Proposal for Ash Protection Experiment (APE) within Hubbard Brook Experimental Forest

Investigators (alphabetical): Matt Ayres, John Battles, Nat Cleavitt, Jeff Garnas, Matt Vadeboncoeur, and others. Further investigators are enthusiastically invited.

29 November 2021

Emerald ash borer (*Agrilus planipennis*, Buprestidae) was discovered within Hubbard Brook for first time in summer 2021. Its arrival had been anticipated. See map below. The abstract from Klooster et al. (2018) describes what we can expect.

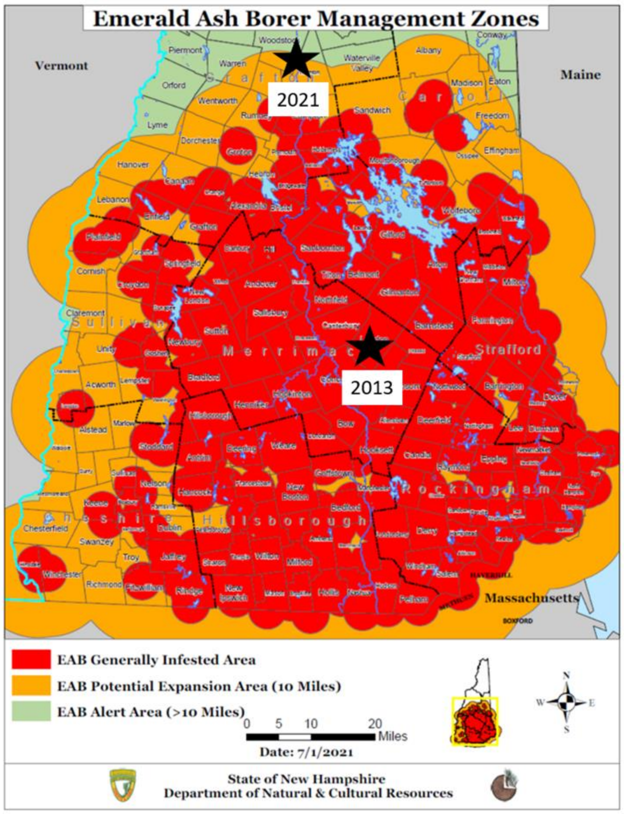


Fig. 1. Emerald ash borer (EAB) was introduced in central NH in 2013 (by campers transporting firewood). In the eight years since, EAB has expanded in all directions by about 50 – 70 km (30 – 45 miles). In June 2021, an EAB adult was captured with a malaise trap by John Deitsch, Cornell undergraduate, who was studying insects for another reason. See John's photo below. The identification was verified by Bill Davidson, Forest health Specialist, NH Division of Forests and Lands. Since then, signs of EAB within trees ("ash blonding") was detected in 5 of 32 ash groves within the Hubbard Brook Experimental Forest that were systematically surveyed for blonding by Nat Cleavitt. Link to NHBugs, source of map at left.

John Deitsche

Klooster, W. S., K. J. K. Gandhi, L. C. Long, K. I. Perry, K. B. Rice, and D. A. Herms. 2018. Ecological impacts of emerald ash borer in forests at the epicenter of the invasion in North America. Forests 9: 250. https://doi.org/10.3390/f9050250

Abstract. We review research on ecological impacts of emerald ash borer (EAB)-induced ash mortality in the Upper Huron River watershed in southeast Michigan near the epicenter of the invasion of North America, where forests have been impacted longer than any others in North America. By 2009, mortality of green, white, and black ash exceeded 99%, and ash seed production and regeneration had ceased. This left an orphaned cohort of saplings too small to be infested, the fate of which may depend on the ability of natural enemies to regulate EAB populations at low densities. There was no relationship between patterns of ash mortality and ash density, ash importance, or community composition. Most trees died over a five-year period, resulting in relatively simultaneous, widespread gap formation. Disturbance resulting from gap formation and accumulation of coarse woody debris caused by ash mortality had cascading impacts on forest communities, including successional trajectories, growth of non-native invasive plants, soil dwelling and herbivorous arthropod communities, and bird foraging behavior, abundance, and community composition. These and other impacts on forest ecosystems are likely to be experienced elsewhere as EAB continues to spread. View Full-Text

Further background on ash trees in Hubbard Brook Experimental Forest

From valleywide vegetation surveys, we (JJB) can estimate that there are about 26,000 canopy ash trees within about 434 ha of HBEF. From bi-annual measurements since 1993 of the size and number of newly dead trees, there has been an average input of dead trees of about 18 Mg · ha^{-1} · 2 $years^{-1}$ (range = 11 – 32 Mg) within HBEF. If, as expected, > 90% of canopy ash trees die in the next 10 years, that will be an increase of about 2.5-old in average dead tree input for a decade. In anticipation of the EAB invasion, Liz Studer, Ph.D. candidate at Dartmouth College, has been comparing the understory flora, invertebrates living in the litter layer, and soil chemistry beneath ash trees vs. other canopy tree species in HBEF. Some results from her studies are in Appendix 1.

Research Question 1

How will the elimination of white ash from the Hubbard Brook forest affect the biota and ecosystem?

Hypotheses

H_1: Effects will be minimal because the ash will be replaced by other tree species that are ecologically redundant with ash.

H_2: Effects on some taxa and processes will be pronounced because of unique ecological features of ash.

H_3: Effects will be contingent on soil type, elevation, and local density of ash trees.

Research Question 2

Do soils determine the tree species that are present, or do tree species shape the soils?

Hypotheses

H_1: Soil properties are a product of hydropedalogical processes over centuries to millennia. They are little affected by the species identity of trees that grow there during one century or another.

H_2: The identity of dominant tree species can shape some important features of soil and the plant-soil interface, thereby producing a feedback in ecological time between soil and vegetation.

Study design (subject to revision based on input from community)

We (NLC) identified and surveyed 68 candidate research plots within the Hubbard Brook Experimental forest (see associated file: Ash.PotentialPlots.v08.xlsx). Each plot (defined to be 20 m diameter) contained 4 – 15 canopy ash trees (dbh of largest tree = 33 – 99 cm; ash basal area of ash = 8 – 42 m^2 / ha). Whenever possible, sites were included where previous studies have been conducted. We used the current map of predicted hydropedalogical units (Scott Bailey et al.) to classify plots by soil type (16 pixels of 4 x 4 m per plot that were classified as one of eight soil types). The candidate plots were about equally split between those predicted to be chiefly Bh podzol, chiefly typical podzol, or mixed between Bh and typical podzols. We then identified a subset of these plots to propose for protection of ash trees within and adjacent to the plot. Our considerations for plot selection were as follows:

- No more than ~ 300 trees in total to treat.
- Distribute treatment plots as broadly as possible within HBEF.
- Have as much spatial intermixing as possible between plots to be treated or not treated.
- Distribute treatment and control plots across soil types to permit tests for main effects and interactions involving soil type.
- No protection treatments within the bird study area (because the treatment would reduce food availability by some unknown amount for species that feed on caterpillars).
- No undue burden in accessing the sites.

We invite input during the upcoming Town Hall on the selection of which plots to treat. The accompanying spreadsheet (Ash.PotentialPlots.v08.xlsx) allows for easily opting plots in or out and seeing the effects on protection effort and overall experimental design. Figure 2 shows a map of our initial proposal for treatment plots and Table 1 shows the summary attributes of this proposal for treatment plots.

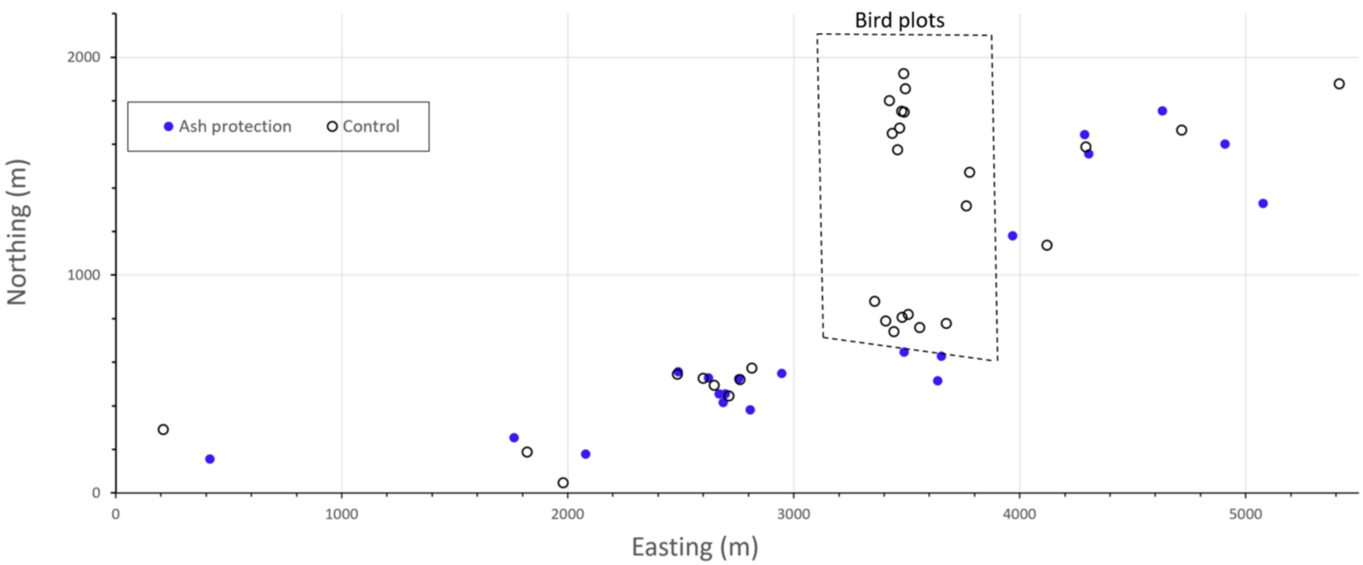


Fig. 2. Locations of 68 potential ash plots within HBEF. See associated materials for the waypoints as shape files, in google earth format (*.kmz), and as GPS eXchange format (*.gpx). One proposal for ash protection plots is indicated by the blue symbols. The attributes of this selection set are indicated in Table 1 below. See Ash.PotentialPlots.v08.xlsx for full set of plot attributes.

Table 1. Attributes of proposal for treatment plots in Fig. 2

Total ash trees to treat	308
Total plots to treat	32

	Number of plots by soil type	
Soil type	Treatment	Control
Bh podzol	9	12
Typical podzol	10	10
Mixed podzols	9	11
Unknown	4	2

The determination of treatment plots will be finalized during winter of 2021-22. Ash trees within and adjacent to treatment plots will be protected by injection of emamectin benzoate (TREE-äge®) in summer of 2022 and repeated at 3-year intervals. In protected plots, each ash tree within the plot will be protected as well as any nearby ash trees that are destined to fall into the plot when they die.

The project would involve a partnership with Arborjet, per memorandum of understanding (attached) with Joe Doccola, Director of Research and Development, Arborjet.

Arborjet will provide:

- emamectin benzoate (as TREE-äge®)
- training in the application of treatments
- consultation

The Hubbard Brook research community will:

- acquire their own injectors for the protection treatment (probably two Quik-Jet Air Injectors)
- apply protection treatments in compliance with applicable laws, regulations, and labelling
- acknowledge Arborjet in publications and products that result from the Ash Protection Experiment
- share resulting information with Arborjet that is relevant to their research and development (e.g., data addressing the question of herd immunity in ash trees)

If this proposal is supported by the HB Research Approval Committee and the Forest Service, we will pursue the possibility of an NSF Grant for Rapid Response Research (RAPID) to support implementation of treatments and baseline measurements during summer of 2022. The upcoming Town Hall is an opportunity for (1) discussion and strategizing on making a pitch to NSF Rapid and (2) outlining the proposed research that would be included in a proposal to NSF RAPID.

"The RAPID funding mechanism is used for proposals having a severe urgency with regard to availability of, or access to data, facilities or specialized equipment, including quick-response research on natural or anthropogenic disasters and similar unanticipated events. PI(s) must contact the NSF program officer(s) whose expertise is most germane to the proposal topic before submitting a RAPID proposal. This will facilitate determining whether the proposed work is appropriate for RAPID funding.

… Requests may be for up to $200K and of one year duration. The award size, however, will be consistent with the project scope and of a size comparable to grants in similar areas."

Measurements

All interested researchers are invited to propose and participate in studies that take advantage of the ash protection experiment. Measurements that have been proposed so far include:

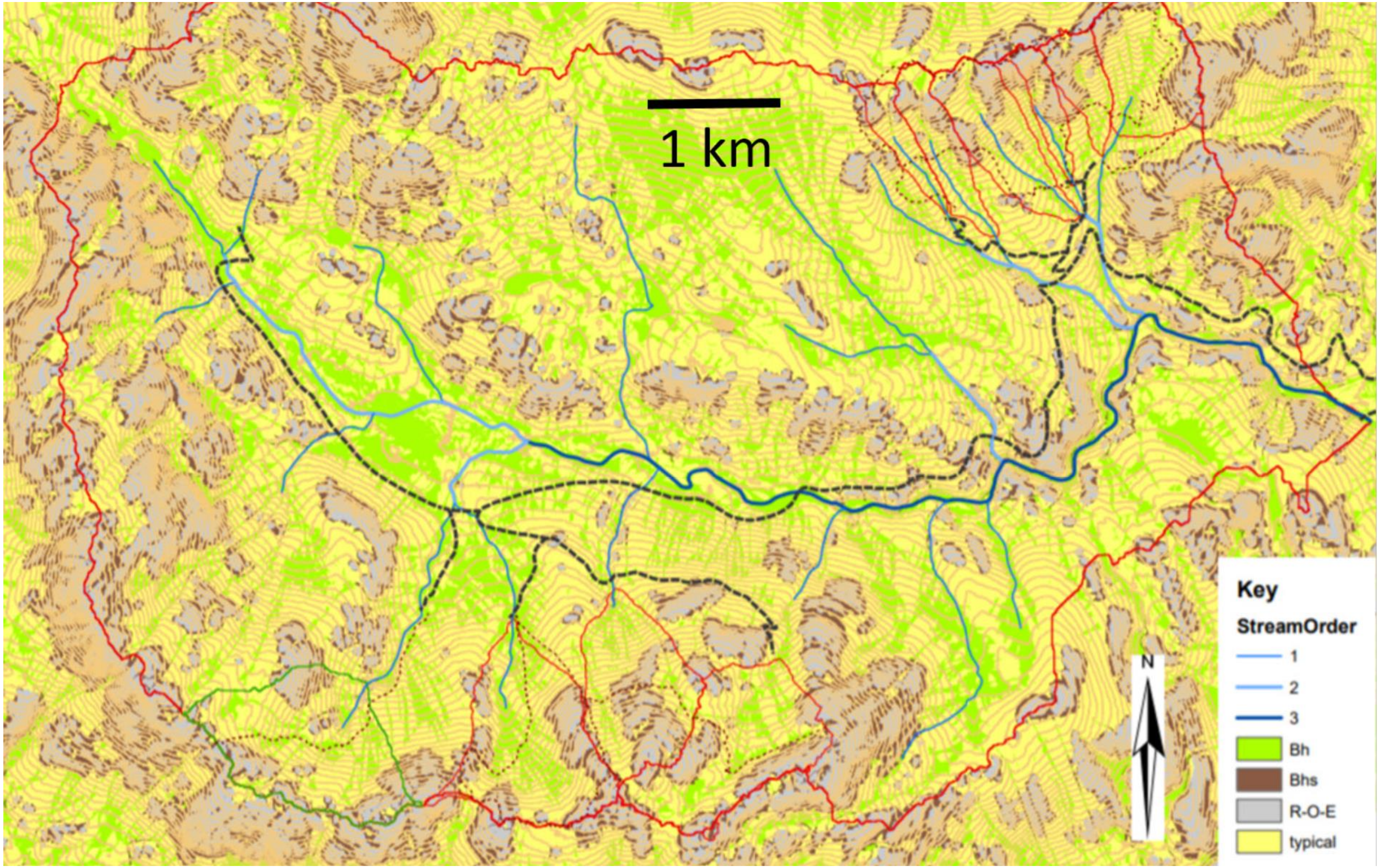
- Brown-web invertebrates (e.g., Collembola) (Studer, Garnas, Ayres, others?)
- Demography of spring ephemerals, orchids, and other understory flora (Cleavitt, Studer, Ayres,
- Mushrooms, ectomycorrhizal fungi, PLFAs, sequencing (Palmer, Ayres, Garnas, others?)
- Canopy light and canopy structure dynamics (Battles, Cleavitt, others?)
- Changes in leaf litter inputs (Battles, Cleavitt, others?)
- Nitrogen cycling and availability (Groffman et al., others?)
- Soil moisture and temperature; litter decomposition rates (Vadeboncoeur, others?)
- LAI phenology ((Vadeboncoeur, Ayres, others?)
- Bat foraging (ter Hofstede)

Appendix. Some results from Liz Studer's dissertation research: Trillium-Ash-Soil-Heterotroph project

Attachments

Ash.PotentialPlots.v08.xlsx
Waypoints.Ash-protection-experiment.zip
Ash-Protection_Experiment.MoU.pdf (memorandum of understanding with Arborjet)
Emamectin-benzoate.History-References.pdf
Emamectin-benzoate.Side_effects_FAQs.pdf
Klooster.etal.2018.pdf

Typical podzol and Bh podzol are the most common soil types in HB where ash grows.



Map based on hydropedalogical model of Scott Bailey et al. (Northern Research Station, USDA Forest Service)

Following slides are from dissertation research by Liz Studer, Dartmouth College

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Trillium-Ash-Soil-Heterotroph (TrASH) Project

4 canopy tree species (Ash, Beech, Sugar Maple, Yellow Birch)
x 2 soil types (Bh podzol and Typical podzol)
x 5 -10 replicates
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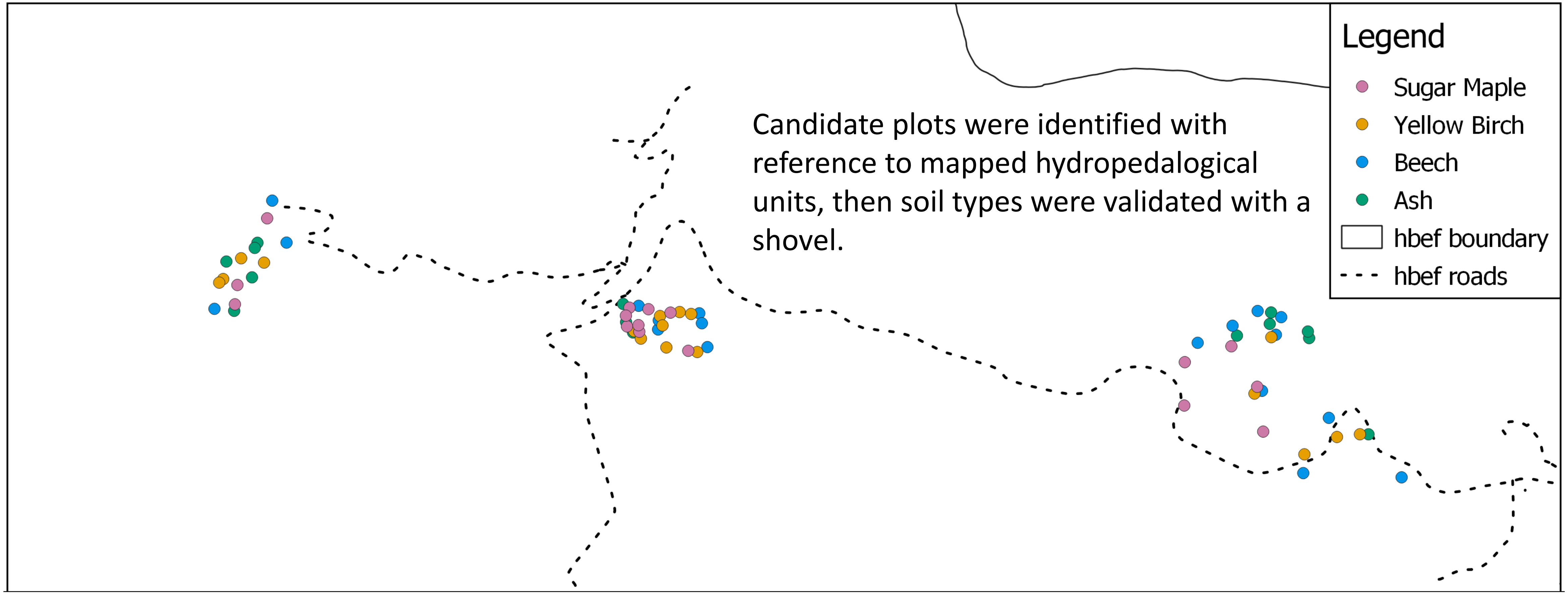
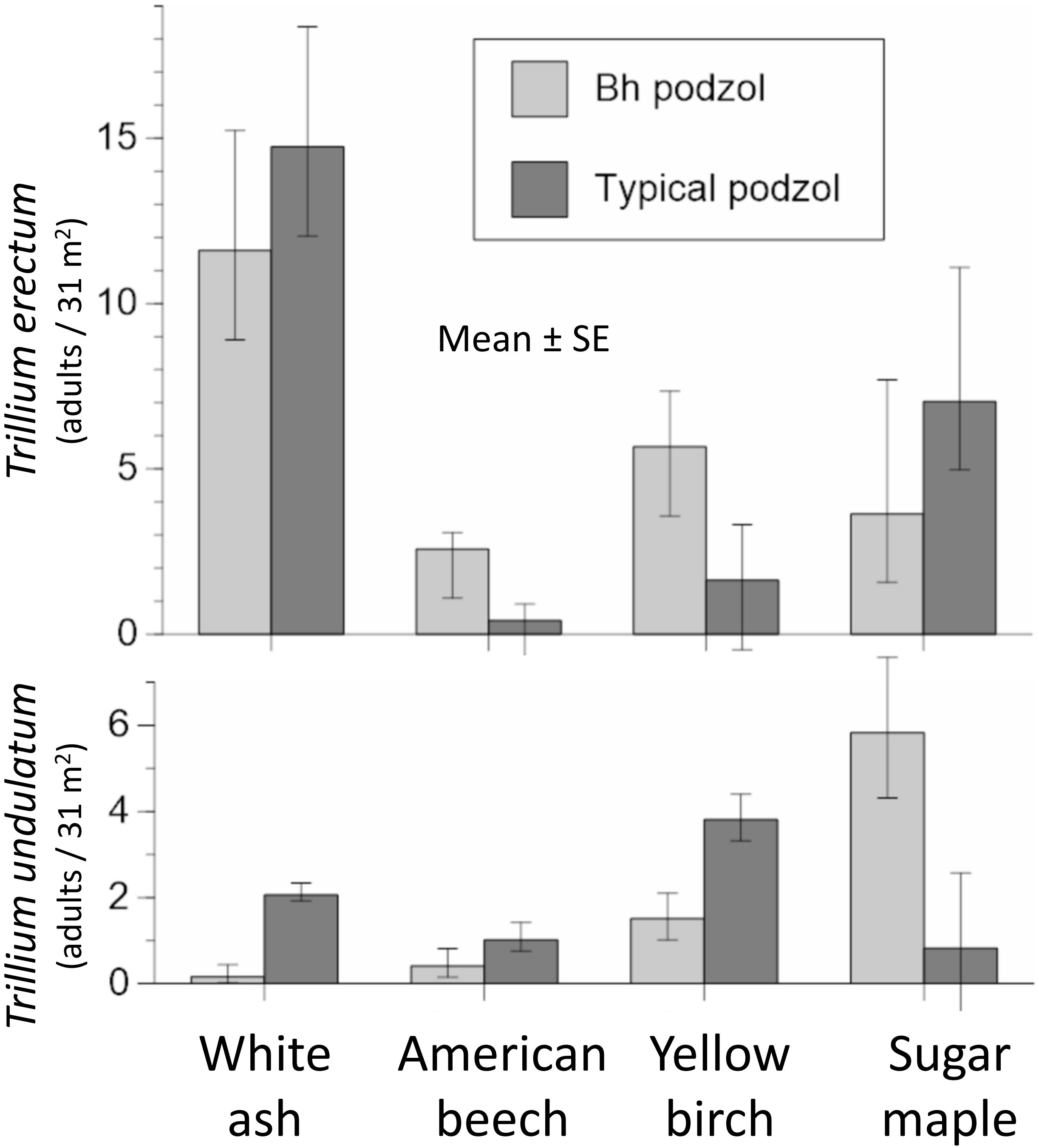
60 plots total



Plot = 10 m diameter with > 50% basal area of focal tree species



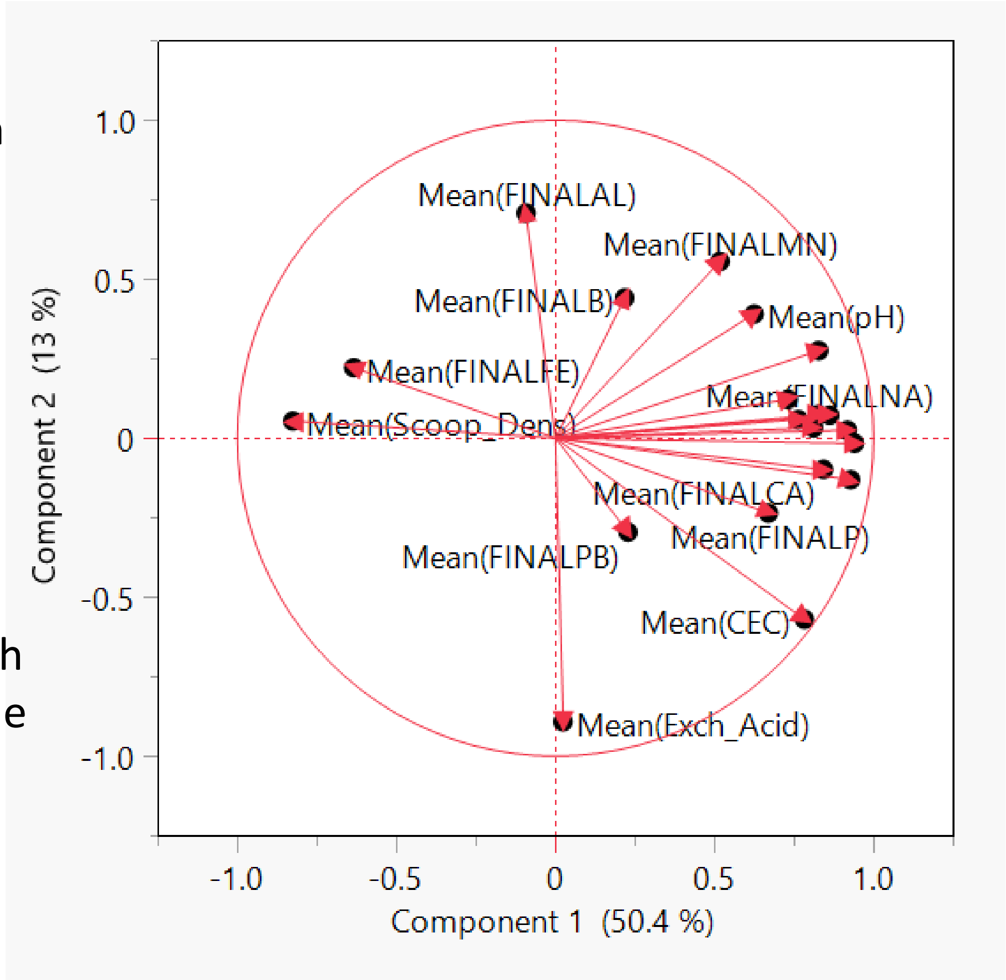
Trillium erectum adults are 3x more abundant beneath ash than beneath other hardwoods.

Trillium undulatum are more abundant beneath sugar maple than other hardwoods, but only on Bh pdozol soils

Standard soil chemistry of organic layer

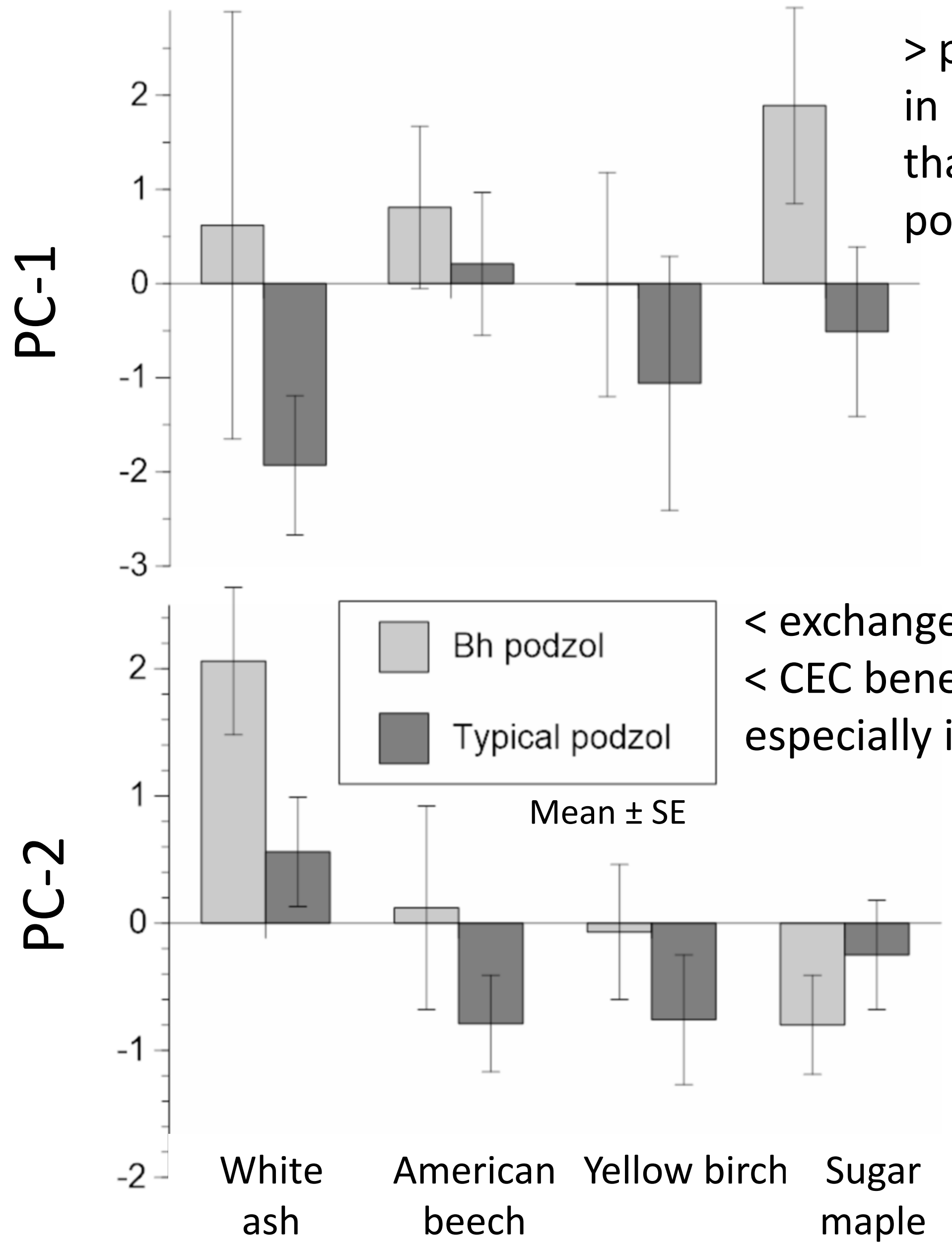
White ash

Yellow birch
Sugar maple
Beech



Typical podzol

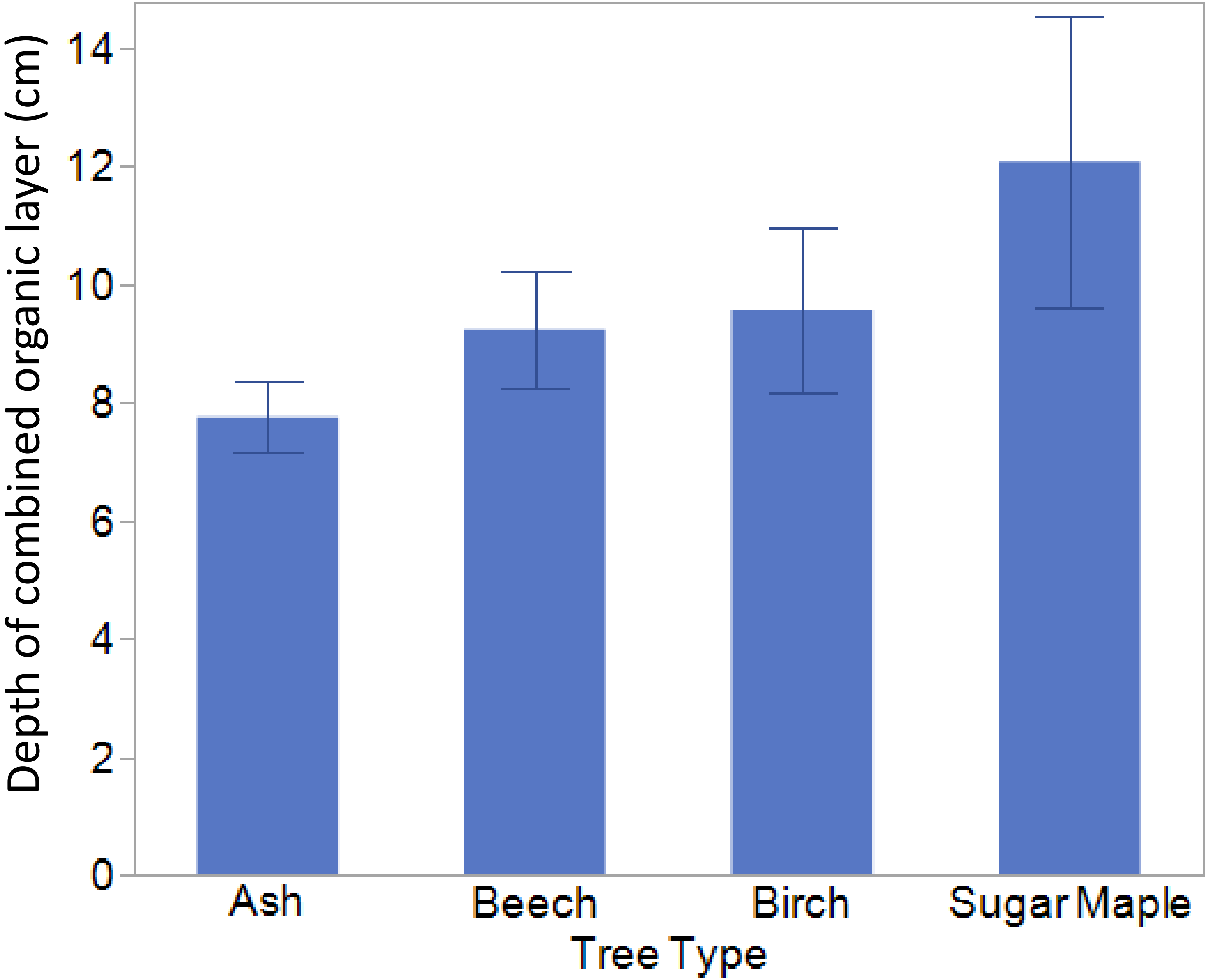
Bh podzol



> pH, Ca, etc., in Bh podzol than in Typical podzol

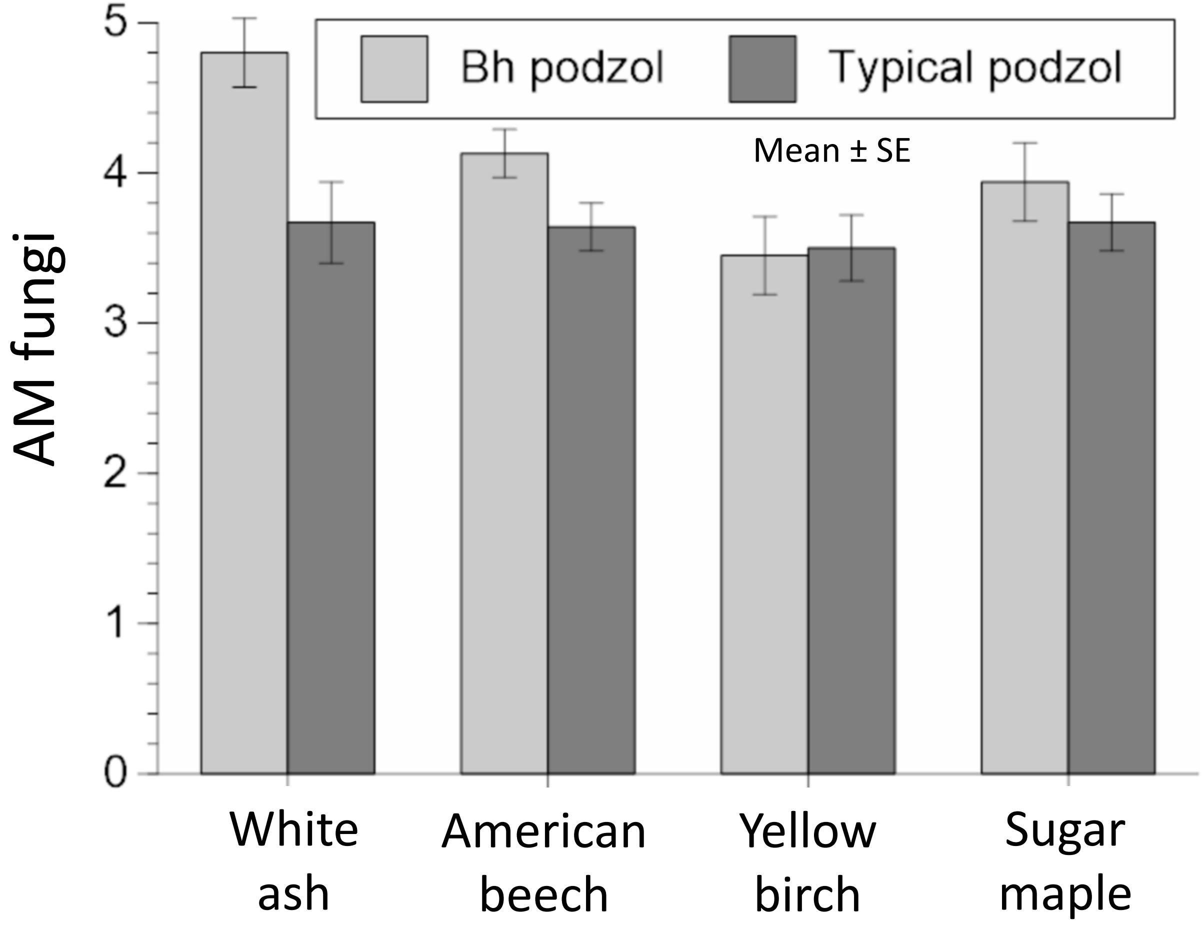
< exchangeable acids , < CEC beneath ash, especially in Bh podzol

Thinner organic layer beneath ash

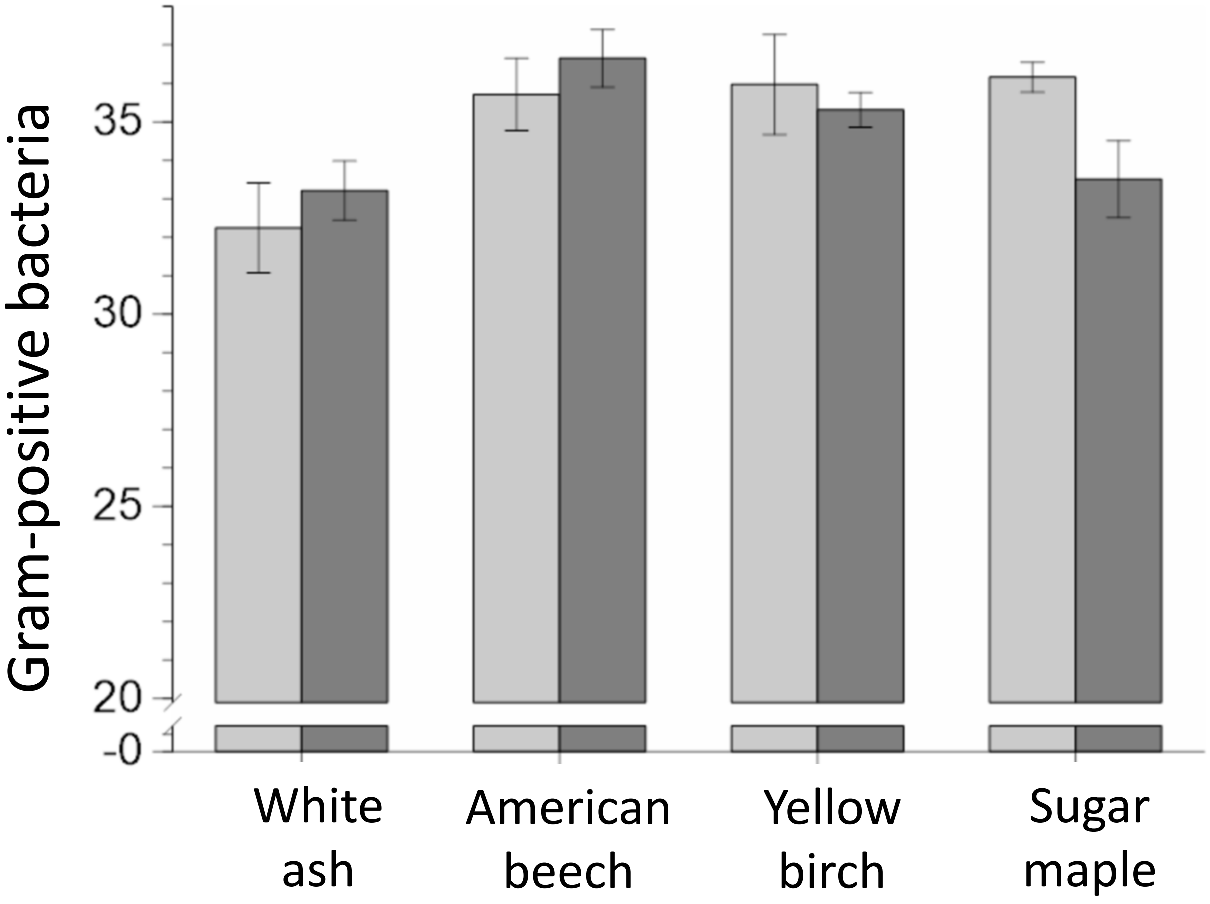


PLFAs (Phospholipid fatty acids)

> AM fungi in Bh podzol, especially beneath ash



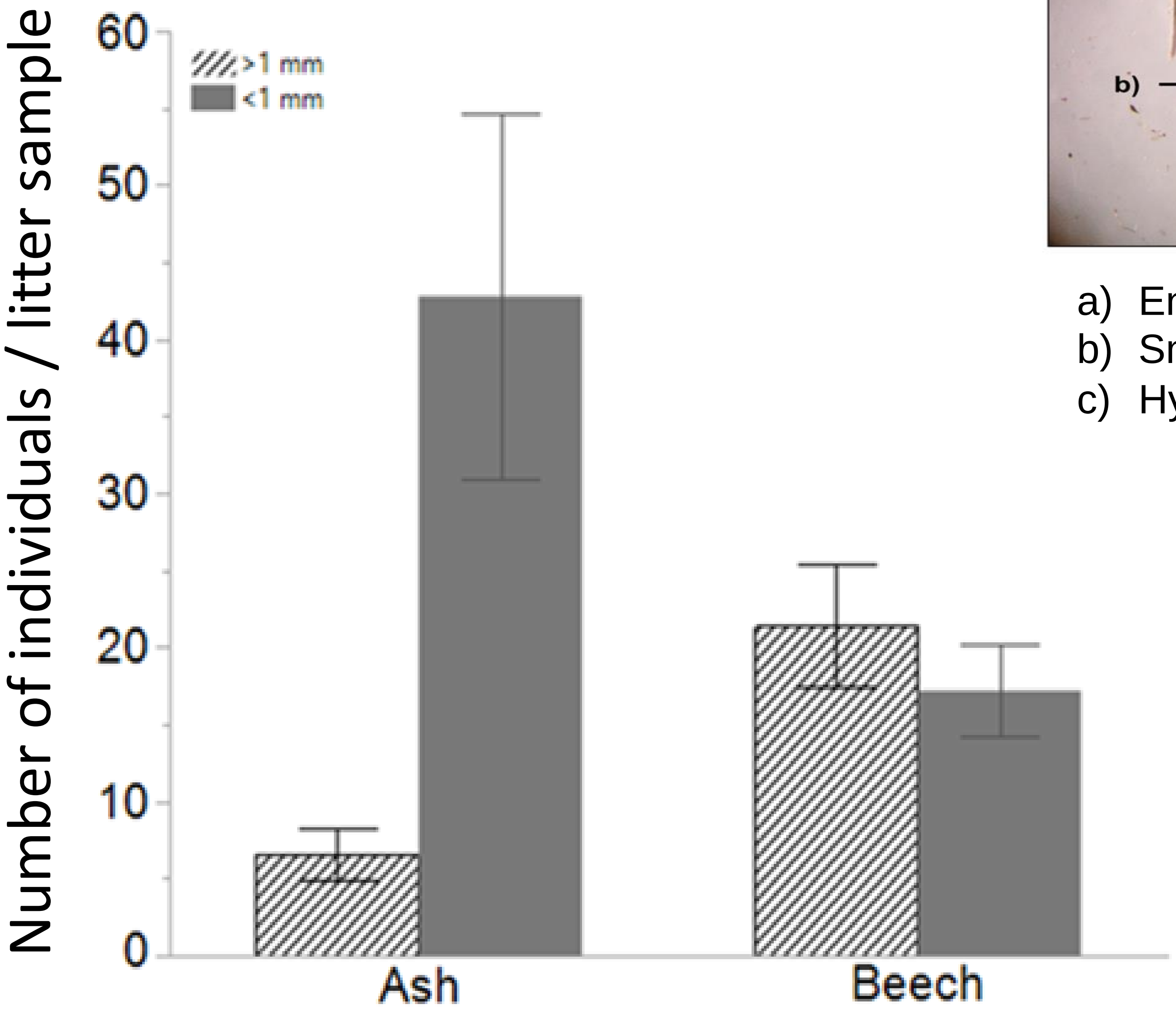
< gram-positive bacteria beneath ash



No patterns with soil type or tree species for: gram-negative bacteria, Actinomycetes, other fungi (including Basidiomycetes), Eukaryotes

Fauna of the brown
food web.

Smaller animals under ash



a) Entomobryidae
b) Sminthuridae
c) Hypogastruridae

Fewer predators under ash: shorter food chain?