Soil Nutrition: Effects of Nitrogen Fertilization and Thinning Treatments on Subsurface Carbon and Nitrogen

NARA
Northwest Advanced Renewables Alliance

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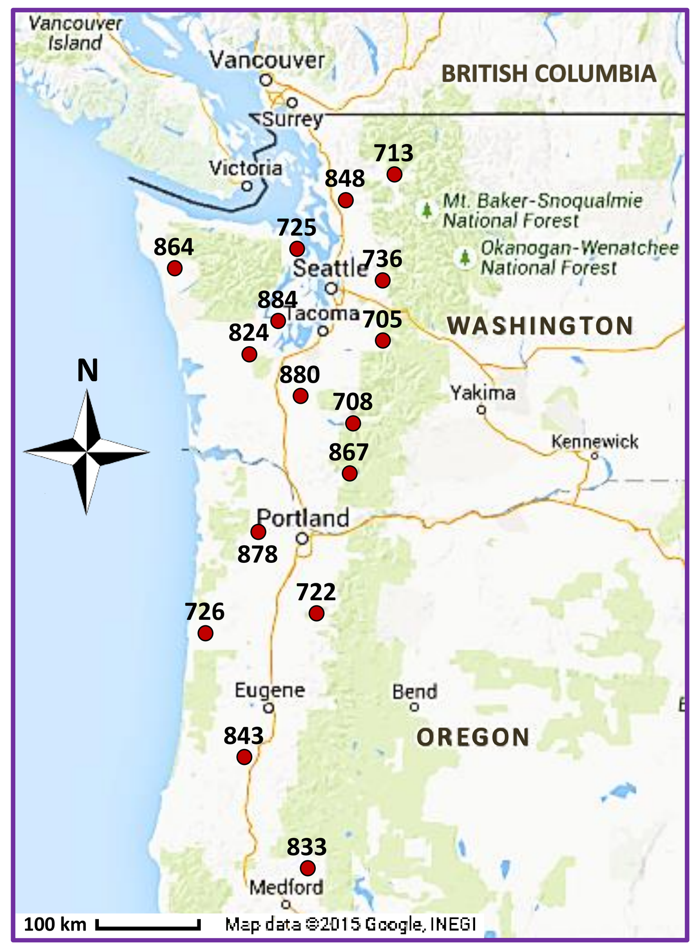
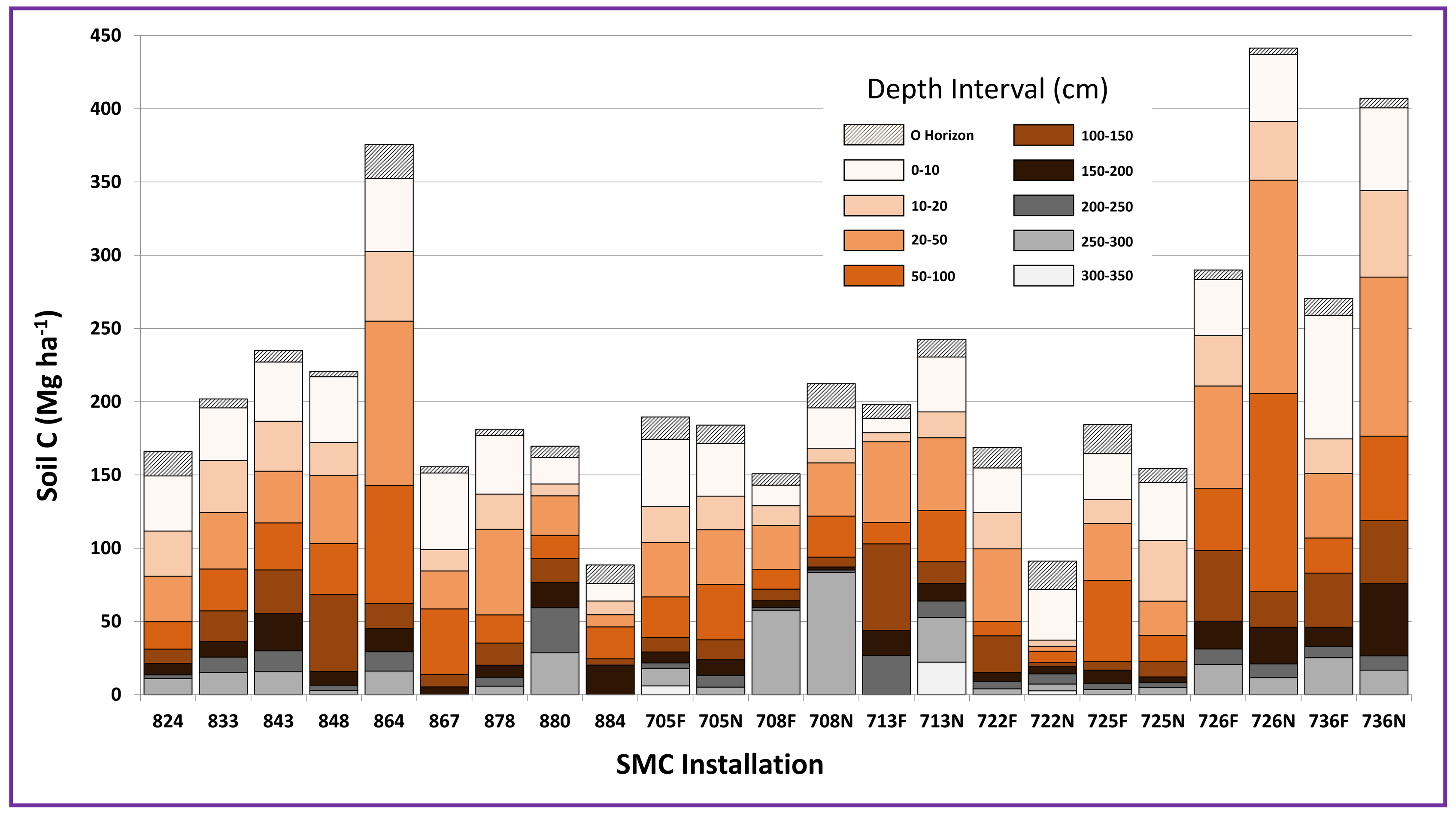
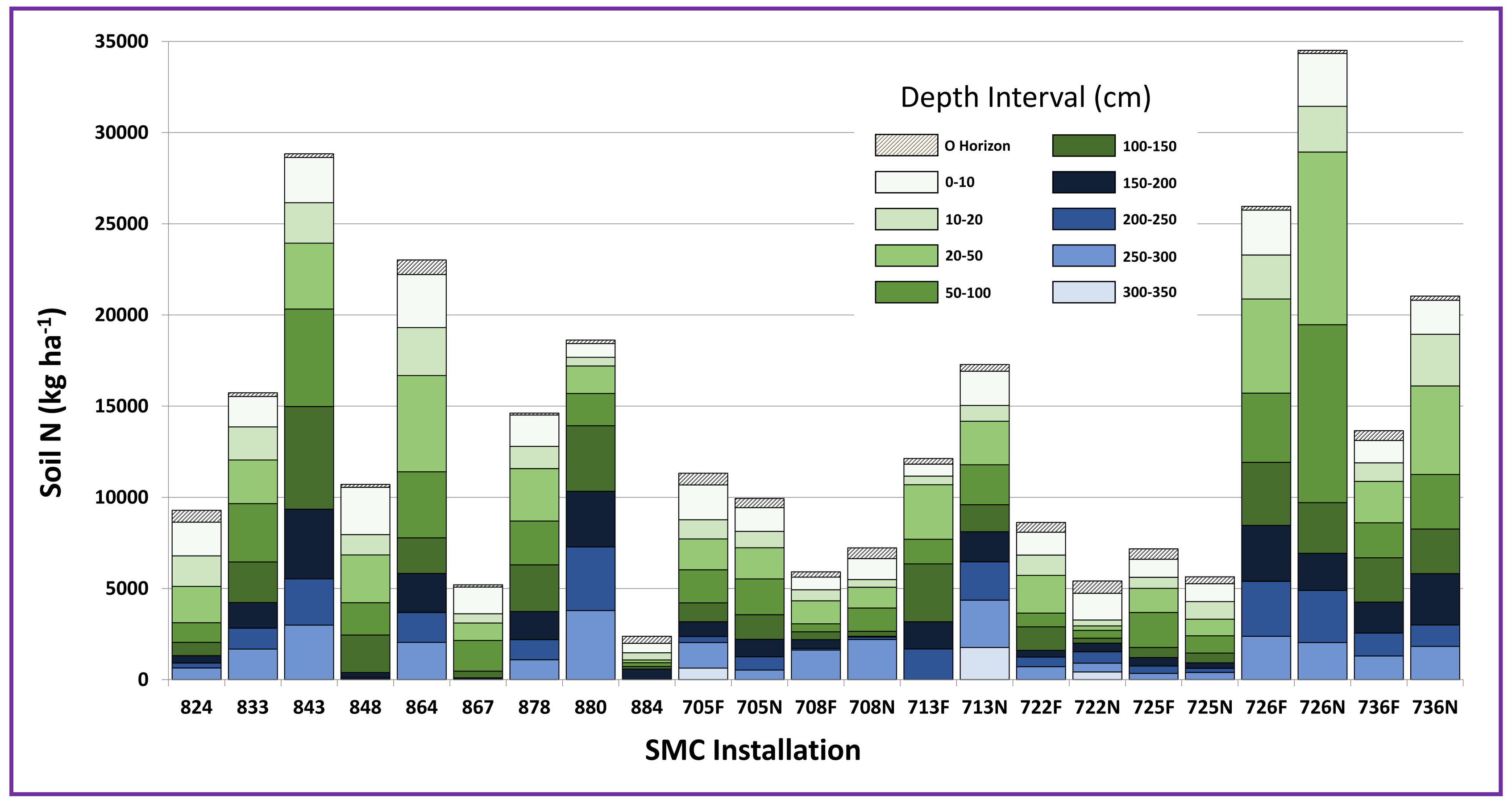
Stand Management Cooperative
SILVICULTURE • NUTRITION • WOOD QUALITY • MODELING

Importance of Studying Deep Soils

- Soil contains more carbon (C) than plant biomass and the atmosphere combined, representing the most important long-term C reservoir in terrestrial ecosystems (Jobbagy and Jackson 2000).
- Substantial amounts of C and nitrogen (N) are stored in subsurface layers across all soil orders, defined here as below 50 cm (Diochon and Kellman 2009; Harrison et al. 2011; James et al. 2014; Kaiser et al. 2002; Whitney and Zabowski 2004; Zabowski et al. 2011).
- Changes in factors and processes that affect soil genesis – such as continuing climate change affecting soil temperature, additions or removals of fresh organic matter, and nitrogen fertilization – can cause C to move rapidly into and out of soil material that has remained stable for long periods of time (Harrison et al. 2011).
- Root-soil interactions are not limited to the surface soil; thus sampling only surface soil ignores biologically available N in subsurface soil and can substantially bias N pool estimates (Whitney and Zabowski 2004).
- A recent deep soil study included 16 sites selected from the Stand Management Cooperative (SMC) Type V Long-Term Site Productivity Installations to cover a range of soils across the parent materials and climatic conditions of the coastal Pacific Northwest region; at seven of the 16 sites, two pits were excavated, one in a fertilized plot and the other in an unfertilized plot (F = fertilized; N = non-fertilized).
- The results show an average of over 35% and 50% soil C and N, respectively, below 50 cm.







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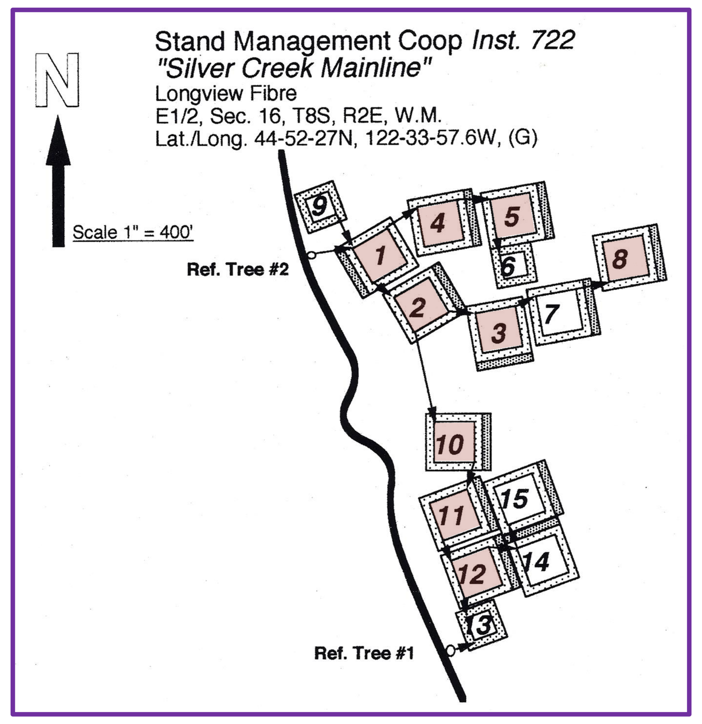
Materials and Methods

- Soil will be sampled by depth to at least 100 cm at SMC Installation 722, a Type I installation established in 1989 in a juvenile stand with ≥90% (by stem count) Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco).
- Samples will be taken at nine 0.2-ha plots (highlighted) with differing thinning and fertilization treatments and/or differing initial stems per acre (ISPA).



Plot	Treatment	Initial Stocking	Regime
1	4	ISPA*	Repeated thinning: RD†55→RD35; RD55→RD40, subsequent thinnings RD60→RD40
2	1	ISPA/4‡	No thinning
3	2	ISPA/2‡	Minimal thinning: RD55→RD35, no further thinning
4	5	ISPA	Minimal thinning: RD55→RD35, no further thinning
5	6	ISPA	No thinning
8	3	ISPA/2	No thinning
10	15	ISPA	Fertilization§ + repeated thinning: N fertilization + treatment #4
11	14	ISPA/2	Fertilization + minimal thinning: N fertilization + treatment #2
12	13	ISPA/4	Fertilization + no thinning: N fertilization + treatment #1

* ISPA = number of stems per acre at time of plot establishment and after preliminary thinning.
† RD = Curtis's (1982) relative density.
‡ ISPA systematically reduced to one-half (ISPA/2) and one-fourth (ISPA/4).
§ Nitrogen fertilizer applied at rate of 224 kg N/ha as urea with frequency of once every four to six years commencing at time of plot establishment.

- Bulk density and chemical analysis samples will be taken using a soil corer in the middle of succeeding soil layers at depth intervals of: 0-10, 10-20, 20-50, 50-100, and 100-150 cm.
- The auger and coring method will be used for repeat sampling at plots with small coarse fractions.
- Forest floor samples will be collected at each of the nine plots from a randomly placed 30 x 20 cm quadrat.

Preliminary Results

- Results from the deep soil study (left) show substantial differences in total and subsurface soil C and N in fertilized versus unfertilized plots at Installation 722, although results were mixed across all installations at which fertilized and unfertilized plots were sampled.
- Soil pits dug at Installation 722 reveal horizon and parent material differences over relatively short distances, with topography likely playing a substantial role in some of the observed changes.
- Roots were observed in all soil profiles to depths of at least 80 cm. Note the roots taking advantage of the macropores in the soil resulting from the large rocks in plots 3, 10, and 12; in turn, these roots aid in creating mechanisms for preferential flow, and organic matter is translocated with water from the surface soil to subsurface soil layers.

Plot 1 | Plot 2 | Plot 3 | Plot 4 | Plot 5 | Plot 8 | Plot 10 | Plot 11 | Plot 12

Progress and Expected Benefits

- Initial bulk density and chemical analysis samples have been taken at all nine plots; seven of the nine plots were sampled to 150 cm, with the remaining two sampled to 100 cm. Additional bulk density and chemical analysis samples were taken in subsurface soil layers where abundant organic matter had been translocated due to preferential flow.
- The results of this study will help guide sustainable and best stand management practices by providing data for regional responses of soil carbon, nitrogen, and other nutrient content by depth to fertilization and thinning treatments.