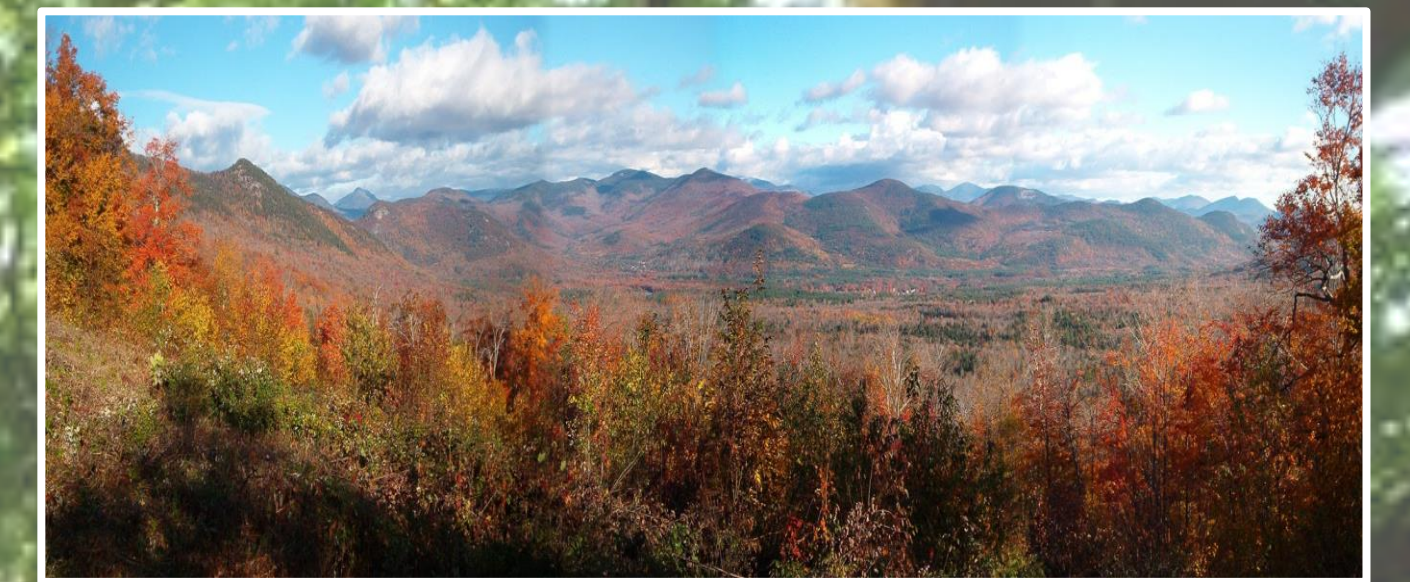# Battle Of the Babies: Beech Interference With Maple Regeneration

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Introduction

➢ Tree species in northern hardwood ecosystems face numerous barriers to regeneration such as invasive species, insects, diseases, herbivory, poor management, and climate change. As forests mature, species composition becomes an important part of vegetation management because hardwood species are used widely as commercial products and as sources of wildlife food and habitat (Kochenderfer *et al.*, 2001).

➢ American beech (*Fagus grandifolia*) is a dominant species in northern hardwoods whose mast is palatable to a large variety of birds and mammals and whose wood is favored for flooring, furniture and fuelwood due to its high density and good burning qualities.

➢ Beech bark disease (BBD) is a pathogenic complex that causes mortality and decline of American beech in northern hardwood ecosystems. First introduced by an invasive sap-feeding beech scale (*Cryptococcus fagisuga*) over one hundred years ago from Europe to Canada, BBD now extends and affects forests ranging from Nova Scotia to Michigan and as far south as North Carolina.

➢ Dying beech trees often produce root sprouts as an evolutionary strategy for vegetative reproduction, which provides a dense population of small beech thickets in the understory that interfere with regeneration of more desirable species, such as sugar maple.

➢ Sugar maple (*Acer saccharum*) is valued not only as a timber species for its use in flooring, furniture, and wooden wares, but also as a sap source for its production of maple sugar products valued at $81 million a year in the U.S.

➢ Phosphorus and nitrogen have been shown to affect the development of beech bark disease (Cale *et al.*, 2015), and base cations such as calcium, magnesium, and manganese have been shown to be important in the health of sugar maple (Juice et al., 2006).

American beech (*Fagus grandifolia*)

Sugar maple (*Acer saccharum*)

Methods

Site description

➢ Twenty-six hardwood stands have been monitored in the White Mountains of central New Hampshire, USA, where each stand consists of four or five transects or plots. Soils are primarily well-drained acid Spodosols (Haplorthods) of sandy-loam texture developed from glacial till. The climate is characterized as humid continental, with temperature and precipitation averaging 5°C and 1400 mm per year.

➢ Thirteen of these stands (CHRONOS) had been set up on a nine-year cycle of inventory collection beginning in 1994 as a part of a chronosequence study and have been reinventoried in the summers of 2003 and 2012.

➢ The other 13 stands (MELNHE) were first inventoried between 2004 and 2008 as a part of the Multiple Element Limitation in Northern Hardwood Ecosystems project and reinventoried in the summers of 2011, 2013, 2015, and 2016. Nitrogen (30 kg N/ha/yr as NH_4NO_3), phosphorus (10 kg P/ha/yr as NaH_2PO_4), and N+P (same amount) were applied annually to plots in each stand beginning in spring 2011; calcium (1150 kg Ca/ha as $CaSiO_3$) was applied once in 2011.

Inventory

➢ Four size-classes of trees were inventoried by their diameters at breast height (DBH): overstory trees (>10 cm DBH), saplings (<2 cm DBH but >50 cm tall), seedlings (+1 y/o), and germinants (1 y/o).

➢ Overstory trees were tagged and measured in each transect or plot. Saplings were inventoried in five 2-meter-square subplots per transect or plot. Every woody plant species <50 cm tall was inventoried and classified as germinants or seedlings in five 1-meter-square subplots per transect or plot.

Soil chemistry

➢ Soil samples from Oe horizon were collected at each stand in 2012 and 2013.

➢ Inorganic N concentration was determined by extraction with 2M KCl from an initial subsample and also from a second subsample after 21-day incubation in the laboratory. The extracts were analyzed on an auto-analyzer (Bran+Luebbe GmbH Norderstedt, Germany) and net N mineralization rate was calculated for the difference in NH_4^+ and NO_3^- concentrations between final and initial extracts.

➢ Exchangeable cations (Ca and Mg) in the Oe soil were determined by extracting a subsample in 1M NH_4Cl and measured on inductively coupled plasma-optical emission spectrometer (ICP-OES; PE-3300DV, Perkin Elmer, Norwalk, CT).

➢ P was extracted in 0.5M $NaHCO_3$ from a subsample and ammonium-molybdate-ascorbic acid method (Murphy and Riley, 1962) was used to analyze the P extracts on UV-1800 spectrophotometer (Shimadzu Corporation, Japan).
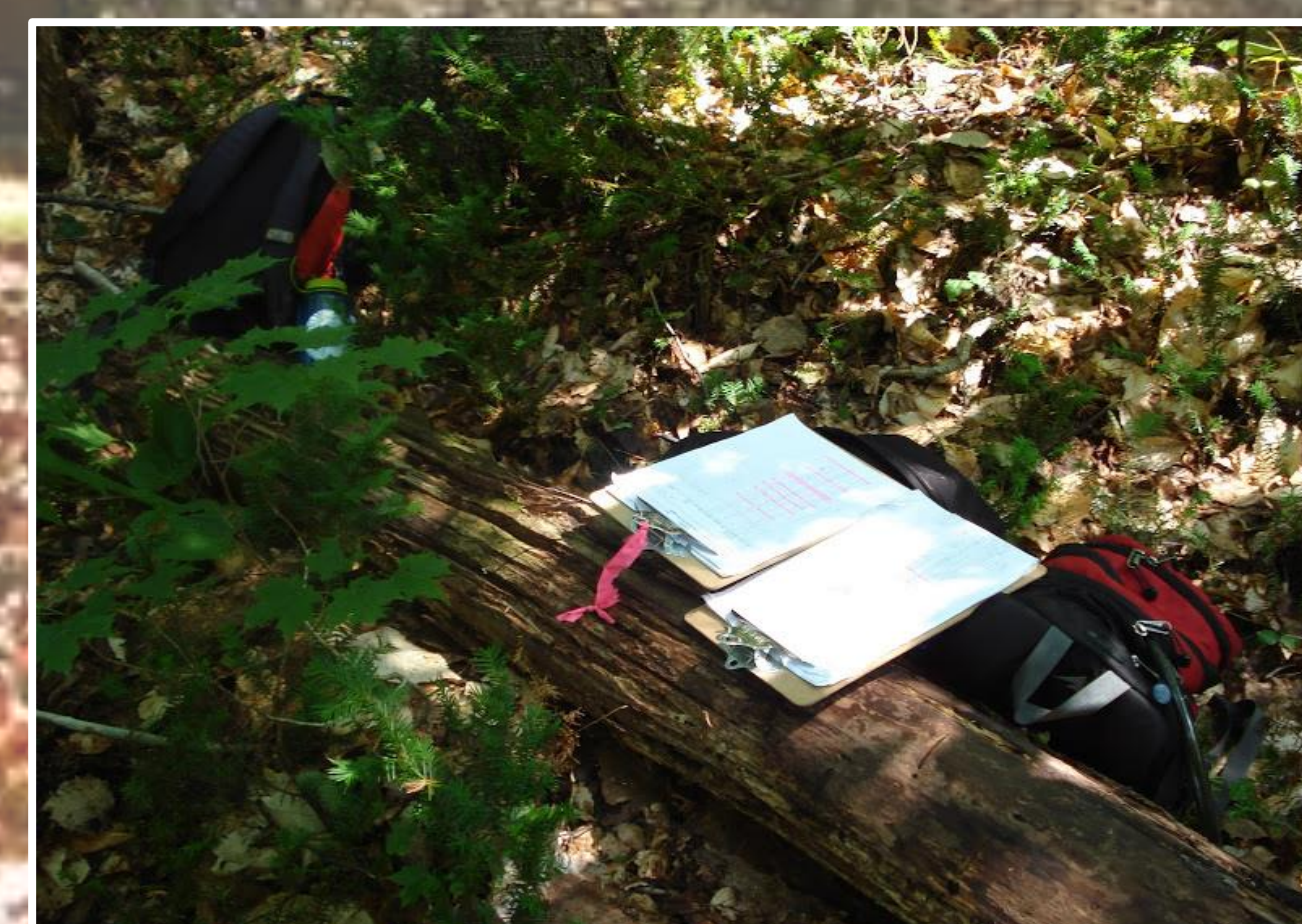
Inventory Process

Photo credit to MELNHE researchers

Figure 3. American beech interference with sugar maple regeneration looking at seedlings and germinants. 2012 CHRONOS and 2016 MELNHE data were used to generate this graph.

Table 1. Summary of stem densities of American beech and sugar maple at the time of inventory and percent change, DIFF, from earliest to latest inventories.

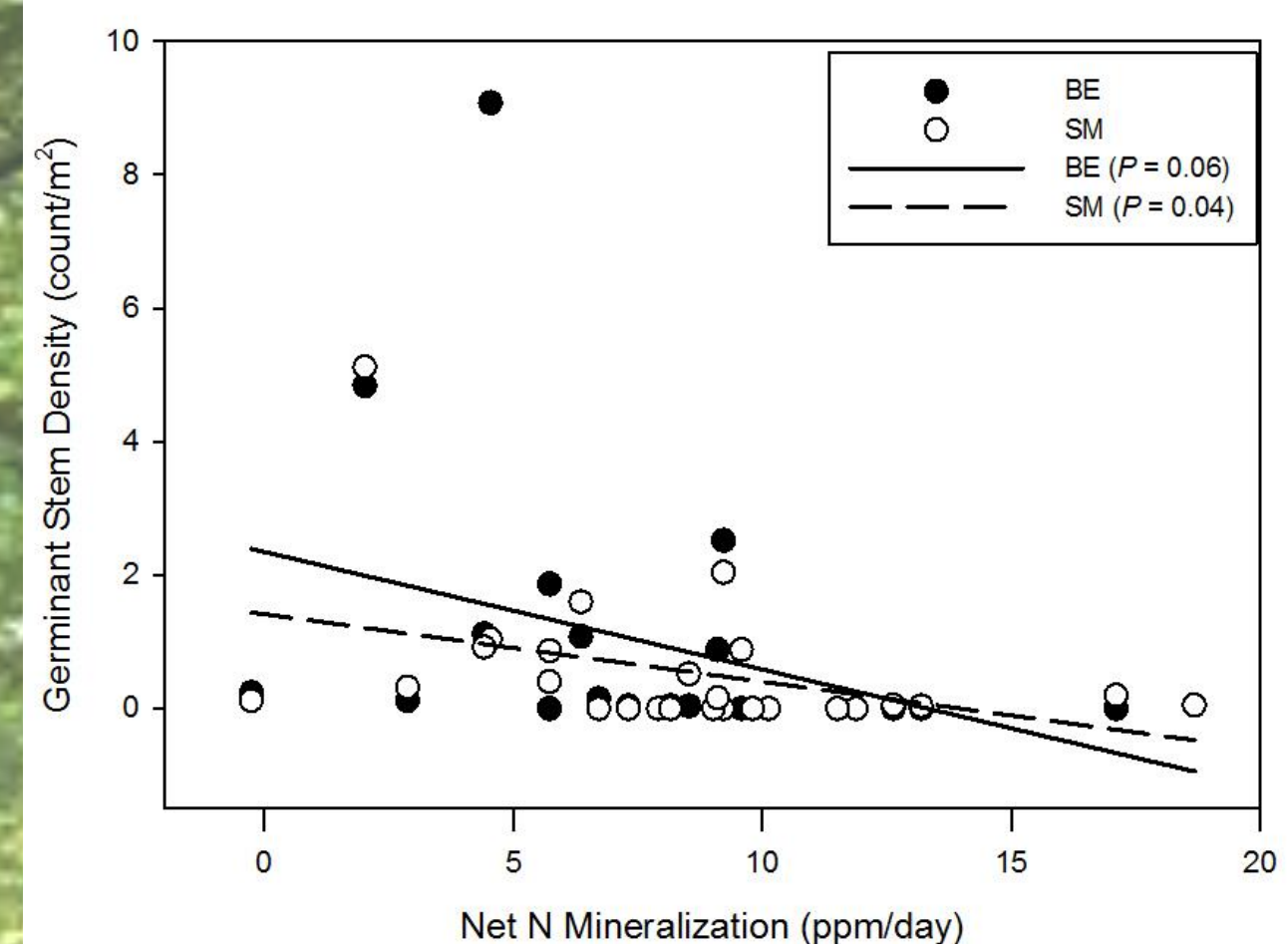| Series	Size Class	American Beech (count/m²)				Sugar Maple (count/m²)			
		1994	2003	2012	DIFF (%)	1994	2003	2012	DIFF (%)
CHRONOS	Germinants	-	-	1.6790		-	-	1.0759	
	Seedlings	0.2115	1.3144	0.4456	111	1.4436	3.0990	0.4959	-66
	Saplings	0.1769	0.2213	0.2290	29	0.1244	0.1883	0.0700	-44
	Overstory	0.0119	0.0145	0.0163	37	0.0102	0.0121	0.0133	30
		2004	2008	2011/13	2015/16	DIFF (%)	2004	2008	2011/13	2015/16	DIFF (%)
MELNHE	Germinants	-	-	0.0211	0.0172	-18	-	-	0.2631	0.0241	-91
	Seedlings	-	3.5947	1.1034		-69	-	1.9158	0.4448		-77
	Saplings	0.5921	0.3059	0.3975		-33	0.1632	0.0900	0.0466		-71
	Overstory	0.0172	0.0172	0.0167	0.0161	-6	0.0124	0.0122	0.0118	0.0116	-7

Figure 4. Effects of net N mineralization rate on germinant densities of American beech and sugar maple. 2012 CHRONOS and 2016 MELNHE data were used to generate this graph.
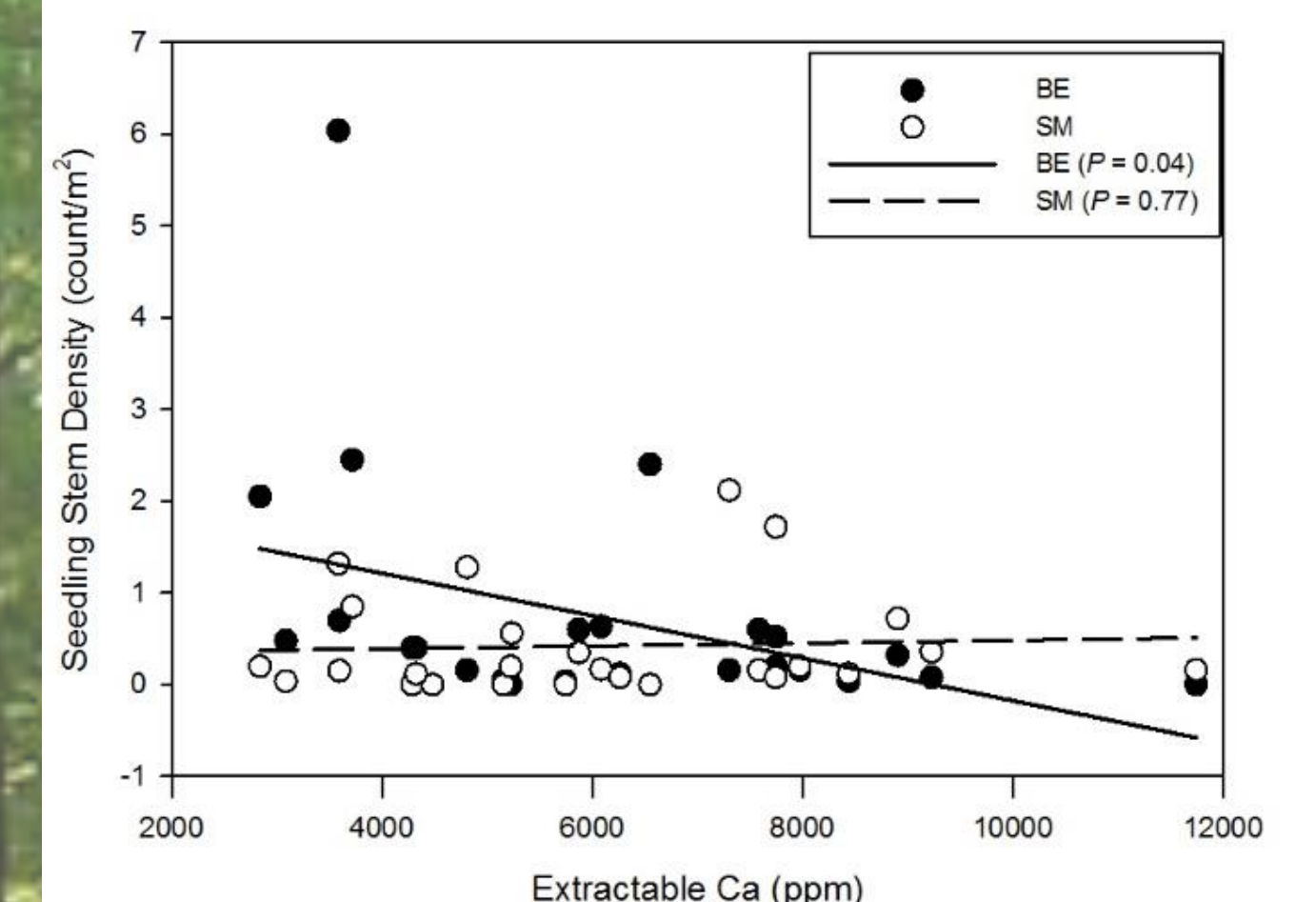

Figure 5. Effects of extractable calcium on seedling densities of American beech and sugar maple. 2012 CHRONOS and 2016 MELNHE data were used to generate this graph.
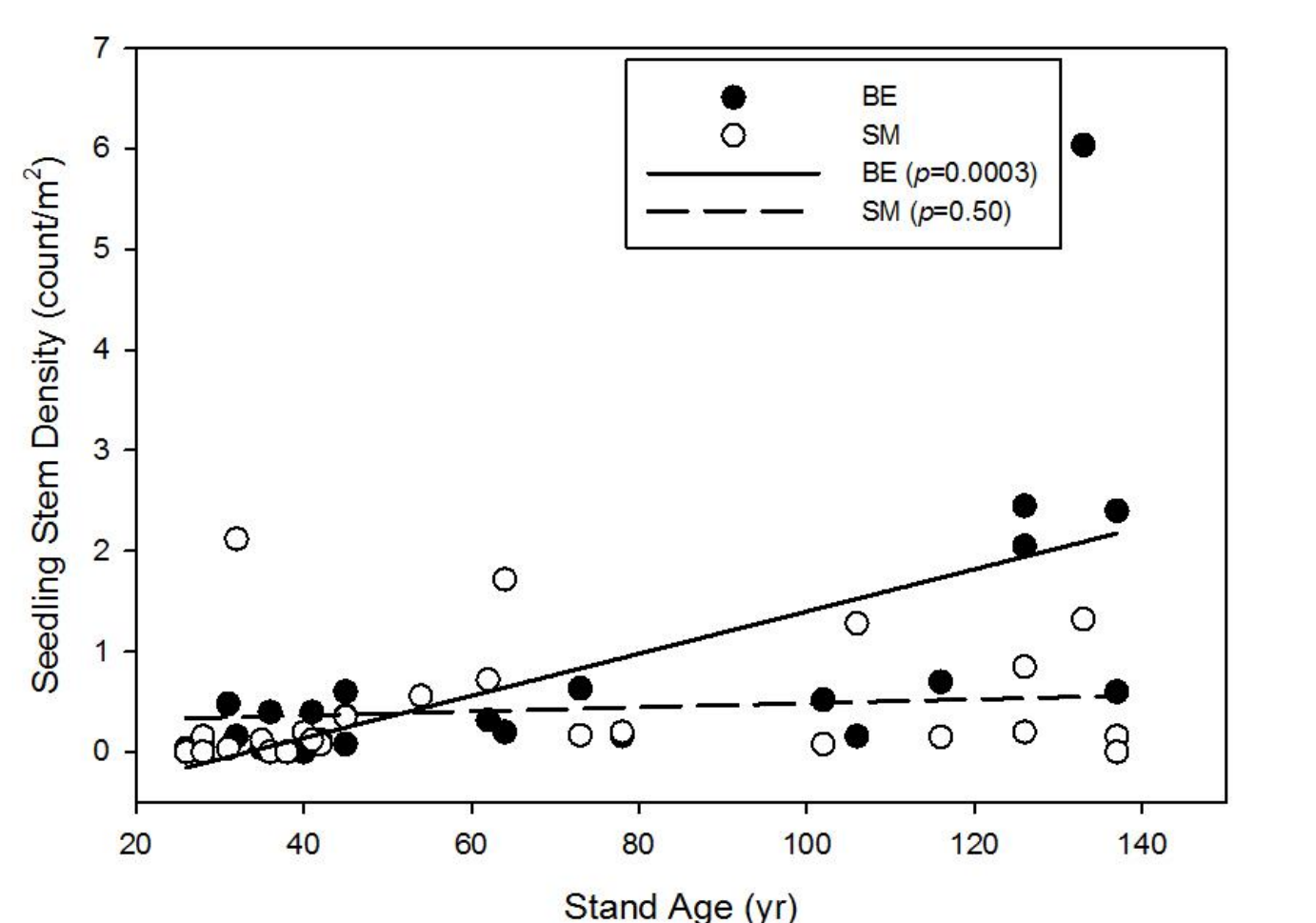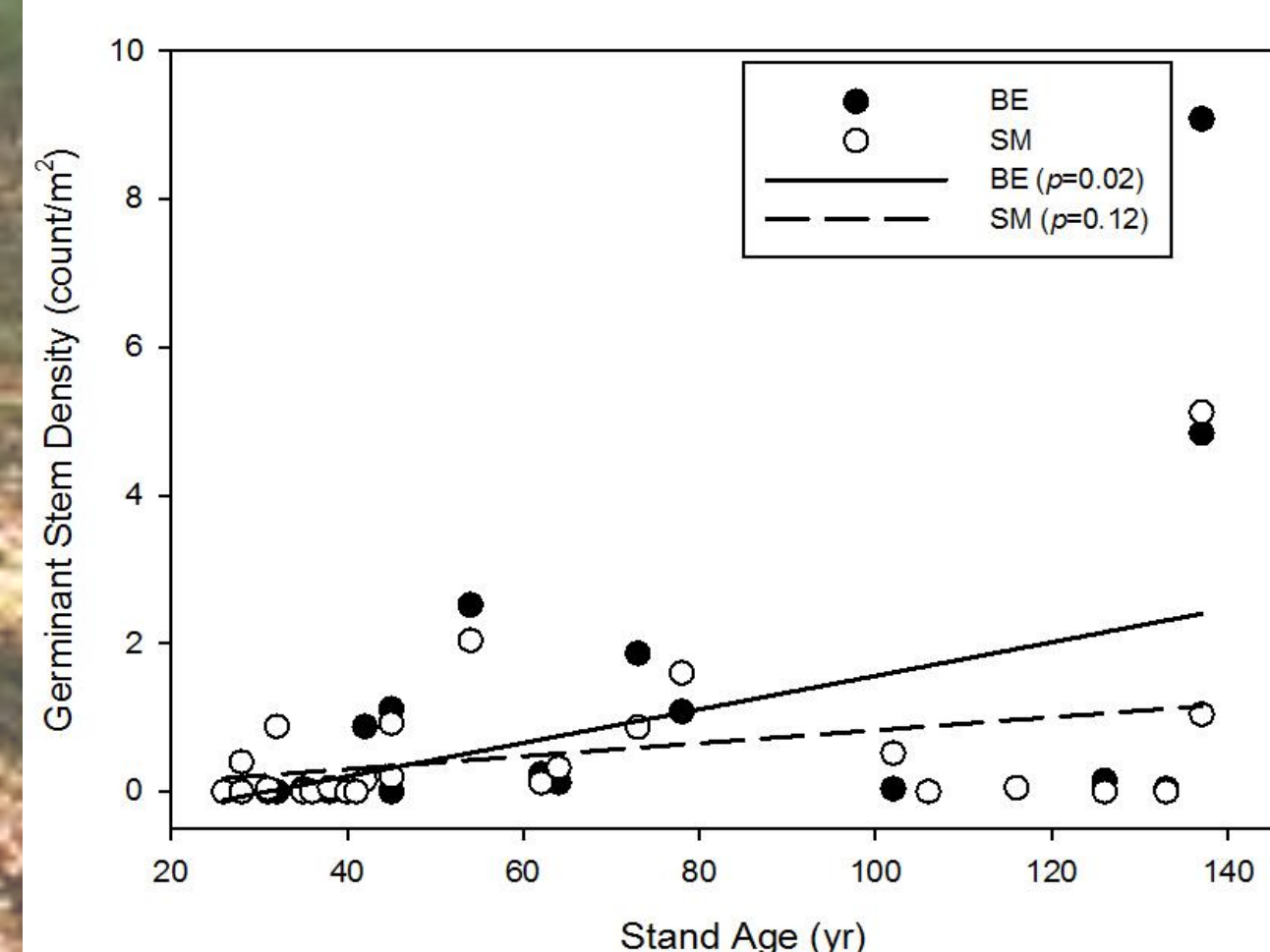

Figure 6. Effects of stand age on germinant and seedling densities of American beech and sugar maple. 2012 CHRONOS and 2016 MELNHE data were used to generate this graph.

Results

➢ There was no fertilization effect on American beech ($p=0.22$) or sugar maple seedlings ($p=0.89$) using ANCOVA. There was an interaction between fertilization and age for beech with old stands having higher densities than middle or young stands ($p=0.07$). However, there was no interaction for sugar maple ($p=0.18$).

➢ No age effect was observed for beech or sugar maple seedling using Tukey Honestly Significant difference. There was no fertilization effect for beech ($p=0.70$) but there was for sugar maple ($p=0.10$) while grouping all stands and partitioning the stand age. Old-age stands have more sugar maple in control plot than in other treated plots ($p=0.02$). Mid-age stands have similar sugar maple in all plots ($p=0.99$).

➢ There were fewer germinants of both beech ($p=0.06$) and sugar maple ($p=0.04$) in stands with high net nitrogen mineralization rate (Fig. 4)

➢ The number of beech seedlings declined with increasing soil extractable calcium ($p=0.04$) (Fig. 5).

➢ There were more germinants ($p=0.02$) and seedlings ($p=0.0003$) of American beech with stand age (Fig. 6).

Future Study

➢ The severity of BBD will be rated in the summer of 2017 and used to evaluate the effects of BBD on the regenerations of American beech and sugar maple.

➢ Another inventory in 2020 may show effects of fertilization.

➢ Using stem maps of the stands, the distances from the locations where seedlings and germinants were inventoried to the nearby American beech or sugar maple mature trees can be calculated and analyzed to look at maternal effect.

Literature Cited

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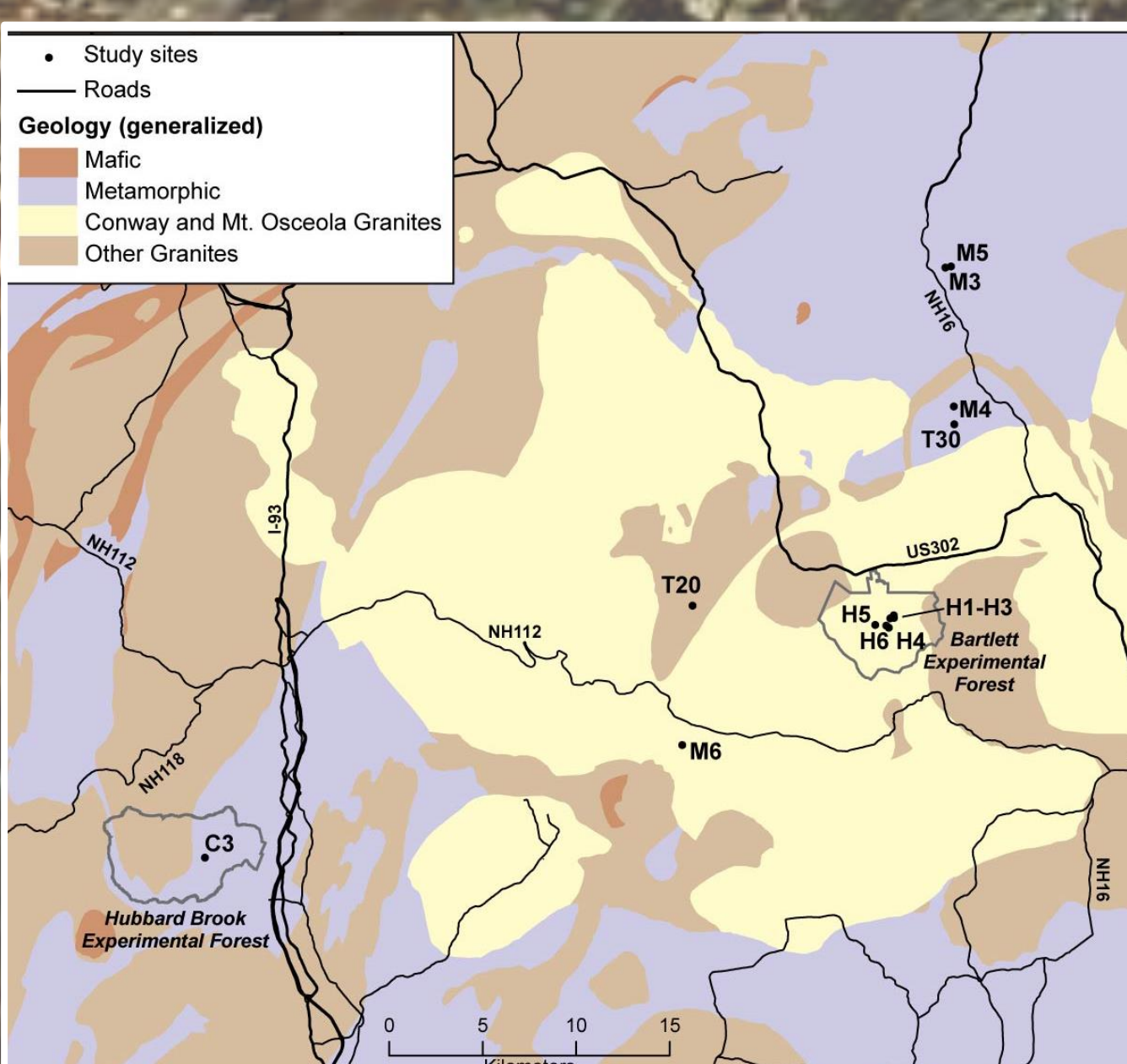
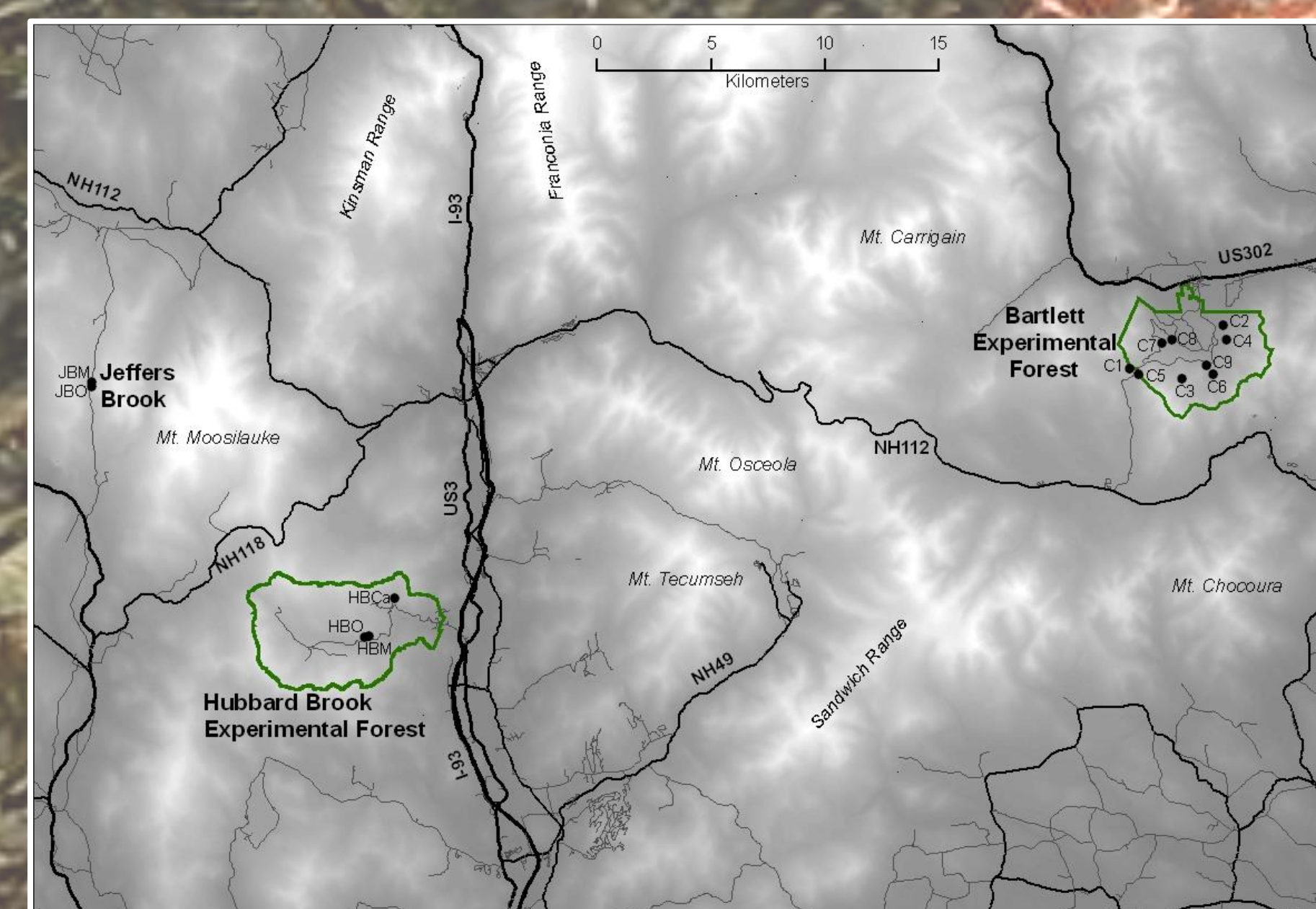Figure 1. CHRONOS stand locations in the White Mountains of central New Hampshire, USA.

Figure 2. MELNHE stand locations in the White Mountains of central New Hampshire, USA.