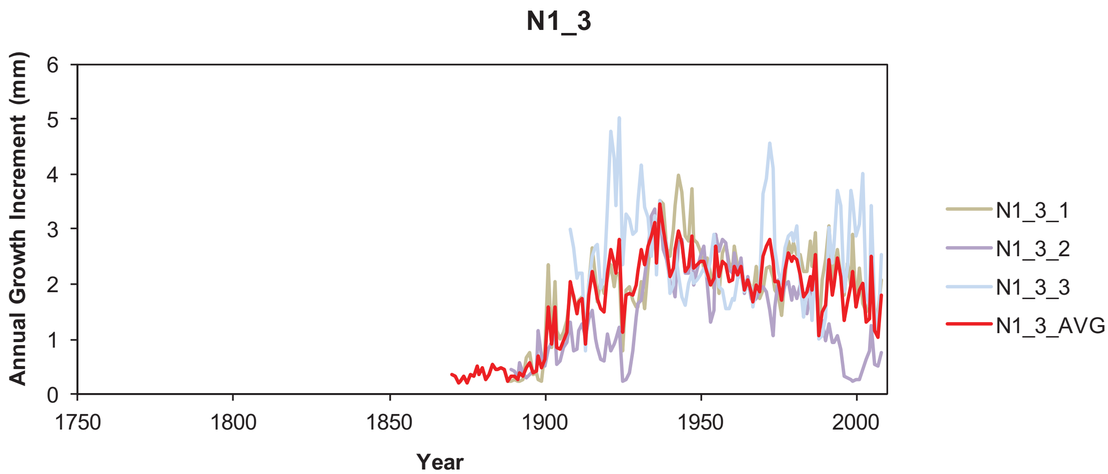


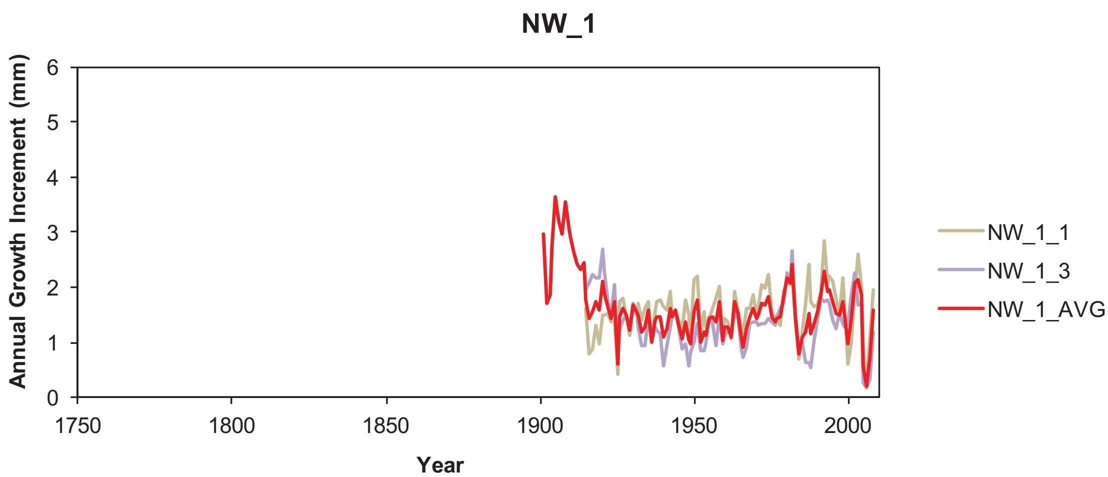
AMP_1
Annual Growth Increment (mm)
Year
AMP_1_1
AMP_1_2
AMP_1_3
AMP_1_AVG

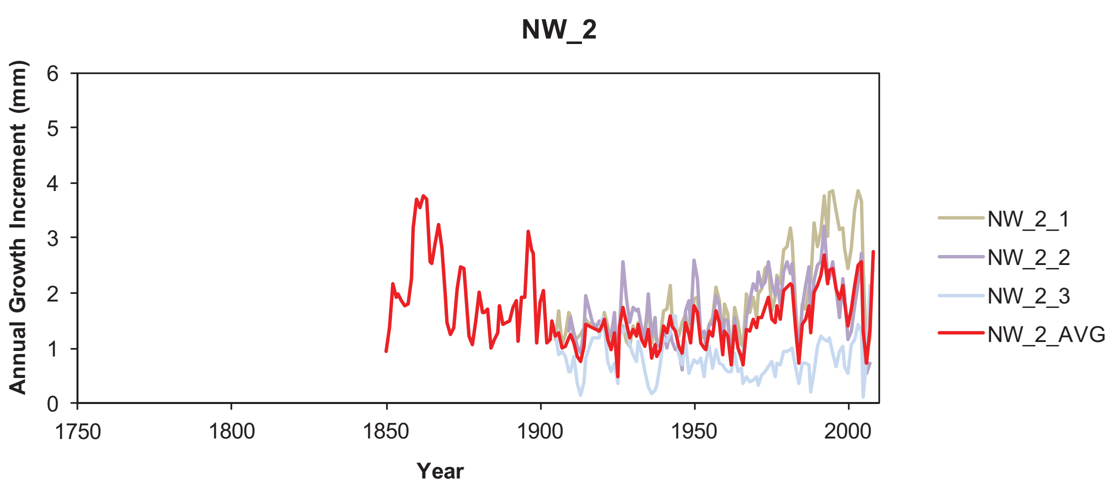

AMP_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
AMP_2_1
AMP_2_2
AMP_2_3
AMP_2_AVG

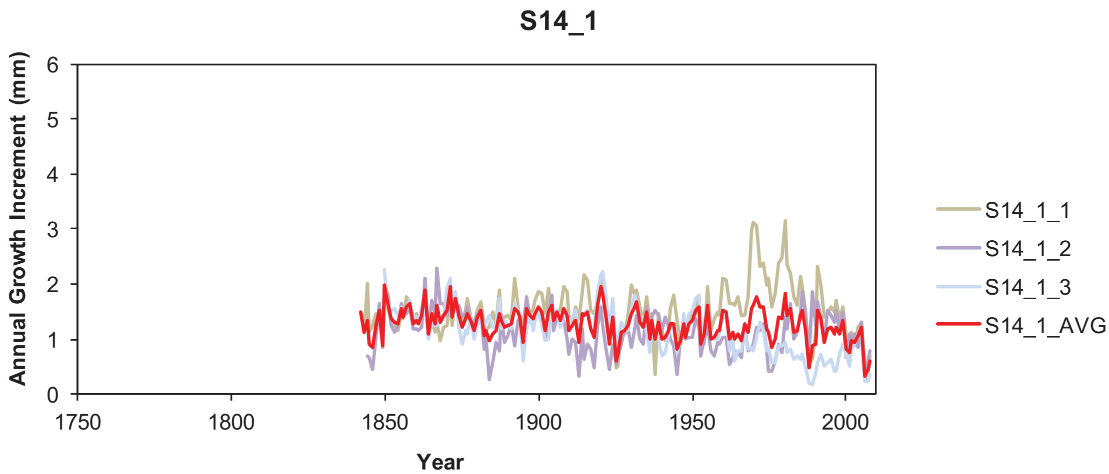

N1_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
N1_1_1
N1_1_2
N1_1_3
N1_1_AVG

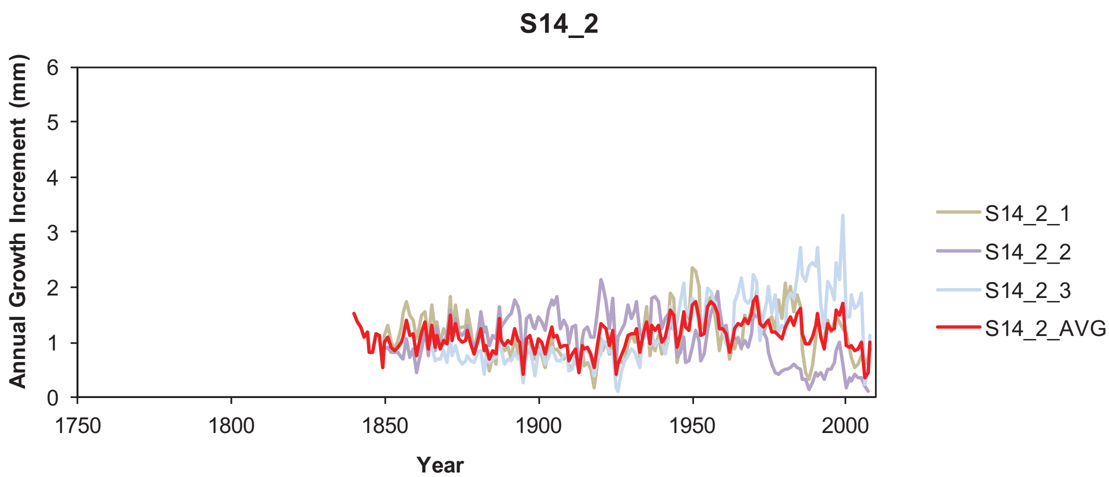

N1_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
N1_2_1
N1_2_2
N1_2_3
N1_2_AVG

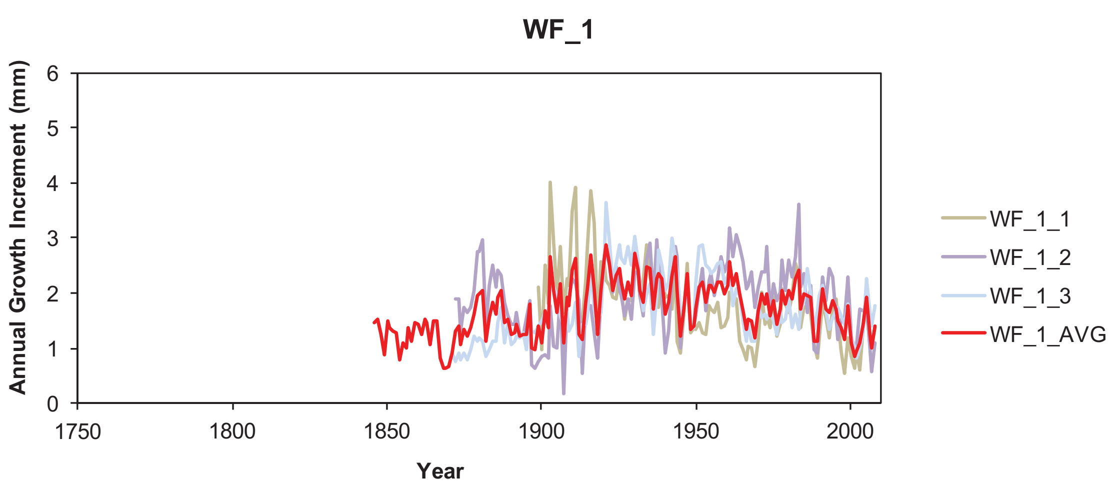

N1_3
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
N1_3_1
N1_3_2
N1_3_3
N1_3_AVG


NW_1
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
NW_1_1
NW_1_3
NW_1_AVG

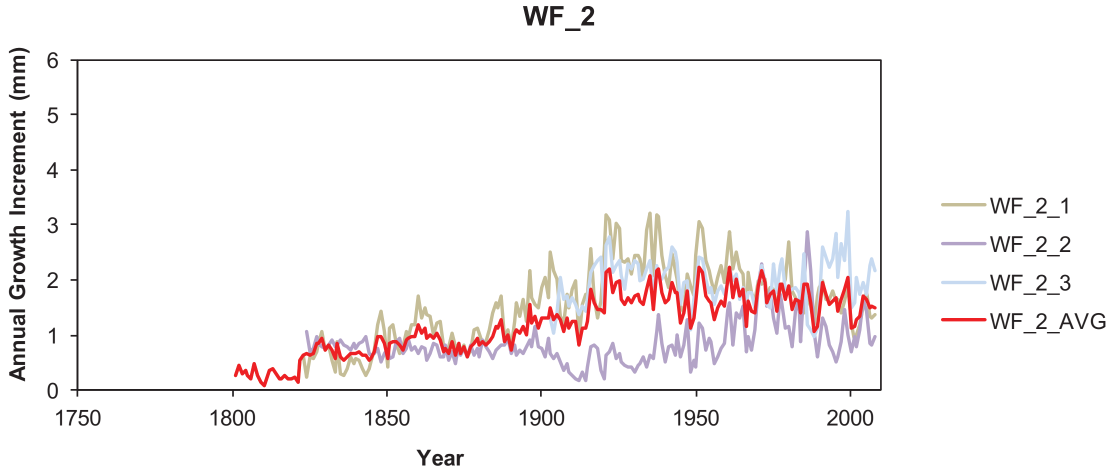

NW_2
Annual Growth Increment (mm)
0
1
2
3
4
5
6
1750
1800
1850
1900
1950
2000
Year
NW_2_1
NW_2_2
NW_2_3
NW_2_AVG


S14_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
S14_1_1
S14_1_2
S14_1_3
S14_1_AVG


S14_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
S14_2_1
S14_2_2
S14_2_3
S14_2_AVG

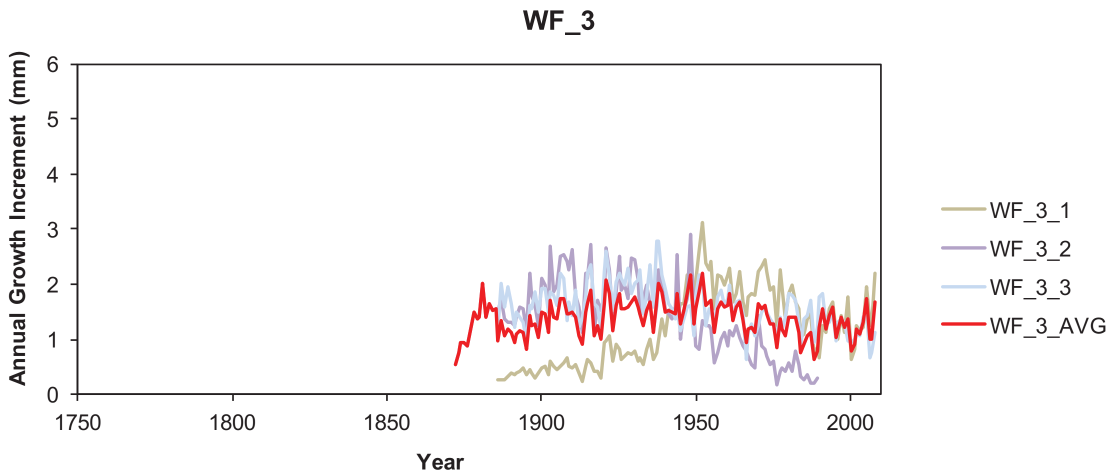

WF_1
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
WF_1_1
WF_1_2
WF_1_3
WF_1_AVG

WF_2



WF_2
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
WF_2_1
WF_2_2
WF_2_3
WF_2_AVG

WF_3

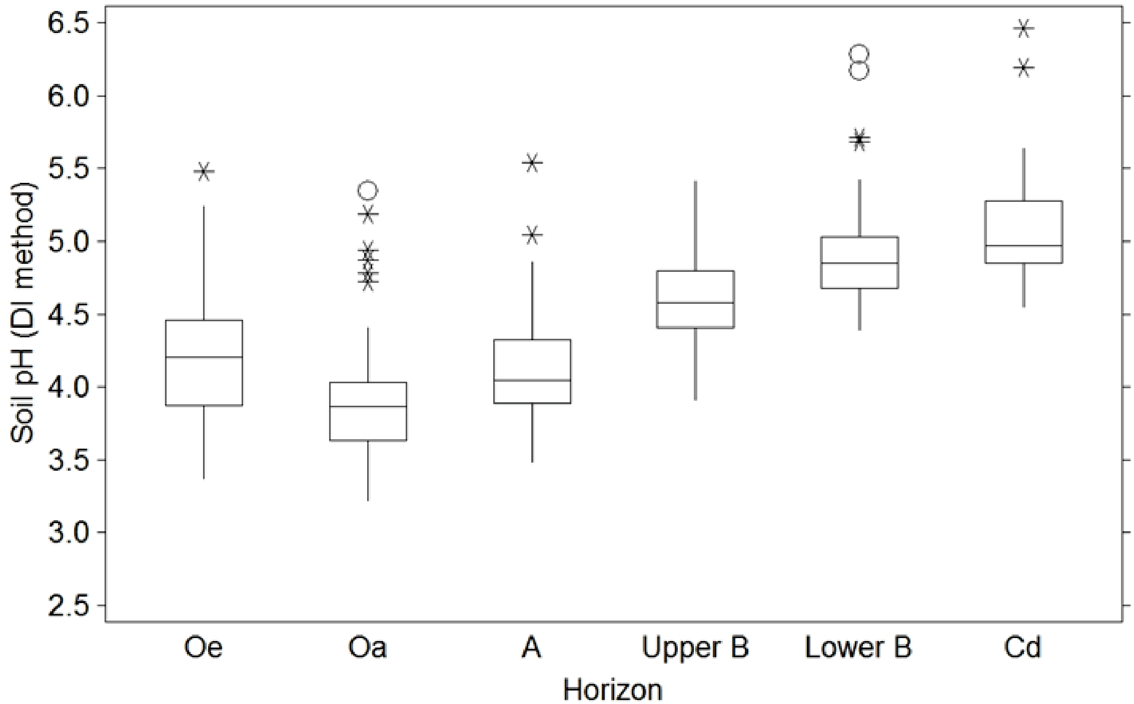


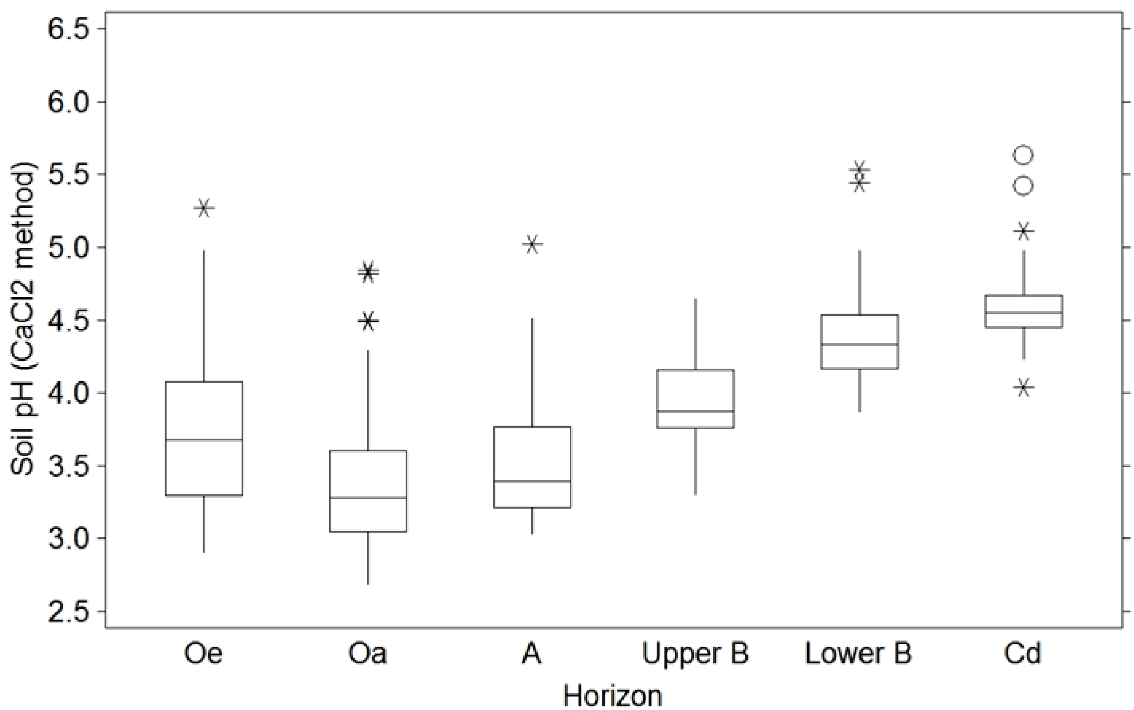
WF_3
Annual Growth Increment (mm)
6
5
4
3
2
1
0
1750
1800
1850
1900
1950
2000
Year
WF_3_1
WF_3_2
WF_3_3
WF_3_AVG

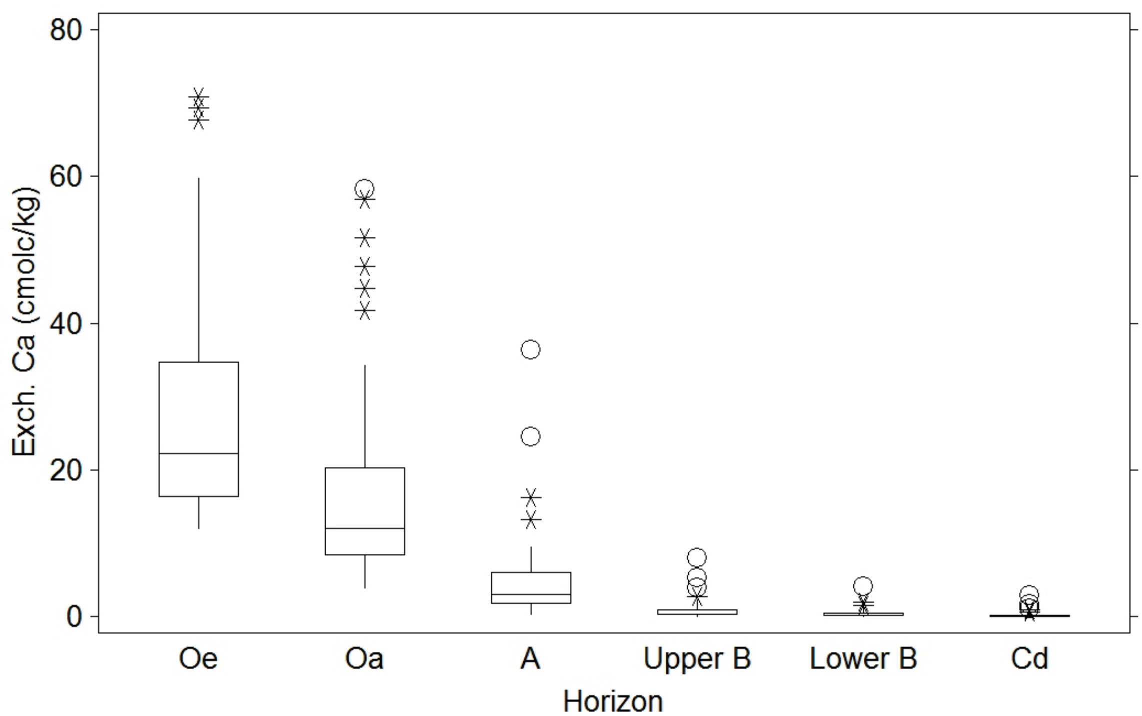
Appendix I

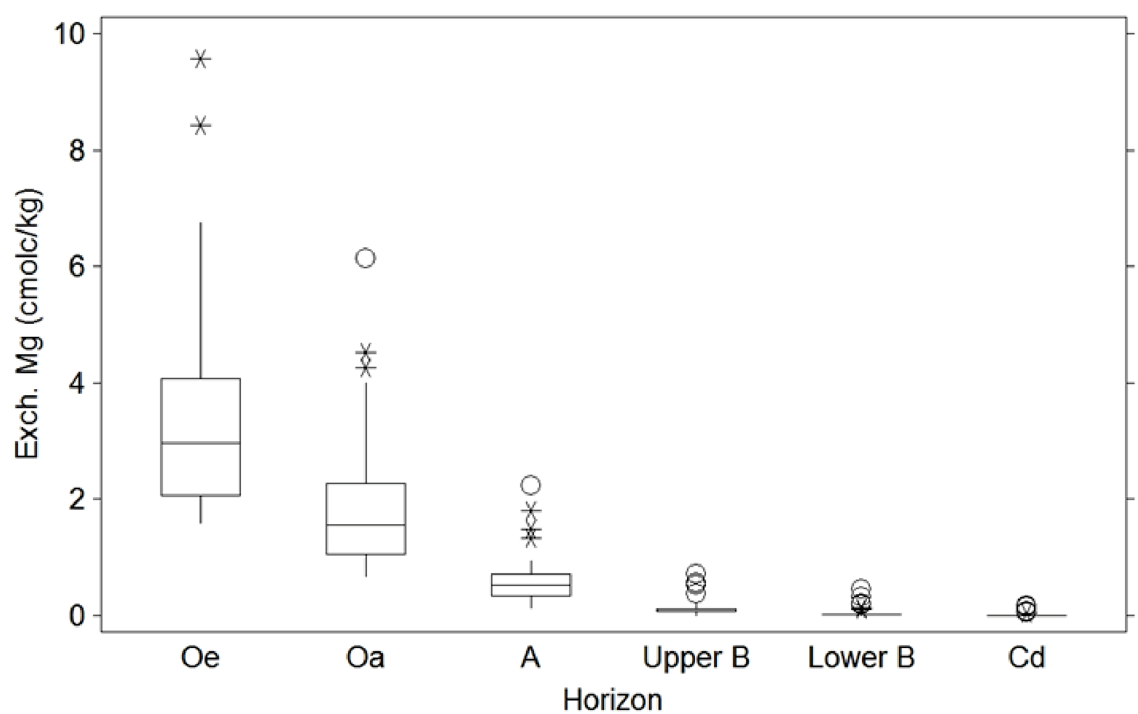
Plot-averaged soil chemistry data shown as box-and-whisker plots.

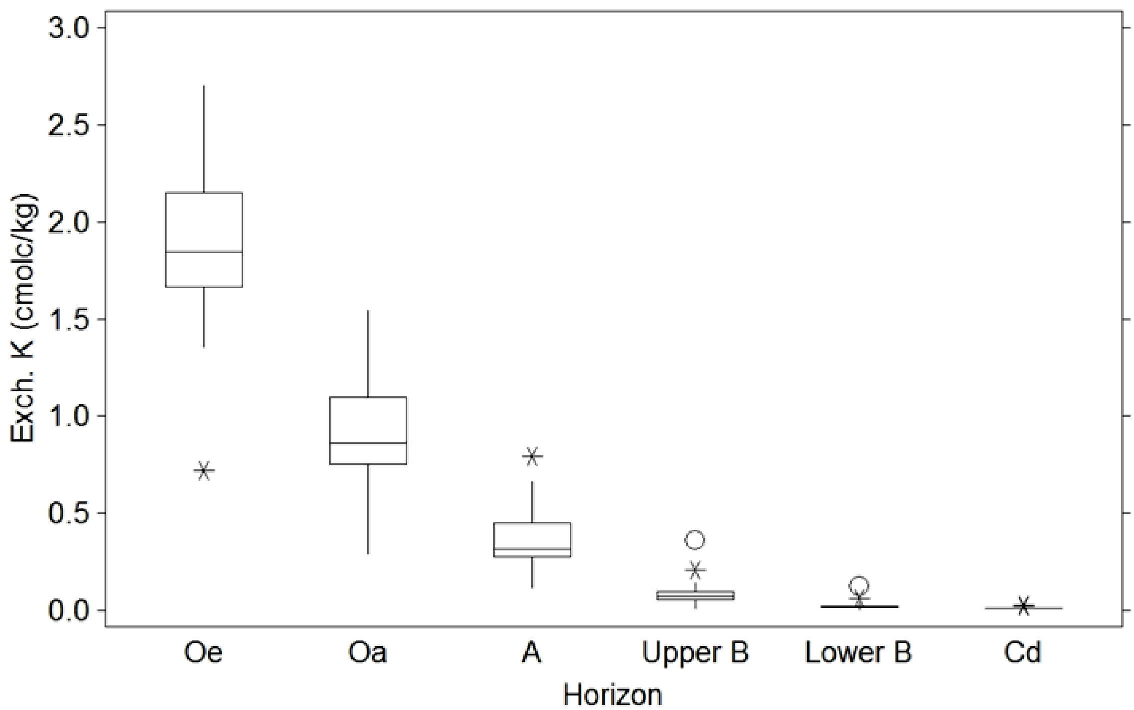
Plot-averaged soil chemistry data from the table in Appendix J are shown here as box-and-whisker plots. Each box-and-whisker represents data from all plots that contained data for a given soil horizon. All 50 plots had data for the Oe, Upper B, and Lower B horizons. The Oa horizon was sampled on 49 of the 50 plots and 43 of the 50 plots were sampled for A and Cd horizon data. Soil horizons are shown on the charts from left to right in the order in which they occur in the soil profile from top to bottom. In this way, it is possible to see any overall increasing or decreasing trends in soil chemistry with depth that may be apparent for a given soil chemical variable.

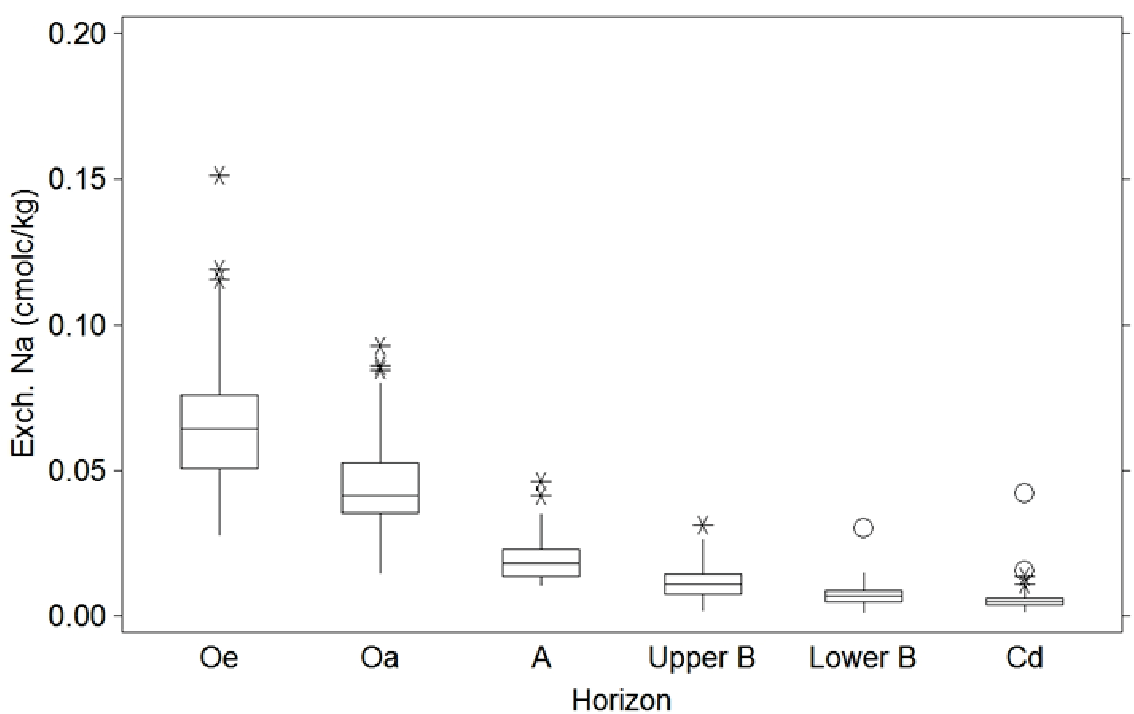

Soil pH (DI method)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

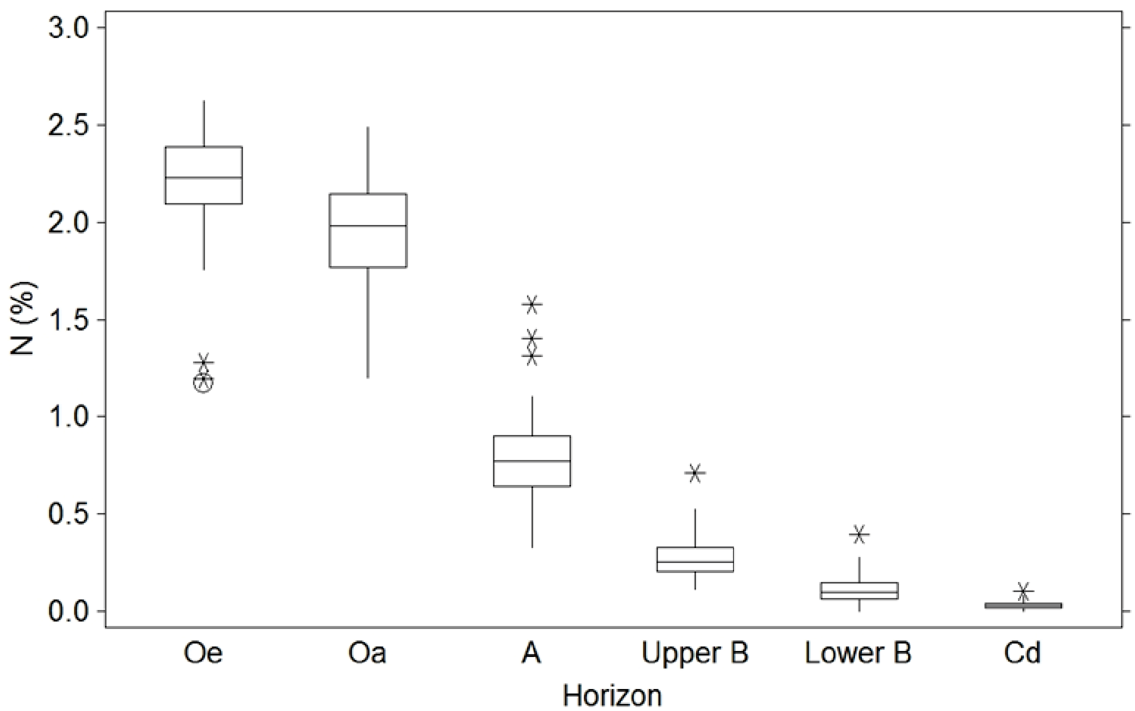

Soil pH (CaCl2 method)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

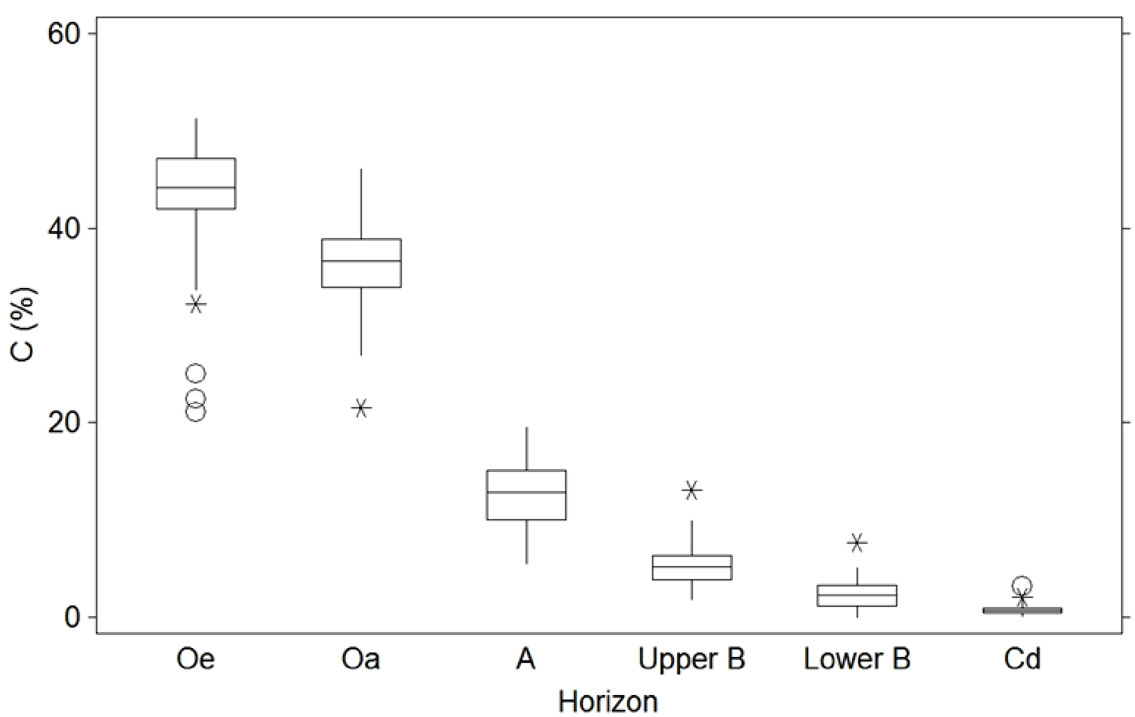

80
60
40
20
0
Exch. Ca (cmolc/kg)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

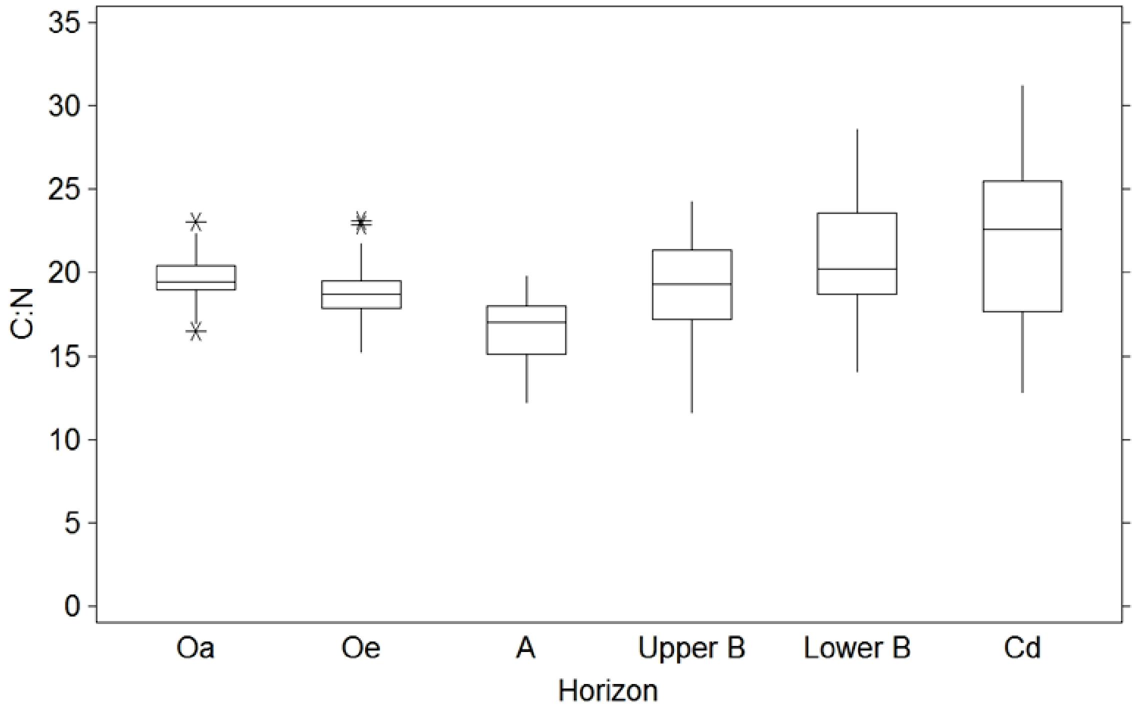

10
8
6
4
2
0
Exch. Mg (cmolc/kg)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

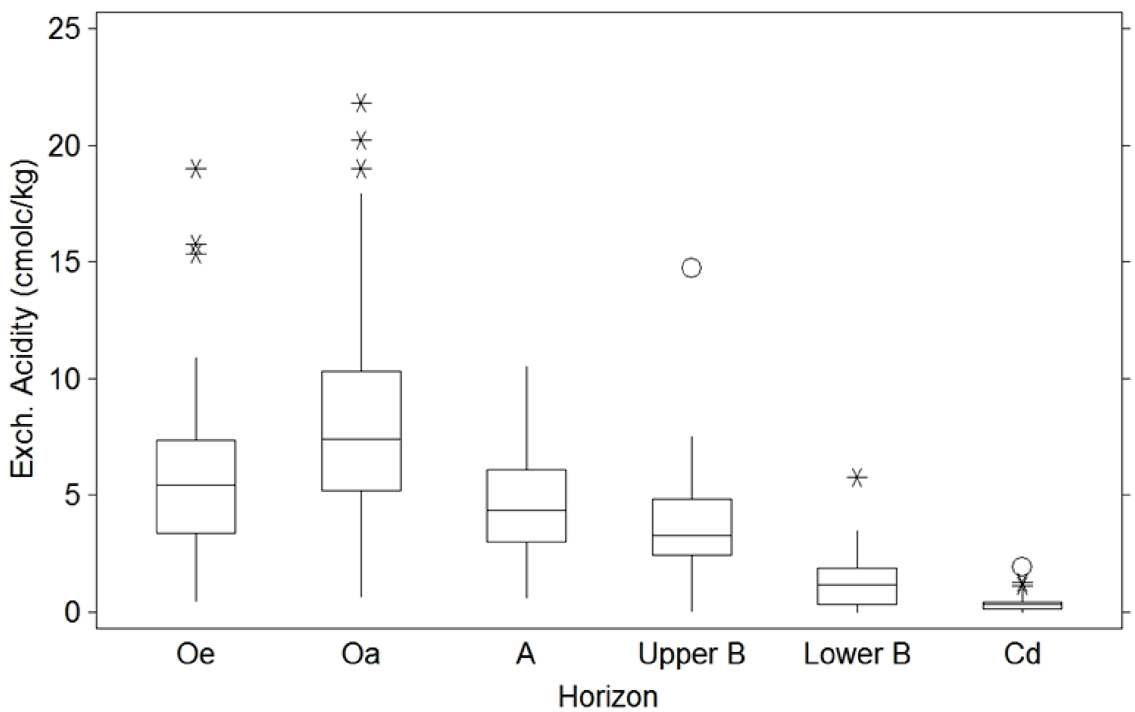

3.0
2.5
2.0
1.5
1.0
0.5
0.0
Exch. K (cmolc/kg)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

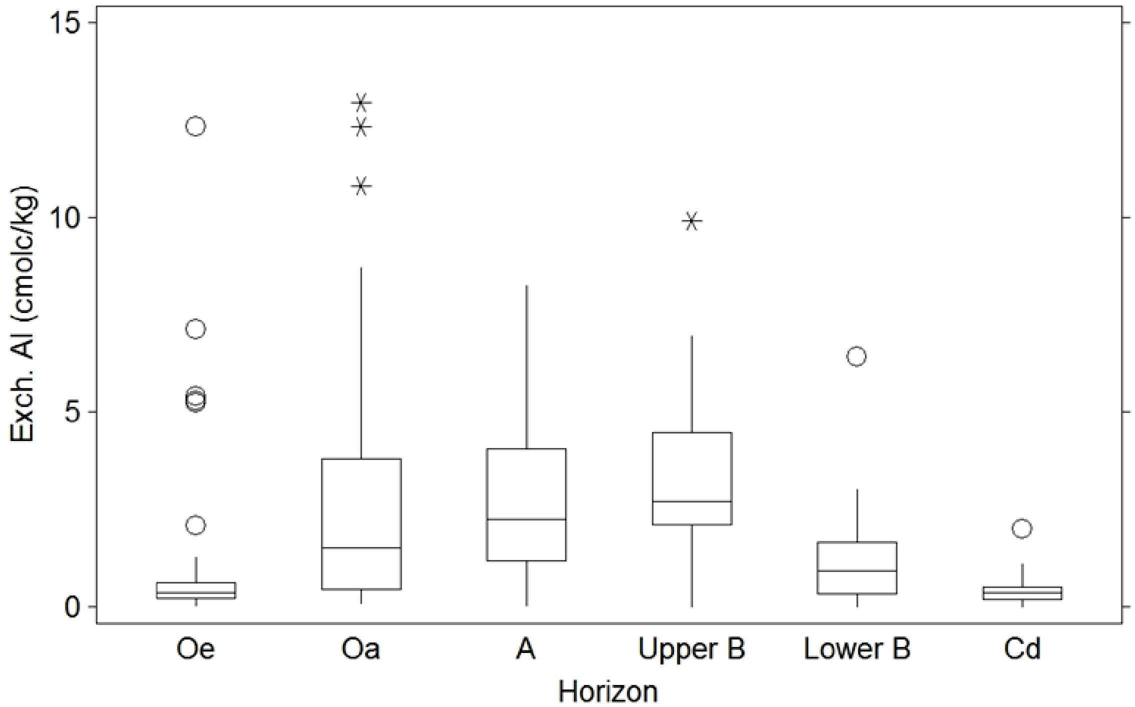

0.20
0.15
0.10
0.05
0.00
Exch. Na (cmolc/kg)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

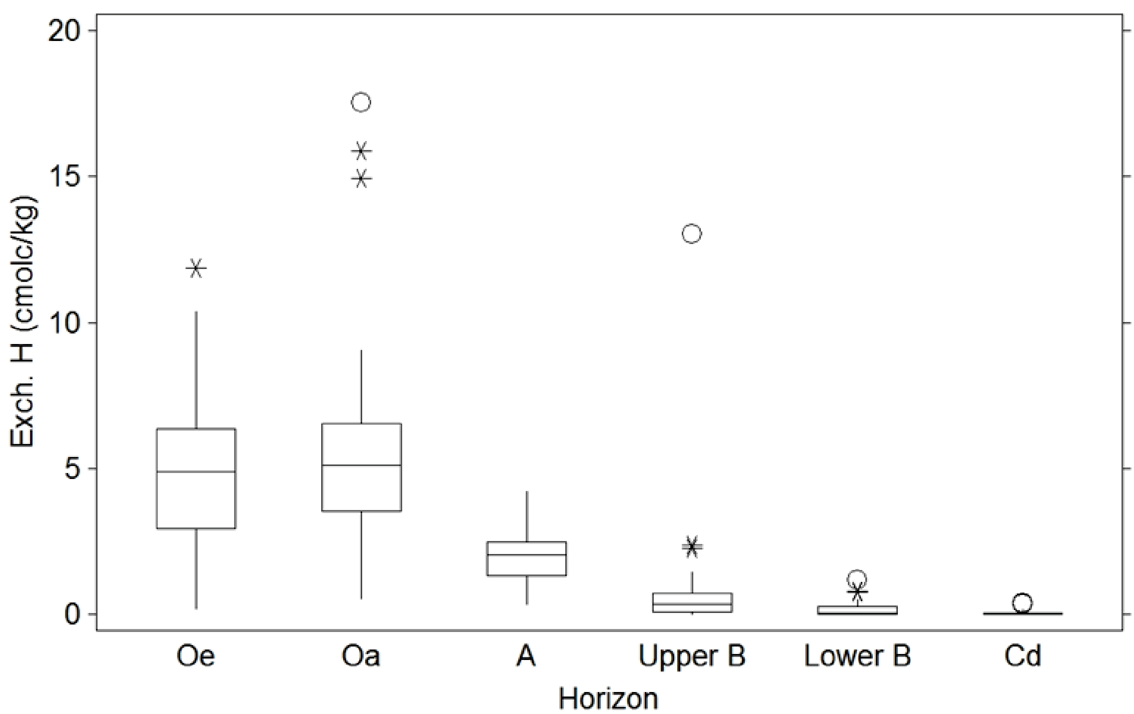

3.0
2.5
2.0
1.5
1.0
0.5
0.0
N (%)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

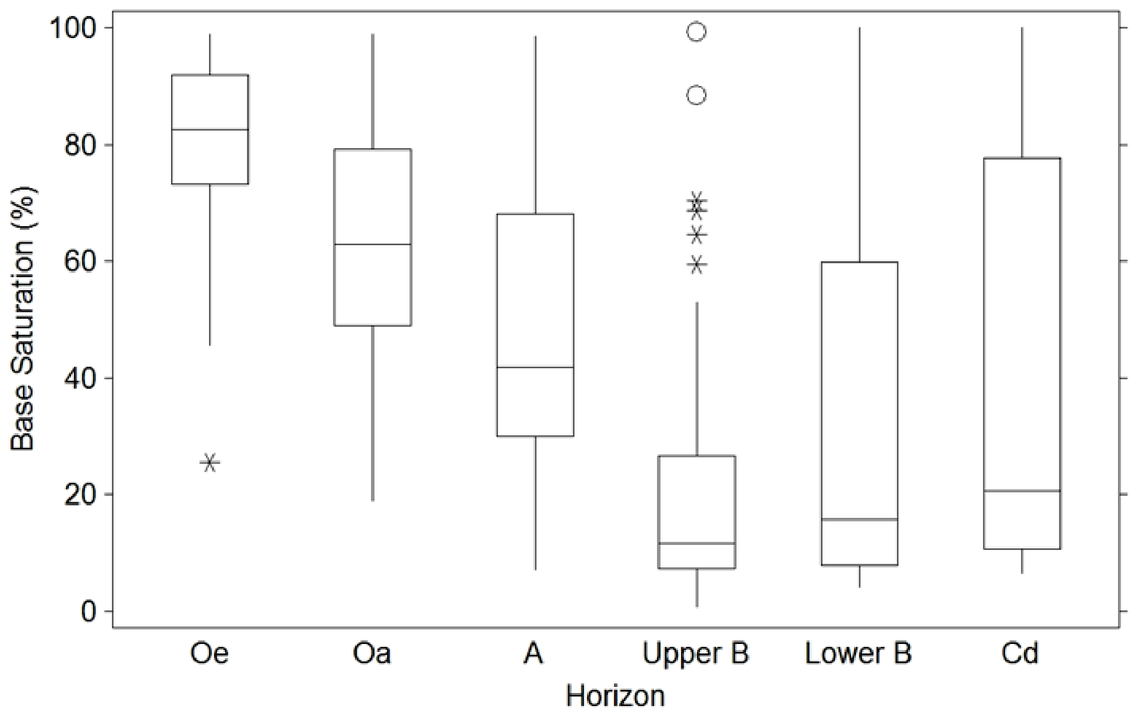

60
40
20
0
C (%)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon


35
30
25
20
15
10
5
0
C:N
Oa
Oe
A
Upper B
Lower B
Cd
Horizon

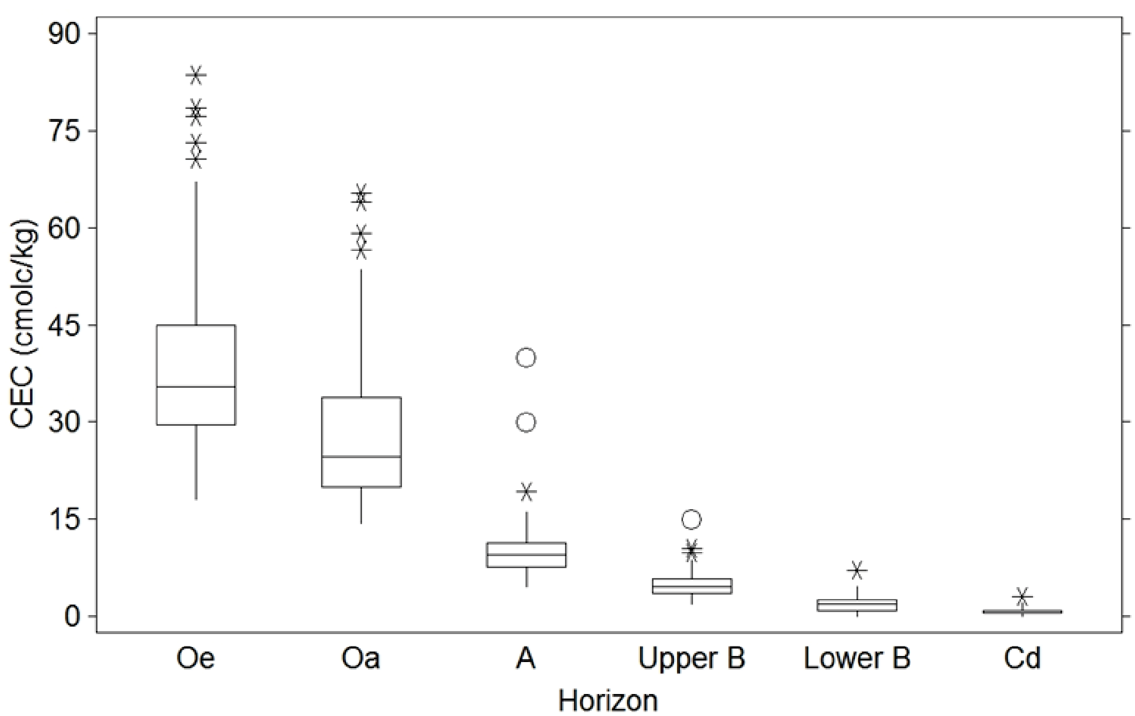

25
20
15
10
5
0
Exch. Acidity (cmolc/kg)
Oe
Oa
A
Upper B
Lower B
Cd
Horizon


Exch. Al (cmolc/kg)
15
10
5
0
Oe
Oa
A
Upper B
Lower B
Cd
Horizon


Exch. H (cmolc/kg)
20
15
10
5
0
Oe
Oa
A
Upper B
Lower B
Cd
Horizon



Base Saturation (%)
0
20
40
60
80
100
Oe
Oa
A
Upper B
Lower B
Cd
Horizon



CEC (cmolc/kg)
0
15
30
45
60
75
90
Oe
Oa
A
Upper B
Lower B
Cd
Horizon

Appendix J

Soil chemistry data, representing the average of all soil chemistry data obtained for each horizon within each plot.

The values included in the table in this appendix represent the average of all soil chemistry data obtained for each horizon within each plot. Organic and A horizon data are typically comprised of five samples. However, some sites are represented by fewer samples because all upper horizons were not consistently observed at each pin block sampling location. Replicate data for mineral soils were averaged with data from the main soil pit at sites where replicate mineral soil samples were collected. The following column heading abbreviations are used:

pH DI	pH measured in sample of soil mixed with deionized water
pH $CaCl_2$	pH measured in sample of soil mixed with a $CaCl_2$ solution
N Pct	Total nitrogen in soil sample as a percentage
C Pct	Total carbon in soil sample as a percentage
C to N	Molar ratio of C to N in soil sample
Acidity	Exchangeable acidity in soil sample ($cmoles_c$/kg)

The following units are used:

pH DI	pH units
pH $CaCl_2$	pH units
Ca	$cmol_c$/kg
Mg	$cmol_c$/kg
K	$cmol_c$/kg
Na	$cmol_c$/kg
N PCT	%
C PCT	%
C to N	dimensionless
Acidity	$cmol_c$/kg
Al	$cmol_c$/kg
H	$cmol_c$/kg
BS	%
CEC	$cmol_c$/kg

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	Oe	3.8	3.2	16.4	2.2	1.4	0.0	2.4	45.4	19.0	9.0	1.3	7.7	69.1	29.0
	Oa	3.6	3.0	10.4	0.8	0.7	0.0	2.0	39.0	19.2	20.2	4.3	15.9	40.1	32.2
	A	3.8	3.2	1.8	0.3	0.5	0.0	1.4	18.6	13.3	10.5	8.2	2.3	20.1	13.1
	Upper B	4.4	3.7	0.2	0.1	0.1	0.0	0.3	6.1	22.6	4.8	5.2	0.0	7.7	5.2
	Lower B	4.6	4.1	0.1	0.0	0.0	0.0	0.1	3.0	24.9	2.1	2.4	0.0	6.6	2.2
	Cd	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.7	29.2	0.4	0.5	0.0	8.2	0.5
12003_2	Oe	4.1	3.6	24.7	3.4	2.1	0.1	2.4	46.5	19.7	5.1	0.3	4.8	85.7	35.3
	Oa	3.5	2.9	13.1	1.3	0.8	0.0	2.0	42.2	20.9	10.1	1.8	8.3	59.7	25.3
	A	3.7	3.1	6.1	0.9	0.8	0.0	1.1	18.6	17.0	6.4	2.2	4.2	55.1	14.3
	Upper B	4.4	3.8	0.5	0.1	0.1	0.0	0.2	5.9	24.2	7.1	5.7	1.4	7.9	7.7
	Lower B	4.8	4.2	0.1	0.0	0.0	0.0	0.1	2.9	25.0	2.8	1.7	1.2	4.3	3.0
	Cd	4.8	4.4	0.0	0.0	0.0	0.0	0.0	0.7	28.0	0.0	0.7	0.0	100.0	0.0
12003_3	Oe	4.2		26.4	3.6	2.2	0.1	2.2	45.3	20.8	6.5	0.3	6.2	83.3	38.8
	Oa	3.9	3.5	12.3	1.6	1.4	0.1	2.1	37.4	18.1	7.1	2.1	5.0	65.2	22.3
	A	4.1	3.5	4.2	0.6	0.7	0.0	0.8	12.8	16.0	3.9	1.9	2.0	57.5	9.4
	Upper B	4.9	4.0	0.3	0.1	0.1	0.0	0.2	3.7	17.2	2.4	2.6	0.0	17.7	2.9
	Lower B	5.0	4.5	0.1	0.0	0.0	0.0	0.0	0.3	14.9	0.3	0.3	0.0	18.7	0.4
	Cd	5.1	4.6	0.0	0.0	0.0	0.0	0.0	0.1	15.7	0.3	0.2	0.1	14.4	0.3
13008_1	Oe	4.0	3.5	18.1	2.4	2.1	0.1	2.2	46.8	21.5	7.5	0.2	7.3	75.1	30.1
	Oa	3.5	3.1	7.9	1.2	1.0	0.0	2.0	39.1	19.6	9.3	1.0	8.3	51.6	19.4
	A	3.9	3.1	1.7	0.3	0.3	0.0	0.6	12.4	19.6	4.9	2.4	2.6	32.1	7.2
	Upper B	4.3	3.7	0.1	0.1	0.1	0.0	0.2	3.4	19.3	3.2	2.9	0.3	7.0	3.5
	Lower B	4.8	4.6	0.0	0.0	0.0	0.0	0.0	0.6	17.5	0.3	0.3	0.0	12.5	0.3
	Cd	4.7	4.6	0.0	0.0	0.0	0.0	0.0	0.1	16.3	0.2	0.1	0.1	12.4	0.2
13008_2	Oe	3.9	3.3	13.6	1.7	2.1	0.1	2.1	42.1	20.3	7.2	0.5	6.7	70.9	24.8
	Oa	3.5	3.0	6.6	0.8	1.1	0.1	1.8	34.2	18.7	7.3	1.2	6.1	51.1	15.9
	A	3.8	3.3	2.0	0.4	0.4	0.0	0.8	13.8	17.6	4.2	2.3	1.9	37.8	7.0
	Upper B	4.2	3.7	0.1	0.1	0.1	0.0	0.2	3.2	17.7	2.7	2.4	0.3	6.4	2.9
	Lower B	4.7	4.5	0.0	0.0	0.0	0.0	0.0	0.3	14.0	0.2	0.2	0.0	10.2	0.2

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Cd	4.8	4.6	0.0	0.0	0.0	0.0	0.0	0.2	67.8	0.2	0.2	0.0	11.9	0.2
17002_1	Oe	4.2	3.5	14.8	1.6	1.4	0.0	1.2	22.4	19.1	8.0	0.7	7.3	69.0	25.7
	Oa	4.0		17.2	1.4	0.8	0.0	1.9	38.9	20.4	6.7	0.3	6.5	74.2	26.0
	A	4.1	3.5	1.3	0.3	0.2	0.0	0.4	7.5	17.3	4.6	1.9	2.7	25.5	6.4
	Upper B	4.8	4.6	0.1	0.0	0.0	0.0	0.2	3.2	20.4	14.7	1.7	13.0	0.8	14.8
	Lower B	4.7	4.3	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.0	0.0	0.0	100.0	0.0
17002_2	Oe	4.2	3.5	12.1	1.7	0.7	0.0	1.3	25.0	19.6	3.4	0.6	2.9	78.0	18.0
	Oa	3.6	3.1	8.0	0.7	0.3	0.0	1.2	21.5	17.9	5.3	0.4	4.9	62.8	14.3
	A	4.2	3.4	1.4	0.2	0.1	0.0	0.4	6.7	16.8	4.1	2.4	1.7	30.0	5.8
	Upper B	4.9	4.2	0.3	0.0	0.0	0.0	0.2	4.3	23.3	2.3	2.2	0.1	11.6	2.6
	Lower B	5.0	4.6	0.0	0.0	0.0	0.0	0.0	0.6	19.6	0.2	0.2	0.0	17.5	0.3
	Cd	5.0	4.8	0.0	0.0	0.0	0.0	0.0	0.3	17.6	0.1	0.1	0.0	22.0	0.1
17002_3	Oe	4.2		16.0	2.3	1.7	0.0	1.2	21.0	17.6	3.1	0.8	2.3	86.5	23.2
	Oa	3.6	3.1	14.5	1.8	1.0	0.0	1.9	34.2	17.8	7.4	1.0	6.4	67.9	24.7
	A	4.3	3.8	0.8	0.2	0.2	0.0	0.4	6.1	14.4	3.4	3.1	0.3	25.2	4.6
	Upper B	4.6	3.9	0.0	0.0	0.0	0.0	0.2	5.3	21.7	3.5	4.0	0.0	0.8	3.5
	Lower B	4.9	4.7	0.3	0.1	0.1	0.0	0.0	0.4	15.6	0.2	0.3	0.0	63.4	0.6
	Cd	4.9	4.8	0.0	0.0	0.0	0.0	0.0	0.1	12.8	0.0	0.1	0.0	44.3	0.1
22019_1	Oe	4.3	4.0	32.5	3.8	2.2	0.1	2.2	48.3	21.6	3.6	0.1	3.5	91.5	42.3
	Oa	3.8	3.1	13.5	1.4	1.0	0.0	2.4	46.1	19.4	7.5	1.7	5.8	65.6	23.5
	A	3.9	3.3	5.8	0.7	0.5	0.0	0.8	15.2	19.8	2.4	0.7	1.7	74.6	9.3
	Upper B	4.4	3.7	0.9	0.1	0.1	0.0	0.4	9.9	23.7	7.5	6.9	0.5	12.5	8.6
	Lower B	4.7	4.2	0.1	0.0	0.0	0.0	0.1	2.0	24.8	1.2	1.2	0.0	8.2	1.3
	Cd	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.4	23.5	0.4	0.3	0.1	9.3	0.4
22019_2	Oe	4.0	3.4	15.8	1.8	1.7	0.1	2.2	44.0	20.4	10.9	5.2	5.7	64.0	30.3
	Oa	3.9	3.3	5.6	0.7	0.6	0.0	1.9	36.3	19.4	10.8	6.7	4.3	37.1	17.8
	A	3.7	3.1	1.9	0.3	0.3	0.0	0.8	15.5	19.4	7.2	5.1	2.2	25.7	9.7
	Upper B	4.1	4.0	0.2	0.0	0.1	0.0	0.2	4.7	19.7	2.7	2.5	0.2	8.5	2.9
	Lower B	4.7	4.2	0.1	0.0	0.0	0.0	0.1	1.6	21.6	2.0	1.2	0.8	5.6	2.1

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
24001_1	Oe	5.2	4.7	69.4	5.3	1.7	0.1	2.3	42.7	18.6	2.2	0.1	2.1	97.1	78.6
	Oa	4.7	4.2	41.8	2.7	0.6	0.0	2.0	32.9	16.6	2.2	0.4	1.8	95.1	47.4
	A	5.5	5.0	36.3	2.2	0.6	0.0	1.6	19.2	12.2	0.6	0.0	0.6	98.4	39.8
	Upper B	4.9	4.3	5.2	0.4	0.1	0.0	0.3	5.8	16.8	2.4	2.0	0.4	70.3	8.1
	Lower B	5.7	4.8	1.9	0.1	0.0	0.0	0.1	2.7	20.3	0.5	0.2	0.4	78.8	2.6
24001_2	Oe	4.7	4.3	59.8	5.8	2.1	0.0	2.4	43.7	18.3	3.0	0.1	2.9	95.8	70.6
	Oa	4.8	4.3	44.8	4.3	1.5	0.0	2.2	35.6	16.1	2.8	0.1	2.7	94.7	53.5
	A	4.9	4.2	13.1	1.5	0.4	0.0	0.7	10.4	14.7	1.1	0.2	0.9	93.0	16.1
	Upper B	4.9	4.3	1.5	0.2	0.1	0.0	0.2	2.1	11.6	1.0	0.6	0.4	64.5	2.8
	Lower B	5.1	4.9	0.7	0.0	0.0	0.0	0.0	0.6	16.4	0.0	0.0	0.0	100.0	0.8
	Cd	5.6	5.1	0.9	0.1	0.0	0.0	0.0	0.5	16.8	0.2	0.0	0.1	84.4	1.1
26008_1	Oe	3.8	3.2	20.5	2.4	2.2	0.1	2.6	49.7	18.9	8.5	0.6	7.8	74.5	33.6
	Oa	3.5	3.1	10.5	1.3	1.1	0.0	2.2	37.2	16.7	21.8	6.9	14.9	39.3	34.8
	A	3.7	3.1	1.6	0.4	0.4	0.0	0.7	12.7	18.1	7.0	4.4	2.5	25.7	9.4
	Upper B	4.5	3.8	0.2	0.1	0.1	0.0	0.2	2.9	17.0	2.8	2.2	0.6	10.0	3.1
	Lower B	4.5	4.1	0.1	0.0	0.0	0.0	0.1	1.9	20.3	1.2	0.8	0.3	10.0	1.3
	Cd	4.7	4.2	0.0	0.0	0.0	0.0	0.0	0.6	23.6	1.0	0.6	0.3	7.3	1.1
26008_2	Oe	3.8	3.3	16.2	2.1	1.5	0.1	2.6	50.7	19.6	9.8	5.3	4.5	67.1	29.7
	Oa	3.9	3.3	5.1	0.9	0.8	0.1	2.1	40.7	19.0	15.5	12.9	2.7	27.2	22.3
	A	4.2	3.6	0.5	0.2	0.3	0.0	0.9	15.7	17.1	9.4	6.8	2.6	10.3	10.5
	Upper B	4.6	4.0	0.2	0.0	0.1	0.0	0.4	8.6	23.8	5.4	4.5	0.9	5.7	5.7
	Lower B	4.6	4.1	0.1	0.0	0.0	0.0	0.2	5.1	25.4	3.5	3.0	0.5	4.9	3.7
	Cd	4.6	4.0	0.1	0.0	0.0	0.0	0.0	0.6	25.7	0.1	0.5	0.0	64.4	0.3
27019_1	Oe	4.0	3.7	25.4	4.6	1.8	0.1	2.3	43.8	19.4	5.2	0.2	5.0	85.9	37.1
	Oa	3.7	3.1	10.4	1.7	0.8	0.0	1.9	34.9	18.0	7.0	1.4	5.6	63.9	19.9
	A	3.9	3.3	1.4	0.4	0.3	0.0	0.7	11.6	17.0	5.3	3.1	2.2	29.9	7.4
	Upper B	4.6	3.7	0.5	0.1	0.1	0.0	0.3	6.9	24.0	5.2	4.8	0.5	11.0	5.9
	Lower B	4.6	4.1	0.2	0.0	0.0	0.0	0.2	4.5	28.6	2.9	2.8	0.1	7.8	3.2
	Cd	4.6	4.3	0.1	0.0	0.0	0.0	0.1	3.2	31.2	1.9	2.0	0.0	7.9	2.1

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
27019_2	Oe	3.8	3.2	12.7	1.7	1.4	0.0	2.4	49.8	20.7	19.0	7.1	11.9	45.6	34.9
	Oa	4.0	3.4	3.9	0.7	0.6	0.0	2.0	36.8	18.0	19.0	10.8	8.2	18.9	24.2
	A	4.2	3.6	0.3	0.1	0.2	0.0	0.7	11.5	17.5	8.3	6.7	1.6	7.1	9.0
	Upper B	4.6	3.8	0.3	0.1	0.1	0.0	0.3	5.9	22.9	4.8	4.3	0.5	9.6	5.3
	Lower B	4.7	4.2	0.1	0.0	0.0	0.0	0.1	3.7	28.1	2.1	1.7	0.4	7.3	2.3
	Cd	4.9	4.4	0.1	0.0	0.0	0.0	0.1	2.1	28.4	1.0	0.6	0.4	10.4	1.1
27019_3	Oe	4.2	3.7	22.0	3.7	2.4	0.1	1.9	43.4	23.0	5.6	0.1	5.5	83.3	33.8
	Oa	3.6	3.0	10.5	1.9	1.2	0.0	1.7	33.6	20.0	8.4	0.8	7.7	61.0	22.2
	A	3.9	3.2	1.7	0.4	0.3	0.0	0.4	7.6	18.2	4.7	2.0	2.7	34.2	7.1
	Upper B	4.6	3.9	0.2	0.1	0.1	0.0	0.2	3.5	17.8	3.6	2.5	1.1	10.0	4.0
	Lower B	4.9	4.6	0.0	0.0	0.0	0.0	0.0	0.9	20.2	0.0	0.3	0.0	70.9	0.1
	Cd	5.0	4.5	0.0	0.0	0.0	0.0	0.0	0.7	19.8	0.0	0.4	0.0	93.2	0.1
28030_1	Oe	4.4		49.3	5.1	2.7	0.1	2.1	46.9	22.3	5.0	0.0	5.0	92.0	62.3
	Oa	3.9	3.7	47.7	4.0	1.3	0.1	2.2	43.8	19.6	3.6	0.1	3.4	93.1	56.6
	A	4.5	3.7	3.9	0.6	0.1	0.0	0.3	5.9	18.2	1.4	0.4	1.0	77.0	6.1
	Upper B	5.1	4.5	3.8	0.7	0.0	0.0	0.1	1.8	15.3	0.0	0.2	0.0	99.2	4.7
	Lower B	6.3	5.5	4.1	0.5	0.0	0.0	0.1	1.1	18.1	0.0	0.0	0.0	100.0	4.6
	Cd	6.5	5.6	1.6	0.2	0.0	0.0	0.0	0.3	20.3	0.0	0.0	0.0	100.0	1.8
28030_2	Oe	3.9	3.3	20.0	2.6	1.7	0.1	2.1	40.0	19.2	5.1	0.3	4.8	80.6	29.5
	Oa	3.7	3.1	12.1	1.5	0.8	0.0	1.9	35.5	18.5	7.6	2.2	5.4	64.5	22.0
	A	3.8	3.2	2.1	0.4	0.3	0.0	0.7	13.0	18.3	4.8	2.1	2.8	35.1	7.7
	Upper B	4.5	3.9	0.3	0.1	0.1	0.0	0.3	6.4	21.3	4.8	4.9	0.0	7.7	5.2
	Lower B	5.0	4.5	0.1	0.0	0.0	0.0	0.1	1.3	21.0	0.6	0.7	0.0	13.9	0.7
	Cd	4.9	4.6	0.0	0.0	0.0	0.0	0.0	0.4	18.9	0.3	0.3	0.0	17.4	0.3
28030_3	Oe	4.1	3.6	26.0	2.7	1.7	0.0	1.8	34.6	18.8	6.2	0.2	6.1	82.0	36.7
	Oa	4.0	3.3	14.7	1.4	0.8	0.0	1.6	29.2	18.6	17.9	0.4	17.5	60.3	34.8
	A	4.1	3.4	4.6	0.6	0.3	0.0	0.5	8.6	16.9	3.3	0.7	2.5	58.4	8.7
	Upper B	4.6	3.8	0.5	0.1	0.0	0.0	0.1	2.3	20.5	3.1	2.1	1.0	15.6	3.7
	Lower B	5.2	4.7	0.1	0.0	0.0	0.0	0.0	0.6	18.6	0.0	0.2	0.0	100.0	0.1

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Cd	5.6	4.9	0.1	0.0	0.0	0.0	0.0	0.1	49.8	0.0	0.0	0.0	100.0	0.1
28037_1	Oe	4.7	4.2	29.4	3.6	1.9	0.1	2.1	43.0	20.5	4.2	0.3	3.9	89.3	39.2
	Oa	4.0	3.3	18.7	2.1	0.8	0.0	1.7	38.6	22.8	6.2	2.1	4.1	75.0	27.9
	A	4.4	3.8	3.4	0.7	0.4	0.0	0.7	11.7	17.1	4.5	3.1	1.4	48.7	9.0
	Upper B	4.5	3.7	2.7	0.7	0.1	0.0	0.2	3.3	19.7	2.4	0.0	2.4	59.6	5.9
	Lower B	4.9	4.2	1.6	0.3	0.0	0.0	0.1	2.7	18.9	1.3	0.8	0.4	60.3	3.2
28037_2	Oe	4.3	3.9	36.9	3.6	2.0	0.1	2.4	44.9	19.0	4.0	0.3	3.7	90.5	46.7
	Oa	4.0	3.7	17.7	1.8	0.7	0.0	1.7	31.5	19.0	5.0	1.5	3.5	78.8	25.4
	Upper B	5.2	4.5	7.9	0.6	0.1	0.0	0.5	8.0	15.3	1.1	1.1	0.0	88.3	9.8
	Lower B	5.3	4.5	2.0	0.1	0.0	0.0	0.1	1.5	19.6	0.6	0.6	0.0	78.6	2.7
	Cd	5.4	4.4	1.0	0.1	0.0	0.0	0.0	0.8	19.7	0.3	0.3	0.0	77.9	1.4
29012_1	Oe	3.8	3.2	17.8	2.0	1.4	0.1	1.8	33.8	19.3	8.2	0.5	7.7	71.3	29.4
	Oa	3.7	3.0	9.6	1.7	0.8	0.1	1.6	29.2	17.7	10.2	1.1	9.0	54.5	22.3
	A	4.0	3.2	0.8	0.2	0.2	0.0	0.4	5.5	15.1	3.6	1.5	2.1	25.2	4.8
	Upper B	4.8	4.1	0.1	0.0	0.0	0.0	0.2	3.7	18.8	2.4	1.5	0.9	7.1	2.6
	Lower B	4.9	4.5	0.0	0.0	0.0	0.0	0.0	0.8	20.9	0.0	0.2	0.0	87.9	0.0
	Cd	4.9	4.7	0.0	0.0	0.0	0.0	0.0	0.2	17.6	0.0	0.0	0.0	100.0	0.0
29012_2	Oe	4.0	3.5	22.0	2.8	1.6	0.1	2.1	41.8	19.5	6.8	0.3	6.5	79.5	33.2
	A	4.0	3.2	3.5	0.5	0.3	0.0	0.6	9.4	16.6	3.4	1.2	2.2	55.8	7.7
	Upper B	4.8	3.9	0.1	0.0	0.0	0.0	0.2	4.0	21.2	2.7	2.4	0.3	6.9	2.9
	Lower B	4.8	4.3	0.1	0.0	0.0	0.0	0.1	2.3	24.5	1.4	1.2	0.3	6.4	1.5
	Cd	4.9	4.7	0.0	0.0	0.0	0.0	0.0	0.1	16.5	0.5	0.2	0.3	6.5	0.5
30009_1	Oe	3.8	3.2	13.5	1.8	2.0	0.1	2.4	49.7	20.5	6.3	0.4	5.9	73.2	23.6
	Oa	3.4	2.8	4.9	0.7	0.7	0.0	1.8	35.9	19.9	10.7	4.6	6.1	36.1	17.0
	A	3.5		1.9	0.4	0.5	0.0	1.0	19.4	19.1	7.4	3.5	3.9	27.0	10.1
	Upper B	4.2	3.7	0.2	0.1	0.1	0.0	0.4	8.2	20.3	7.0	6.0	1.0	6.1	7.5
	Lower B	4.4	4.3	0.0	0.0	0.0	0.0	0.1	2.2	27.1	1.4	1.4	0.0	4.2	1.4
	Cd	5.4	4.7	0.0	0.0	0.0	0.0	0.0	0.3	26.8	0.3	0.3	0.0	10.3	0.3
30009_2	Oe	3.9	3.4	18.0	2.2	2.2	0.1	2.2	43.6	20.0	5.9	0.6	5.3	79.1	28.3

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Oa	3.6	3.1	7.9	1.0	0.9	0.0	1.5	35.2	23.1	9.8	5.5	4.3	45.2	19.6
	A	3.9	3.2	3.6	0.5	0.6	0.0	0.8	14.5	17.4	7.4	4.5	2.8	38.6	12.2
	Upper B	4.2	3.7	0.1	0.1	0.1	0.0	0.3	5.9	20.6	3.3	3.3	0.0	8.0	3.6
	Lower B	5.0	4.3	0.0	0.0	0.0	0.0	0.1	1.7	19.3	0.7	0.7	0.0	10.4	0.8
	Cd	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.3	20.4	0.3	0.3	0.0	13.9	0.4
30009_3	Oe	3.8	3.3	15.9	2.0	2.2	0.1	2.1	40.4	19.2	6.5	1.1	5.3	74.2	26.6
	Oa	3.6	2.9	8.4	0.9	0.8	0.0	1.6	32.7	20.9	8.2	1.8	6.4	54.5	18.4
	A	4.0	3.2	2.5	0.6	0.6	0.0	0.8	13.6	17.7	6.1	4.1	2.1	34.3	9.9
	Upper B	4.3	3.8	0.1	0.1	0.1	0.0	0.3	5.9	18.7	4.8	5.2	0.0	5.8	5.1
	Lower B	4.6	4.5	0.0	0.0	0.0	0.0	0.1	1.1	22.1	0.5	0.6	0.0	7.9	0.6
	Cd	5.2	4.6	0.0	0.0	0.0	0.0	0.0	0.4	22.3	0.3	0.4	0.0	10.3	0.4
31009_1	Oe	3.7	3.2	16.3	2.9	2.2	0.1	2.6	49.1	19.0	6.7	0.4	6.3	75.8	28.2
	Oa	3.4	2.7	6.0	0.8	0.6	0.0	1.7	37.3	21.7	10.6	4.2	6.5	38.5	18.0
	Upper B	4.1	3.5	0.3	0.1	0.1	0.0	0.3	5.7	22.3	6.4	6.3	0.0	7.0	6.8
	Lower B	4.6	4.0	0.1	0.0	0.0	0.0	0.1	2.6	27.2	1.7	1.9	0.0	4.6	1.8
	Cd	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.8	26.9	0.3	0.4	0.0	10.7	0.3
31009_2	Oe	3.9	3.3	16.2	1.8	1.7	0.1	2.5	50.2	20.5	15.7	5.4	10.3	55.7	35.5
	Oa	3.9	3.3	6.1	0.9	0.7	0.0	2.1	39.4	18.6	16.7	8.7	8.0	29.3	24.4
	Upper B	4.5	3.8	0.2	0.1	0.1	0.0	0.4	8.0	18.1	6.8	4.5	2.2	6.5	7.2
	Lower B	4.6	4.0	0.1	0.0	0.0	0.0	0.1	2.5	19.5	2.9	1.8	1.2	5.3	3.1
	Cd	4.7	4.4	0.0	0.0	0.0	0.0	0.0	0.5	23.5	0.0	0.4	0.0	93.4	0.0
31009_3	Oe	3.7	3.2	17.0	2.5	1.4	0.0	2.2	40.6	18.2	7.4	0.6	6.8	72.6	28.3
	Oa	3.4	2.8	7.2	1.0	0.6	0.0	1.6	31.9	19.5	9.5	1.9	7.6	47.2	18.3
	A	3.8	3.0	1.2	0.3	0.3	0.0	0.5	9.9	19.5	4.2	1.3	2.9	30.5	6.0
	Upper B	4.1	3.6	0.1	0.1	0.1	0.0	0.2	5.9	24.2	5.9	6.1	0.0	4.2	6.1
	Lower B	4.7	4.2	0.0	0.0	0.0	0.0	0.1	1.4	24.0	0.8	0.8	0.0	5.7	0.9
	Cd	5.0	4.5	0.0	0.0	0.0	0.0	0.0	0.3	24.6	0.4	0.3	0.1	7.0	0.4
35014_1	Oe	3.4	2.9	13.3	2.0	1.7	0.1	2.6	49.9	19.5	9.2	0.4	8.7	63.7	26.4
	Oa	3.2	2.7	6.6	1.1	0.7	0.1	2.2	44.3	20.1	10.6	2.7	7.9	42.3	19.1

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Upper B	3.9	3.3	0.1	0.1	0.1	0.0	0.3	7.0	20.9	4.3	4.1	0.1	6.5	4.6
	Lower B	4.4	4.1	0.1	0.0	0.0	0.0	0.2	4.0	23.9	1.7	1.9	0.0	5.6	1.8
	Cd	5.2	4.4	0.0	0.0	0.0	0.0	0.0	0.8	23.3	0.5	0.6	0.0	7.6	0.5
35014_2	Oe	3.9	3.3	17.2	2.0	1.9	0.1	2.5	48.8	19.3	6.1	0.4	5.8	77.5	27.2
	Oa	3.4	2.9	10.1	1.3	0.8	0.0	2.0	38.7	19.6	7.6	1.8	5.8	60.1	19.7
	Upper B	3.9	3.6	0.5	0.1	0.1	0.0	0.4	8.4	20.1	7.3	6.9	0.4	10.1	8.2
	Lower B	4.6	4.2	0.1	0.0	0.0	0.0	0.2	4.5	23.6	2.4	2.6	0.0	6.4	2.6
	Cd	4.8	4.6	0.0	0.0	0.0	0.0	0.0	0.7	24.9	0.4	0.4	0.0	9.3	0.4
7001_1	Oe	4.4	3.8	22.7	3.1	2.3	0.1	2.0	45.7	22.3	5.1	0.4	4.7	84.6	33.3
	Oa	3.9	3.3	12.0	1.6	1.1	0.0	2.0	37.6	18.6	8.6	3.5	5.1	57.6	23.2
	A	3.9	3.2	1.6	0.3	0.3	0.0	0.8	14.3	17.5	7.3	4.8	2.5	22.6	9.5
	Upper B	4.6	3.9	0.4	0.1	0.1	0.0	0.3	6.3	19.3	4.6	3.9	0.7	11.5	5.2
	Lower B	4.7	4.1	0.2	0.0	0.0	0.0	0.2	3.4	22.2	2.3	2.2	0.1	10.4	2.5
	Cd	4.9	4.3	0.1	0.0	0.0	0.0	0.0	1.0	22.4	0.9	0.8	0.1	10.6	1.0
7001_2	Oe	4.8	4.3	53.1	8.4	2.1	0.1	2.2	46.6	21.3	3.4	0.1	3.3	95.0	67.0
	Oa	4.3	3.8	27.8	3.3	1.3	0.0	1.9	36.3	19.3	3.3	0.3	3.1	89.4	35.7
	A	4.0	3.4	6.4	0.7	0.3	0.0	0.9	15.9	18.1	2.5	0.6	1.8	73.8	9.9
	Upper B	4.7	4.0	1.0	0.1	0.1	0.0	0.2	4.4	21.3	3.3	2.4	0.8	26.2	4.4
	Lower B	5.3	4.5	1.6	0.2	0.0	0.0	0.1	1.9	18.7	1.2	0.7	0.4	60.0	3.0
	Cd	5.5	4.8	0.7	0.2	0.0	0.0	0.0	0.2	17.1	0.0	0.1	0.0	99.7	0.9
7001_3	Oe	4.5	4.1	32.8	6.8	2.5	0.1	2.5	47.2	18.9	2.7	0.2	2.5	94.0	44.8
	Oa	4.0	3.5	20.6	3.5	1.3	0.0	2.0	35.6	17.5	4.8	0.5	4.3	79.4	30.3
	A	3.9	3.3	2.9	0.5	0.3	0.0	0.6	9.2	14.7	2.1	0.7	1.4	66.1	5.8
	Upper B	4.6	3.8	0.5	0.1	0.1	0.0	0.4	6.8	18.2	4.9	4.5	0.4	12.5	5.6
	Lower B	4.9	4.4	0.0	0.0	0.0	0.0	0.0	0.8	20.3	0.3	0.3	0.0	12.3	0.3
	Cd	4.9	4.4	0.0	0.0	0.0	0.0	0.0	0.7	22.6	0.4	0.3	0.0	11.0	0.4
9006_1	Oe	4.4	3.8	22.3	4.0	2.3	0.1	2.4	47.4	20.2	7.3	2.1	5.2	79.6	36.0
	Oa	3.7	3.1	11.3	1.6	1.1	0.1	2.4	45.9	19.0	11.5	4.9	6.7	50.2	25.7
	Upper B	4.7	4.0	0.3	0.1	0.1	0.0	0.3	5.8	18.1	3.5	2.6	0.9	12.4	4.0

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Lower B	4.8	4.1	0.2	0.1	0.1	0.0	0.2	4.0	19.1	2.5	1.8	0.7	12.7	2.9
	Cd	5.0	4.5	0.1	0.0	0.0	0.0	0.0	0.6	23.8	0.0	0.2	0.0	89.4	0.1
9006_2	Oe	4.2	3.9	20.3	2.9	1.7	0.1	2.2	42.0	19.0	5.0	0.4	4.6	83.2	30.0
	Oa	3.8	3.3	12.5	1.5	1.0	0.0	1.9	33.9	18.2	6.1	1.4	4.7	64.1	21.2
	A	3.9	3.4	1.9	0.4	0.3	0.0	0.9	13.8	15.3	6.0	3.8	2.2	30.5	8.7
	Upper B	4.8	4.2	0.3	0.0	0.0	0.0	0.3	6.8	19.6	3.1	2.9	0.2	11.3	3.5
	Lower B	4.8	4.4	0.1	0.0	0.0	0.0	0.2	3.2	20.6	1.2	1.1	0.1	11.8	1.4
	Cd	4.9	4.5	0.1	0.0	0.0	0.0	0.1	1.4	22.4	0.6	0.6	0.1	10.5	0.7
9006_3	Oe	3.9	3.5	14.9	2.0	1.7	0.0	2.4	42.3	17.8	54.4	0.9	53.4	25.6	73.0
	Oa	3.7	3.0	9.3	1.3	0.9	0.0	1.5	26.9	18.0	6.1	1.3	4.8	65.5	17.7
	A	3.9	3.3	2.2	0.4	0.3	0.0	0.8	13.8	17.5	4.5	2.4	2.0	40.8	7.4
	Upper B	4.4	3.8	0.3	0.1	0.1	0.0	0.3	4.4	16.2	3.1	2.5	0.6	13.3	3.6
	Lower B	4.7	4.2	0.2	0.0	0.0	0.0	0.1	2.9	19.9	1.7	1.5	0.2	11.3	1.9
	Cd	4.9	4.5	0.1	0.0	0.0	0.0	0.0	1.2	23.5	0.5	0.4	0.1	19.2	0.6
AMP_1	Oe	4.4	4.0	37.4	3.8	1.6	0.1	2.4	47.2	19.7	3.2	0.5	2.7	92.2	46.1
	Oa	3.8	3.3	29.6	2.4	0.7	0.0	2.4	44.7	19.0	7.0	1.5	5.5	81.6	39.7
	A	4.8	3.9	4.2	0.5	0.2	0.0	0.9	13.8	15.1	5.5	4.4	1.1	48.0	10.5
	Upper B	4.8	4.1	1.0	0.1	0.0	0.0	0.2	5.0	22.0	3.3	2.9	0.4	24.3	4.5
	Lower B	4.9	4.3	0.6	0.0	0.0	0.0	0.1	3.4	23.7	1.9	1.7	0.2	24.8	2.6
	Cd	5.1	4.4	0.3	0.0	0.0	0.0	0.1	1.4	25.5	1.1	1.1	0.1	22.2	1.5
AMP_2	Oe	4.9	4.5	45.9	5.2	1.9	0.1	2.2	42.8	19.3	2.1	0.2	1.9	96.1	55.2
	Oa	4.1	3.6	18.9	2.0	1.1	0.1	2.2	36.6	17.0	6.7	3.0	3.7	70.6	28.8
	A	4.5	3.9	6.4	0.6	0.4	0.0	1.3	17.6	13.4	8.0	7.7	0.3	48.2	15.5
	Upper B	4.8	4.3	0.3	0.0	0.1	0.0	0.3	4.5	16.4	1.7	1.9	0.0	21.1	2.1
	Lower B	5.0	4.3	0.6	0.0	0.0	0.0	0.2	3.1	18.6	1.6	1.7	0.0	29.9	2.3
	Cd	5.1	4.6	0.2	0.0	0.0	0.0	0.0	0.9	22.7	0.4	0.4	0.0	33.0	0.6
N1_1	Oe	4.4	3.9	31.4	3.0	1.8	0.1	2.2	45.3	20.6	3.5	0.1	3.3	91.2	39.8
	Oa	3.9	3.4	20.3	1.9	0.9	0.0	2.1	40.3	19.5	5.4	1.0	4.4	79.1	28.5
	A	4.2	3.5	7.0	0.6	0.3	0.0	0.7	12.3	18.3	3.3	1.3	2.0	68.3	11.2

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Upper B	4.8	4.2	0.2	0.0	0.0	0.0	0.2	2.5	15.8	1.6	1.7	0.0	15.5	1.8
	Lower B	5.0	4.4	0.2	0.0	0.0	0.0	0.1	2.2	19.2	0.9	1.0	0.0	19.0	1.1
	Cd	5.1	4.7	0.1	0.0	0.0	0.0	0.0	1.0	22.6	0.5	0.4	0.1	20.6	0.6
N1_2	Oe	4.3	3.8	12.0	1.7	1.6	0.2	2.5	47.5	18.9	15.3	12.3	3.0	50.1	30.7
	Oa	4.0	3.4	8.5	1.3	0.8	0.1	2.4	38.9	16.5	14.2	12.3	2.8	41.6	24.9
	Upper B	4.5	3.8	2.1	0.5	0.4	0.0	0.7	13.0	18.4	7.5	9.9	0.0	28.9	10.5
	Lower B	4.6	3.9	1.1	0.1	0.1	0.0	0.4	7.7	19.5	5.8	6.4	0.0	18.7	7.1
N1_3	Oe	5.0	4.6	34.3	3.5	1.6	0.1	2.1	42.4	20.2	0.5	0.3	0.2	98.8	39.9
	Oa	4.4	3.9	34.2	3.2	1.4	0.1	2.0	36.6	18.0	2.3	0.3	2.0	93.5	41.1
	A	4.6	3.9	9.4	0.9	0.2	0.0	0.7	10.4	15.0	2.2	1.3	0.9	81.4	12.8
	Upper B	4.8	4.2	2.2	0.2	0.1	0.0	0.3	4.4	17.3	2.2	2.8	0.0	52.8	4.7
	Lower B	6.2	5.4	4.1	0.2	0.0	0.0	0.1	1.9	17.5	0.0	0.0	0.0	99.8	4.3
	Cd	6.2	5.4	2.8	0.1	0.0	0.0	0.1	1.2	17.4	0.0	0.0	0.0	99.9	3.0
NW_1	Oe	5.2	5.0	51.0	6.5	2.0	0.0	2.0	33.7	16.5	1.0	0.1	0.9	98.4	60.5
	Oa	4.9	4.5	31.5	4.5	1.1	0.0	1.9	30.2	15.6	0.7	0.2	0.5	98.2	37.8
	A	4.6	4.0	6.7	1.3	0.4	0.0	0.8	12.3	15.0	2.3	1.4	0.9	75.3	10.8
	Upper B	4.8	4.2	0.8	0.1	0.1	0.0	0.2	4.3	17.4	2.1	2.2	0.1	33.5	3.1
	Lower B	5.2	4.6	0.3	0.0	0.0	0.0	0.1	1.5	18.1	0.5	0.5	0.0	39.1	0.9
	Cd	5.3	4.6	0.2	0.0	0.0	0.0	0.1	1.0	16.0	0.5	0.4	0.1	36.1	0.8
NW_2	Oe	4.8	4.4	36.2	4.8	1.7	0.0	1.9	32.2	16.9	1.7	0.1	1.6	96.2	44.4
	Oa	4.1	3.7	26.0	2.9	1.0	0.0	2.0	33.6	17.0	3.3	0.4	2.9	89.6	33.2
	A	4.3	3.8	5.4	0.8	0.3	0.0	0.7	8.8	13.5	1.8	0.7	1.1	77.9	8.3
	Upper B	4.5	3.8	1.2	0.2	0.2	0.0	0.2	2.8	15.2	1.9	1.4	0.5	47.2	3.5
	Lower B	5.0	4.4	0.8	0.1	0.0	0.0	0.3	4.4	15.8	1.6	1.8	0.0	37.6	2.6
	Cd	5.3	4.7	0.3	0.0	0.0	0.0	0.0	0.8	16.9	0.4	0.4	0.0	43.5	0.7
S14_1	Oe	4.9	4.5	47.2	5.9	1.8	0.1	2.3	41.8	18.3	2.1	0.2	1.8	96.4	57.1
	Oa	4.9	4.5	51.6	4.0	1.4	0.1	2.5	38.0	15.3	2.1	0.3	1.8	95.0	59.1
	A	4.4	3.7	8.7	0.8	0.3	0.0	0.9	12.8	14.1	4.3	3.1	1.3	63.8	14.2
	Upper B	4.4	3.8	2.7	0.2	0.1	0.0	0.3	4.0	15.5	2.7	2.6	0.2	48.8	5.7

Plot ID	Horizon	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
	Lower B	5.4	4.6	1.3	0.0	0.0	0.0	0.2	4.6	18.7	1.1	1.2	0.0	55.4	2.5
	Cd	5.5	4.8	0.5	0.0	0.0	0.0	0.1	1.8	23.0	0.5	0.7	0.0	52.9	1.1
S14_2	Oe	5.5	5.3	70.8	9.6	2.2	0.1	2.3	41.1	17.7	0.9	0.1	0.8	98.9	83.6
	Oa	5.2	4.8	56.9	6.1	1.5	0.1	2.3	35.3	15.2	0.7	0.1	0.6	98.9	65.3
	A	5.0	4.5	16.2	1.8	0.3	0.0	1.1	14.4	13.4	0.9	0.6	0.3	93.0	19.2
	Upper B	5.4	4.7	1.2	0.1	0.0	0.0	0.2	3.8	15.6	0.6	0.5	0.0	68.7	1.9
	Lower B	5.7	5.0	0.4	0.0	0.0	0.0	0.1	1.0	16.7	0.1	0.1	0.0	82.6	0.6
	Cd	5.6	5.0	0.3	0.0	0.0	0.0	0.1	0.9	16.3	0.1	0.1	0.0	75.0	0.5
WF_1	Oe	4.2	3.7	25.2	3.0	1.7	0.0	2.0	44.2	22.1	6.6	1.2	5.4	81.8	36.5
	Oa	4.1	3.6	12.6	1.9	1.3	0.0	2.0	38.4	19.3	9.6	6.0	3.6	61.3	25.5
	A	4.0	3.4	3.1	0.6	0.5	0.0	1.1	17.4	15.8	5.9	4.1	1.8	41.9	10.1
	Upper B	4.7	4.1	0.6	0.1	0.1	0.0	0.3	5.4	16.2	4.0	3.4	0.7	17.1	4.9
	Lower B	5.2	4.4	0.7	0.0	0.0	0.0	0.2	4.9	23.4	1.7	1.5	0.2	30.2	2.5
WF_2	Oe	4.4	3.9	27.5	3.8	2.7	0.1	2.4	47.0	19.3	4.5	0.2	4.3	88.4	38.5
	Oa	3.7	3.2	8.6	1.7	0.9	0.1	1.7	31.6	18.8	6.9	1.7	5.2	58.1	18.1
	A	4.3	3.8	5.8	0.9	0.5	0.0	0.8	13.2	16.3	4.2	2.2	1.9	62.2	11.4
	Upper B	4.6	3.9	0.4	0.1	0.1	0.0	0.4	8.9	22.7	3.7	3.5	0.1	12.6	4.2
	Lower B	4.7	4.1	0.2	0.0	0.0	0.0	0.1	2.5	21.5	0.8	0.5	0.3	25.1	1.1
WF_3	Oe	4.6	4.1	67.7	4.5	1.9	0.1	2.4	51.2	21.5	2.9	0.2	2.7	96.2	77.1
	Oa	5.3	4.8	58.3	3.2	0.7	0.1	2.4	42.0	17.5	1.8	0.3	1.5	95.9	64.1
	A	4.3	3.8	24.5	1.8	0.6	0.0	1.0	16.3	16.6	3.0	0.4	2.6	90.0	29.8
	Upper B	4.9	4.2	2.1	0.2	0.1	0.0	0.3	4.6	18.2	2.8	2.1	0.8	44.9	5.2
	Lower B	5.1	4.2	1.9	0.1	0.0	0.0	0.2	3.6	19.9	2.2	1.7	0.4	49.0	4.3
	Cd	5.1	4.4	0.6	0.0	0.0	0.0	0.0	1.2	26.0	1.3	0.9	0.4	33.3	1.9

Soil Chemistry in Oe horizon - 50 plots

PLOT_ID	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	3.8	3.2	16.4	2.2	0.0	1.4	2.4	45.4	19.0	9.0	1.3	7.7	69.1	29.0
12003_2	4.1	3.6	24.7	3.4	0.1	2.1	2.4	46.5	19.7	5.1	0.3	4.8	85.7	35.3
12003_3	4.2		26.4	3.6	0.1	2.2	2.2	45.3	20.8	6.5	0.3	6.2	83.3	38.8
13008_1	4.0	3.5	18.1	2.4	0.1	2.1	2.2	46.8	21.5	7.5	0.2	7.3	75.1	30.1
13008_2	3.9	3.3	13.6	1.7	0.1	2.1	2.1	42.1	20.3	7.2	0.5	6.7	70.9	24.8
17002_1	4.2	3.5	14.8	1.6	0.0	1.4	1.2	22.4	19.1	8.0	0.7	7.3	69.0	25.7
17002_2	4.2	3.5	12.1	1.7	0.0	0.7	1.3	25.0	19.6	3.4	0.6	2.9	78.0	18.0
17002_3	4.2		16.0	2.3	0.0	1.7	1.2	21.0	17.6	3.1	0.8	2.3	86.5	23.2
22019_1	4.3	4.0	32.5	3.8	0.1	2.2	2.2	48.3	21.6	3.6	0.1	3.5	91.5	42.3
22019_2	4.0	3.4	15.8	1.8	0.1	1.7	2.2	44.0	20.4	10.9	5.2	5.7	64.0	30.3
24001_1	5.2	4.7	69.4	5.3	0.1	1.7	2.3	42.7	18.6	2.2	0.1	2.1	97.1	78.6
24001_2	4.7	4.3	59.8	5.8	0.0	2.1	2.4	43.7	18.3	3.0	0.1	2.9	95.8	70.6
26008_1	3.8	3.2	20.5	2.4	0.1	2.2	2.6	49.7	18.9	8.5	0.6	7.8	74.5	33.6
26008_2	3.8	3.3	16.2	2.1	0.1	1.5	2.6	50.7	19.6	9.8	5.3	4.5	67.1	29.7
27019_1	4.0	3.7	25.4	4.6	0.1	1.8	2.3	43.8	19.4	5.2	0.2	5.0	85.9	37.1
27019_2	3.8	3.2	12.7	1.7	0.0	1.4	2.4	49.8	20.7	19.0	7.1	11.9	45.6	34.9
27019_3	4.2	3.7	22.0	3.7	0.1	2.4	1.9	43.4	23.0	5.6	0.1	5.5	83.3	33.8
28030_1	4.4		49.3	5.1	0.1	2.7	2.1	46.9	22.3	5.0	0.0	5.0	92.0	62.3
28030_2	3.9	3.3	20.0	2.6	0.1	1.7	2.1	40.0	19.2	5.1	0.3	4.8	80.6	29.5
28030_3	4.1	3.6	26.0	2.7	0.0	1.7	1.8	34.6	18.8	6.2	0.2	6.1	82.0	36.7
28037_1	4.7	4.2	29.4	3.6	0.1	1.9	2.1	43.0	20.5	4.2	0.3	3.9	89.3	39.2
28037_2	4.3	3.9	36.9	3.6	0.1	2.0	2.4	44.9	19.0	4.0	0.3	3.7	90.5	46.7
29012_1	3.8	3.2	17.8	2.0	0.1	1.4	1.8	33.8	19.3	8.2	0.5	7.7	71.3	29.4
29012_2	4.0	3.5	22.0	2.8	0.1	1.6	2.1	41.8	19.5	6.8	0.3	6.5	79.5	33.2
30009_1	3.8	3.2	13.5	1.8	0.1	2.0	2.4	49.7	20.5	6.3	0.4	5.9	73.2	23.6
30009_2	3.9	3.4	18.0	2.2	0.1	2.2	2.2	43.6	20.0	5.9	0.6	5.3	79.1	28.3
30009_3	3.8	3.3	15.9	2.0	0.1	2.2	2.1	40.4	19.2	6.5	1.1	5.3	74.2	26.6
31009_1	3.7	3.2	16.3	2.9	0.1	2.2	2.6	49.1	19.0	6.7	0.4	6.3	75.8	28.2
31009_2	3.9	3.3	16.2	1.8	0.1	1.7	2.5	50.2	20.5	15.7	5.4	10.3	55.7	35.5
31009_3	3.7	3.2	17.0	2.5	0.0	1.4	2.2	40.6	18.2	7.4	0.6	6.8	72.6	28.3
35014_1	3.4	2.9	13.3	2.0	0.1	1.7	2.6	49.9	19.5	9.2	0.4	8.7	63.7	26.4
35014_2	3.9	3.3	17.2	2.0	0.1	1.9	2.5	48.8	19.3	6.1	0.4	5.8	77.5	27.2
7001_1	4.4	3.8	22.7	3.1	0.1	2.3	2.0	45.7	22.3	5.1	0.4	4.7	84.6	33.3
7001_2	4.8	4.3	53.1	8.4	0.1	2.1	2.2	46.6	21.3	3.4	0.1	3.3	95.0	67.0
7001_3	4.5	4.1	32.8	6.8	0.1	2.5	2.5	47.2	18.9	2.7	0.2	2.5	94.0	44.8
9006_1	4.4	3.8	22.3	4.0	0.1	2.3	2.4	47.4	20.2	7.3	2.1	5.2	79.6	36.0
9006_2	4.2	3.9	20.3	2.9	0.1	1.7	2.2	42.0	19.0	5.0	0.4	4.6	83.2	30.0
9006_3	3.9	3.5	14.9	2.0	0.0	1.7	2.4	42.3	17.8	54.4	0.9	53.4	25.6	73.0
AMP_1	4.4	4.0	37.4	3.8	0.1	1.6	2.4	47.2	19.7	3.2	0.5	2.7	92.2	46.1
AMP_2	4.9	4.5	45.9	5.2	0.1	1.9	2.2	42.8	19.3	2.1	0.2	1.9	96.1	55.2
N1_1	4.4	3.9	31.4	3.0	0.1	1.8	2.2	45.3	20.6	3.5	0.1	3.3	91.2	39.8
N1_2	4.3	3.8	12.0	1.7	0.2	1.6	2.5	47.5	18.9	15.3	12.3	3.0	50.1	30.7
N1_3	5.0	4.6	34.3	3.5	0.1	1.6	2.1	42.4	20.2	0.5	0.3	0.2	98.8	39.9
NW_1	5.2	5.0	51.0	6.5	0.0	2.0	2.0	33.7	16.5	1.0	0.1	0.9	98.4	60.5
NW_2	4.8	4.4	36.2	4.8	0.0	1.7	1.9	32.2	16.9	1.7	0.1	1.6	96.2	44.4
S14_1	4.9	4.5	47.2	5.9	0.1	1.8	2.3	41.8	18.3	2.1	0.2	1.8	96.4	57.1
S14_2	5.5	5.3	70.8	9.6	0.1	2.2	2.3	41.1	17.7	0.9	0.1	0.8	98.9	83.6
WF_1	4.2	3.7	25.2	3.0	0.0	1.7	2.0	44.2	22.1	6.6	1.2	5.4	81.8	36.5
WF_2	4.4	3.9	27.5	3.8	0.1	2.7	2.4	47.0	19.3	4.5	0.2	4.3	88.4	38.5
WF_3	4.6	4.1	67.7	4.5	0.1	1.9	2.4	51.2	21.5	2.9	0.2	2.7	96.2	77.1

Soil Chemistry in Oa horizon - 49 plots

PLOT_ID	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	3.6	3.0	10.4	0.8	0.0	0.7	2.0	39.0	19.2	20.2	4.3	15.9	40.1	32.2
12003_2	3.5	2.9	13.1	1.3	0.0	0.8	2.0	42.2	20.9	10.1	1.8	8.3	59.7	25.3
12003_3	3.9	3.5	12.3	1.6	0.1	1.4	2.1	37.4	18.1	7.1	2.1	5.0	65.2	22.3
13008_1	3.5	3.1	7.9	1.2	0.0	1.0	2.0	39.1	19.6	9.3	1.0	8.3	51.6	19.4
13008_2	3.5	3.0	6.6	0.8	0.1	1.1	1.8	34.2	18.7	7.3	1.2	6.1	51.1	15.9
17002_1	4.0		17.2	1.4	0.0	0.8	1.9	38.9	20.4	6.7	0.3	6.5	74.2	26.0
17002_2	3.6	3.1	8.0	0.7	0.0	0.3	1.2	21.5	17.9	5.3	0.4	4.9	62.8	14.3
17002_3	3.6	3.1	14.5	1.8	0.0	1.0	1.9	34.2	17.8	7.4	1.0	6.4	67.9	24.7
22019_1	3.8	3.1	13.5	1.4	0.0	1.0	2.4	46.1	19.4	7.5	1.7	5.8	65.6	23.5
22019_2	3.9	3.3	5.6	0.7	0.0	0.6	1.9	36.3	19.4	10.8	6.7	4.3	37.1	17.8
24001_1	4.7	4.2	41.8	2.7	0.0	0.6	2.0	32.9	16.6	2.2	0.4	1.8	95.1	47.4
24001_2	4.8	4.3	44.8	4.3	0.0	1.5	2.2	35.6	16.1	2.8	0.1	2.7	94.7	53.5
26008_1	3.5	3.1	10.5	1.3	0.0	1.1	2.2	37.2	16.7	21.8	6.9	14.9	39.3	34.8
26008_2	3.9	3.3	5.1	0.9	0.1	0.8	2.1	40.7	19.0	15.5	12.9	2.7	27.2	22.3
27019_1	3.7	3.1	10.4	1.7	0.0	0.8	1.9	34.9	18.0	7.0	1.4	5.6	63.9	19.9
27019_2	4.0	3.4	3.9	0.7	0.0	0.6	2.0	36.8	18.0	19.0	10.8	8.2	18.9	24.2
27019_3	3.6	3.0	10.5	1.9	0.0	1.2	1.7	33.6	20.0	8.4	0.8	7.7	61.0	22.2
28030_1	3.9	3.7	47.7	4.0	0.1	1.3	2.2	43.8	19.6	3.6	0.1	3.4	93.1	56.6
28030_2	3.7	3.1	12.1	1.5	0.0	0.8	1.9	35.5	18.5	7.6	2.2	5.4	64.5	22.0
28030_3	4.0	3.3	14.7	1.4	0.0	0.8	1.6	29.2	18.6	17.9	0.4	17.5	60.3	34.8
28037_1	4.0	3.3	18.7	2.1	0.0	0.8	1.7	38.6	22.8	6.2	2.1	4.1	75.0	27.9
28037_2	4.0	3.7	17.7	1.8	0.0	0.7	1.7	31.5	19.0	5.0	1.5	3.5	78.8	25.4
29012_1	3.7	3.0	9.6	1.7	0.1	0.8	1.6	29.2	17.7	10.2	1.1	9.0	54.5	22.3
30009_1	3.4	2.8	4.9	0.7	0.0	0.7	1.8	35.9	19.9	10.7	4.6	6.1	36.1	17.0
30009_2	3.6	3.1	7.9	1.0	0.0	0.9	1.5	35.2	23.1	9.8	5.5	4.3	45.2	19.6
30009_3	3.6	2.9	8.4	0.9	0.0	0.8	1.6	32.7	20.9	8.2	1.8	6.4	54.5	18.4
31009_1	3.4	2.7	6.0	0.8	0.0	0.6	1.7	37.3	21.7	10.6	4.2	6.5	38.5	18.0
31009_2	3.9	3.3	6.1	0.9	0.0	0.7	2.1	39.4	18.6	16.7	8.7	8.0	29.3	24.4
31009_3	3.4	2.8	7.2	1.0	0.0	0.6	1.6	31.9	19.5	9.5	1.9	7.6	47.2	18.3
35014_1	3.2	2.7	6.6	1.1	0.1	0.7	2.2	44.3	20.1	10.6	2.7	7.9	42.3	19.1
35014_2	3.4	2.9	10.1	1.3	0.0	0.8	2.0	38.7	19.6	7.6	1.8	5.8	60.1	19.7
7001_1	3.9	3.3	12.0	1.6	0.0	1.1	2.0	37.6	18.6	8.6	3.5	5.1	57.6	23.2
7001_2	4.3	3.8	27.8	3.3	0.0	1.3	1.9	36.3	19.3	3.3	0.3	3.1	89.4	35.7
7001_3	4.0	3.5	20.6	3.5	0.0	1.3	2.0	35.6	17.5	4.8	0.5	4.3	79.4	30.3
9006_1	3.7	3.1	11.3	1.6	0.1	1.1	2.4	45.9	19.0	11.5	4.9	6.7	50.2	25.7
9006_2	3.8	3.3	12.5	1.5	0.0	1.0	1.9	33.9	18.2	6.1	1.4	4.7	64.1	21.2
9006_3	3.7	3.0	9.3	1.3	0.0	0.9	1.5	26.9	18.0	6.1	1.3	4.8	65.5	17.7
AMP_1	3.8	3.3	29.6	2.4	0.0	0.7	2.4	44.7	19.0	7.0	1.5	5.5	81.6	39.7
AMP_2	4.1	3.6	18.9	2.0	0.1	1.1	2.2	36.6	17.0	6.7	3.0	3.7	70.6	28.8
N1_1	3.9	3.4	20.3	1.9	0.0	0.9	2.1	40.3	19.5	5.4	1.0	4.4	79.1	28.5
N1_2	4.0	3.4	8.5	1.3	0.1	0.8	2.4	38.9	16.5	14.2	12.3	2.8	41.6	24.9

N1_3	4.4	3.9	34.2	3.2	0.1	1.4	2.0	36.6	18.0	2.3	0.3	2.0	93.5	41.1
NW_1	4.9	4.5	31.5	4.5	0.0	1.1	1.9	30.2	15.6	0.7	0.2	0.5	98.2	37.8
NW_2	4.1	3.7	26.0	2.9	0.0	1.0	2.0	33.6	17.0	3.3	0.4	2.9	89.6	33.2
S14_1	4.9	4.5	51.6	4.0	0.1	1.4	2.5	38.0	15.3	2.1	0.3	1.8	95.0	59.1
S14_2	5.2	4.8	56.9	6.1	0.1	1.5	2.3	35.3	15.2	0.7	0.1	0.6	98.9	65.3
WF_1	4.1	3.6	12.6	1.9	0.0	1.3	2.0	38.4	19.3	9.6	6.0	3.6	61.3	25.5
WF_2	3.7	3.2	8.6	1.7	0.1	0.9	1.7	31.6	18.8	6.9	1.7	5.2	58.1	18.1
WF_3	5.3	4.8	58.3	3.2	0.1	0.7	2.4	42.0	17.5	1.8	0.3	1.5	95.9	64.1

Soil Chemistry in A horizon - 43 plots

PLOT_ID	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	3.8	3.2	1.8	0.3	0.0	0.5	1.4	18.6	13.3	10.5	8.2	2.3	20.1	13.1
12003_2	3.7	3.1	6.1	0.9	0.0	0.8	1.1	18.6	17.0	6.4	2.2	4.2	55.1	14.3
12003_3	4.1	3.5	4.2	0.6	0.0	0.7	0.8	12.8	16.0	3.9	1.9	2.0	57.5	9.4
13008_1	3.9	3.1	1.7	0.3	0.0	0.3	0.6	12.4	19.6	4.9	2.4	2.6	32.1	7.2
13008_2	3.8	3.3	2.0	0.4	0.0	0.4	0.8	13.8	17.6	4.2	2.3	1.9	37.8	7.0
17002_1	4.1	3.5	1.3	0.3	0.0	0.2	0.4	7.5	17.3	4.6	1.9	2.7	25.5	6.4
17002_2	4.2	3.4	1.4	0.2	0.0	0.1	0.4	6.7	16.8	4.1	2.4	1.7	30.0	5.8
17002_3	4.3	3.8	0.8	0.2	0.0	0.2	0.4	6.1	14.4	3.4	3.1	0.3	25.2	4.6
22019_1	3.9	3.3	5.8	0.7	0.0	0.5	0.8	15.2	19.8	2.4	0.7	1.7	74.6	9.3
22019_2	3.7	3.1	1.9	0.3	0.0	0.3	0.8	15.5	19.4	7.2	5.1	2.2	25.7	9.7
24001_1	5.5	5.0	36.3	2.2	0.0	0.6	1.6	19.2	12.2	0.6	0.0	0.6	98.4	39.8
24001_2	4.9	4.2	13.1	1.5	0.0	0.4	0.7	10.4	14.7	1.1	0.2	0.9	93.0	16.1
26008_1	3.7	3.1	1.6	0.4	0.0	0.4	0.7	12.7	18.1	7.0	4.4	2.5	25.7	9.4
26008_2	4.2	3.6	0.5	0.2	0.0	0.3	0.9	15.7	17.1	9.4	6.8	2.6	10.3	10.5
27019_1	3.9	3.3	1.4	0.4	0.0	0.3	0.7	11.6	17.0	5.3	3.1	2.2	29.9	7.4
27019_2	4.2	3.6	0.3	0.1	0.0	0.2	0.7	11.5	17.5	8.3	6.7	1.6	7.1	9.0
27019_3	3.9	3.2	1.7	0.4	0.0	0.3	0.4	7.6	18.2	4.7	2.0	2.7	34.2	7.1
28030_1	4.5	3.7	3.9	0.6	0.0	0.1	0.3	5.9	18.2	1.4	0.4	1.0	77.0	6.1
28030_2	3.8	3.2	2.1	0.4	0.0	0.3	0.7	13.0	18.3	4.8	2.1	2.8	35.1	7.7
28030_3	4.1	3.4	4.6	0.6	0.0	0.3	0.5	8.6	16.9	3.3	0.7	2.5	58.4	8.7
28037_1	4.4	3.8	3.4	0.7	0.0	0.4	0.7	11.7	17.1	4.5	3.1	1.4	48.7	9.0
29012_1	4.0	3.2	0.8	0.2	0.0	0.2	0.4	5.5	15.1	3.6	1.5	2.1	25.2	4.8
29012_2	4.0	3.2	3.5	0.5	0.0	0.3	0.6	9.4	16.6	3.4	1.2	2.2	55.8	7.7
30009_1	3.5		1.9	0.4	0.0	0.5	1.0	19.4	19.1	7.4	3.5	3.9	27.0	10.1
30009_2	3.9	3.2	3.6	0.5	0.0	0.6	0.8	14.5	17.4	7.4	4.5	2.8	38.6	12.2
30009_3	4.0	3.2	2.5	0.6	0.0	0.6	0.8	13.6	17.7	6.1	4.1	2.1	34.3	9.9
31009_3	3.8	3.0	1.2	0.3	0.0	0.3	0.5	9.9	19.5	4.2	1.3	2.9	30.5	6.0
7001_1	3.9	3.2	1.6	0.3	0.0	0.3	0.8	14.3	17.5	7.3	4.8	2.5	22.6	9.5
7001_2	4.0	3.4	6.4	0.7	0.0	0.3	0.9	15.9	18.1	2.5	0.6	1.8	73.8	9.9
7001_3	3.9	3.3	2.9	0.5	0.0	0.3	0.6	9.2	14.7	2.1	0.7	1.4	66.1	5.8
9006_2	3.9	3.4	1.9	0.4	0.0	0.3	0.9	13.8	15.3	6.0	3.8	2.2	30.5	8.7
9006_3	3.9	3.3	2.2	0.4	0.0	0.3	0.8	13.8	17.5	4.5	2.4	2.0	40.8	7.4
AMP_1	4.8	3.9	4.2	0.5	0.0	0.2	0.9	13.8	15.1	5.5	4.4	1.1	48.0	10.5
AMP_2	4.5	3.9	6.4	0.6	0.0	0.4	1.3	17.6	13.4	8.0	7.7	0.3	48.2	15.5
N1_1	4.2	3.5	7.0	0.6	0.0	0.3	0.7	12.3	18.3	3.3	1.3	2.0	68.3	11.2
N1_3	4.6	3.9	9.4	0.9	0.0	0.2	0.7	10.4	15.0	2.2	1.3	0.9	81.4	12.8
NW_1	4.6	4.0	6.7	1.3	0.0	0.4	0.8	12.3	15.0	2.3	1.4	0.9	75.3	10.8
NW_2	4.3	3.8	5.4	0.8	0.0	0.3	0.7	8.8	13.5	1.8	0.7	1.1	77.9	8.3
S14_1	4.4	3.7	8.7	0.8	0.0	0.3	0.9	12.8	14.1	4.3	3.1	1.3	63.8	14.2
S14_2	5.0	4.5	16.2	1.8	0.0	0.3	1.1	14.4	13.4	0.9	0.6	0.3	93.0	19.2
WF_1	4.0	3.4	3.1	0.6	0.0	0.5	1.1	17.4	15.8	5.9	4.1	1.8	41.9	10.1
WF_2	4.3	3.8	5.8	0.9	0.0	0.5	0.8	13.2	16.3	4.2	2.2	1.9	62.2	11.4
WF_3	4.3	3.8	24.5	1.8	0.0	0.6	1.0	16.3	16.6	3.0	0.4	2.6	90.0	29.8

Soil Chemistry in Upper B horizon - 50 plots

PLOT_ID	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	4.4	3.7	0.2	0.1	0.0	0.1	0.3	6.1	22.6	4.8	5.2	0.0	7.7	5.2
12003_2	4.4	3.8	0.5	0.1	0.0	0.1	0.2	5.9	24.2	7.1	5.7	1.4	7.9	7.7
12003_3	4.9	4.0	0.3	0.1	0.0	0.1	0.2	3.7	17.2	2.4	2.6	0.0	17.7	2.9
13008_1	4.3	3.7	0.1	0.1	0.0	0.1	0.2	3.4	19.3	3.2	2.9	0.3	7.0	3.5
13008_2	4.2	3.7	0.1	0.1	0.0	0.1	0.2	3.2	17.7	2.7	2.4	0.3	6.4	2.9
17002_1	4.8	4.6	0.1	0.0	0.0	0.0	0.2	3.2	20.4	14.7	1.7	13.0	0.8	14.8
17002_2	4.9	4.2	0.3	0.0	0.0	0.0	0.2	4.3	23.3	2.3	2.2	0.1	11.6	2.6
17002_3	4.6	3.9	0.0	0.0	0.0	0.0	0.2	5.3	21.7	3.5	4.0	0.0	0.8	3.5
22019_1	4.4	3.7	0.9	0.1	0.0	0.1	0.4	9.9	23.7	7.5	6.9	0.5	12.5	8.6
22019_2	4.1	4.0	0.2	0.0	0.0	0.1	0.2	4.7	19.7	2.7	2.5	0.2	8.5	2.9
24001_1	4.9	4.3	5.2	0.4	0.0	0.1	0.3	5.8	16.8	2.4	2.0	0.4	70.3	8.1
24001_2	4.9	4.3	1.5	0.2	0.0	0.1	0.2	2.1	11.6	1.0	0.6	0.4	64.5	2.8
26008_1	4.5	3.8	0.2	0.1	0.0	0.1	0.2	2.9	17.0	2.8	2.2	0.6	10.0	3.1
26008_2	4.6	4.0	0.2	0.0	0.0	0.1	0.4	8.6	23.8	5.4	4.5	0.9	5.7	5.7
27019_1	4.6	3.7	0.5	0.1	0.0	0.1	0.3	6.9	24.0	5.2	4.8	0.5	11.0	5.9
27019_2	4.6	3.8	0.3	0.1	0.0	0.1	0.3	5.9	22.9	4.8	4.3	0.5	9.6	5.3
27019_3	4.6	3.9	0.2	0.1	0.0	0.1	0.2	3.5	17.8	3.6	2.5	1.1	10.0	4.0
28030_1	5.1	4.5	3.8	0.7	0.0	0.0	0.1	1.8	15.3	0.0	0.2	0.0	99.2	4.7
28030_2	4.5	3.9	0.3	0.1	0.0	0.1	0.3	6.4	21.3	4.8	4.9	0.0	7.7	5.2
28030_3	4.6	3.8	0.5	0.1	0.0	0.0	0.1	2.3	20.5	3.1	2.1	1.0	15.6	3.7
28037_1	4.5	3.7	2.7	0.7	0.0	0.1	0.2	3.3	19.7	2.4	0.0	2.4	59.6	5.9
28037_2	5.2	4.5	7.9	0.6	0.0	0.1	0.5	8.0	15.3	1.1	1.1	0.0	88.3	9.8
29012_1	4.8	4.1	0.1	0.0	0.0	0.0	0.2	3.7	18.8	2.4	1.5	0.9	7.1	2.6
29012_2	4.8	3.9	0.1	0.0	0.0	0.0	0.2	4.0	21.2	2.7	2.4	0.3	6.9	2.9
30009_1	4.2	3.7	0.2	0.1	0.0	0.1	0.4	8.2	20.3	7.0	6.0	1.0	6.1	7.5
30009_2	4.2	3.7	0.1	0.1	0.0	0.1	0.3	5.9	20.6	3.3	3.3	0.0	8.0	3.6
30009_3	4.3	3.8	0.1	0.1	0.0	0.1	0.3	5.9	18.7	4.8	5.2	0.0	5.8	5.1
31009_1	4.1	3.5	0.3	0.1	0.0	0.1	0.3	5.7	22.3	6.4	6.3	0.0	7.0	6.8
31009_2	4.5	3.8	0.2	0.1	0.0	0.1	0.4	8.0	18.1	6.8	4.5	2.2	6.5	7.2
31009_3	4.1	3.6	0.1	0.1	0.0	0.1	0.2	5.9	24.2	5.9	6.1	0.0	4.2	6.1
35014_1	3.9	3.3	0.1	0.1	0.0	0.1	0.3	7.0	20.9	4.3	4.1	0.1	6.5	4.6
35014_2	3.9	3.6	0.5	0.1	0.0	0.1	0.4	8.4	20.1	7.3	6.9	0.4	10.1	8.2
7001_1	4.6	3.9	0.4	0.1	0.0	0.1	0.3	6.3	19.3	4.6	3.9	0.7	11.5	5.2
7001_2	4.7	4.0	1.0	0.1	0.0	0.1	0.2	4.4	21.3	3.3	2.4	0.8	26.2	4.4
7001_3	4.6	3.8	0.5	0.1	0.0	0.1	0.4	6.8	18.2	4.9	4.5	0.4	12.5	5.6
9006_1	4.7	4.0	0.3	0.1	0.0	0.1	0.3	5.8	18.1	3.5	2.6	0.9	12.4	4.0
9006_2	4.8	4.2	0.3	0.0	0.0	0.0	0.3	6.8	19.6	3.1	2.9	0.2	11.3	3.5
9006_3	4.4	3.8	0.3	0.1	0.0	0.1	0.3	4.4	16.2	3.1	2.5	0.6	13.3	3.6
AMP_1	4.8	4.1	1.0	0.1	0.0	0.0	0.2	5.0	22.0	3.3	2.9	0.4	24.3	4.5
AMP_2	4.8	4.3	0.3	0.0	0.0	0.1	0.3	4.5	16.4	1.7	1.9	0.0	21.1	2.1
N1_1	4.8	4.2	0.2	0.0	0.0	0.0	0.2	2.5	15.8	1.6	1.7	0.0	15.5	1.8
N1_2	4.5	3.8	2.1	0.5	0.0	0.4	0.7	13.0	18.4	7.5	9.9	0.0	28.9	10.5
N1_3	4.8	4.2	2.2	0.2	0.0	0.1	0.3	4.4	17.3	2.2	2.8	0.0	52.8	4.7
NW_1	4.8	4.2	0.8	0.1	0.0	0.1	0.2	4.3	17.4	2.1	2.2	0.1	33.5	3.1
NW_2	4.5	3.8	1.2	0.2	0.0	0.2	0.2	2.8	15.2	1.9	1.4	0.5	47.2	3.5
S14_1	4.4	3.8	2.7	0.2	0.0	0.1	0.3	4.0	15.5	2.7	2.6	0.2	48.8	5.7
S14_2	5.4	4.7	1.2	0.1	0.0	0.0	0.2	3.8	15.6	0.6	0.5	0.0	68.7	1.9
WF_1	4.7	4.1	0.6	0.1	0.0	0.1	0.3	5.4	16.2	4.0	3.4	0.7	17.1	4.9
WF_2	4.6	3.9	0.4	0.1	0.0	0.1	0.4	8.9	22.7	3.7	3.5	0.1	12.6	4.2
WF_3	4.9	4.2	2.1	0.2	0.0	0.1	0.3	4.6	18.2	2.8	2.1	0.8	44.9	5.2

Soil Chemistry in Lower B horizon - 50 plots

PLOT_ID	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	4.6	4.1	0.1	0.0	0.0	0.0	0.1	3.0	24.9	2.1	2.4	0.0	6.6	2.2
12003_2	4.8	4.2	0.1	0.0	0.0	0.0	0.1	2.9	25.0	2.8	1.7	1.2	4.3	3.0
12003_3	5.0	4.5	0.1	0.0	0.0	0.0	0.0	0.3	14.9	0.3	0.3	0.0	18.7	0.4
13008_1	4.8	4.6	0.0	0.0	0.0	0.0	0.0	0.6	17.5	0.3	0.3	0.0	12.5	0.3
13008_2	4.7	4.5	0.0	0.0	0.0	0.0	0.0	0.3	14.0	0.2	0.2	0.0	10.2	0.2
17002_1	4.7	4.3	0.0	0.0	0.0	0.0	0.0	0.0	NA	0.0	0.0	0.0	100.0	0.0
17002_2	5.0	4.6	0.0	0.0	0.0	0.0	0.0	0.6	19.6	0.2	0.2	0.0	17.5	0.3
17002_3	4.9	4.7	0.3	0.1	0.0	0.1	0.0	0.4	15.6	0.2	0.3	0.0	63.4	0.6
22019_1	4.7	4.2	0.1	0.0	0.0	0.0	0.1	2.0	24.8	1.2	1.2	0.0	8.2	1.3
22019_2	4.7	4.2	0.1	0.0	0.0	0.0	0.1	1.6	21.6	2.0	1.2	0.8	5.6	2.1
24001_1	5.7	4.8	1.9	0.1	0.0	0.0	0.1	2.7	20.3	0.5	0.2	0.4	78.8	2.6
24001_2	5.1	4.9	0.7	0.0	0.0	0.0	0.0	0.6	16.4	0.0	0.0	0.0	100.0	0.8
26008_1	4.5	4.1	0.1	0.0	0.0	0.0	0.1	1.9	20.3	1.2	0.8	0.3	10.0	1.3
26008_2	4.6	4.1	0.1	0.0	0.0	0.0	0.2	5.1	25.4	3.5	3.0	0.5	4.9	3.7
27019_1	4.6	4.1	0.2	0.0	0.0	0.0	0.2	4.5	28.6	2.9	2.8	0.1	7.8	3.2
27019_2	4.7	4.2	0.1	0.0	0.0	0.0	0.1	3.7	28.1	2.1	1.7	0.4	7.3	2.3
27019_3	4.9	4.6	0.0	0.0	0.0	0.0	0.0	0.9	20.2	0.0	0.3	0.0	70.9	0.1
28030_1	6.3	5.5	4.1	0.5	0.0	0.0	0.1	1.1	18.1	0.0	0.0	0.0	100.0	4.6
28030_2	5.0	4.5	0.1	0.0	0.0	0.0	0.1	1.3	21.0	0.6	0.7	0.0	13.9	0.7
28030_3	5.2	4.7	0.1	0.0	0.0	0.0	0.0	0.6	18.6	0.0	0.2	0.0	100.0	0.1
28037_1	4.9	4.2	1.6	0.3	0.0	0.0	0.1	2.7	18.9	1.3	0.8	0.4	60.3	3.2
28037_2	5.3	4.5	2.0	0.1	0.0	0.0	0.1	1.5	19.6	0.6	0.6	0.0	78.6	2.7
29012_1	4.9	4.5	0.0	0.0	0.0	0.0	0.0	0.8	20.9	0.0	0.2	0.0	87.9	0.0
29012_2	4.8	4.3	0.1	0.0	0.0	0.0	0.1	2.3	24.5	1.4	1.2	0.3	6.4	1.5
30009_1	4.4	4.3	0.0	0.0	0.0	0.0	0.1	2.2	27.1	1.4	1.4	0.0	4.2	1.4
30009_2	5.0	4.3	0.0	0.0	0.0	0.0	0.1	1.7	19.3	0.7	0.7	0.0	10.4	0.8
30009_3	4.6	4.5	0.0	0.0	0.0	0.0	0.1	1.1	22.1	0.5	0.6	0.0	7.9	0.6
31009_1	4.6	4.0	0.1	0.0	0.0	0.0	0.1	2.6	27.2	1.7	1.9	0.0	4.6	1.8
31009_2	4.6	4.0	0.1	0.0	0.0	0.0	0.1	2.5	19.5	2.9	1.8	1.2	5.3	3.1
31009_3	4.7	4.2	0.0	0.0	0.0	0.0	0.1	1.4	24.0	0.8	0.8	0.0	5.7	0.9
35014_1	4.4	4.1	0.1	0.0	0.0	0.0	0.2	4.0	23.9	1.7	1.9	0.0	5.6	1.8
35014_2	4.6	4.2	0.1	0.0	0.0	0.0	0.2	4.5	23.6	2.4	2.6	0.0	6.4	2.6
7001_1	4.7	4.1	0.2	0.0	0.0	0.0	0.2	3.4	22.2	2.3	2.2	0.1	10.4	2.5
7001_2	5.3	4.5	1.6	0.2	0.0	0.0	0.1	1.9	18.7	1.2	0.7	0.4	60.0	3.0
7001_3	4.9	4.4	0.0	0.0	0.0	0.0	0.0	0.8	20.3	0.3	0.3	0.0	12.3	0.3
9006_1	4.8	4.1	0.2	0.1	0.0	0.1	0.2	4.0	19.1	2.5	1.8	0.7	12.7	2.9
9006_2	4.8	4.4	0.1	0.0	0.0	0.0	0.2	3.2	20.6	1.2	1.1	0.1	11.8	1.4
9006_3	4.7	4.2	0.2	0.0	0.0	0.0	0.1	2.9	19.9	1.7	1.5	0.2	11.3	1.9
AMP_1	4.9	4.3	0.6	0.0	0.0	0.0	0.1	3.4	23.7	1.9	1.7	0.2	24.8	2.6
AMP_2	5.0	4.3	0.6	0.0	0.0	0.0	0.2	3.1	18.6	1.6	1.7	0.0	29.9	2.3
N1_1	5.0	4.4	0.2	0.0	0.0	0.0	0.1	2.2	19.2	0.9	1.0	0.0	19.0	1.1
N1_2	4.6	3.9	1.1	0.1	0.0	0.1	0.4	7.7	19.5	5.8	6.4	0.0	18.7	7.1
N1_3	6.2	5.4	4.1	0.2	0.0	0.0	0.1	1.9	17.5	0.0	0.0	0.0	99.8	4.3
NW_1	5.2	4.6	0.3	0.0	0.0	0.0	0.1	1.5	18.1	0.5	0.5	0.0	39.1	0.9
NW_2	5.0	4.4	0.8	0.1	0.0	0.0	0.3	4.4	15.8	1.6	1.8	0.0	37.6	2.6
S14_1	5.4	4.6	1.3	0.0	0.0	0.0	0.2	4.6	18.7	1.1	1.2	0.0	55.4	2.5
S14_2	5.7	5.0	0.4	0.0	0.0	0.0	0.1	1.0	16.7	0.1	0.1	0.0	82.6	0.6
WF_1	5.2	4.4	0.7	0.0	0.0	0.0	0.2	4.9	23.4	1.7	1.5	0.2	30.2	2.5
WF_2	4.7	4.1	0.2	0.0	0.0	0.0	0.1	2.5	21.5	0.8	0.5	0.3	25.1	1.1
WF_3	5.1	4.2	1.9	0.1	0.0	0.0	0.2	3.6	19.9	2.2	1.7	0.4	49.0	4.3

Soil Chemistry in A horizon - 43 plots

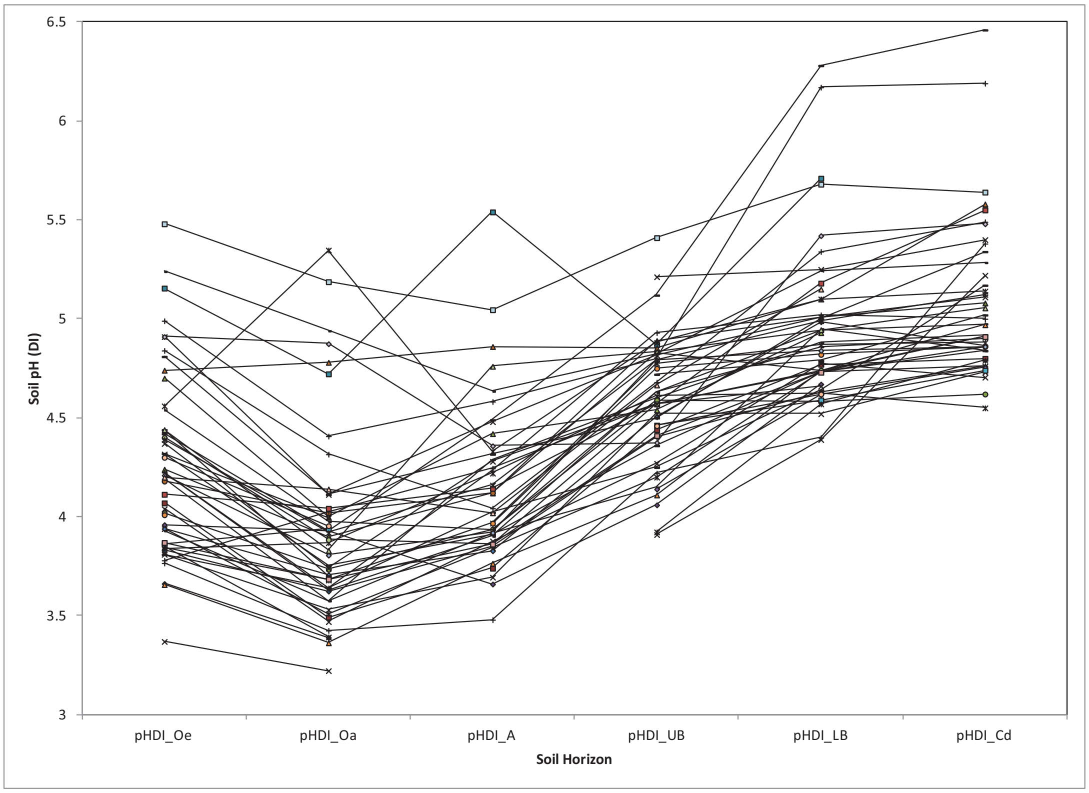
PLOT_ID	pH DI	pH $CaCl_2$	Ca	Mg	K	Na	N PCT	C PCT	C to N	Acidity	Al	H	BS	CEC
12003_1	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.7	29.2	0.4	0.5	0.0	8.2	0.5
12003_2	4.8	4.4	0.0	0.0	0.0	0.0	0.0	0.7	28.0	0.0	0.7	0.0	100.0	0.0
12003_3	5.1	4.6	0.0	0.0	0.0	0.0	0.0	0.1	15.7	0.3	0.2	0.1	14.4	0.3
13008_1	4.7	4.6	0.0	0.0	0.0	0.0	0.0	0.1	16.3	0.2	0.1	0.1	12.4	0.2
13008_2	4.8	4.6	0.0	0.0	0.0	0.0	0.0	0.2	67.8	0.2	0.2	0.0	11.9	0.2
17002_2	5.0	4.8	0.0	0.0	0.0	0.0	0.0	0.3	17.6	0.1	0.1	0.0	22.0	0.1
17002_3	4.9	4.8	0.0	0.0	0.0	0.0	0.0	0.1	12.8	0.0	0.1	0.0	44.3	0.1
22019_1	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.4	23.5	0.4	0.3	0.1	9.3	0.4
24001_2	5.6	5.1	0.9	0.1	0.0	0.0	0.0	0.5	16.8	0.2	0.0	0.1	84.4	1.1
26008_1	4.7	4.2	0.0	0.0	0.0	0.0	0.0	0.6	23.6	1.0	0.6	0.3	7.3	1.1
26008_2	4.6	4.0	0.1	0.0	0.0	0.0	0.0	0.6	25.7	0.1	0.5	0.0	64.4	0.3
27019_1	4.6	4.3	0.1	0.0	0.0	0.0	0.1	3.2	31.2	1.9	2.0	0.0	7.9	2.1
27019_2	4.9	4.4	0.1	0.0	0.0	0.0	0.1	2.1	28.4	1.0	0.6	0.4	10.4	1.1
27019_3	5.0	4.5	0.0	0.0	0.0	0.0	0.0	0.7	19.8	0.0	0.4	0.0	93.2	0.1
28030_1	6.5	5.6	1.6	0.2	0.0	0.0	0.0	0.3	20.3	0.0	0.0	0.0	100.0	1.8
28030_2	4.9	4.6	0.0	0.0	0.0	0.0	0.0	0.4	18.9	0.3	0.3	0.0	17.4	0.3
28030_3	5.6	4.9	0.1	0.0	0.0	0.0	0.0	0.1	49.8	0.0	0.0	0.0	100.0	0.1
28037_2	5.4	4.4	1.0	0.1	0.0	0.0	0.0	0.8	19.7	0.3	0.3	0.0	77.9	1.4
29012_1	4.9	4.7	0.0	0.0	0.0	0.0	0.0	0.2	17.6	0.0	0.0	0.0	100.0	0.0
29012_2	4.9	4.7	0.0	0.0	0.0	0.0	0.0	0.1	16.5	0.5	0.2	0.3	6.5	0.5
30009_1	5.4	4.7	0.0	0.0	0.0	0.0	0.0	0.3	26.8	0.3	0.3	0.0	10.3	0.3
30009_2	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.3	20.4	0.3	0.3	0.0	13.9	0.4
30009_3	5.2	4.6	0.0	0.0	0.0	0.0	0.0	0.4	22.3	0.3	0.4	0.0	10.3	0.4
31009_1	4.8	4.5	0.0	0.0	0.0	0.0	0.0	0.8	26.9	0.3	0.4	0.0	10.7	0.3
31009_2	4.7	4.4	0.0	0.0	0.0	0.0	0.0	0.5	23.5	0.0	0.4	0.0	93.4	0.0
31009_3	5.0	4.5	0.0	0.0	0.0	0.0	0.0	0.3	24.6	0.4	0.3	0.1	7.0	0.4
35014_1	5.2	4.4	0.0	0.0	0.0	0.0	0.0	0.8	23.3	0.5	0.6	0.0	7.6	0.5
35014_2	4.8	4.6	0.0	0.0	0.0	0.0	0.0	0.7	24.9	0.4	0.4	0.0	9.3	0.4
7001_1	4.9	4.3	0.1	0.0	0.0	0.0	0.0	1.0	22.4	0.9	0.8	0.1	10.6	1.0
7001_2	5.5	4.8	0.7	0.2	0.0	0.0	0.0	0.2	17.1	0.0	0.1	0.0	99.7	0.9
7001_3	4.9	4.4	0.0	0.0	0.0	0.0	0.0	0.7	22.6	0.4	0.3	0.0	11.0	0.4
9006_1	5.0	4.5	0.1	0.0	0.0	0.0	0.0	0.6	23.8	0.0	0.2	0.0	89.4	0.1
9006_2	4.9	4.5	0.1	0.0	0.0	0.0	0.1	1.4	22.4	0.6	0.6	0.1	10.5	0.7
9006_3	4.9	4.5	0.1	0.0	0.0	0.0	0.0	1.2	23.5	0.5	0.4	0.1	19.2	0.6
AMP_1	5.1	4.4	0.3	0.0	0.0	0.0	0.1	1.4	25.5	1.1	1.1	0.1	22.2	1.5
AMP_2	5.1	4.6	0.2	0.0	0.0	0.0	0.0	0.9	22.7	0.4	0.4	0.0	33.0	0.6
N1_1	5.1	4.7	0.1	0.0	0.0	0.0	0.0	1.0	22.6	0.5	0.4	0.1	20.6	0.6
N1_3	6.2	5.4	2.8	0.1	0.0	0.0	0.1	1.2	17.4	0.0	0.0	0.0	99.9	3.0
NW_1	5.3	4.6	0.2	0.0	0.0	0.0	0.1	1.0	16.0	0.5	0.4	0.1	36.1	0.8

NW_2	5.3	4.7	0.3	0.0	0.0	0.0	0.0	0.8	16.9	0.4	0.4	0.0	43.5	0.7
S14_1	5.5	4.8	0.5	0.0	0.0	0.0	0.1	1.8	23.0	0.5	0.7	0.0	52.9	1.1
S14_2	5.6	5.0	0.3	0.0	0.0	0.0	0.1	0.9	16.3	0.1	0.1	0.0	75.0	0.5
WF_3	5.1	4.4	0.6	0.0	0.0	0.0	0.0	1.2	26.0	1.3	0.9	0.4	33.3	1.9

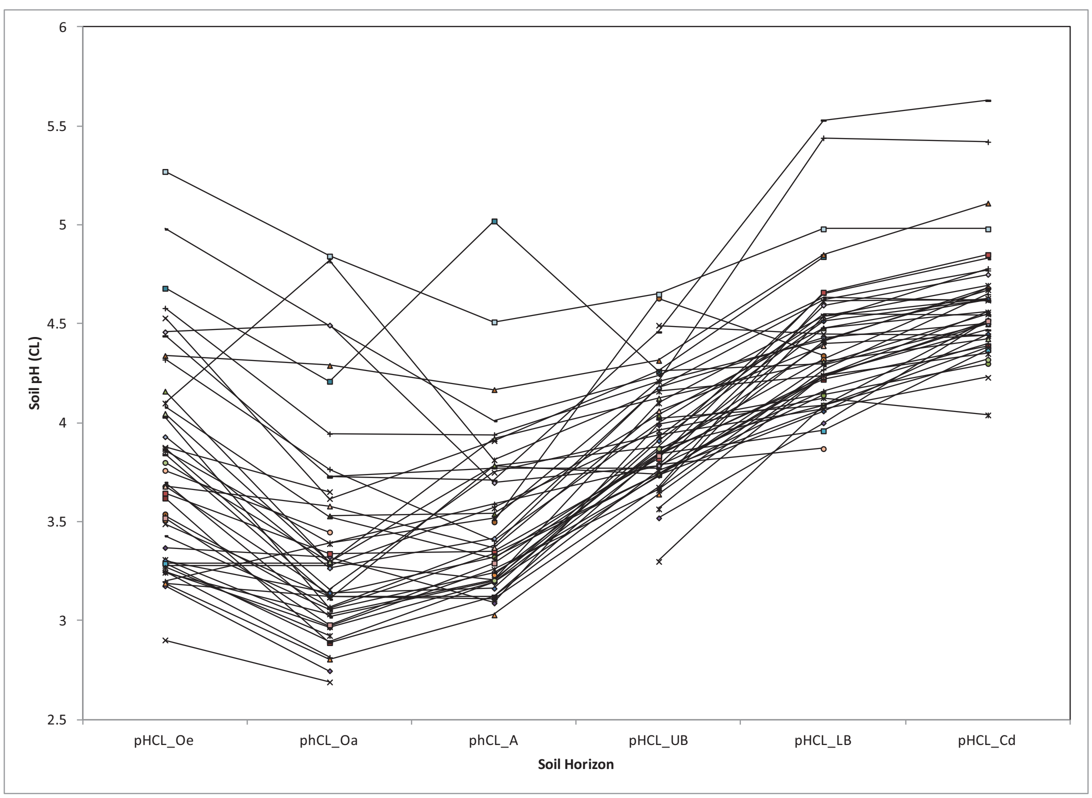
Appendix K

Plot-averaged soil chemistry data shown as line charts.

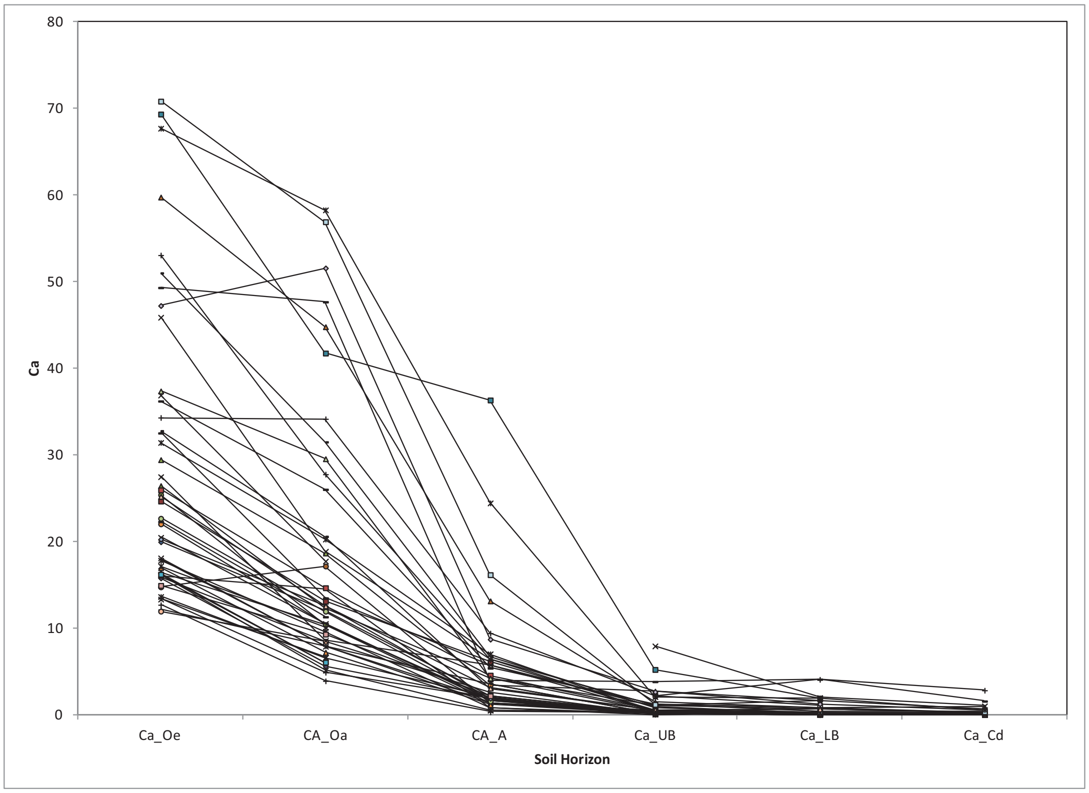
Plot-averaged soil chemistry data from the table in Appendix J are shown here as line charts. Each line represents the average data for a given soil chemical parameter from the top of the soil profile (left side of chart) to the bottom of the soil profile (right side of chart). These charts provide more detail than the box-and-whisker plots shown in Appendix I. With these charts, it is possible to determine the degree to which an overall increasing or decreasing trend with depth in soil chemistry occurs across the plots. It is also possible to compare the plots based on the magnitude of change in a given parameter with soil depth.

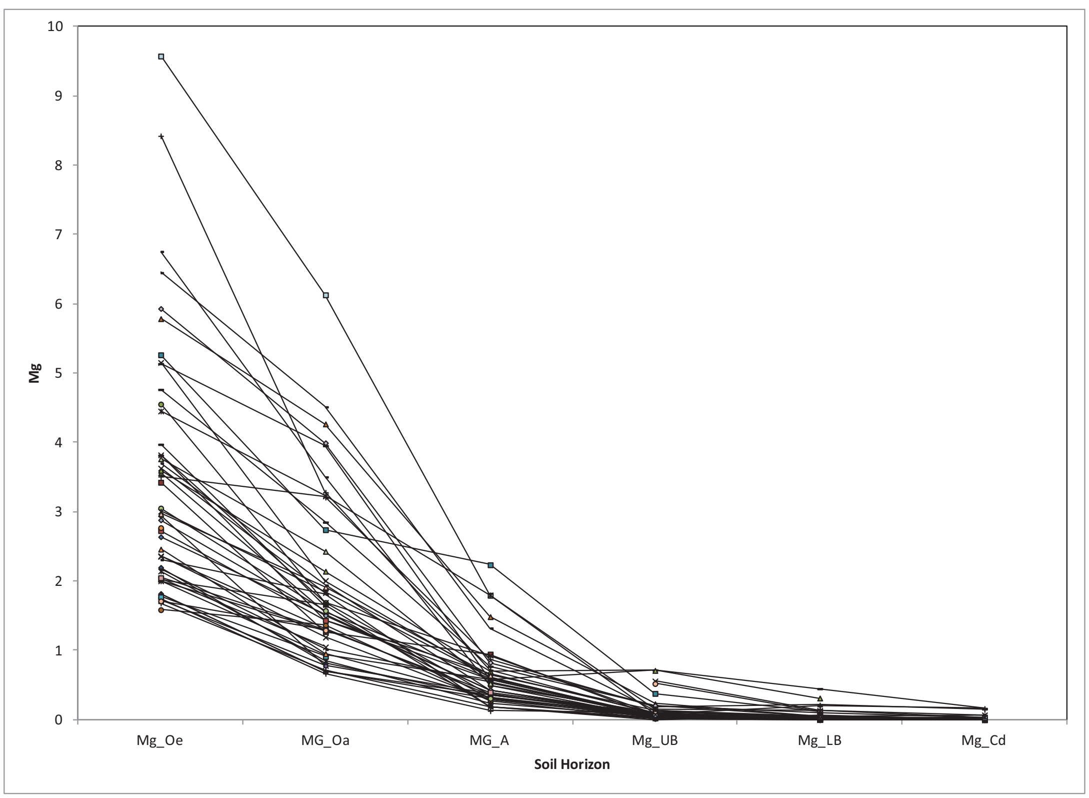


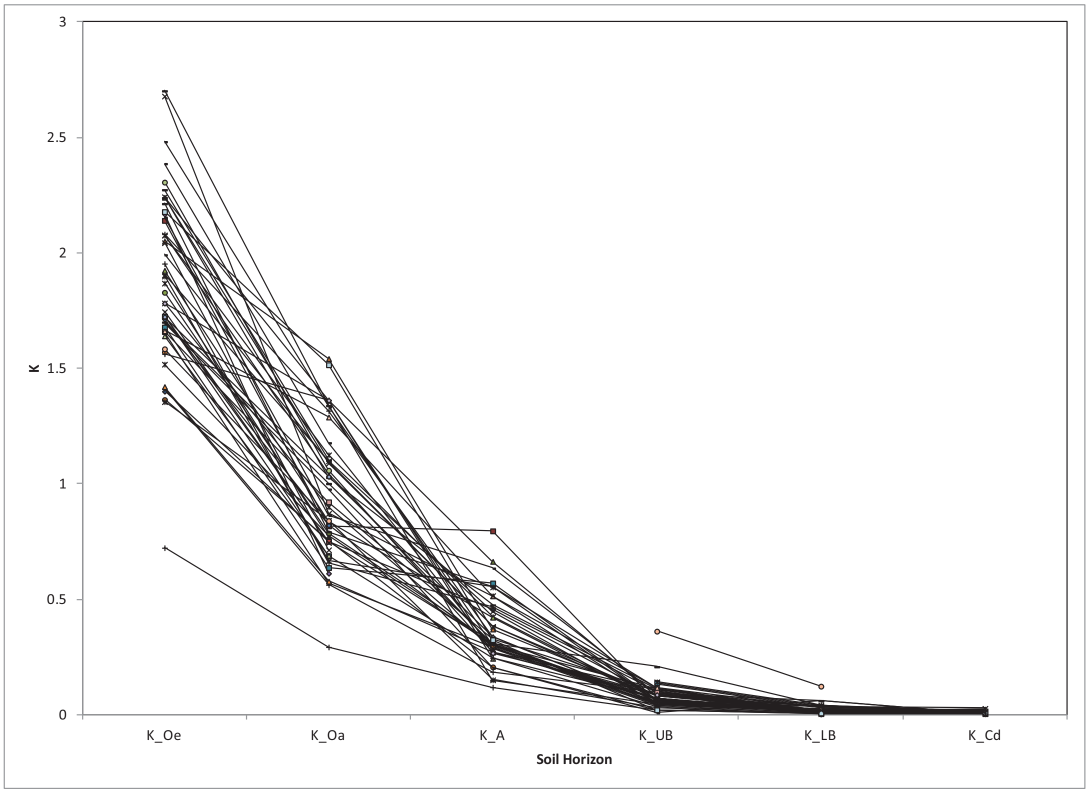
6.5
6
5.5
5
4.5
4
3.5
3
Soil pH (DI)
pHDI_Oe
pHDI_Oa
pHDI_A
pHDI_UB
pHDI_LB
pHDI_Cd
Soil Horizon

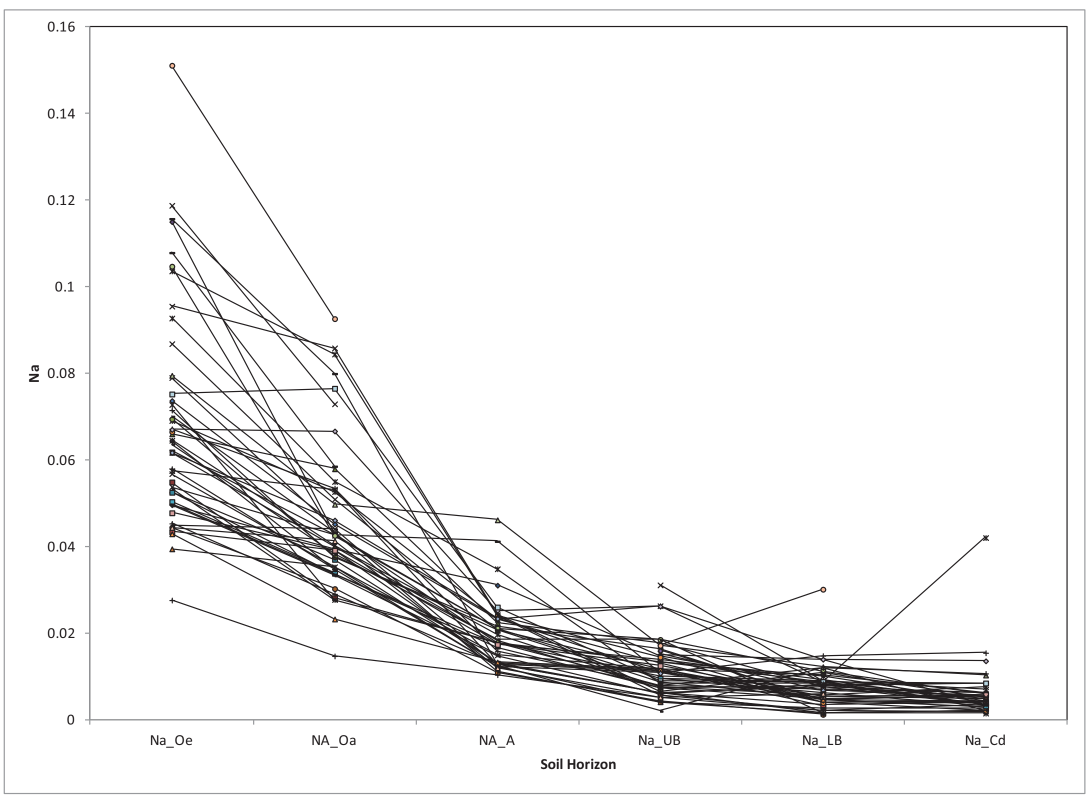


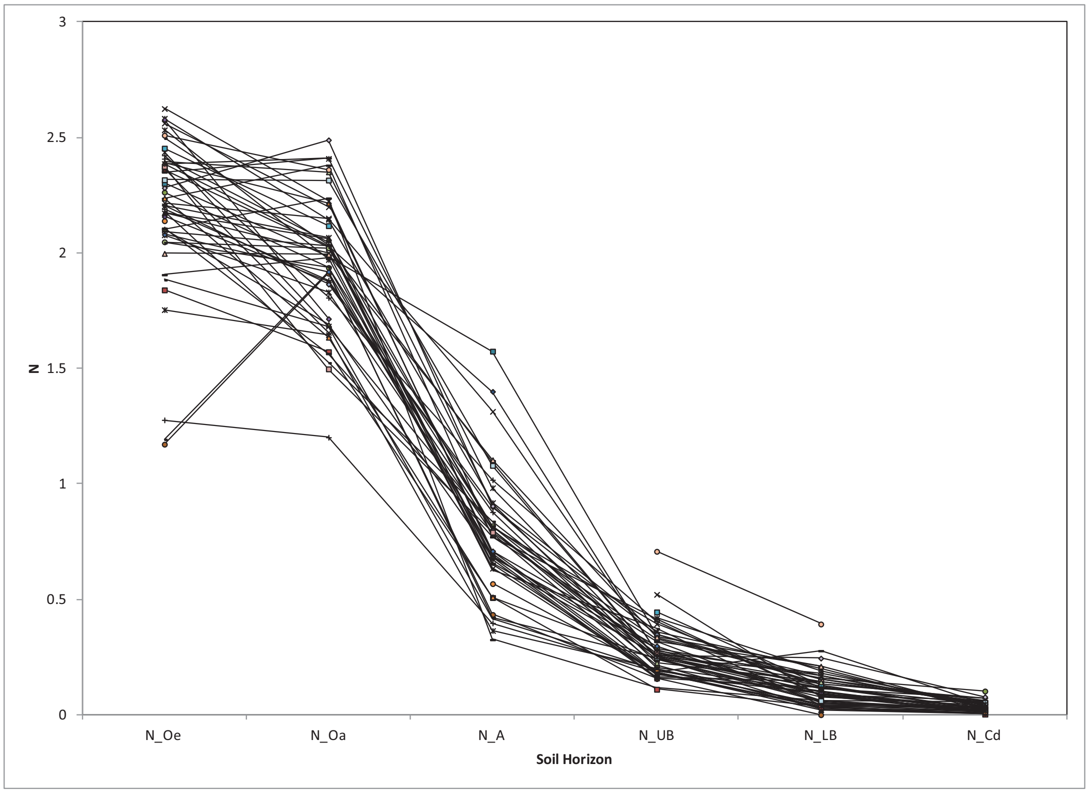
6
5.5
5
4.5
4
3.5
3
2.5
Soil pH (CL)
pHCL_Oe
phCL_Oa
phCL_A
pHCL_UB
pHCL_LB
pHCL_Cd
Soil Horizon

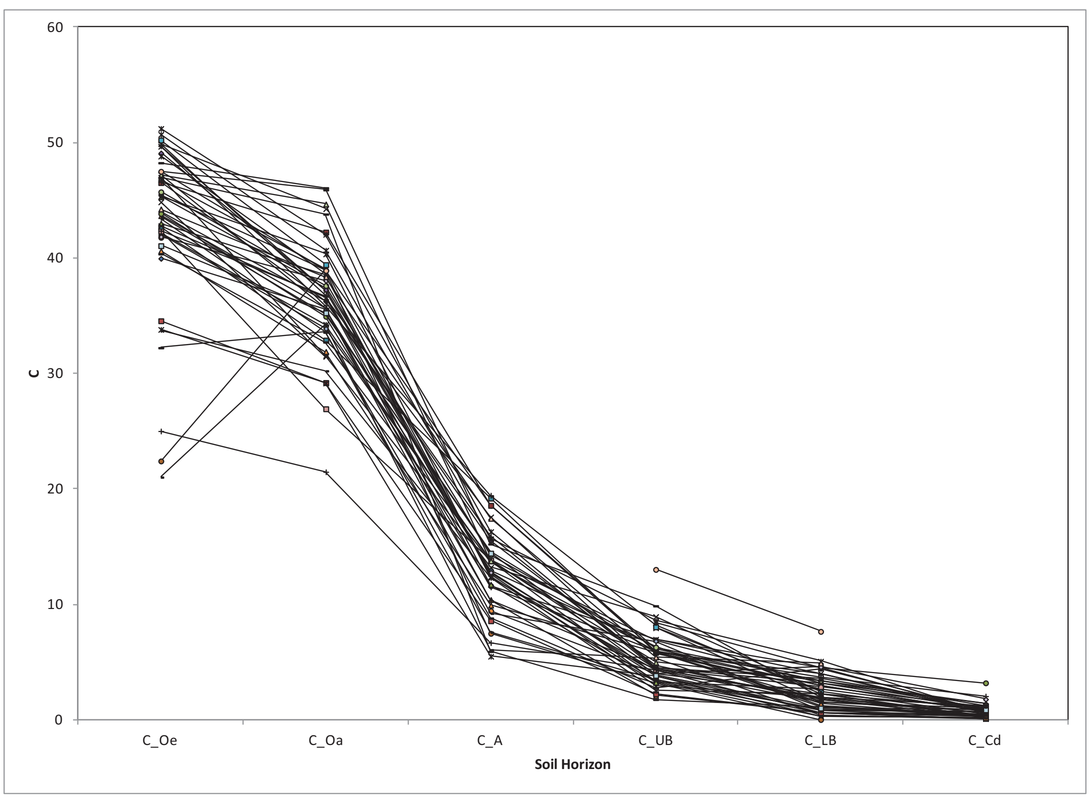

80
70
60
50
40
30
20
10
0
Ca
Ca_Oe
CA_Oa
CA_A
Ca_UB
Ca_LB
Ca_Cd
Soil Horizon

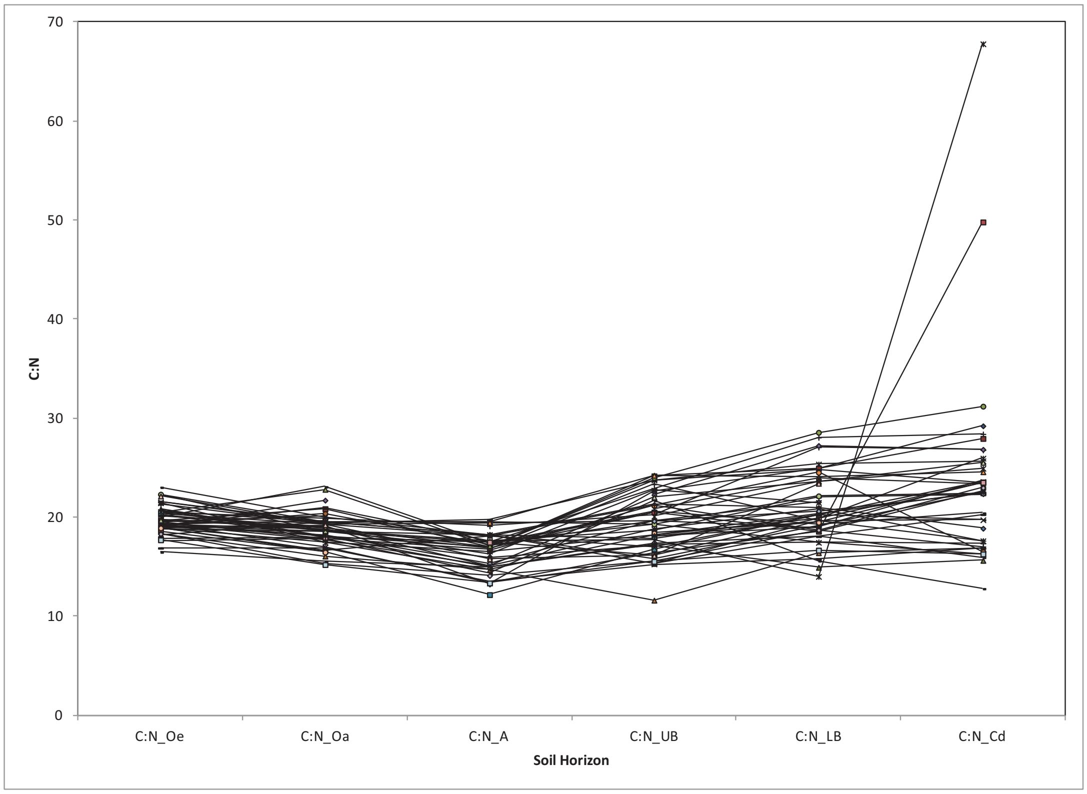

10
9
8
7
6
5
4
3
2
1
0
Mg
Mg_Oe
MG_Oa
MG_A
Mg_UB
Mg_LB
Mg_Cd
Soil Horizon


3
2.5
2
1.5
1
0.5
0
K
K_Oe
K_Oa
K_A
K_UB
K_LB
K_Cd
Soil Horizon

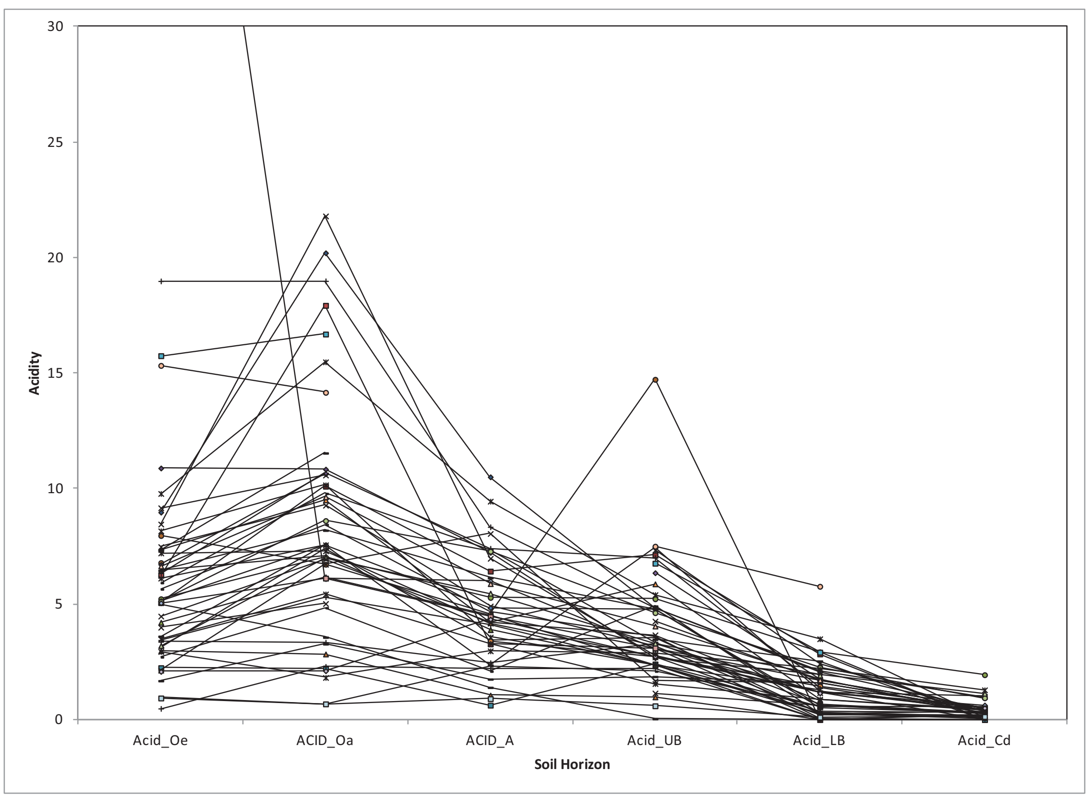

0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Na
Na_Oe
NA_Oa
NA_A
Na_UB
Na_LB
Na_Cd
Soil Horizon


3
2.5
2
1.5
1
0.5
0
N
N_Oe
N_Oa
N_A
N_UB
N_LB
N_Cd
Soil Horizon

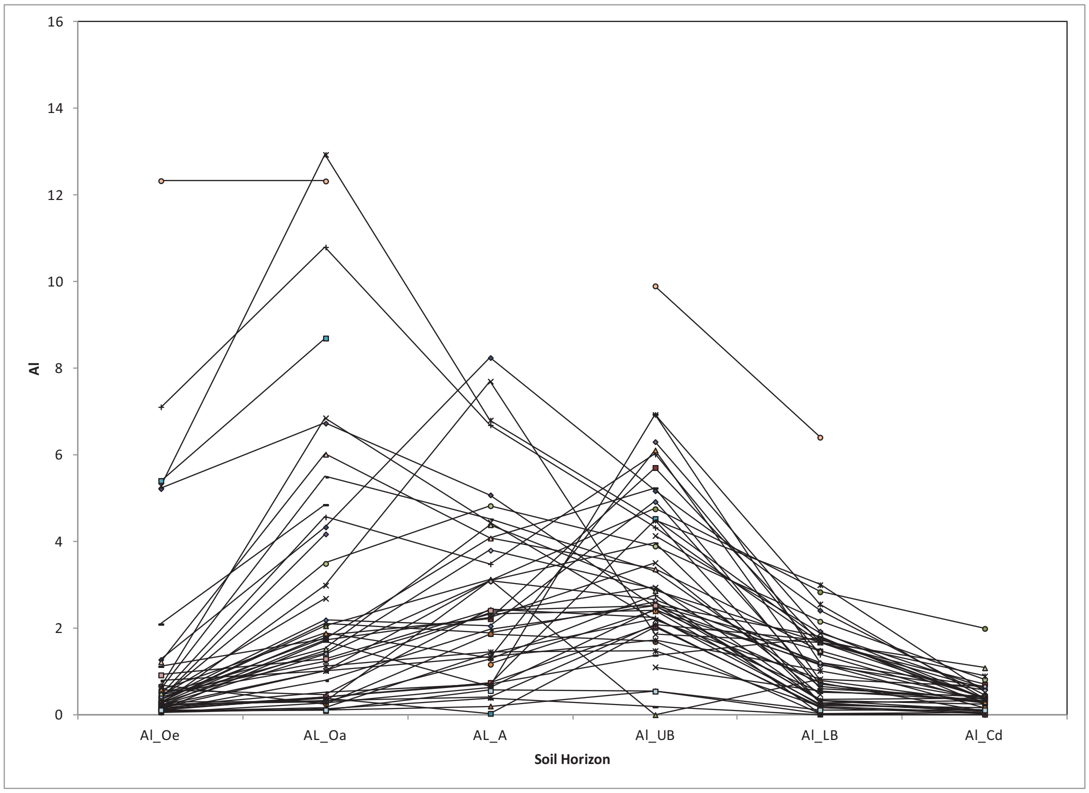

60
50
40
30
20
10
0
C
C_Oe
C_Oa
C_A
C_UB
C_LB
C_Cd
Soil Horizon

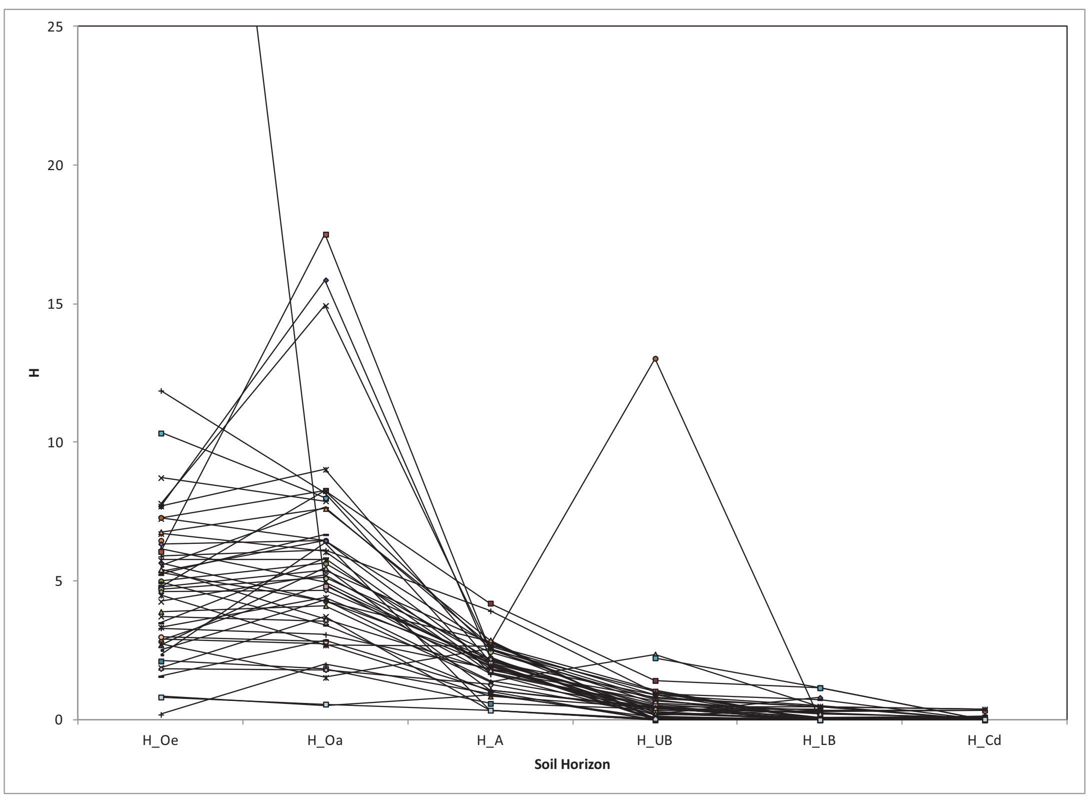


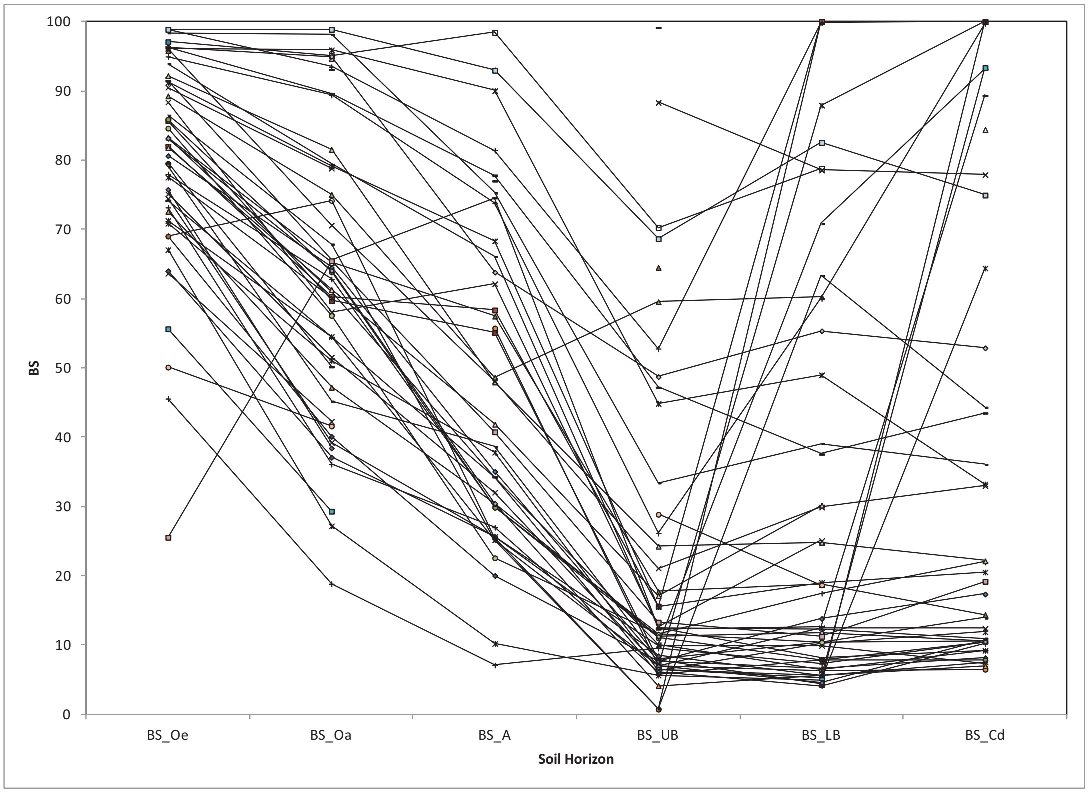
70
60
50
40
30
20
10
0
C:N
C:N_Oe
C:N_Oa
C:N_A
C:N_UB
C:N_LB
C:N_Cd
Soil Horizon



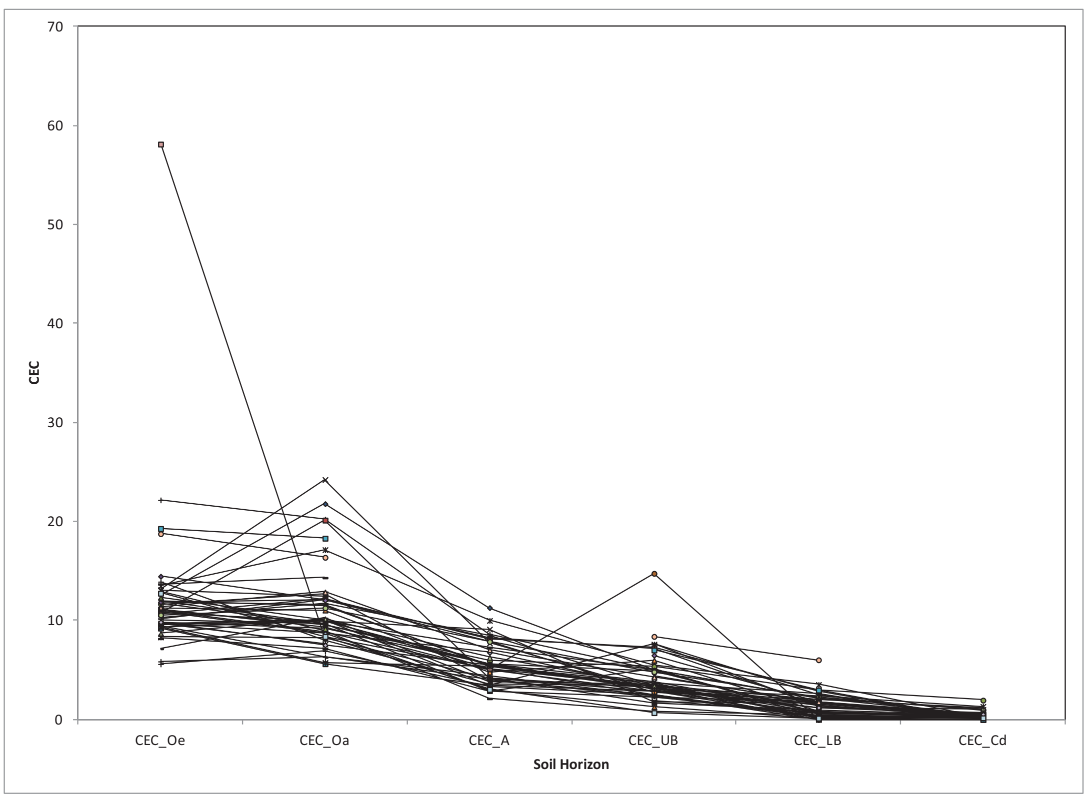
30
25
20
15
10
5
0
Acidity
Acid_Oe
ACID_Oa
ACID_A
Acid_UB
Acid_LB
Acid_Cd
Soil Horizon


16
14
12
10
8
6
4
2
0
Al
Al_Oe
AL_Oa
AL_A
Al_UB
Al_LB
Al_Cd
Soil Horizon


25
20
15
10
5
0
H
H_Oe
H_Oa
H_A
H_UB
H_LB
H_Cd
Soil Horizon



BS
Soil Horizon
BS_Oe
BS_Oa
BS_A
BS_UB
BS_LB
BS_Cd



CEC
Soil Horizon
CEC_Oe
CEC_Oa
CEC_A
CEC_UB
CEC_LB
CEC_Cd

Appendix L

ANOVA results from comparison of plot attributes between groups of plots based on Sugar maple (SM) seedling presence/absence.

ANOVA results from comparison of plot attributes between groups of plots based on SM seedling presence/absence. Plots were classified by the number of SM trees that occurred on plot as such: Low = 8 to 18 trees, Moderate = 19 - 25 trees, High = 25 to 59 trees. Each class contained a generally equal number of plots. "+" indicates that higher values were associated with SM seedlings presence. "-" indicates that higher values were associated with SM seedling absence. The number of "+" or "-" indicates the level of significance: 1 = $p < 0.1$, 2 = $p < 0.05$, 3 = $p < 0.01$, 4 = $p < 0.001$, and 5 = $p < 0.0001$.

		SM Seedling Presence/Absence			Low # of SM Trees				Moderate # of SM Trees				High # of SM Trees			
		Low # of SM Trees	Moderate # of SM Trees	High # of SM Trees	SM Seedling Absence (n = 9)[1]		SM Seedling Presence (n = 9)[2]		SM Seedling Absence (n = 6)[3]		SM Seedling Presence (n = 10)[4]		SM Seedling Absence (n = 8)[5]		SM Seedling Presence (n = 8)[6]	
Variable	Horizon	*p* - value	*p* - value	*p* - value	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
BS	Oe		+ +	+ + +					67.2	6.2	90.0	4.8	76.0	2.4	89.8	2.4
	Oa	+ +	+ + +	+ +	46.8	6.2	66.8	6.2	51.1	7.2	79.2	5.6	55.5	5.8	76.9	5.4
	A		+ + +	+ +					26.2	9.4	66.0	7.0	35.8	7.2	65.0	7.7
	UB	+ +	+ +	+ +	8.3	6.9	29.4	6.9	9.5	7.4	35.4	5.7	7.7	8.3	36.4	8.3
	LB	+ +			7.4	8.5	41.3	8.5								
Exch. Ca	Oe	+ +	+ +	+ +	18.6	3.8	31.0	3.8	18.7	6.3	38.1	4.9	18.5	5.1	38.9	5.1
	Oa	+ +	+ +	+ +	8.1	4.2	21.8	4.2	9.2	5.8	27.9	4.5	10.5	3.9	23.4	3.6
	A	+ +	+	+	2.1	0.9	4.7	0.7	1.4	2.8	8.2	2.1	2.5	2.9	10.2	3.2
	UB	+ +	+ +	+	0.3	0.3	1.3	0.3	0.2	0.3	1.2	0.2	0.2	0.7	2.0	0.7
	LB	+		+ +	0.1	0.3	0.9	0.3					0.1	0.2	0.8	0.2
Exch. Mg	Oe	+ +	+	+ +					2.6	0.8	4.6	0.6	2.4	0.6	4.3	0.6
	Oa	+ +	+ +	+ +	1.1	0.3	2.1	0.3	1.4	0.5	3.0	0.4	1.2	0.3	2.3	0.3
	A	+ +	+ +		0.4	0.1	0.6	0.1	0.3	0.2	1.0	0.1				
	UB			+									0.0	0.0	0.2	0.0
	LB			+ +									0.0	0.0	0.1	0.0
Exch. Ca + Exch. Mg	Oe	+ +	+ +	+ +	21.3	4.2	34.6	4.2	21.3	7.0	42.7	5.4	20.9	5.5	43.1	5.5
	Oa	+ +	+ +	+ +	9.2	4.4	23.9	4.4	10.6	6.2	30.9	4.8	11.7	4.2	25.7	3.9
	A	+ +	+	+	2.5	0.9	5.3	0.8	1.7	2.9	9.1	2.2	3.0	3.1	11.1	3.3
	UB	+	+ +	+	0.4	0.4	1.5	0.4	0.3	0.3	1.4	0.3	0.2	0.8	2.2	0.8
	LB	+		+ +	0.1	0.3	1.0	0.3					0.1	0.2	0.9	0.2
Exch Ca: Exch. Al	Oe		+	+ +					34.4	73.6	229.4	57.0	57.9	99.0	364.1	99.0
	Oa		+ +	+												
	A			+												
	UB			+									0.1	0.6	1.6	0.6
	LB															
pH ($CaCl_2$ method)	Oe	+ +	+ +	+ + +	3.4	0.1	3.9	0.2	3.5	0.2	4.2	0.2	3.5	0.1	4.1	0.1
	Oa	+ +	+ +	+ +	3.0	0.1	3.4	0.1	3.5	0.1	3.1	0.1	3.1	0.1	3.6	0.1
	A	+ +	+ +	+ +	3.3	0.1	3.6	0.1	3.3	0.2	3.7	0.1	3.2	0.2	3.8	0.2
	UB	+ +			0.1		4.0	0.1								

		SM Seedling Presence/Absence			Low # of SM Trees				Moderate # of SM Trees				High # of SM Trees			
		Low # of SM Trees	Moderate # of SM Trees	High # of SM Trees	SM Seedling Absence (n = 9)[1]		SM Seedling Presence (n = 9)[2]		SM Seedling Absence (n = 6)[3]		SM Seedling Presence (n = 10)[4]		SM Seedling Absence (n = 8)[5]		SM Seedling Presence (n = 8)[6]	
	LB			+ +									4.3	0.1	4.6	0.1
Exch Acidity	Oe		-	- - -					15.4	4.8	3.6	3.7	6.8	0.7	3.9	0.7
	Oa			- -									10.2	1.6	5.4	1.5
	A			- -									5.4	0.7	3.2	0.7
	UB			-									5.1	1.1	2.3	1.1
	LB															
Exch. Al	Oe		-						1.6	0.5	0.4	0.4				
	Oa															
	A															
	UB															
	LB															
Exch. H	Oe	- - -		- -	7.1	0.8	3.9	0.8					5.7	0.7	3.7	0.5
	Oa			- -									7.6	1.0	3.9	0.9
	A		- -	- -					2.4	0.3	1.4	0.2	2.5	0.3	1.5	0.3
	UB															
	LB															
C	Oe															
	Oa															
	A															
	UB															
	LB															
N	Oe															
	Oa															
	A															
	UB															
	LB															
C:N	Oe	+ +	+ +	+ +	8.1	1.8	14.0	1.8	8.6	2.8	17.3	2.2	9.7	2.0	17.9	2.0
	Oa															
	A		- -	-					17.3	0.7	14.9	0.5	17.6	0.6	15.9	0.6
	UB		+ +	+ +					0.8	1.6	5.4	1.2	0.9	1.6	5.8	1.6
	LB			+ +									0.9	2.6	11.7	2.5
Elevation																
Slope			+ +						11.1	3.6	23.6	2.8				

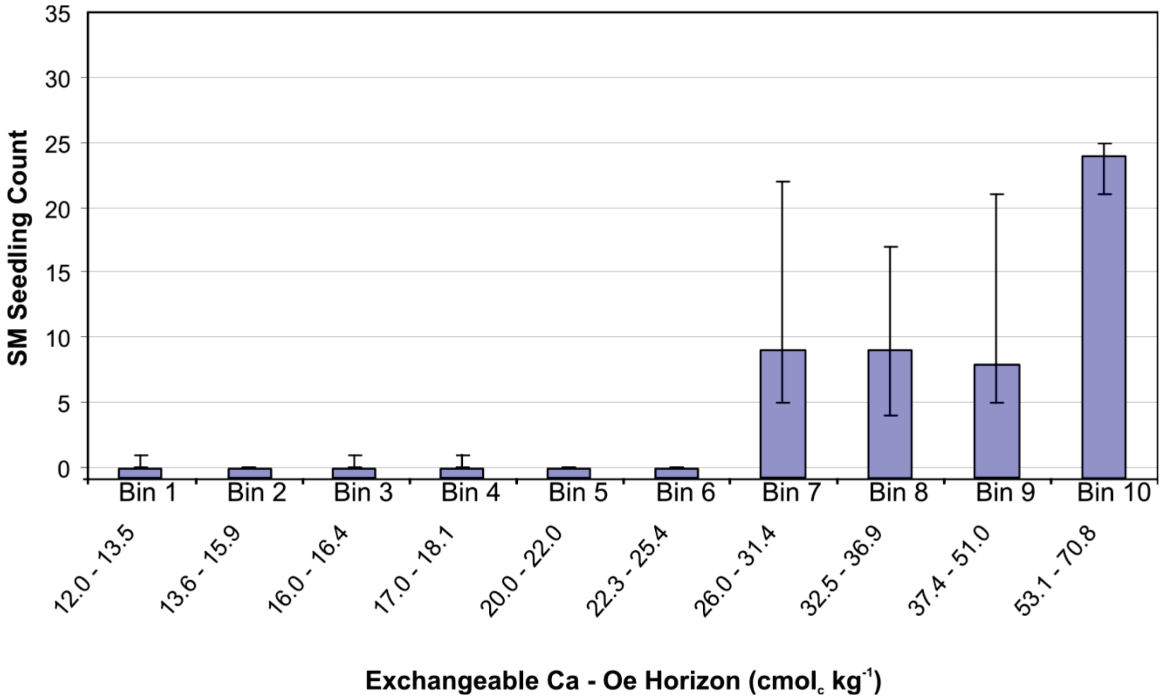
		SM Seedling Presence/Absence			Low # of SM Trees				Moderate # of SM Trees				High # of SM Trees			
		Low # of SM Trees	Moderate # of SM Trees	High # of SM Trees	SM Seedling Absence (n = 9)[1]		SM Seedling Presence (n = 9)[2]		SM Seedling Absence (n = 6)[3]		SM Seedling Presence (n = 10)[4]		SM Seedling Absence (n = 8)[5]		SM Seedling Presence (n = 8)[6]	
Physiographic Position			- -						2.7	0.2	3.7	0.3				
Light Availability (photo)																
Light Availability (model)			-						91462.0	24525.0	175506.0	31662.0				
Total S Depostion		- -			67.3	2.8	57.1	2.8								
Total N Deposition		- - -		-	78.3	3.2	65.1	3.2					79.3	2.6	72.4	2.6
Total S + N Deposition		- -		-	145.6	5.9	122.3	5.9					146.3	4.9	134.0	4.9
[1] n = 6 for A horizon	[3] n = 5 for A horizon		[5] n = 7 for Oa horizon													
[2] n = 8 for A horizon	[4] n = 9 for A horizon		[6] n = 7 for A horizon													

Appendix M

Distribution of Sugar maple (SM) seedling abundance with respect to exchangeable Ca and base saturation in the Oe, Oa, A, and upper B soil horizons.

This appendix provides an additional perspective on the distribution of sugar maple (SM) seedling abundance with respect to exchangeable Ca and base saturation in the Oe, Oa, A, and upper B (UB) soil horizons. Figure M-1 shows the median (columns) and quartile (error bars) SM seedling count within various classes of a) exchangeable Ca and b) soil BS within the Oe, Oa, A, and UB horizons. Figure M-2 includes the median (columns) and quartile (error bars) ratio of SM seedlings to all seedlings within various classes of a) exchangeable Ca and b) soil BS within the Oe and UB horizons (data for Oa and A horizons are shown in Figure 4-10 and Figure 4-11). Each bin contains data from 5 plots, except for bins with the highest values for Oa and A horizon data. These bins contain 4 and 3 plots respectively.

a)



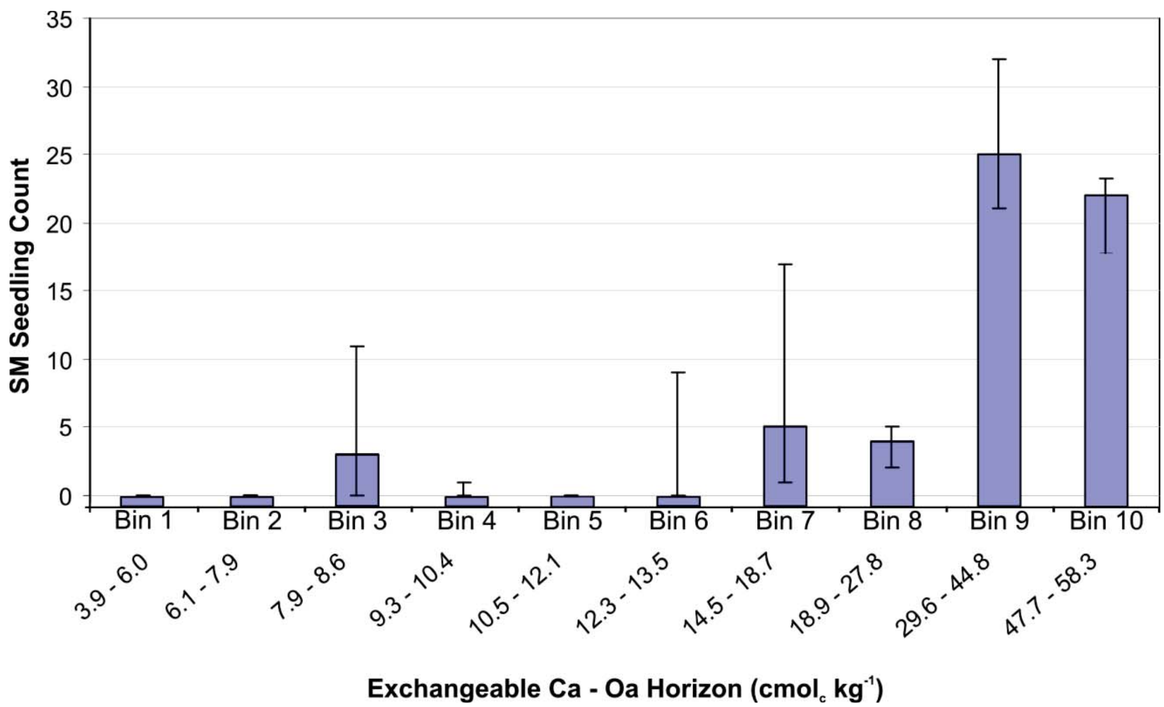
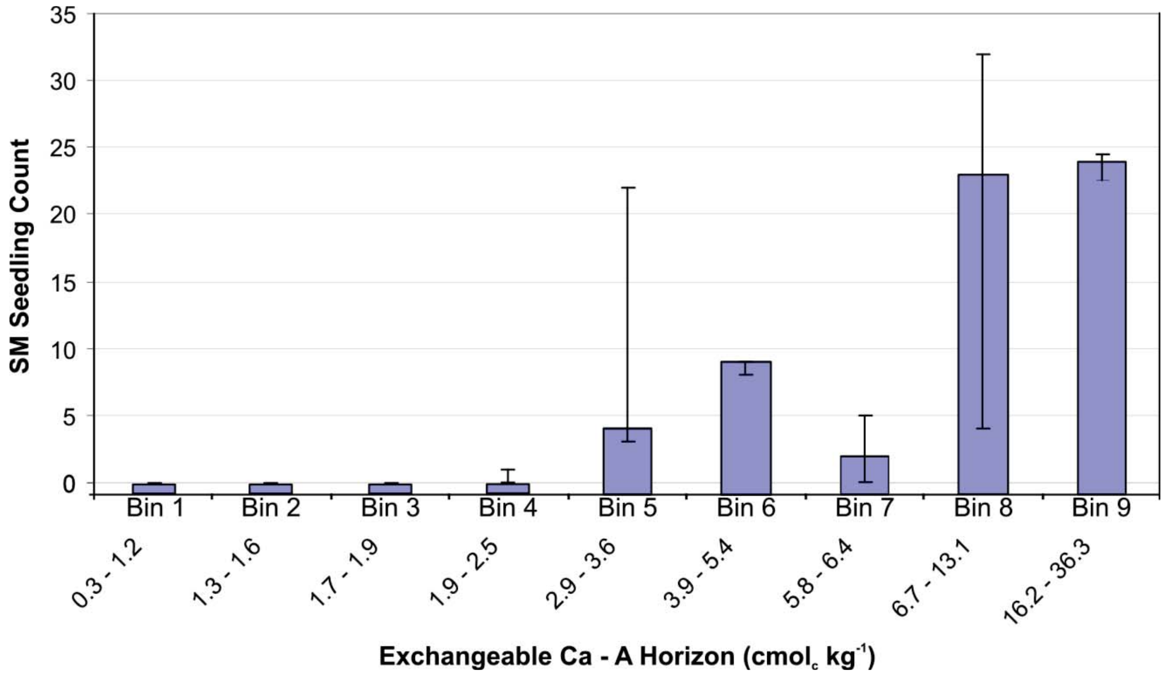


Figure M-1. Sugar maple (SM) seedling counts within plots having varying amounts of a) exchangeable Ca and b) base saturation in four soil horizons, expressed as bins containing generally five plots ranging from lowest to highest values.



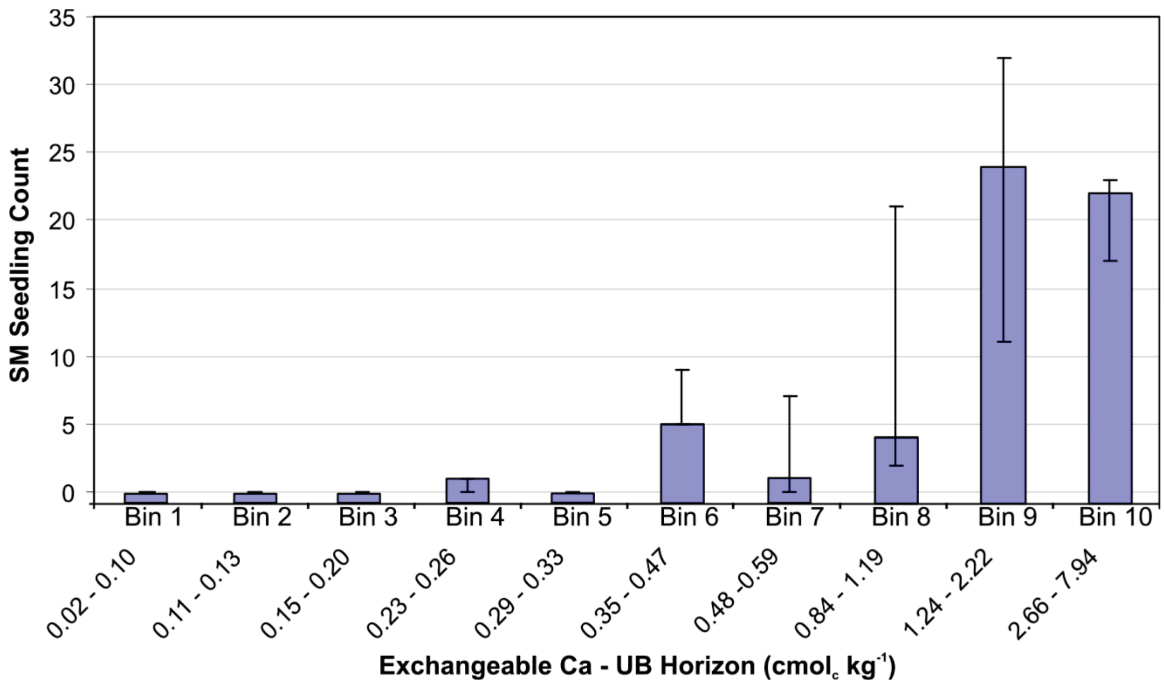
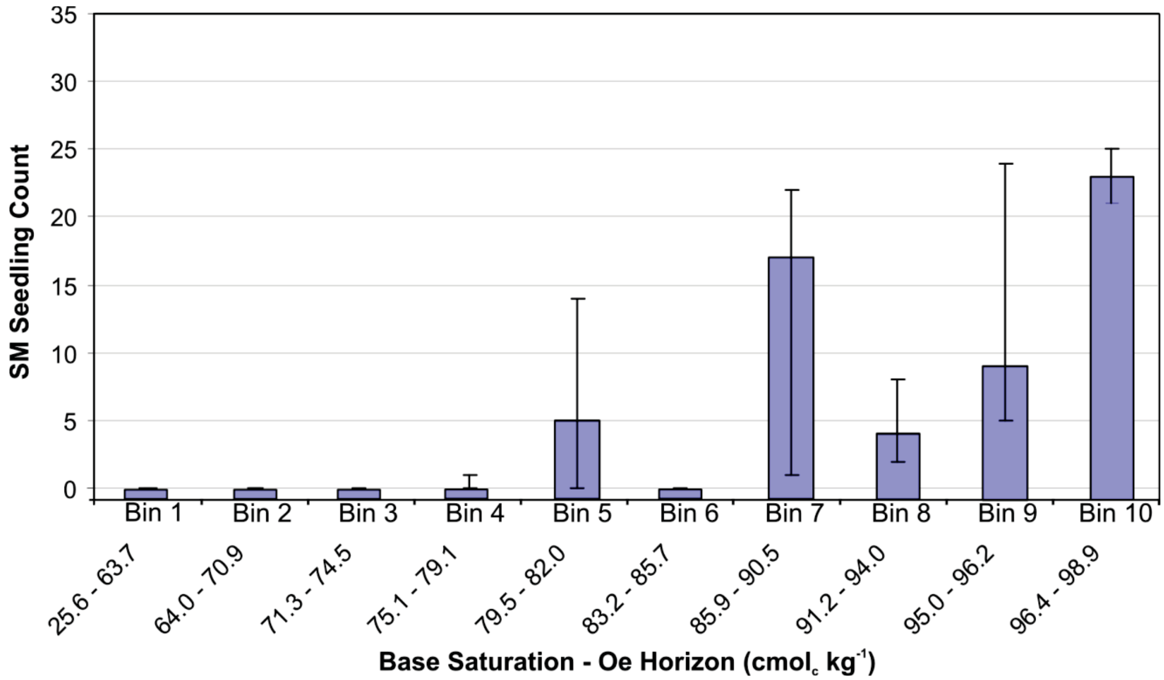


Figure M-1. Continued.

b)



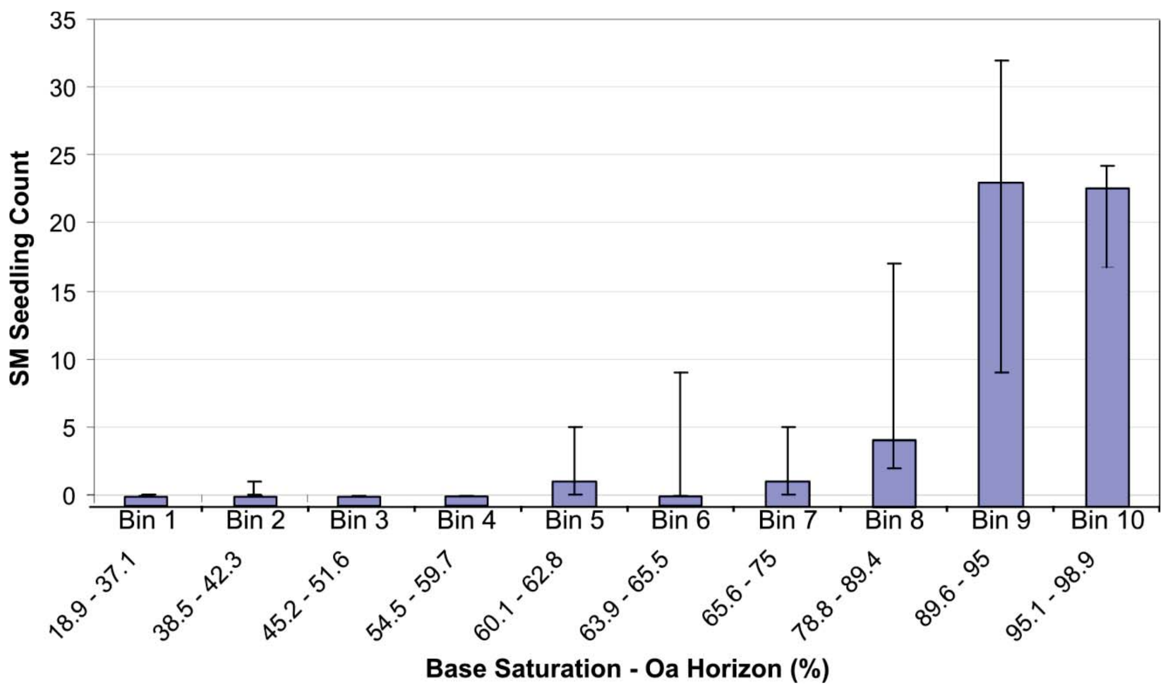
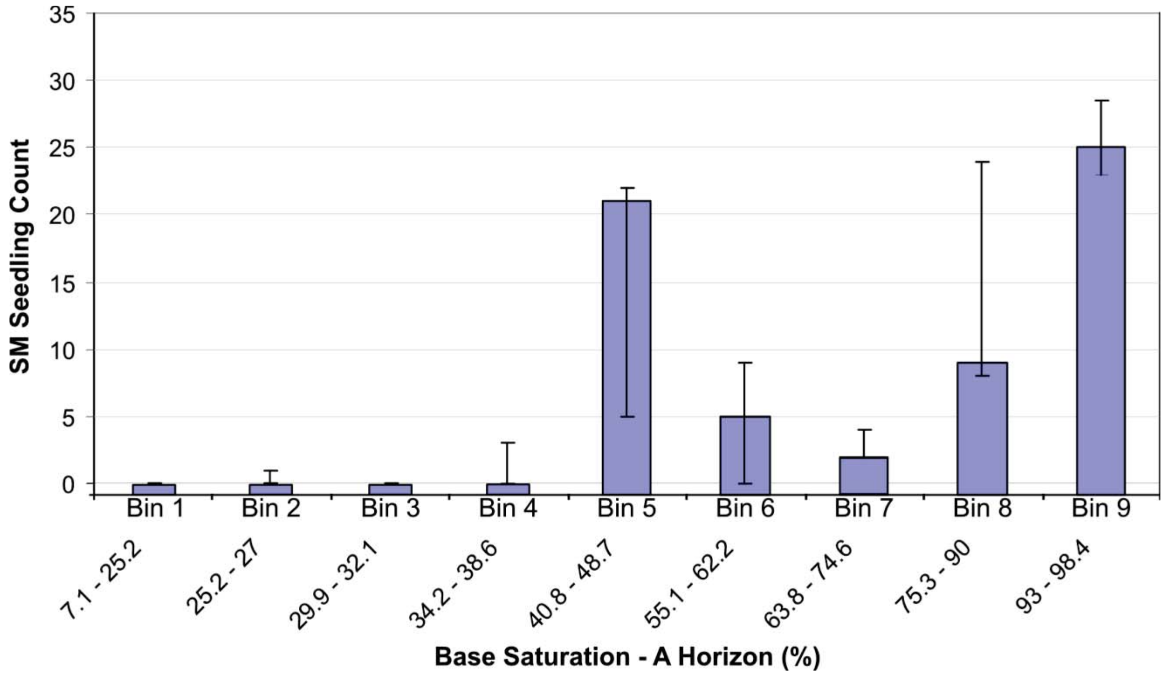


Figure M-1. Continued



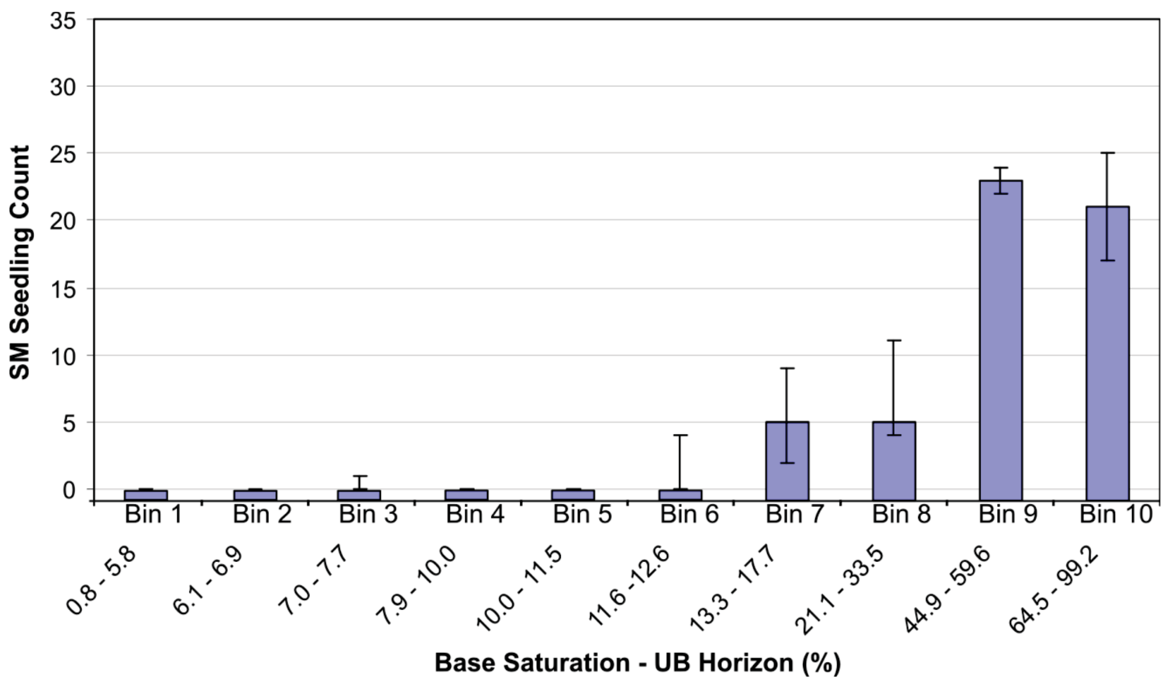
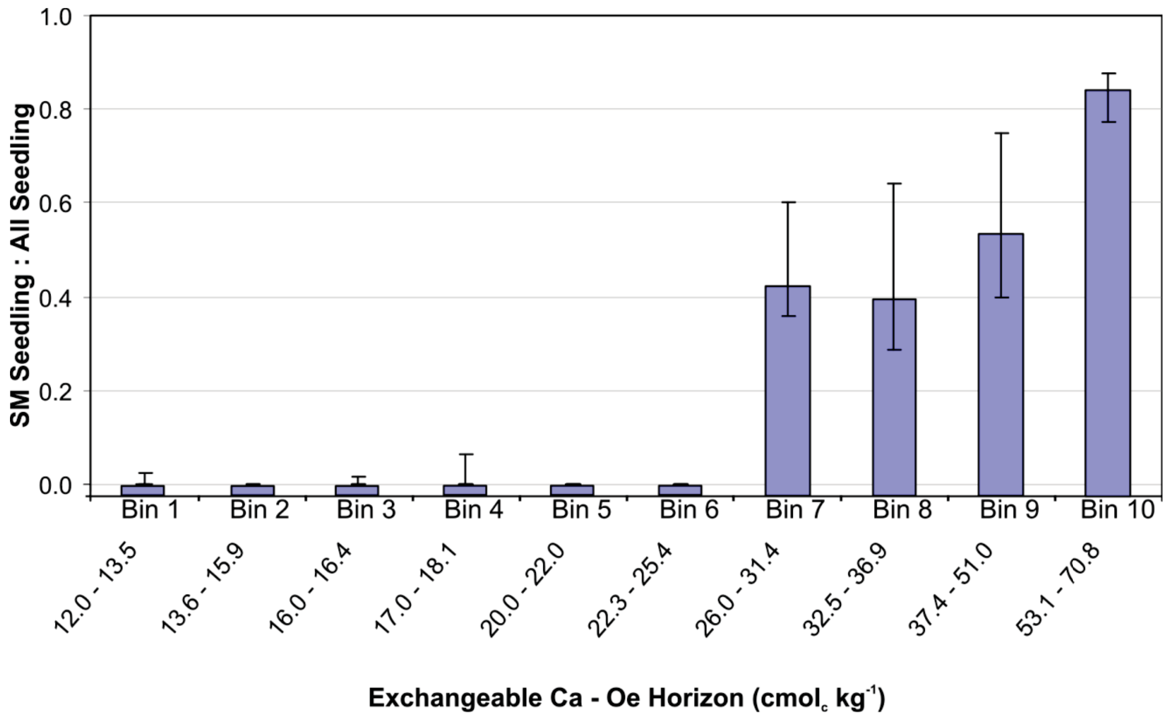


Figure M-1. Continued

a)



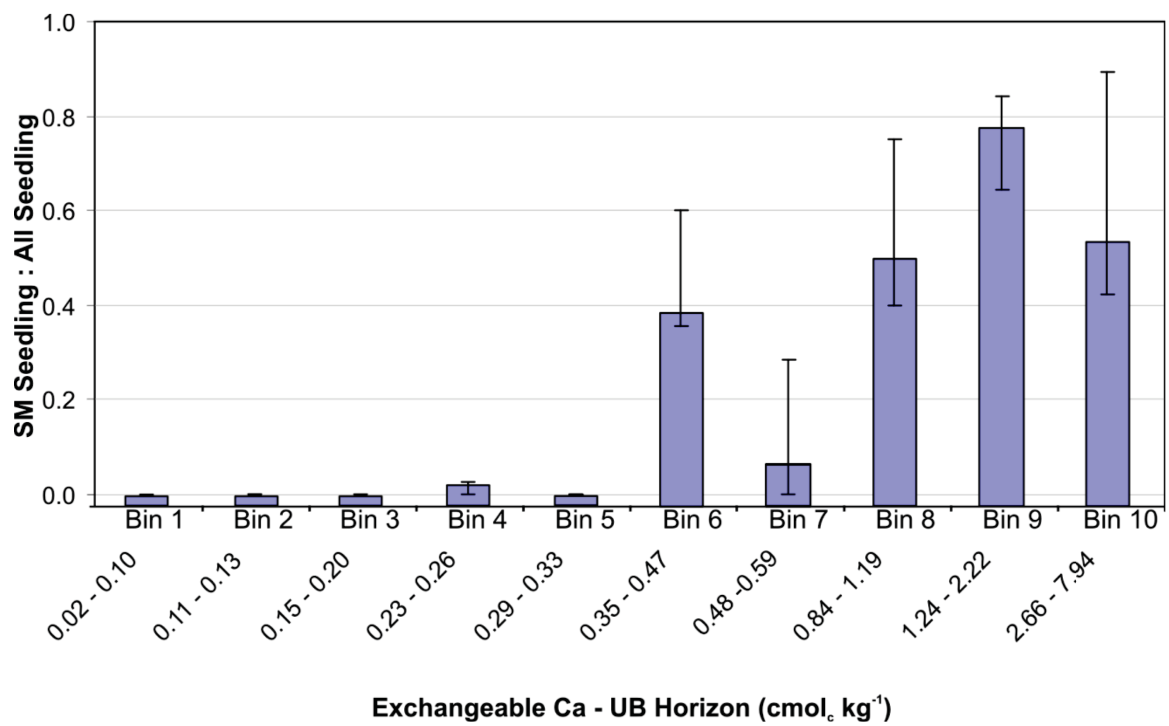
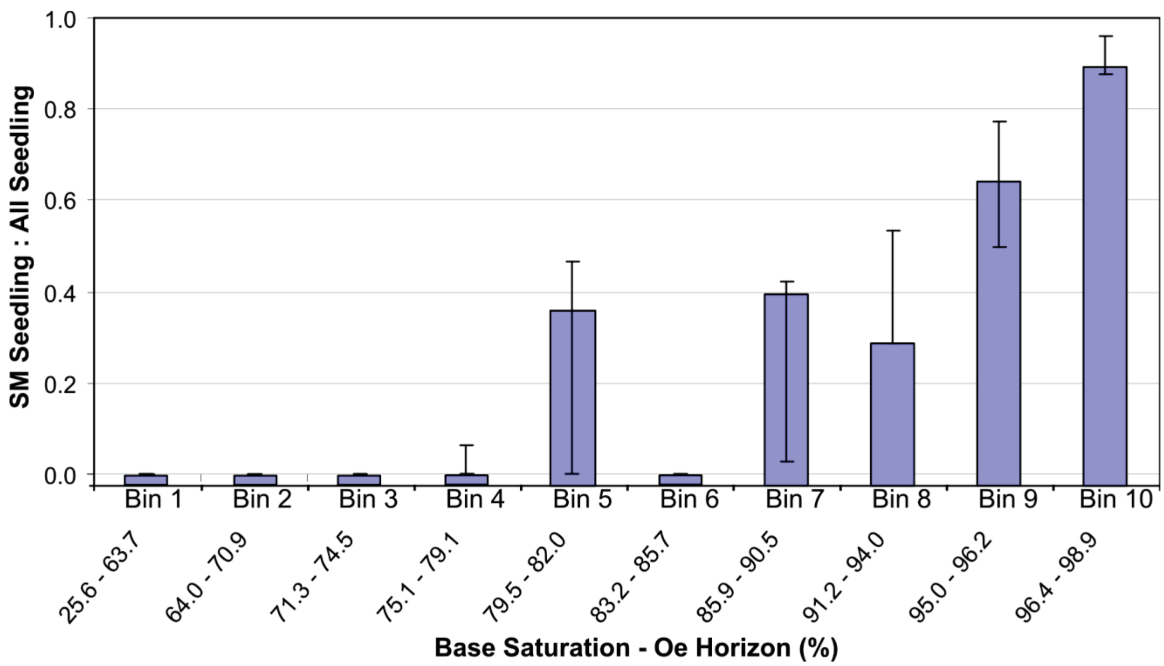


Figure M-2. Sugar maple (SM) seedling counts within plots having varying amounts of a) exchangeable Ca and b) base saturation in four soil horizons, expressing sugar maple (SM) seedling count as percentage of seedlings of all species.

b)



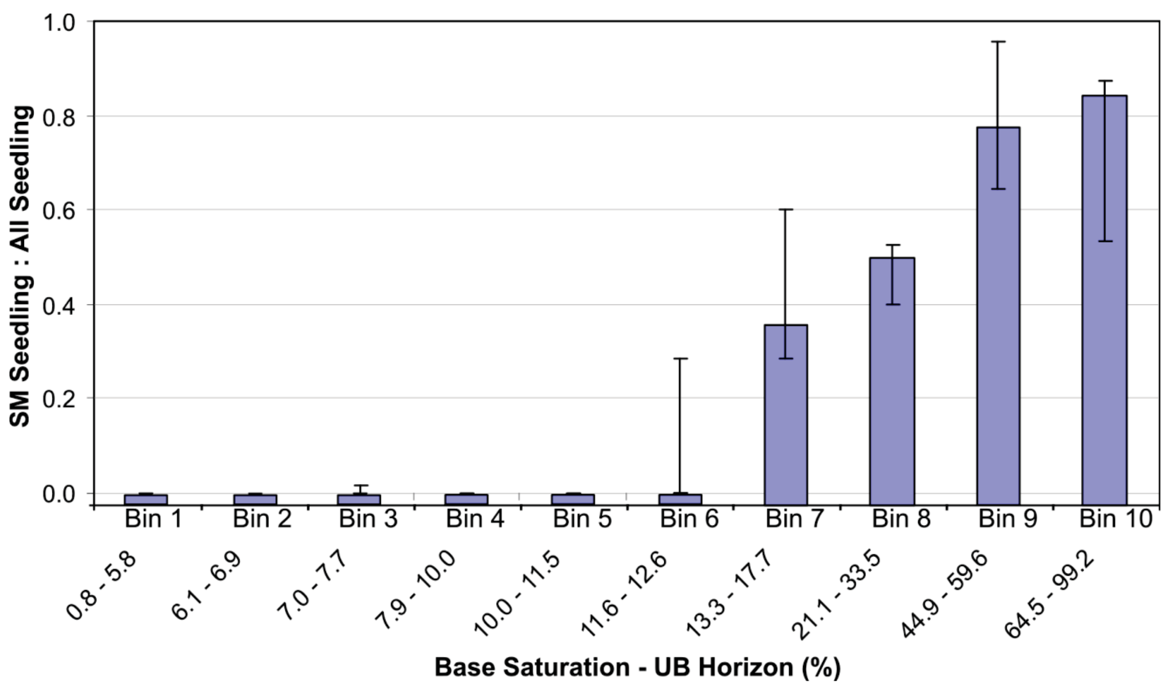


Figure M-2. Continued.

Appendix N

Data used to generate the *p*-values for comparisons of sugar maple canopy condition.

The data that were used in the ANOVA to generate the *p*-values for comparisons of sugar maple (SM) canopy condition shown in Figure 4-14 are here. The mean and standard error (SE) of soil and landscape characteristics corresponding with groups of plots associated with “Low” and “High” canopy condition ratings are provided. Each group of plots contains 17 values except analyses of A horizon data; these groups contain 15 plots.

Variable[1]	Horizon	Low Vigor mean	Low Vigor (SE)	High Vigor mean	High Vigor (SE)	Low Defoliation mean	Low Defoliation SE	High Defoliation mean	High Defoliation SE	Low Dieback mean	Low Dieback SE	High Dieback mean	High Dieback SE	Low Discoloration mean	Low Discoloration SE	High Discoloration mean	High Discoloration SE	Low Transparency mean	Low Transparency SE	High Transparency mean	High Transparency SE
BS (%)	Oe	78.8	2.2	86.6	2.2									75.736	3.7	84.7	3.7				
	Oa																				
	A	37.3	5.2	55.9	5.2					36.6	6.5	58.0	6.2	38.0	6.0	58.9	6.2	38.8	6.7	57.9	6.5
	UB																	11.7	5.6	33.1	5.2
	LB																	22.1	8.1	45.5	7.6
Exch. Ca ($cmol_c\ kg^{-1}$)	Oe									21.5	4.0	32.6	4.0								
	Oa																				
	A	2.5	1.1	6.1	1.1	3.5	1.9	9.1	2.0	2.4	2.0	8.6	1.9	2.7	1.2	6.9	1.2	2.9	2.1	9.1	2.0
	UB																	0.3	0.4	1.6	0.4
	LB																	0.2	0.2	0.7	0.1
Exch. Mg ($cmol_c\ kg^{-1}$)	Oe																				
	Oa																				
	A	0.4	0.1	0.7	0.1	0.5															
	UB																	0.1	0.0	0.2	0.0
	LB																				
Exch. Ca + Exch. Mg	Oe									24.3	4.4	36.3	4.4								
($cmol_c\ kg^{-1}$)	Oa																				
	A	2.9	1.2	6.8	1.2	4.0	2.0	10.0	2.1	2.7	2.1	9.5	2.0	3.2	1.3	7.8	1.3	3.4	2.2	10.0	2.2
	UB																	0.4	0.4	1.8	0.4
	LB																	0.3	0.2	0.8	0.2
Exch Ca: Exch. Al	Oe																				
	Oa																				
	A													2.3	3.8	13.0	3.9				
	UB																				
	LB																				
pH ($CaCl_2$ method)	Oe																				

Variable[1]	Horizon	Low Vigor mean	Low Vigor (SE)	High Vigor mean	High Vigor (SE)	Low Defoliation mean	Low Defoliation SE	High Defoliation mean	High Defoliation SE	Low Dieback mean	Low Dieback SE	High Dieback mean	High Dieback SE	Low Discoloration mean	Low Discoloration SE	High Discoloration mean	High Discoloration SE	Low Transparency mean	Low Transparency SE	High Transparency mean	High Transparency SE
	Oa									3.1	0.1	3.6	0.1								
	A									3.4	0.1	3.7	0.1	3.4	0.1	3.6	0.1	3.4	0.1	3.8	0.2
	UB																				
	LB																				
Exch Acidity	Oe	6.2	0.5	4.8	0.5																
($cmol_c$ kg^{-1})	Oa																				
	A																				
	UB																				
	LB																				
Exch. Al	Oe	0.9	0.2	0.3	0.2																
($cmol_c$ kg^{-1})	Oa																				
	A																				
	UB																				
	LB																				
Exch. H	Oe																				
($cmol_c$ kg^{-1})	Oa																				
	A																				
	UB																				
	LB																				
C (%)	Oe	39.8	1.7	45.6	1.7					40.7	1.8	45.4	1.8					41.0	1.6	45.2	1.5
	Oa																				
	A					11.1	1.0	13.6	1.0												
	UB																				
	LB																				
N (%)	Oe	2.0	0.1	2.3	0.1	2.1	0.1	2.3	0.1	2.0	0.1	2.3	0.1	2.1	0.1	2.3	0.1	2.1	0.1	2.3	0.1
	Oa													1.9	0.1	2.0	0.1				
	A																				
	UB																				

Variable[1]	Horizon	Low Vigor		High Vigor		Low Defoliation		High Defoliation		Low Dieback		High Dieback		Low Discoloration		High Discoloration		Low Transparency		High Transparency	
		mean	(SE)	mean	(SE)	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
	LB																				
C:N	Oe																				
	Oa																				
	A																				
	UB																	1.2	1.1	5.4	1.0
	LB																	2.3	1.7	6.4	1.5
Elevation (m)		480	17	579	17	517	20	566	20	500	16	582	16	521	17	572	17	489	15	595	14
Slope (%)		12.4	2.2	19.0	2.2					11.4	2.0	18.3	2.0								
Physiographic Position																					
Light Availability-photo (WH m^{-2} yr^{-1})		111,198	10,540	71,176	10,540	99,075	9,583	70,868	9,583	104,882	10,517	64,197	10,517	100,819	10,864	68,321	10,864	103,292	10,497	69,308	9,860
Light Availability-model (WH m^{-2} yr^{-1})																					
Total S Deposition (meq m^{-2} yr^{-1})																					
Total N Deposition (meq m^{-2} yr^{-1})		75.9	2.2	70.2	2.2																
Total S+N Deposition (meq m^{-2} yr^{-1})																					

[1] Data completeness was 94 percent for soil pH data and greater than or equal to 98 percent for the remaining soil chemical parameters

Appendix O

Coordinates of sample plot locations

PLOT_ID	Longitude	Latitude
30009_1	-75.09283149	43.59571037
30009_2	-75.09081452	43.59698889
30009_3	-75.09510710	43.59931450
29012_1	-75.28005714	43.55519006
29012_2	-75.27931368	43.55471417
7001_1	-75.12363904	44.13025429
7001_2	-75.11948771	44.13084651
7001_3	-75.11869570	44.12976700
9006_1	-74.82020750	44.21177562
9006_2	-74.81890343	44.21014513
9006_3	-74.81946389	44.21123489
22019_1	-75.15075227	43.85191616
22019_2	-75.15180765	43.85166072
13008_1	-75.09480046	44.02828967
13008_2	-75.09428613	44.02808395
12003_1	-75.13757453	44.03774171
12003_2	-75.13795088	44.03796930
12003_3	-75.13584151	44.03857823
WF_1	-74.83032849	43.80265683
WF_2	-74.82826289	43.80323995
WF_3	-74.82768803	43.80458706
28030_1	-74.74253848	43.75322414
28030_2	-74.73782457	43.75068248
28030_3	-74.73943464	43.75255609
31009_1	-74.96985796	43.51861391
31009_2	-74.97115195	43.51245066
31009_3	-74.97168146	43.50671270
35014_1	-75.00055983	43.48910413
35014_2	-74.99985307	43.49027340

PLOT_ID	Longitude	Latitude
26008_1	-75.07510521	43.67254085
26008_2	-75.07410931	43.67337371
17002_1	-75.26770363	43.94823302
17002_2	-75.27256695	43.95155052
17002_3	-75.27310951	43.94950470
27019_1	-74.75795352	43.71454542
27019_2	-74.75873094	43.71489690
27019_3	-74.76091016	43.71556009
28037_1	-74.66066517	43.66104579
28037_2	-74.67238904	43.65833117
N1_1	-74.31446960	44.01094808
N1_2	-74.32030717	44.01394258
N1_3	-74.31482056	44.01365922
24001_1	-74.72043957	43.76752592
24001_2	-74.72027536	43.76933108
AMP_1	-74.26258535	44.23929951
AMP_2	-74.26265325	44.23780485
S14_1	-74.24636726	44.00386834
S14_2	-74.24506883	44.00390722
NW_1	-74.05013826	43.80943474
NW_2	-74.05043090	43.81012030

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Effects of Acidic Deposition and Soil Acidification on Sugar Maple Trees in the Adirondack Mountains, New York

Final Report
January 2013

State of New York
Andrew M. Cuomo, Governor

New York State Energy Research and Development Authority
Francis J. Murray, Jr., President and CEO