

The Effects of Organic Matter Removal and Vegetation Control Treatments on Douglas-fir Soil and Site Productivity

Dr. Kim Littke

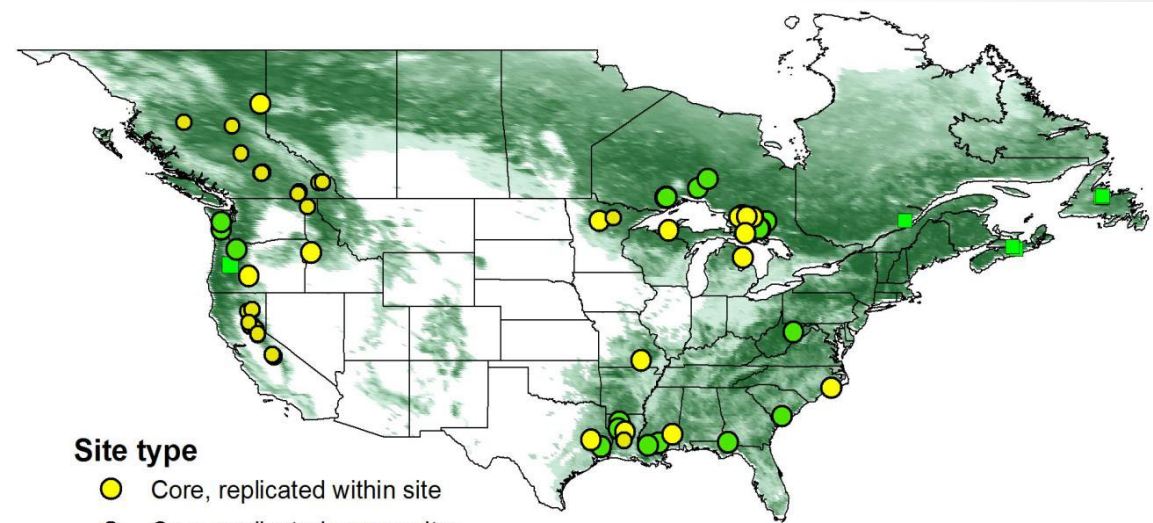
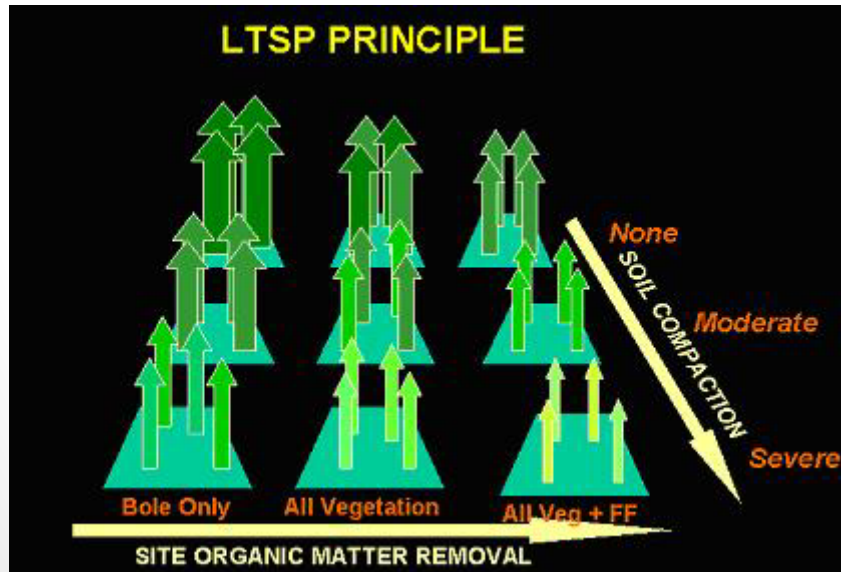
Stand Management Cooperative

University of Washington



Long-term Soil Productivity Study

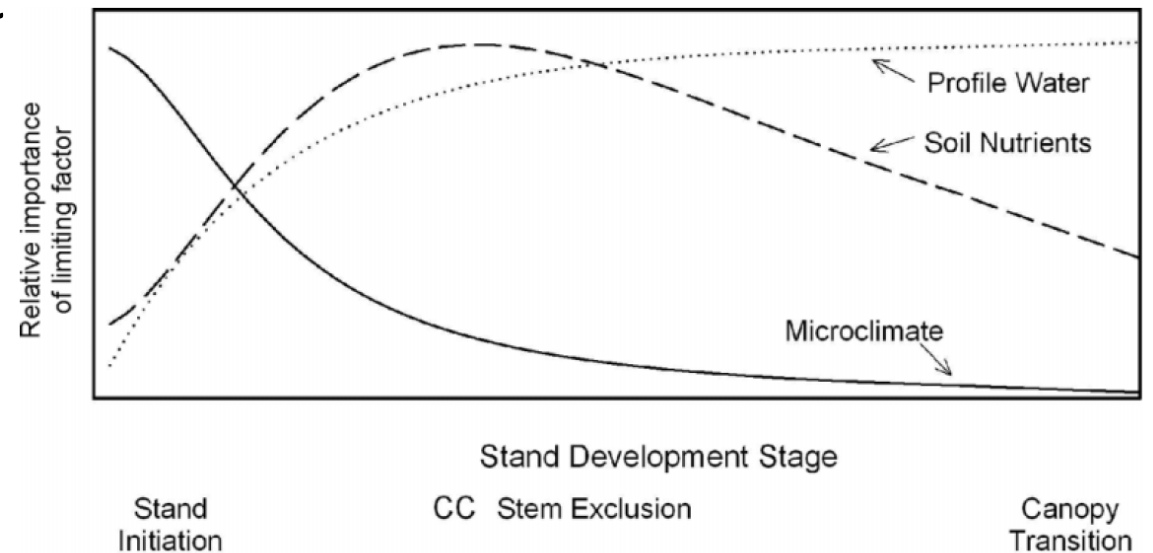
- World-wide study on soil and site productivity
- Identify the effects of intensive disturbance due to organic matter removals and compaction
- Affiliate sites incorporated vegetation control treatments



- Site type**
- Core, replicated within site
 - Core, replicated across sites
 - Candidate, replicated within site
 - Candidate, replicated across sites
 - Affiliate, replicated within site

Treatment Effects over Time

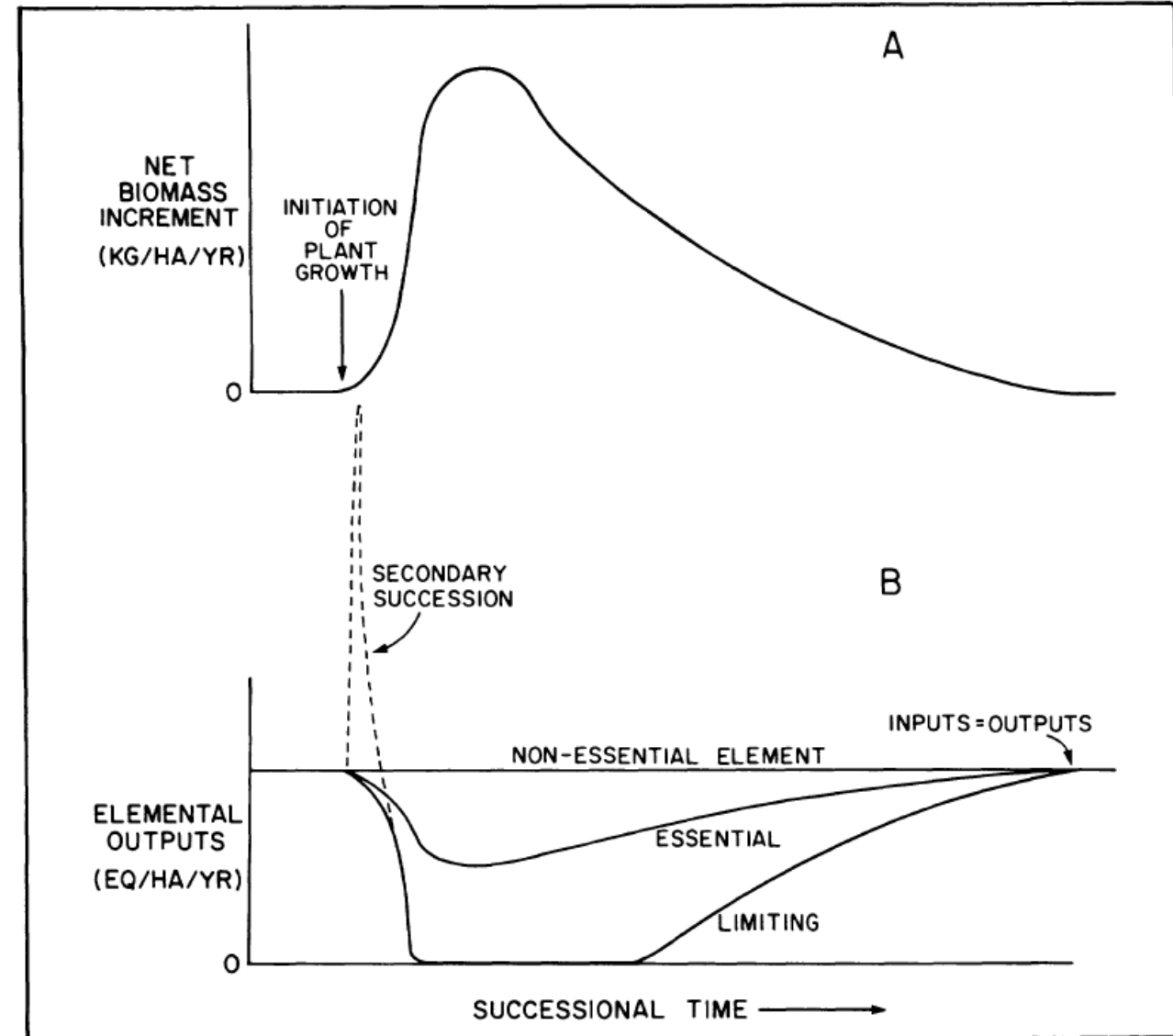
- Improvement in microclimate most important during stand initiation
 - Benefits of vegetation control and organic matter removal
- Availability of soil water and nutrients more important during canopy closure
 - Negative effects from loss of nutrients expected during this stage



Thiffault et al. 2011

Effect of Nutrient Limitations on Uptake and Loss

- Stands with limiting essential nutrients will hold more nutrients aboveground to limit losses belowground
 - Understory helps retain nutrients on a site
- Non-limiting essential and non-essential nutrients are not held as tightly
- Canopy closure leads to the greatest demand for nutrients
- Loss of nutrients through organic matter removal or leaching is an extra output that cannot be controlled



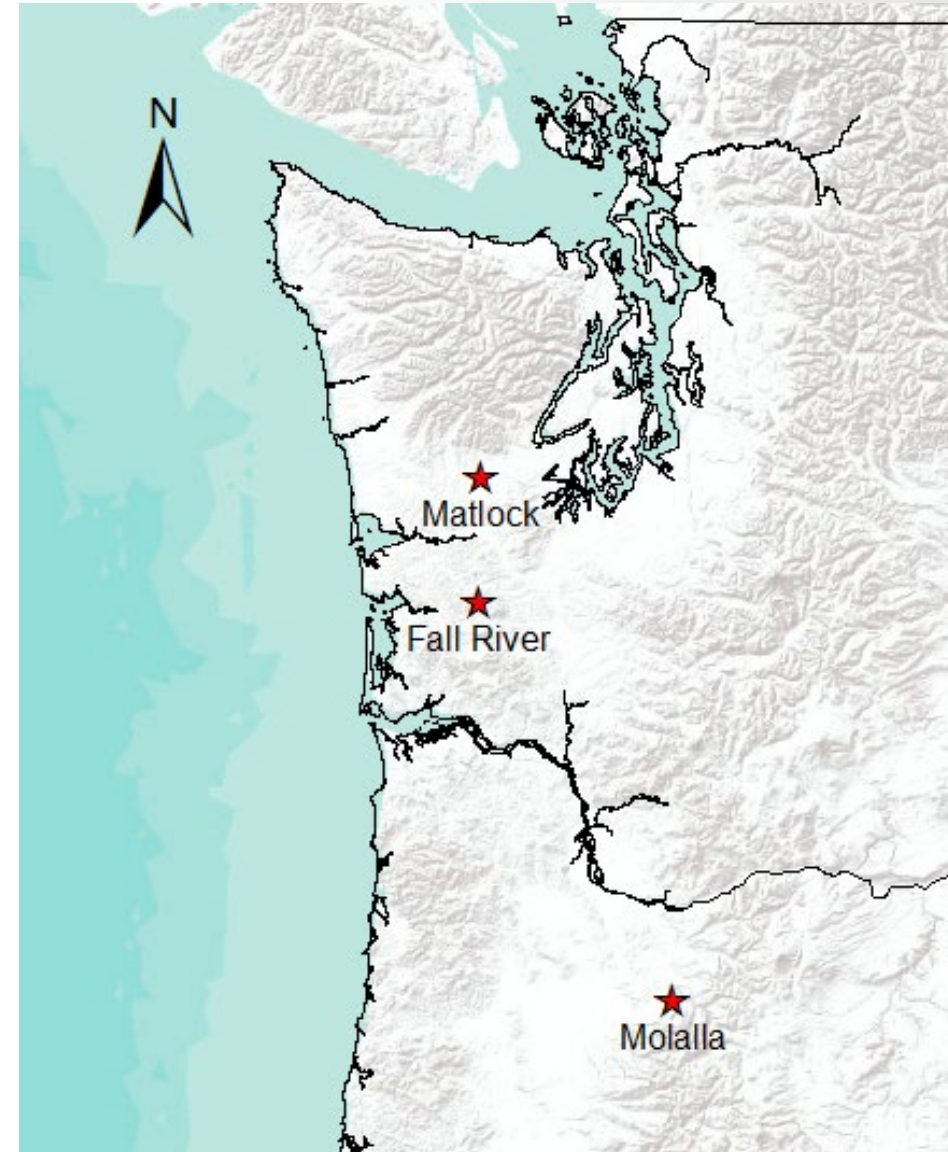
Pacific Northwest LTSP Research

- Determine the long-term effects of organic matter removals and vegetation control on soil and site productivity
 - Three sites with unique climate, soil, and productivity
- Organic matter removals
 - Bole Only (**BO**), Whole Tree (**WT**), and WT plus coarse woody debris removal (**WT+**)
- Vegetation control
 - Initial (**IVC**) and 5 years of annual (**AVC**)



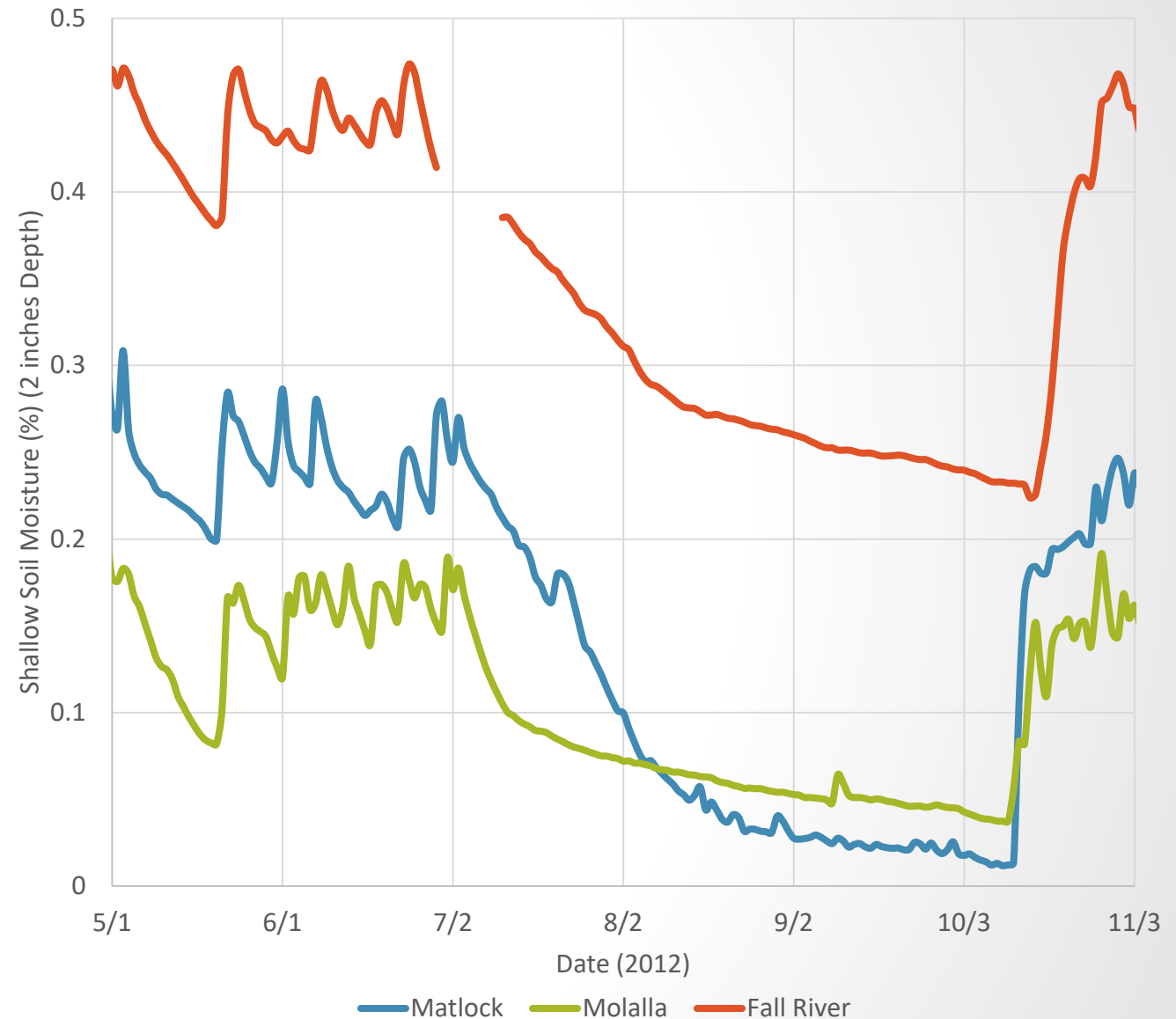
LTSP Sites

- Fall River
 - 19 years old
 - BOIVC, BOAVC, WTAVC, WT+AVC
- Matlock
 - 15 years old
 - BOIVC, BOAVC, WTIVC, WTAVC
- Molalla
 - 15 years old
 - BOIVC, BOAVC, WTIVC, WTAVC



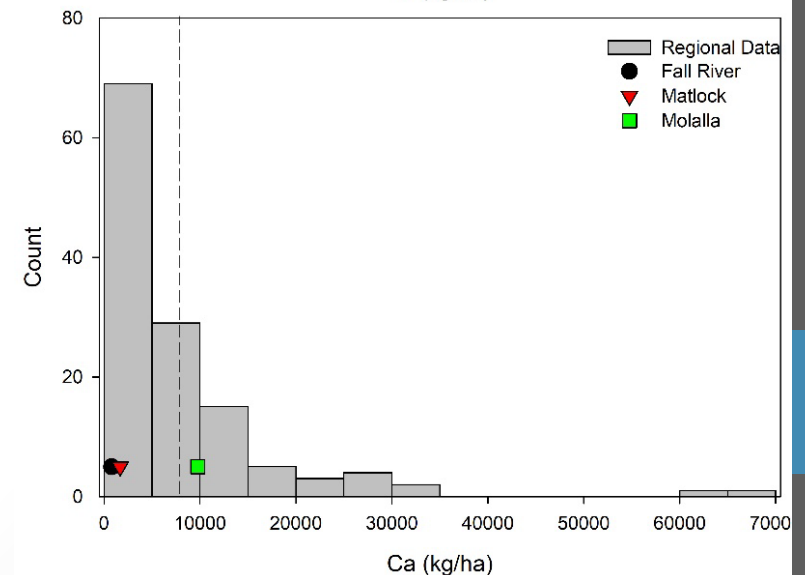
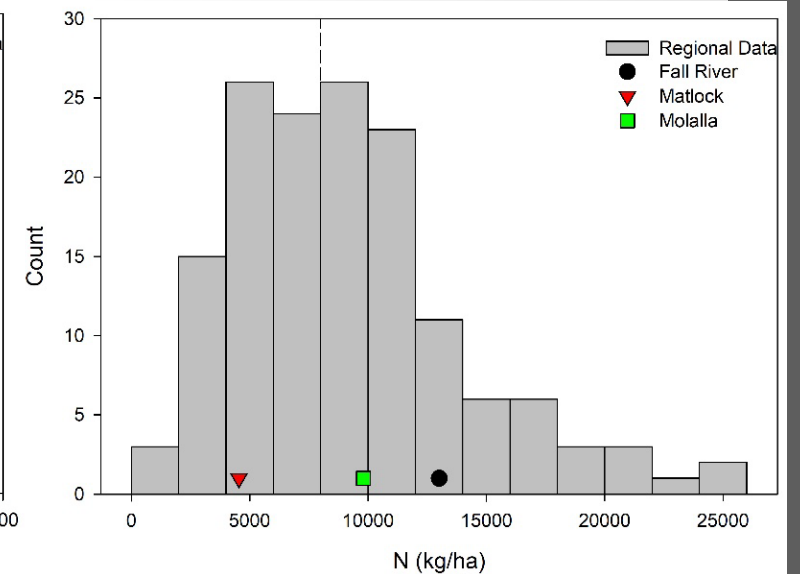
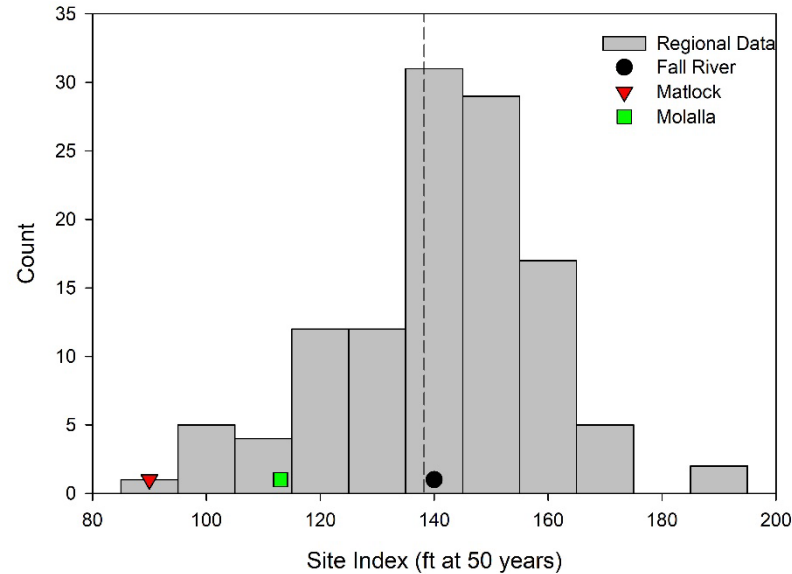
Soil Moisture

- All tree sites have unique climates and soils which affect soil moisture availability
- Lowest soil moisture at Matlock
 - Coarse glacial outwash soil
- Fall River contains the greatest summer soil moisture
 - Silt loam-silty clay soil texture and cooler summer temperatures
- Moderate soil moisture at Molalla
 - Loam-clay loam soil and rocks with warmer summer temperatures



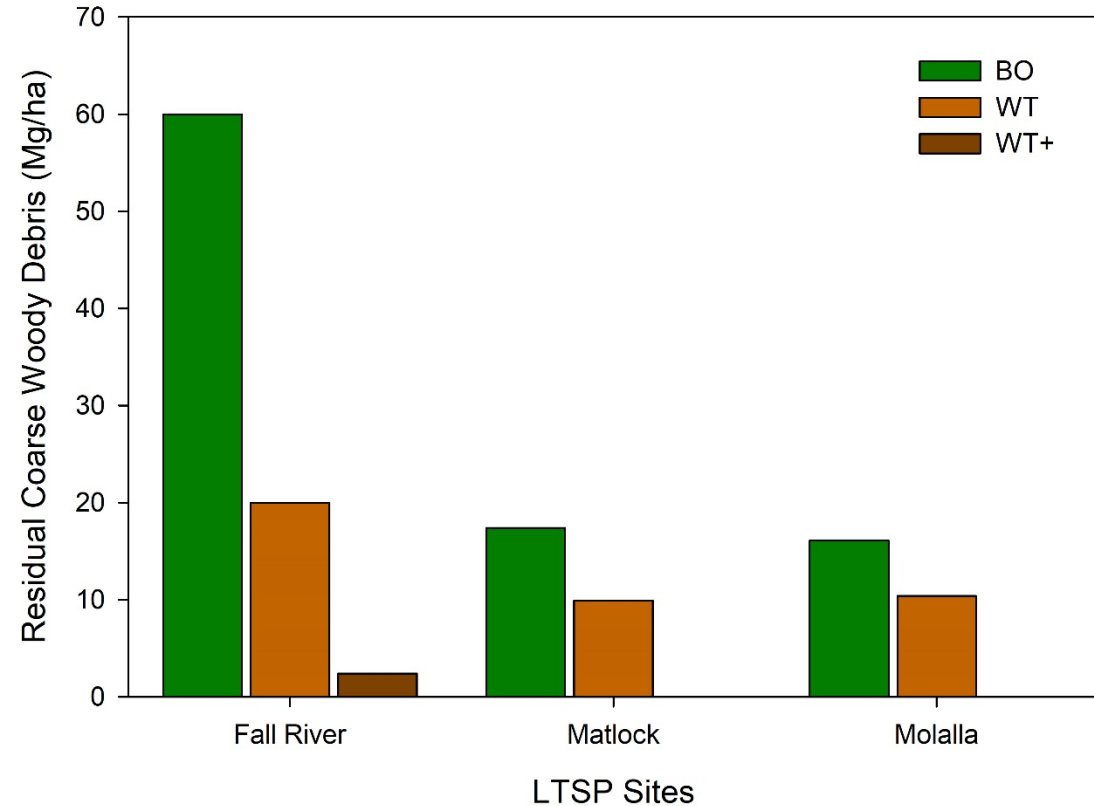
Differences in Soil and Site Productivity

- Fall River
 - 138 ft Site Index at harvest
 - 140 ft SI at 15 years
 - High soil N and low soil Ca
- Matlock
 - 118 ft SI at harvest
 - 90 ft SI at 15 years
 - Low soil N and Ca
- Molalla
 - 118 ft SI at harvest
 - 113 ft SI at 15 years
 - Average soil N and high soil Ca



Organic Matter Removals

- Treatments removed a variable amount of debris by site
- Large amount of CWD in BO treatment at Fall River
- Matlock and Molalla treatments resulted in similar residuals
 - Contained much less CWD than Fall River



Fall River Vegetation Control

- Aimed for 95% vegetation control with varying treatments by year
- Presence of ferns, oxalis, and salmonberry
- More information in Ares et al. 2007
- March 2000 - Sulfometuron (0.21 kg/ha) and glyphosate (4.67 L/ha)
- Spring 2001 – Atrazine (9.3 L/ha) and Glyphosate (0.75%)
- Spring 2002 – Atrazine (9.3 L/ha), Sulfometuron (0.17 kg/ha), Clopyralid (1%), and Glyphosate (0.75%)
- Spring 2003 – Hexazinone (7.0 L/ha), Clopyralid (1%), and Glyphosate (0.75%)
- April 2004 – Hexazinone (5.85 L/ha)



Matlock Vegetation Treatments

- Operational vegetation control treatments
- Heavy Scotch broom presence after harvest and in IVC treatment
- More information in Harrington and Schoenholtz 2010
- September 2003 – Triclopyr ester (2.8 kg a.i./ha) (applied to all plots)
- December 2003 – Sulfometuron (0.2 kg a.i./ha)
- October 2004 – Triclopyr ester (2.5% suspension)
- April 2005 – Glyphosate + clopyralid (1.5% + 0.75%)
- April 2006 – Glyphosate + clopyralid (1.5% + 0.75%)
- April 2007 – Glyphosate + clopyralid (1.5% + 0.75%)
- June 2007 – Triclopyr ester (20% suspension) (applied to Scotch broom only)
- May 2008 – Glyphosate + clopyralid (1.5% + 0.75%)
- May 2008 – Triclopyr ester (20% suspension) (applied to Scotch broom only)

BOIVC BOAVC



WTIVC WTAVC

Molalla Vegetation Treatments

- **Operational vegetation control treatments**
- **Less control of hardwoods resulted in heavy presence of cascara and cherry in plots**
- **More information in Harrington and Schoenholtz 2010**
- August 2003 – Glyphosate (2.2 kg a.i./ha) (applied to all plots)
- October 2003 – **Sulfometuron** (0.2 kg a.i./ha)
- October 2004 – Glyphosate + **sulfometuron** (1.1 + 0.2 kg a.i./ha)
- May 2006 – Glyphosate + atrazine (1% solution + 4.9 kg a.i./ha)
- May 2007 – Clopyralid + atrazine (0.8 + 4.9 kg a.i./ha)
- May 2008 – Triclopyr ester + 2,4-D ester (2% + 2% suspension)

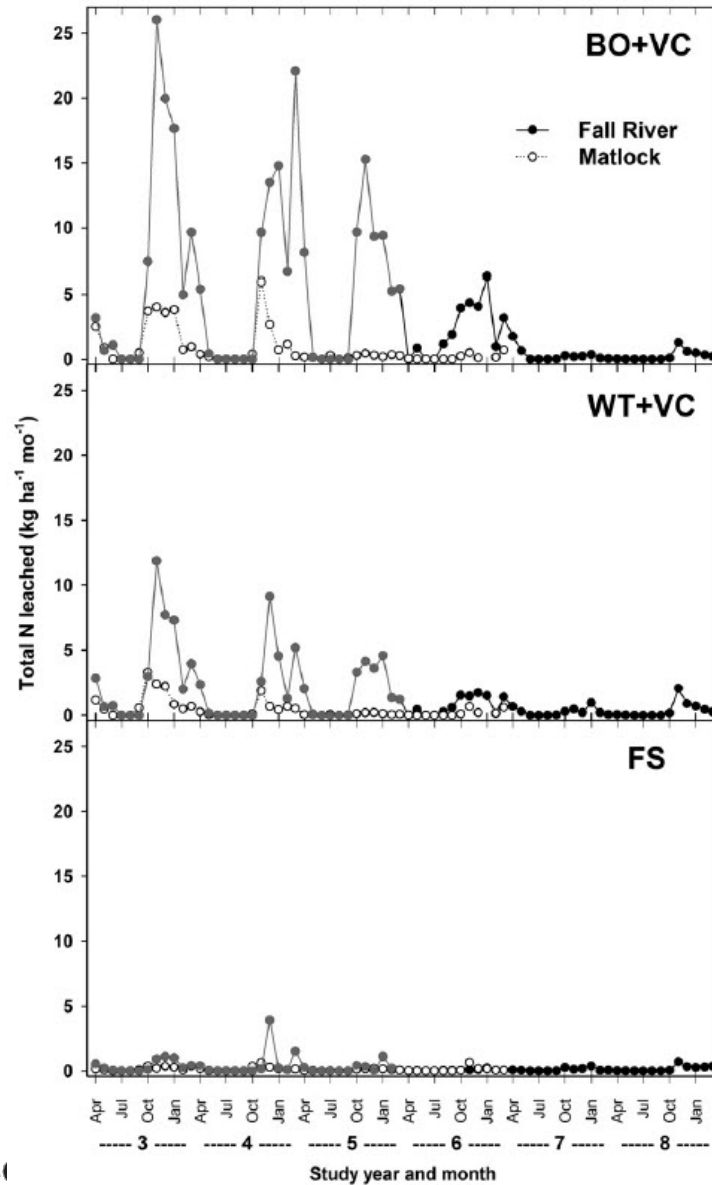
BOIVC BOAVC



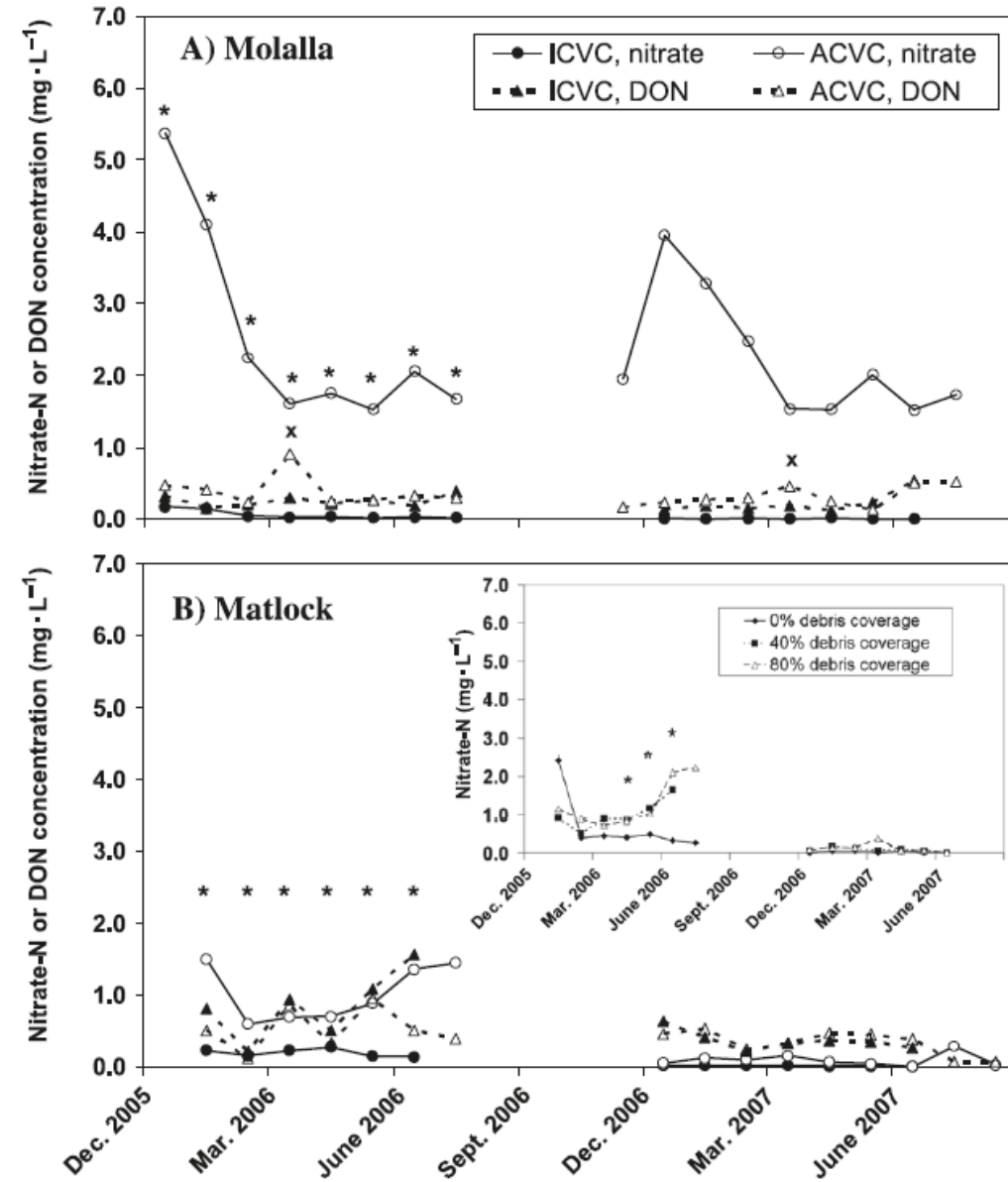
WTIVC WTAVC

N Leaching after Harvest

- Fall River and Matlock: Greater N leaching after harvest in BO treatments than WT
- Molalla and Matlock: AVC resulted in greater N leaching than IVC
- Stand with the greatest soil N (Fall River) had the greatest N leaching
- Potential for leaching of other nutrients along with N



Devine et al. 2012



Slesak et al. 2009

Methods

- April 2017 - Removed forest floor and shallow soil samples from four composited points per plot
 - Analyzed samples for C, N, available N (NO_3^- , NH_4^+), exchangeable cations (Ca, Mg, K), P, and pH
- Installed plant root simulator (PRS) probes at 2-in soil depth
 - Four composited samples per plot
 - Removed PRS probes after 12 weeks



**Anion
PRS Probe**

adsorbs:
 NO_3^- , H_2PO_4^- ,
 SO_4^{2-} , micros, etc.

Anion Resin Qua-
ternary R-NH_4^+



**Cation
PRS Probe**

adsorbs:
 NH_4^+ , K^+ , Ca^{2+} ,
 Mg^{2+} , etc.

Cation Resin sul-
fonic acid R-SO_3^-



Competing Vegetation Methods

- August 2018 – Sampled competing vegetation
 - Ten 0.2 m² samples per plot were composited
 - Samples were split into understory (herbaceous and small shrubs) and overstory (large shrubs and trees)
 - Understory and overstory samples were ground separately and analyzed for total N, Ca, Mg, K, and P



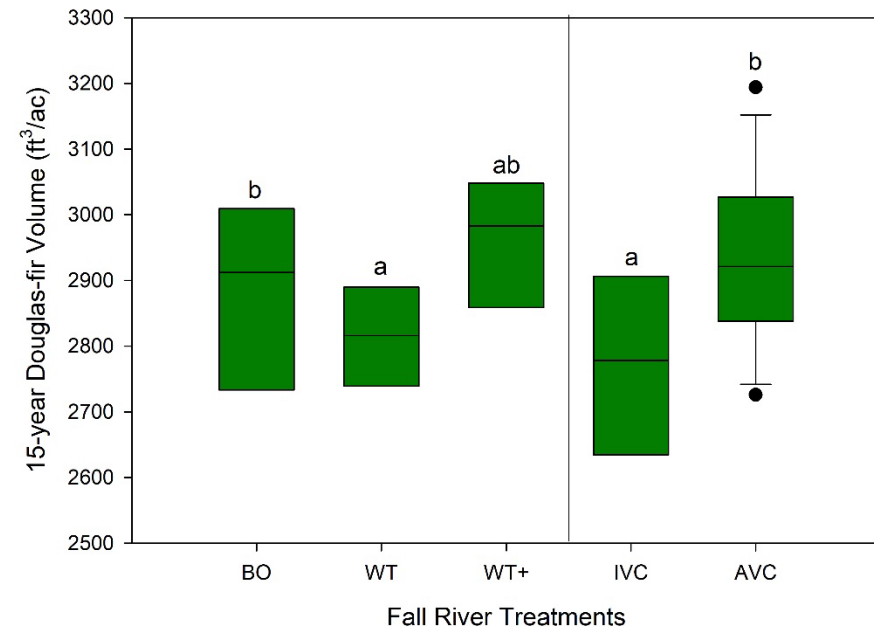
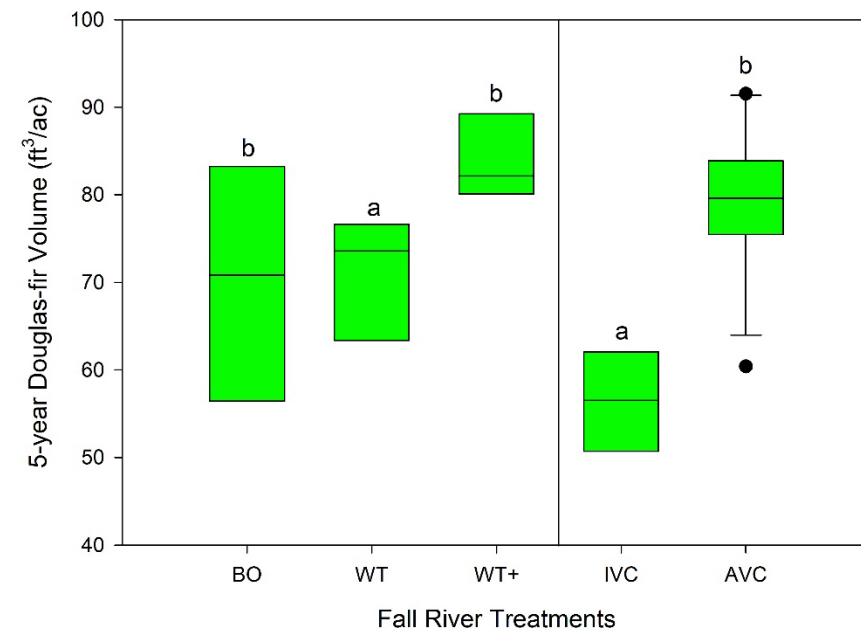
Douglas-fir Methods

- Stand volume measured at 5, 8, 10, and 15 years
- Fall 2018 – Sampled Douglas-fir biomass
 - One tree from each plot at Matlock and Molalla
 - Sampled branches and boles at 4.5, 8, 15, 21, 28, and 34 ft up the stem
 - Branches and needles were subsampled to determine total biomass for each tree
 - Will be analyzed for total N, Ca, Mg, K, and P



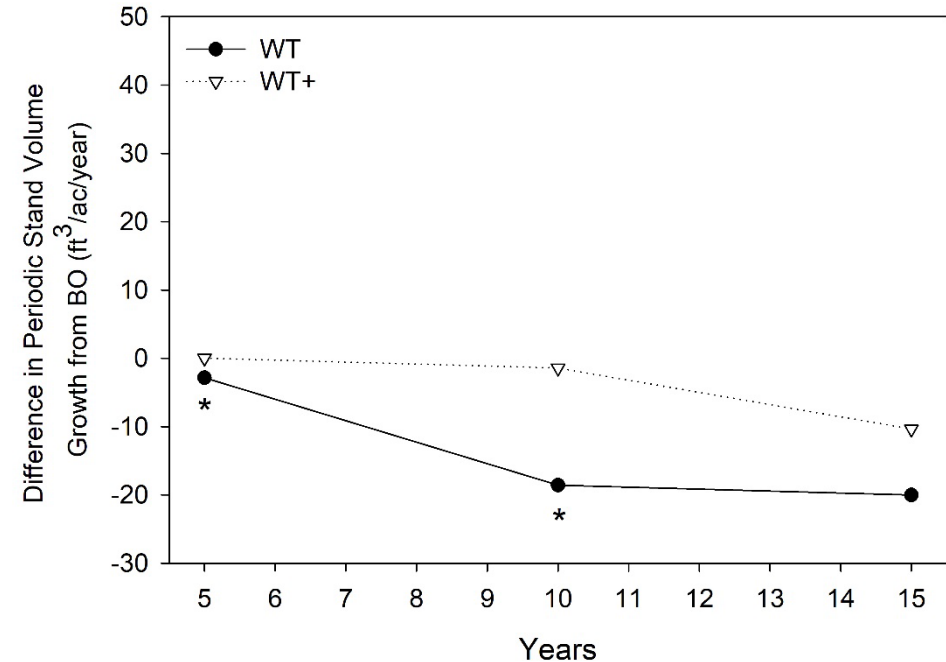
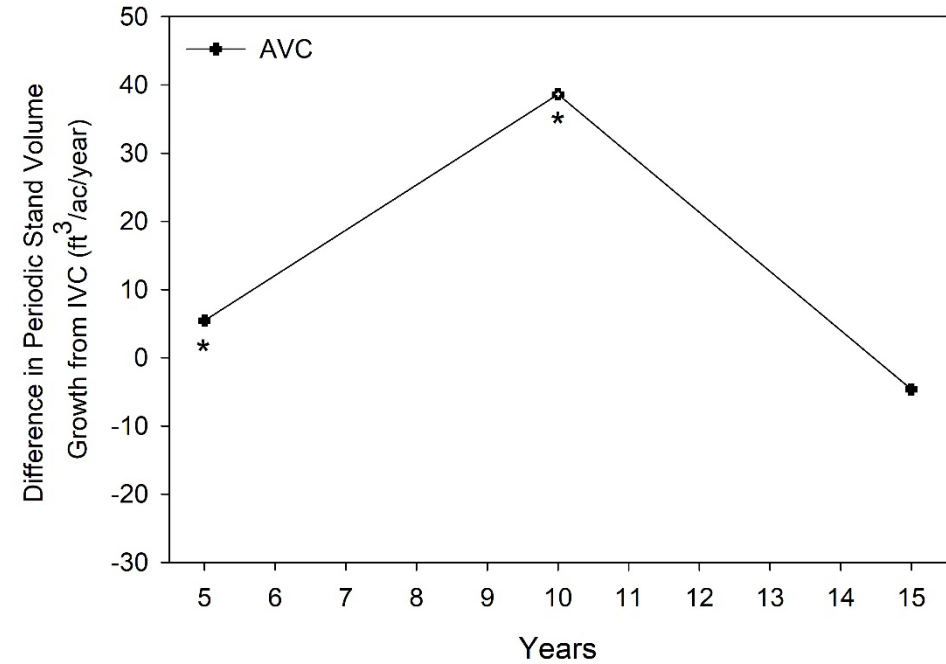
Fall River Stand Volume

- At 5 years, WT and IVC treatments had significantly lower stand volume
 - WT+ coarse woody debris treatment grew slightly more than the traditional BO treatment
- At 15 years, still significantly lower volume in WT and IVC treatments, but differences between treatments are smaller



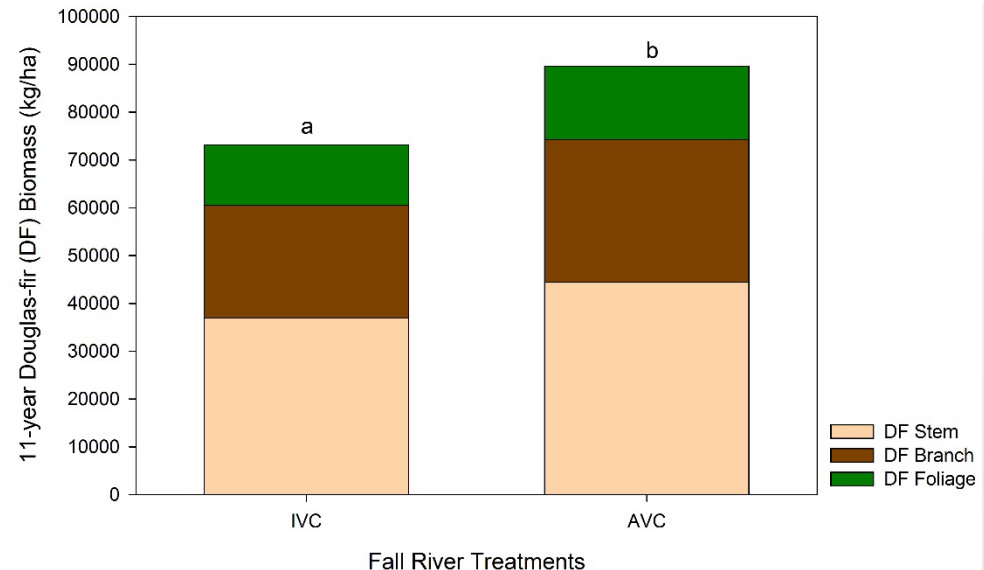
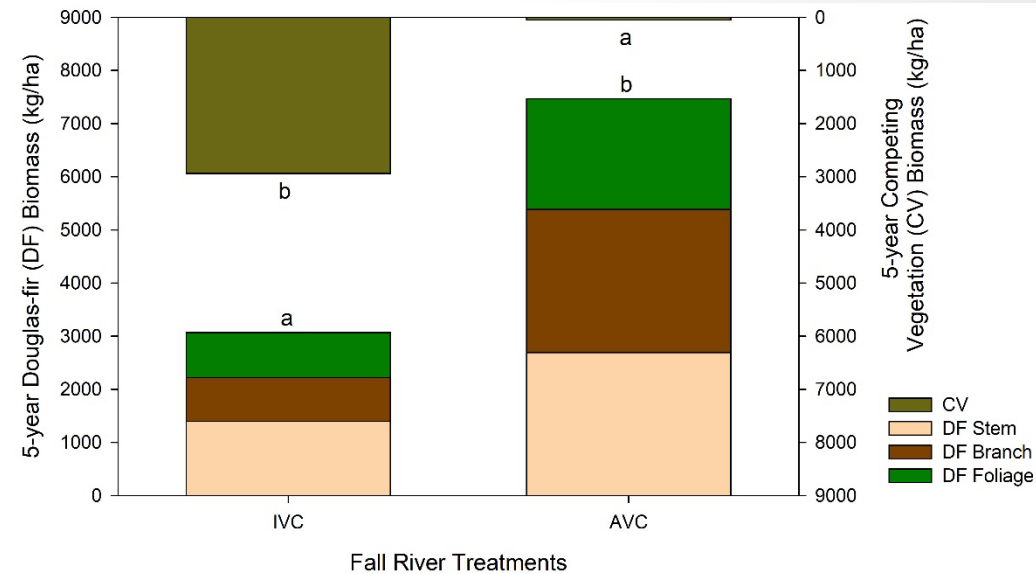
Fall River Volume Growth

- AVC resulted in significantly greater periodic stand volume growth from 0-10 years
- No difference in stand volume growth from years 10-15 between organic removal and vegetation control treatments
 - Vegetation control effects on microclimate have worn off
 - Nutrient limitations more important to growth



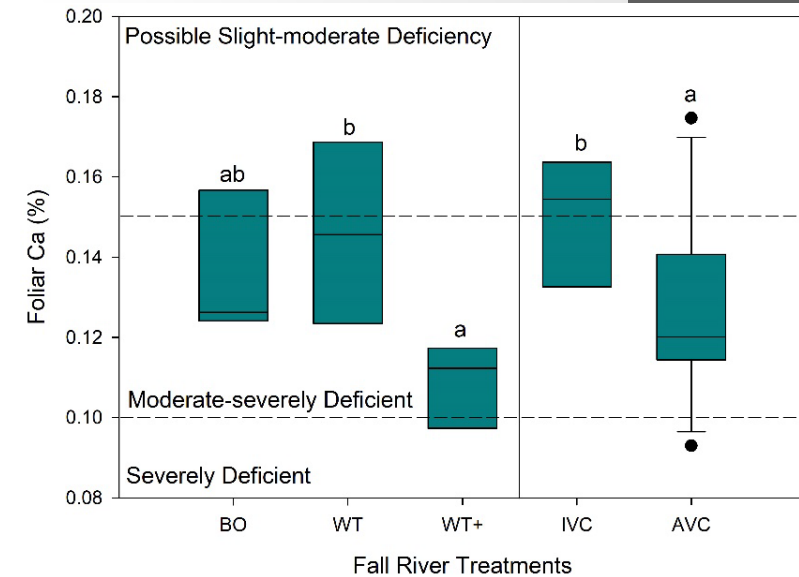
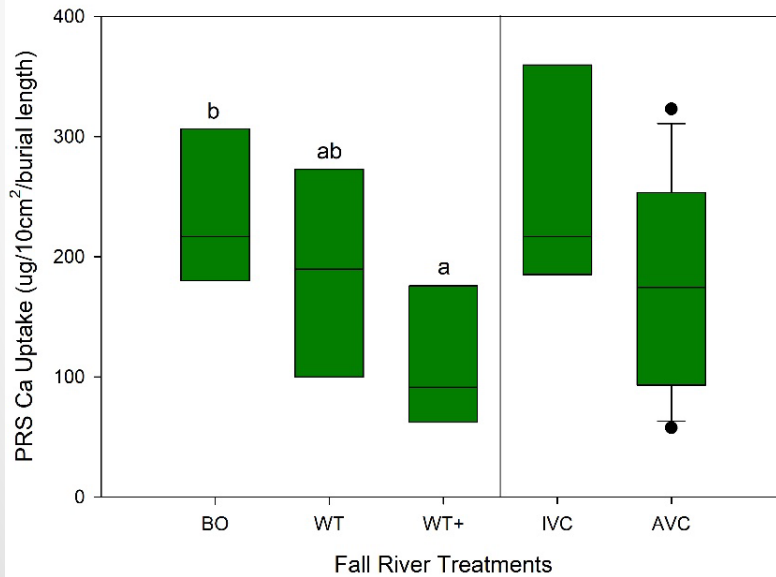
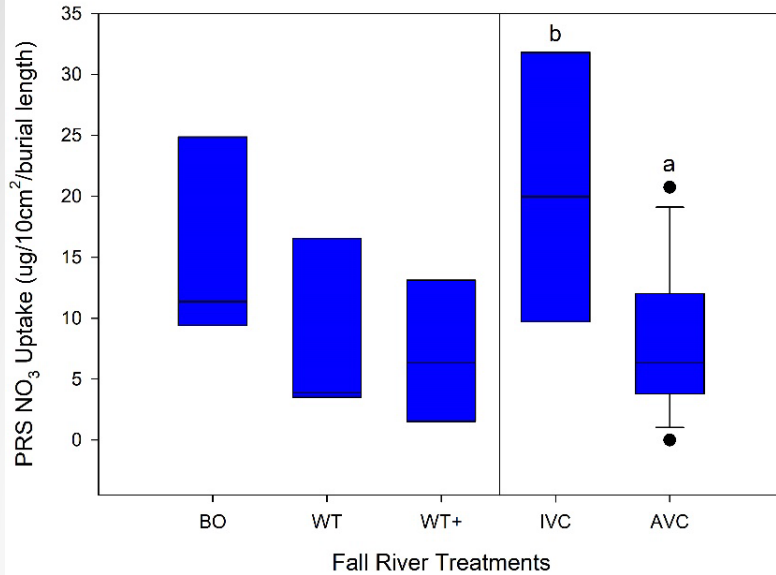
Fall River Aboveground Biomass

- At 5 years, BO treatment with AVC had over 2X Douglas-fir biomass
 - 1/60 competing vegetation biomass
- Significantly greater Douglas-fir biomass at 11 years
- WT and WT+ treatments were not tested



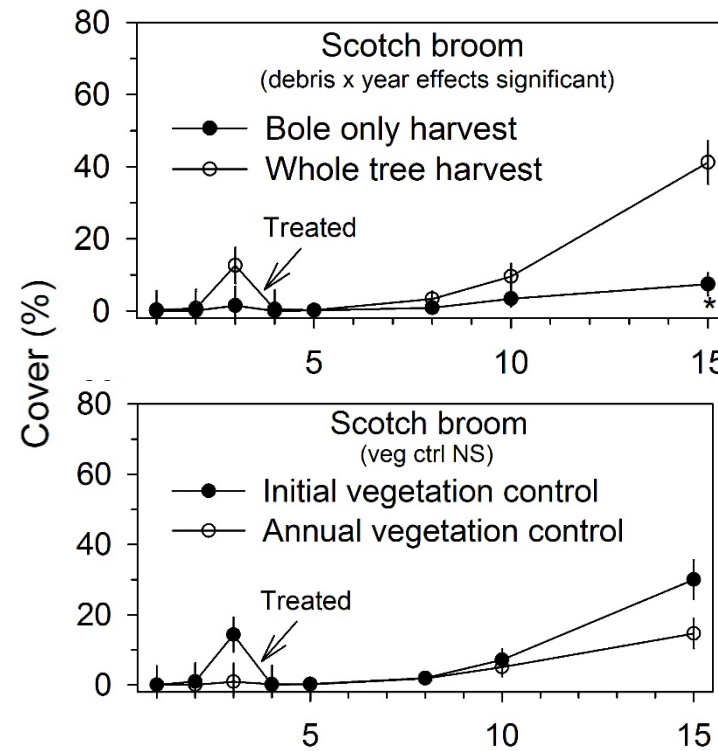
Fall River Nutrition

- AVC treatments decreased soil N, Ca, K, and Mg
 - More leaching of nutrients and/or greater uptake?
- Coarse woody debris removal resulted in lower soil Ca
- Foliar Ca concentration supports a decrease in availability of soil cations
 - Loss of a limiting essential nutrient
 - Already low foliar Ca compared to other LTSP sites (0.2-0.3)
 - Large decrease due to coarse woody debris removal (WT+) to severely deficient levels
- Fall River is a candidate for fertilization with lime to increase pH and availability of Ca

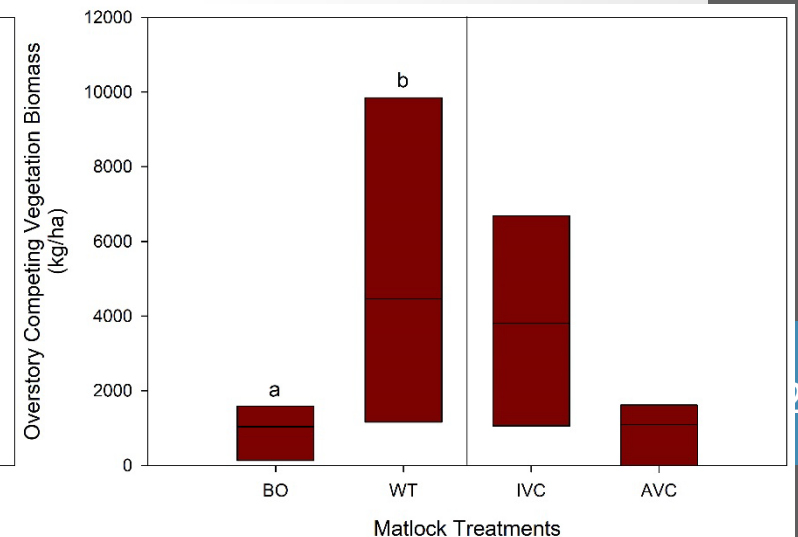
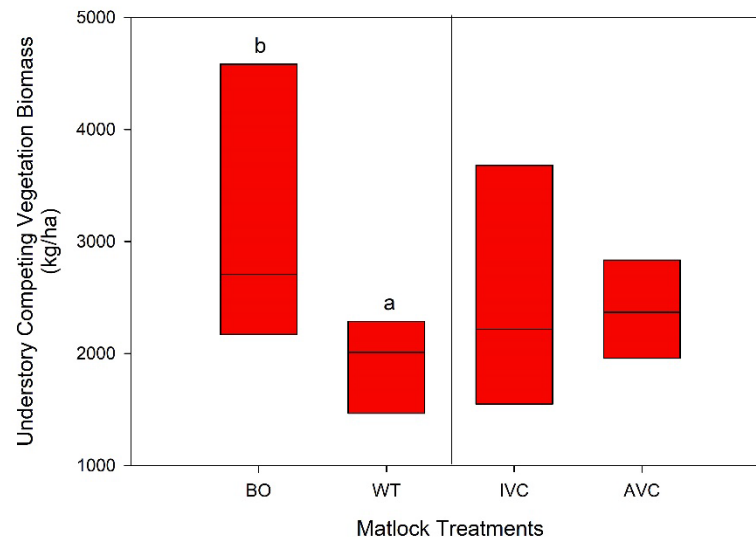


Matlock Competing Vegetation

- Heavy Scotch broom cover in IVC and WT treatments
 - BO treatment has greater effect on Scotch broom than AVC
- At 15 years, the BO treatment resulted in greater understory and less overstory biomass than in WT treatment
 - Greater cover of native understory species
 - No significant differences between IVC and AVC treatments

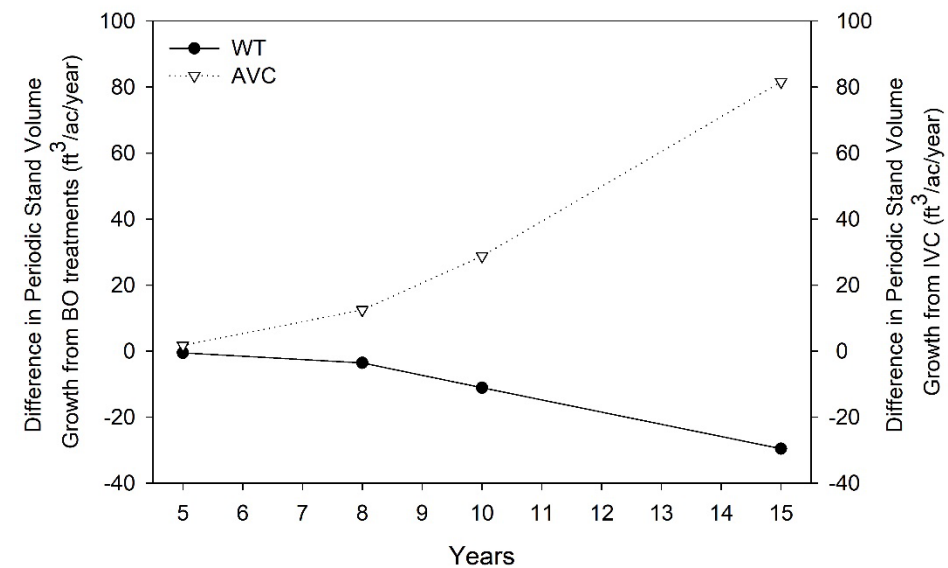
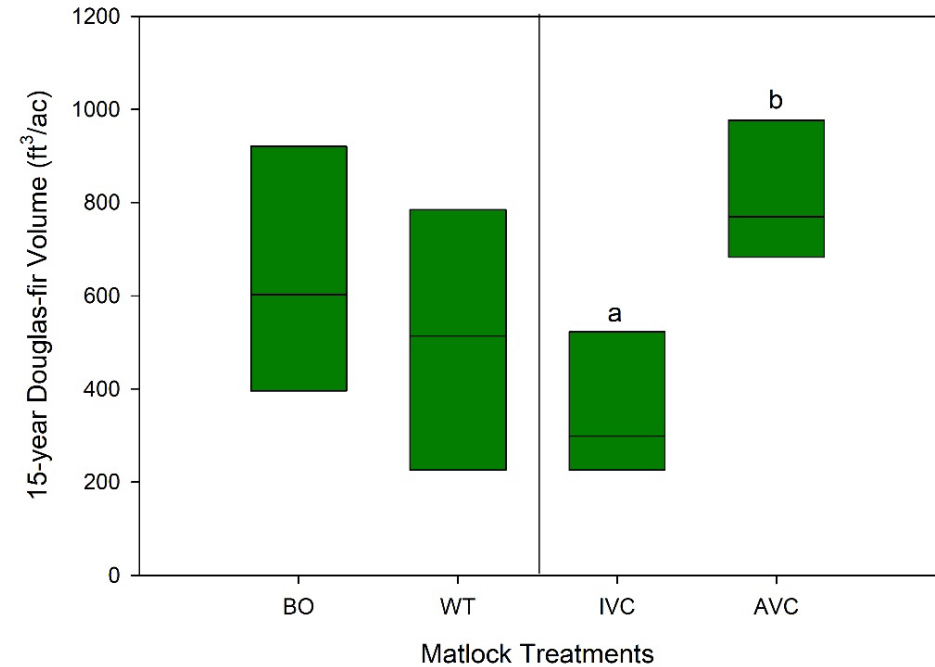


Harrington et al.,
In preparation



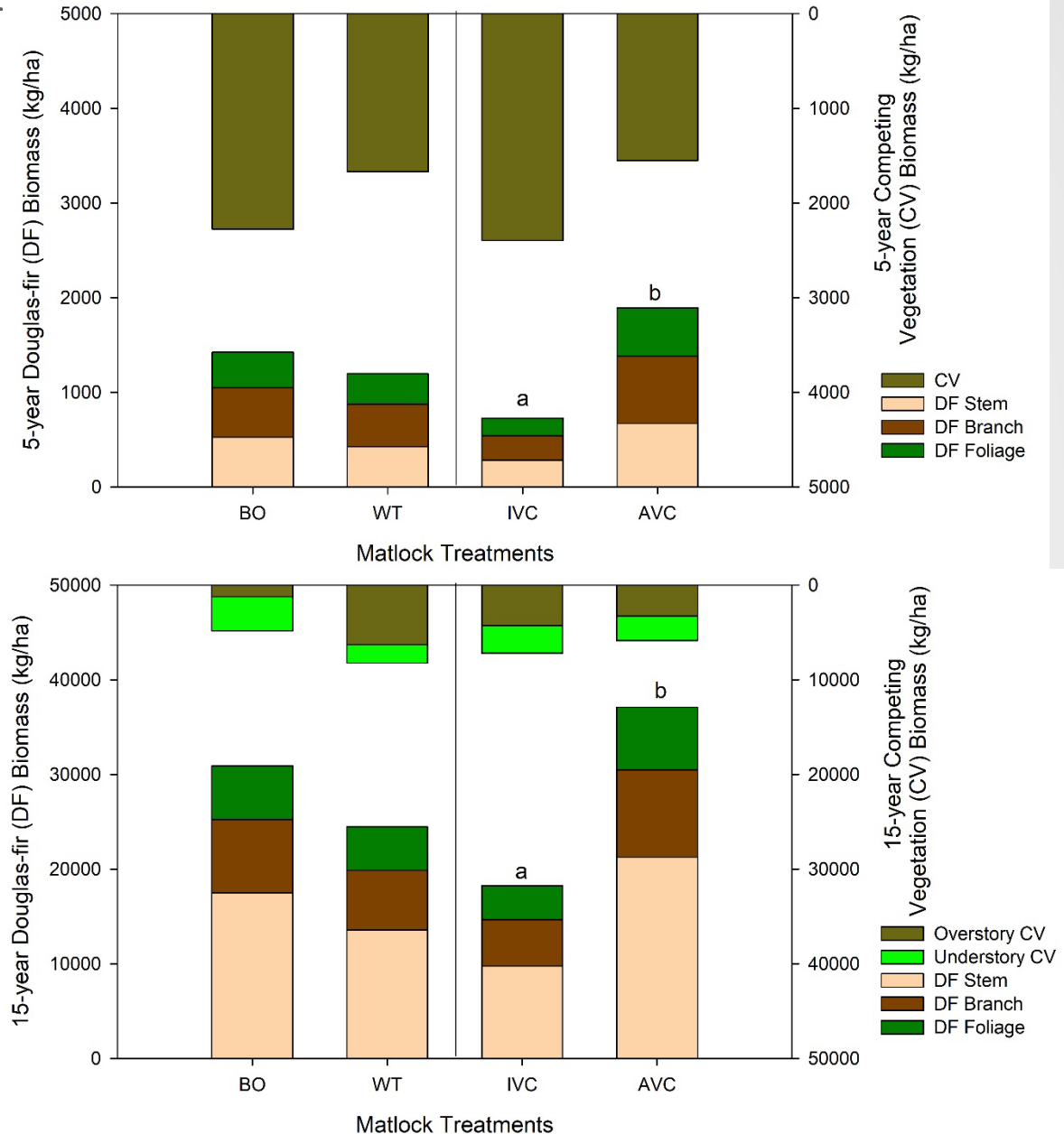
Matlock Stand Volume

- Over 5-15 years there has been significantly greater stand volume and periodic stand volume growth on the AVC treatment
- WT treatment continues to decrease in stand volume growth compared to the BO treatment, but not significantly



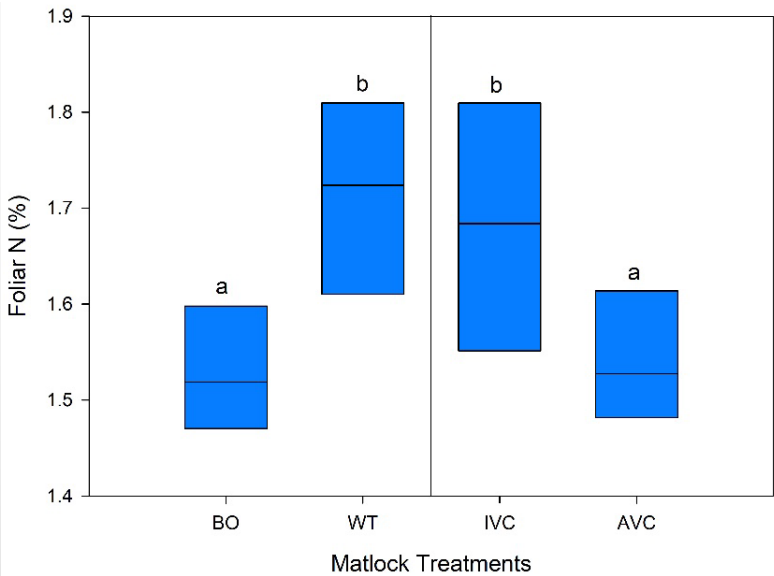
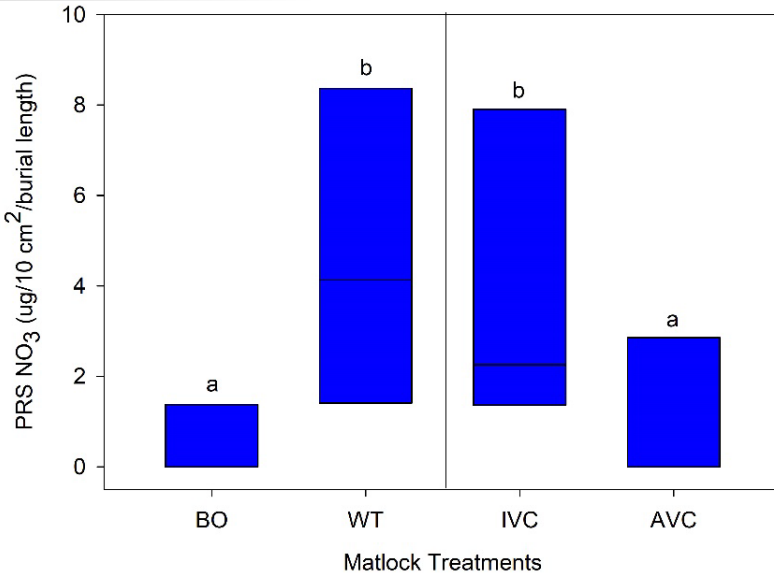
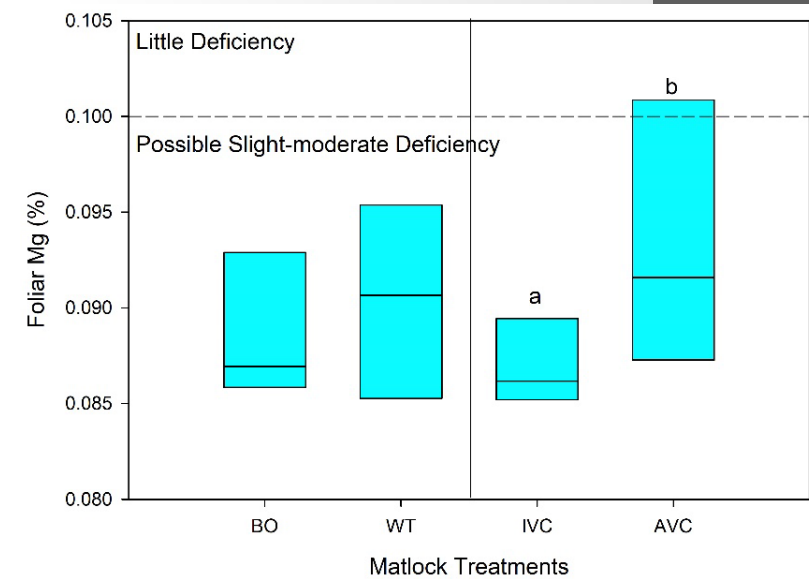
Matlock Aboveground Biomass

- Significantly higher Douglas-fir biomass due to AVC from 5-15 years
- No significant difference in competing vegetation biomass



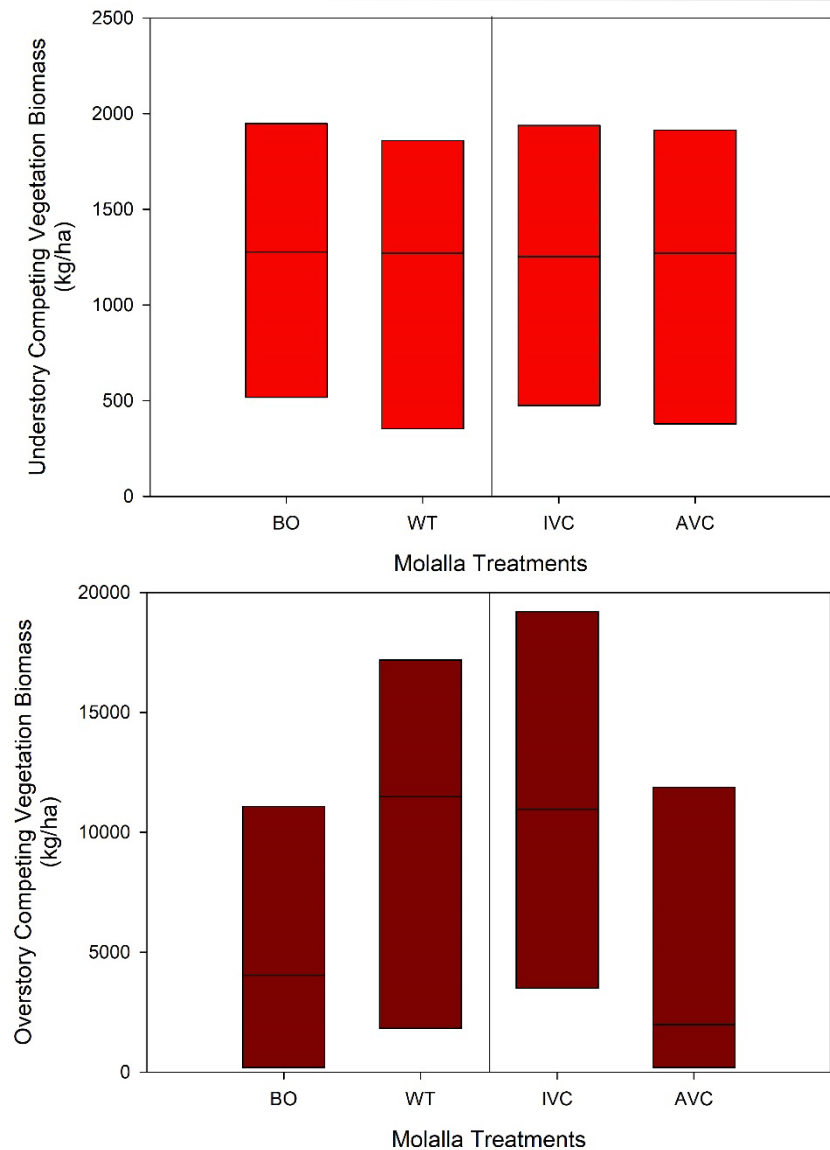
Matlock Nutrition

- Scotch broom colonization in WT and IVC treatments added N to the forest floor, soil, and foliage
 - No excess nitrate uptake found in BOAVC treatment
- Annual vegetation control increased foliar Mg
 - Decreased competition from understory



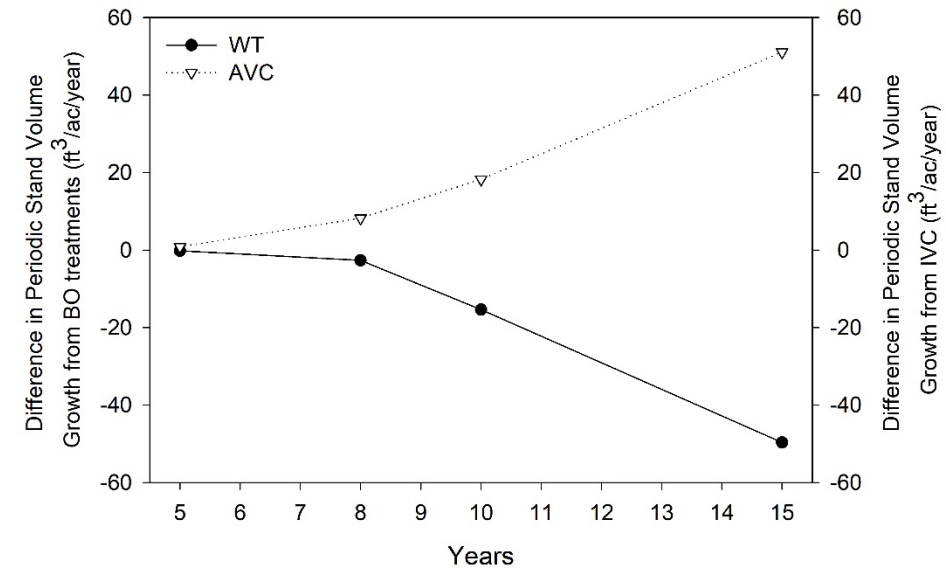
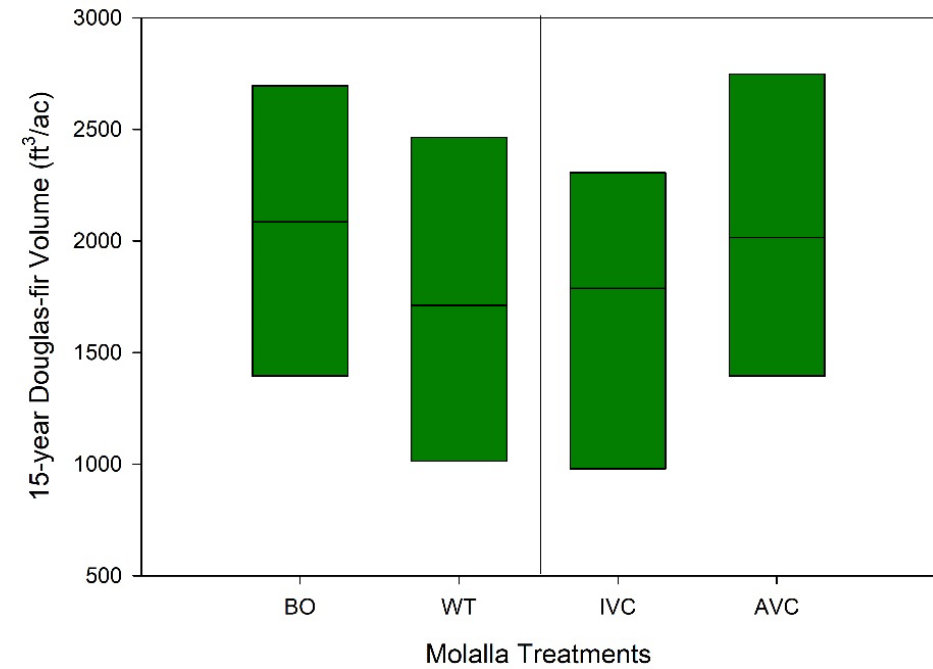
Molalla Competing Vegetation

- At 15 years, there was no effect of treatments on understory and overstory biomass of competing vegetation
- Large quantity of overstory vegetation due to release of hardwoods by vegetation treatments



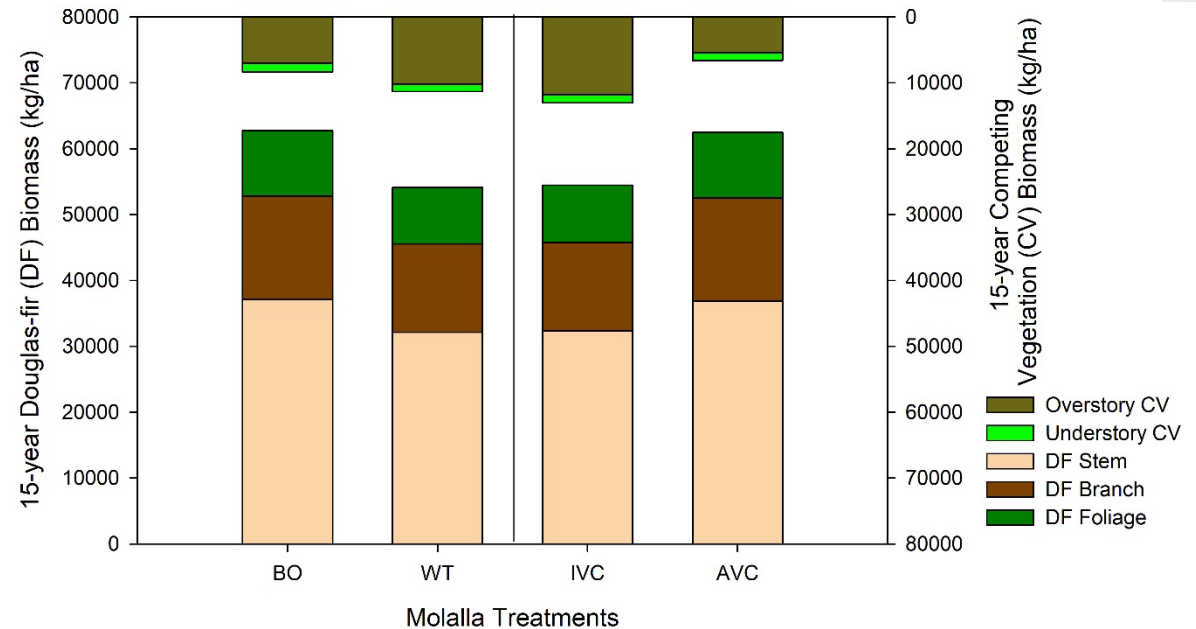
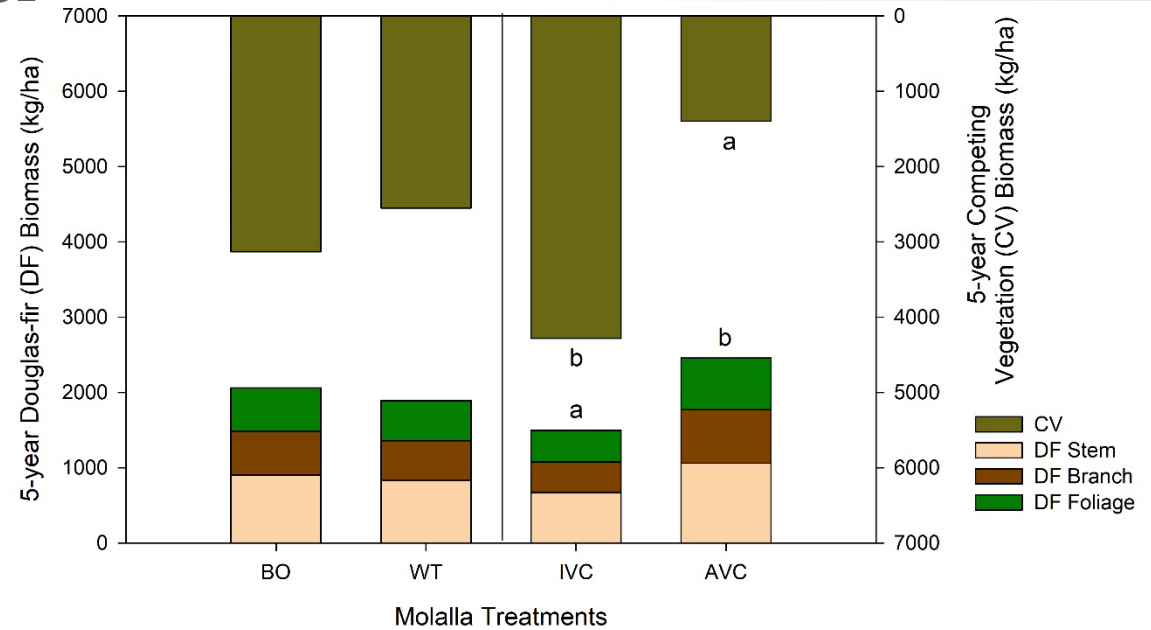
Molalla Stand Volume

- No significant effect of treatments on stand volume from 5-15 years
 - High variability within treatments
- Increasing differences in periodic stand volume growth between WT-BO and AVC-IVC treatments



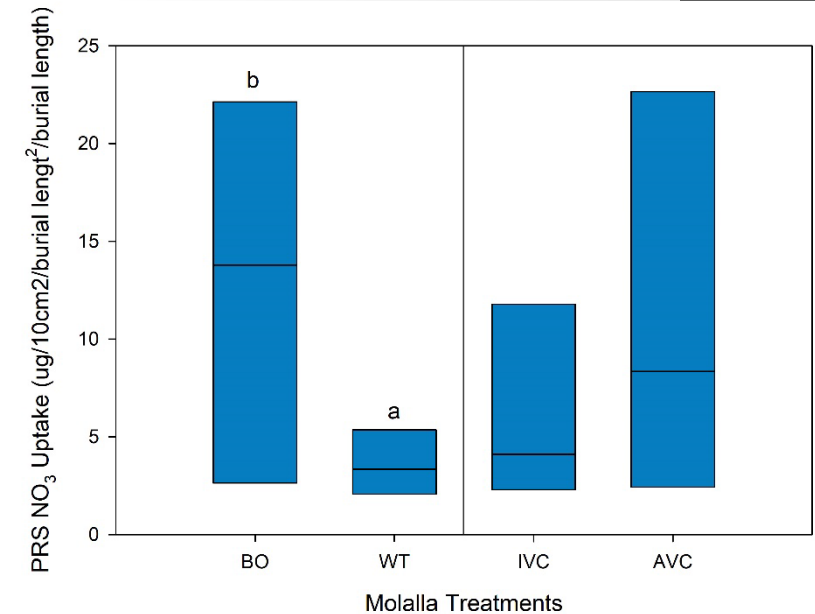
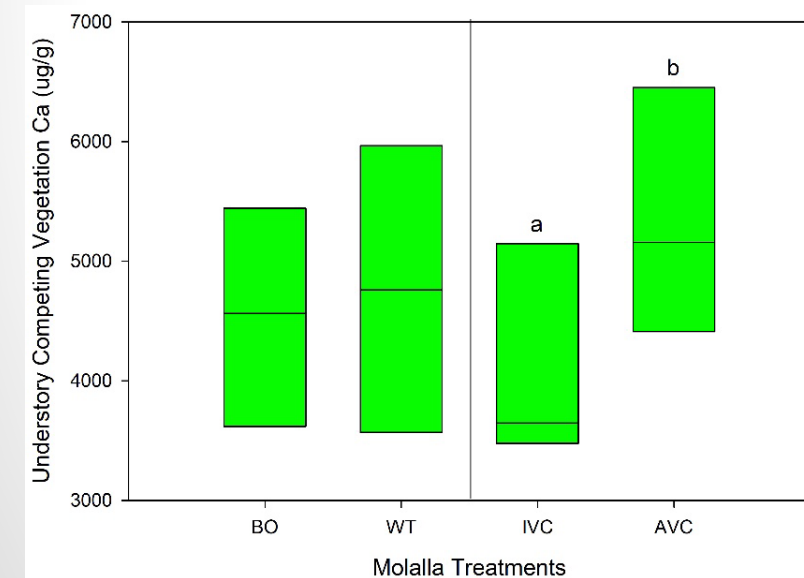
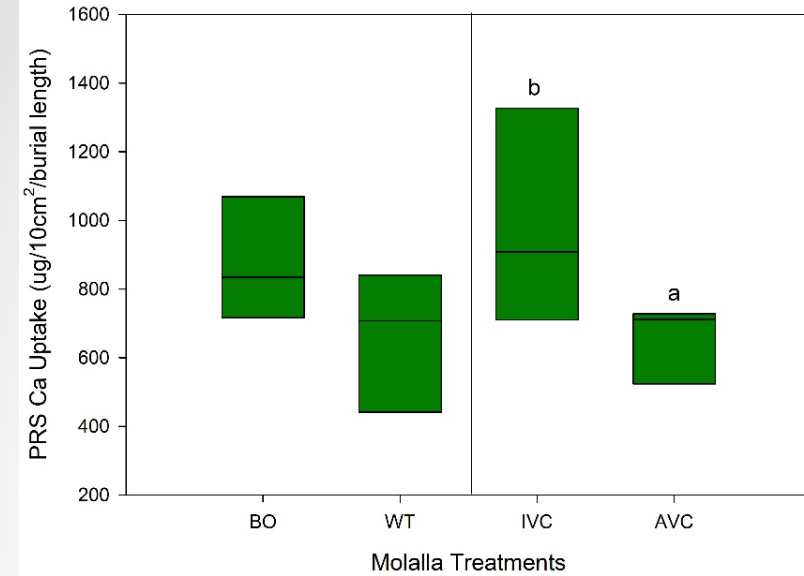
Molalla Aboveground Biomass

- Douglas-fir and competing vegetation significantly different at 5 years, but not at 15 years
 - Lowest competing vegetation biomass on treatment with greatest Douglas-fir biomass (AVC)
- IVC and WT treatments have slightly less DF biomass and higher competing vegetation at 15 years

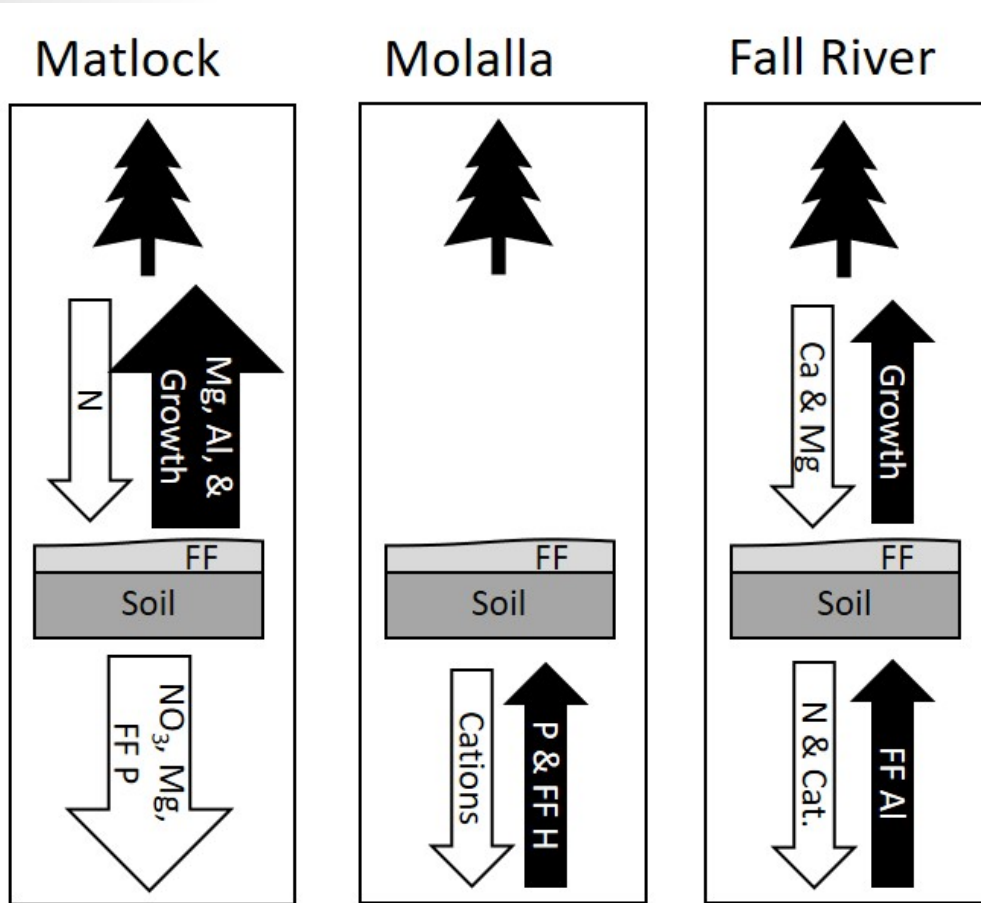


Molalla Nutrition

- Lower soil Ca and Mg due to AVC
 - Non-limiting essential nutrient
 - Some of the Ca and Mg was taken up by the understory in the AVC treatment
- BO treatment has more excess nitrate than WT
 - Greater N availability
- No significant effects on Douglas-fir foliar nutrition

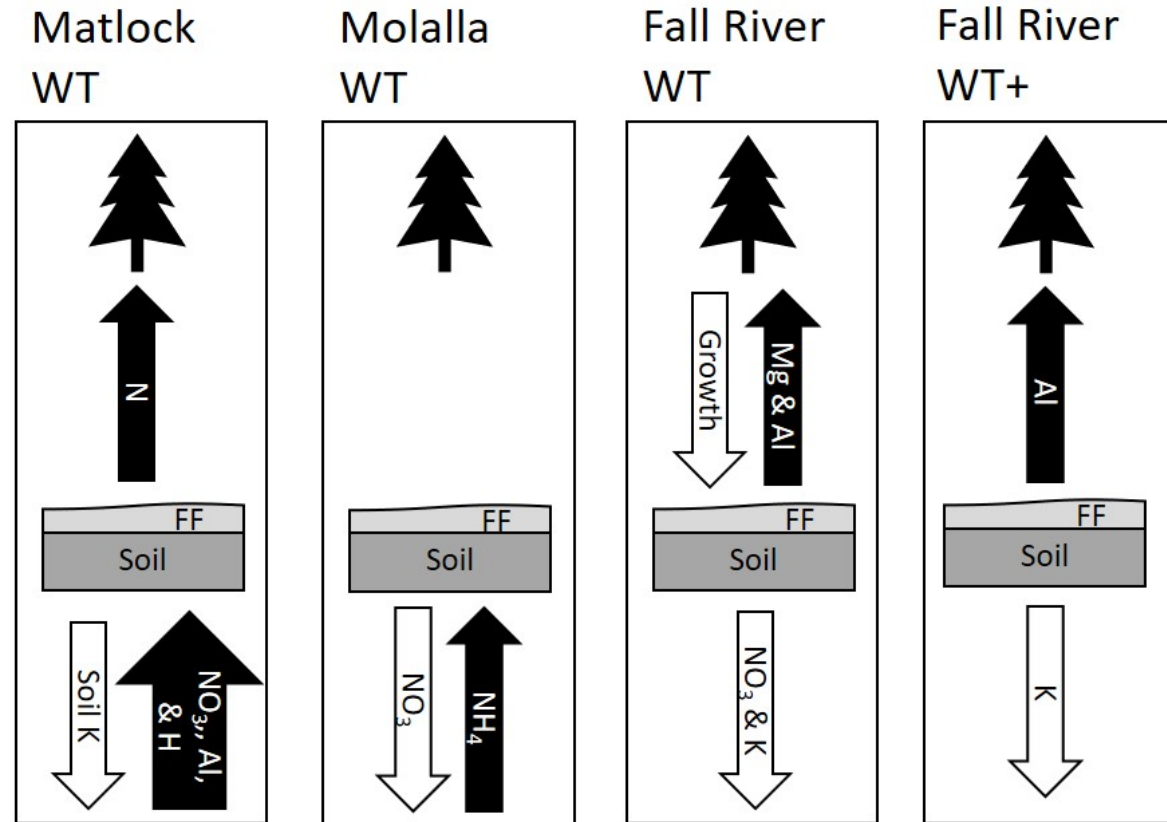


Overview of Annual Vegetation Control



- ▶ Loss of soil N and cations
- ▶ Increase in Al in forest floor and foliage
- ▶ Improved growth in most treatments
- ▶ Controlled invasive species

Overview of Whole Tree Removal



- ▶ No one size fits all answer
 - ▶ Dependent on soil nutrition and treatment severity
- ▶ Permanent removal of nutrients from the soil
 - ▶ Loss of N and K
- ▶ No effect or negative effect on volume growth
- ▶ Allowed colonization of invasive species

Summary of Treatments on Soil and Stand Productivity

- Annual vegetation control improved microclimate especially on the low productivity stand (Matlock)
 - + Greater soil moisture and less competition from understory
 - + Improved stand volume
 - Losses of nutrients due to greater leaching
- Whole tree harvesting removed nutrients that could be returned to the soil
 - + Short-term improvement in microclimate
 - Released invasive species
 - Most detrimental during the canopy closure stage
- Additional coarse woody debris removal
 - Potential to affect long-term soil productivity through nutrient losses

Questions?

- Thanks:
 - NCASI
 - Stand Management Cooperative
 - Green Diamond
 - Port Blakely
 - Weyerhaeuser



- Release Clopyralid is useful for elderberry and thistle control. Triclopyr and 2,4-D can be used selectively (but avoid high rates; see label) over Douglas-fir seedlings but will injure ponderosa pine and noble fir. Glyphosate and imazapyr can be used selectively to favor conifers only in late summer or early fall. Glyphosate is highly effective only on deciduous and herbaceous species in full foliage development. In fall, glyphosate will selectively remove brush and herbs from conifers. In midsummer, glyphosate damages conifers and brush severely. Imazapyr is active on maple, alder, and other brush as a growth inhibitor. It also damages conifers when applied to foliage during the growing season. Imazapyr is well adapted for trunk injection or spot treatments. Triclopyr salt formulations may be injected as a concentrate as well. Picloram (when not mixed with other products) is useful only in site preparation and trunk injection or stump treatment.
- For grass and weed control in conifer plantations several products have utility. Sulfometuron is a soil active product used at very low rates for grass, fern, and general herb control in reforestation areas. It does not control thistles, and so may need to be tank mixed with other products. Atrazine is a soil active product that is a restricted use material. It is useful at preventing weed and grass invasion on generally clean sites. Clopyralid or 2,4-D are often used to control broadleaved plants in conifer plantations and are often used as a tank mix partner with soil active products.
- Species such as vine maple (see tables later in this chapter for recommendations) may be satisfactorily controlled by this method, but only with highly systemic products such as glyphosate and imazapyr. Manzanita, *Ceanothus* spp., madrone, and other persistent-leaved brush species lend themselves to satisfactory control with foliage treatments of growth regulator products (e.g., 2,4-D or triclopyr esters) at any season from late dormancy until late midsummer, but treatments often work best in early spring.
- Herbicides 2,4-D, aminopyralid, clopyralid, fluroxypyr, triclopyr, imazapyr, glyphosate, metsulfuron, and picloram are the herbicides used for foliage applications. For application rates, see the tables later in this chapter. Glyphosate plus imazapyr gives excellent control of mixed deciduous brush species. Picloram, aminopyralid, and metsulfuron are highly toxic to most conifers when applied directly, but seedlings planted the next season after treatment normally are unaffected. Water is almost always used as a carrier; in late summer a small amount of an oil additive (up to 5%) may be added to emulsifiable products including mixtures containing 2,4-D or triclopyr (see labels).