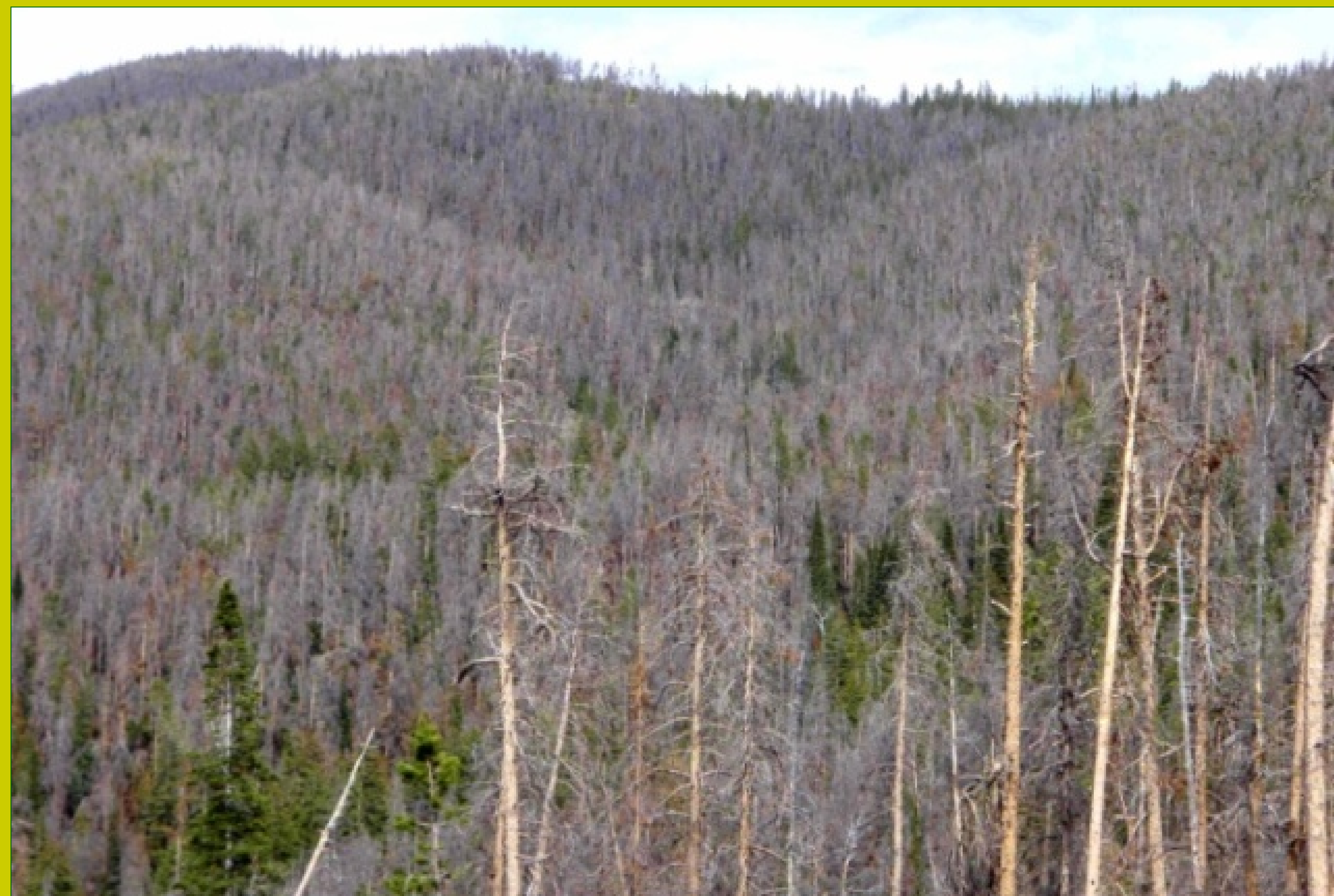
Linking stream nitrate to forest response and recovery after severe bark beetle infestation

Chuck Rhoades, Rob Hubbard, Kelly Elder, Derek Pierson; USFS Rocky Mountain Research Station (AGU POSTER H11D-118)



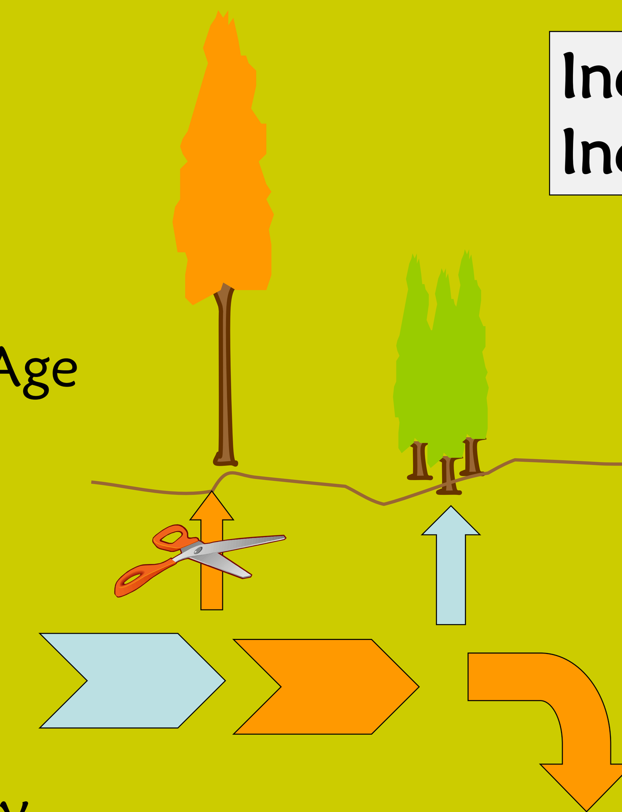
Biogeochemical Response and Linkages

Reduced Nutrient Uptake

Overstory Mortality
Old Growth > Mixed Age

Increased Soil Resources

Response
Proportional to Mortality



Increased Tree Growth = Increased Soil Nutrient Demand

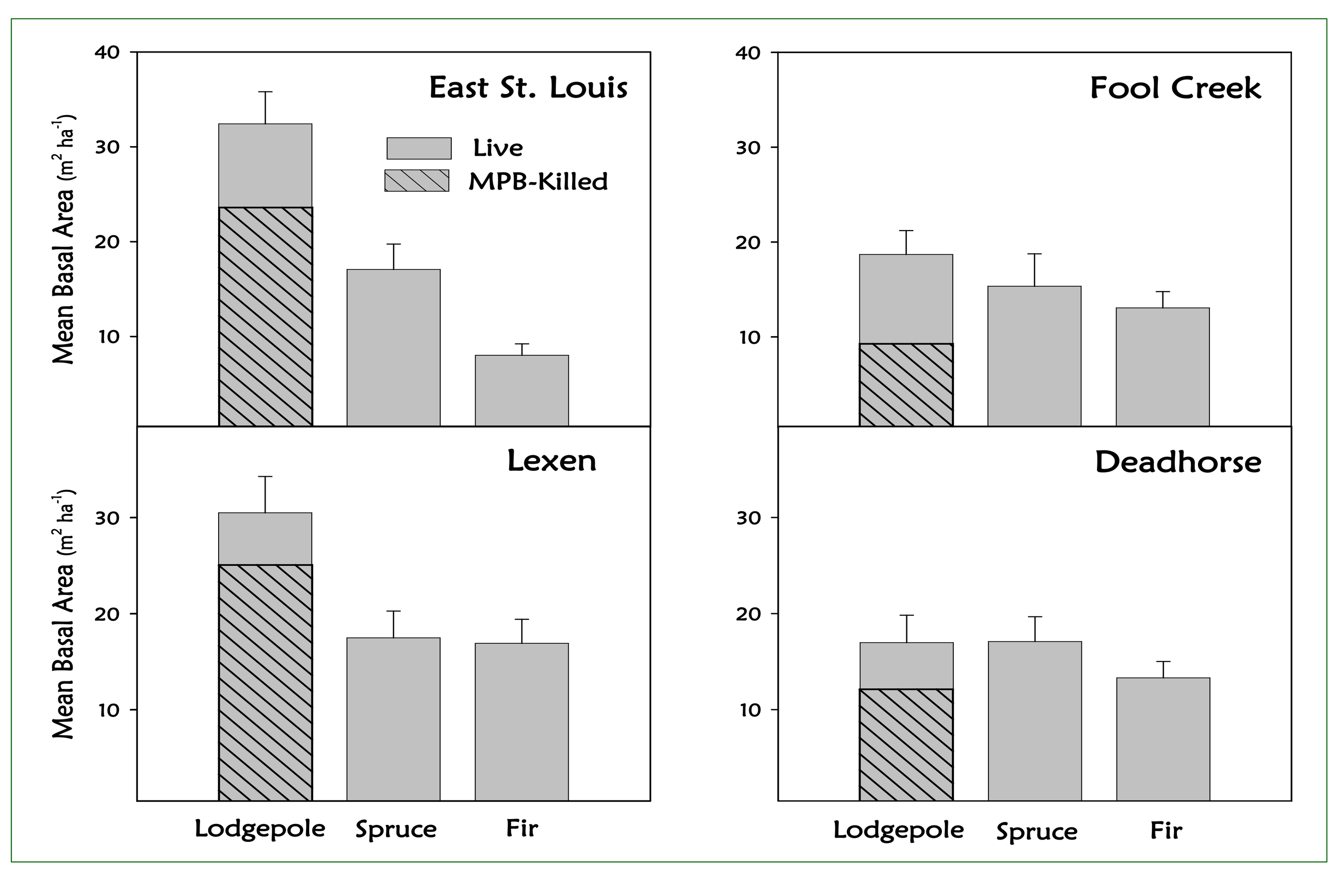
Leaf Area Index
Mixed Age ≥ Old Growth

Soil Resource Demand
Mixed Age >> Old Growth

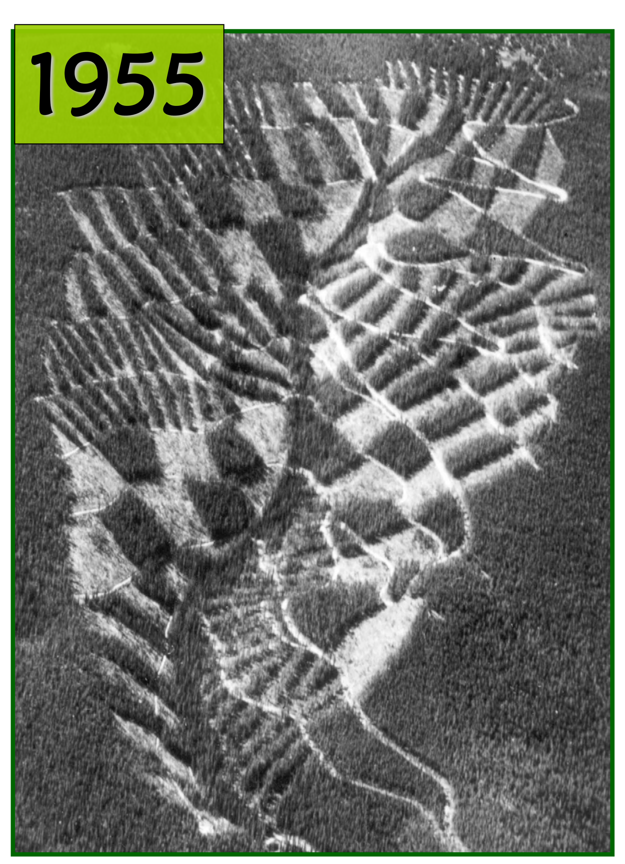
Stream Export

Seasonally Dependent
Old Growth > Mixed Age

Forested watersheds of western North America are experiencing rapid and extensive canopy mortality caused by a variety of insect species. The mountain pine bark beetle (*Dendroctonus ponderosae*) began to attack lodgepole pine (*Pinus contorta*) at the USFS Fraser Experimental Forest in 2002. By 2007, bark beetles had killed 50 to 80% of the overstory pine in Fraser's research watersheds.



Unmanaged **Managed**

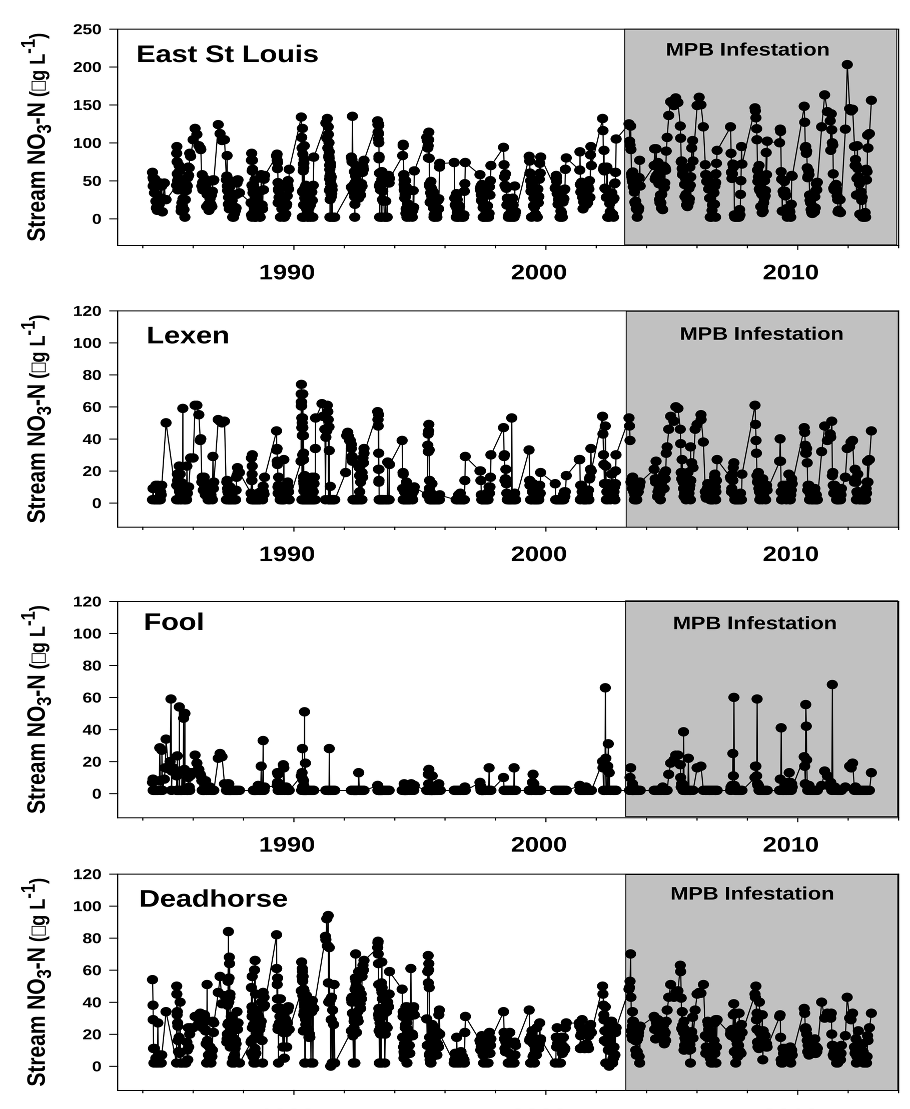


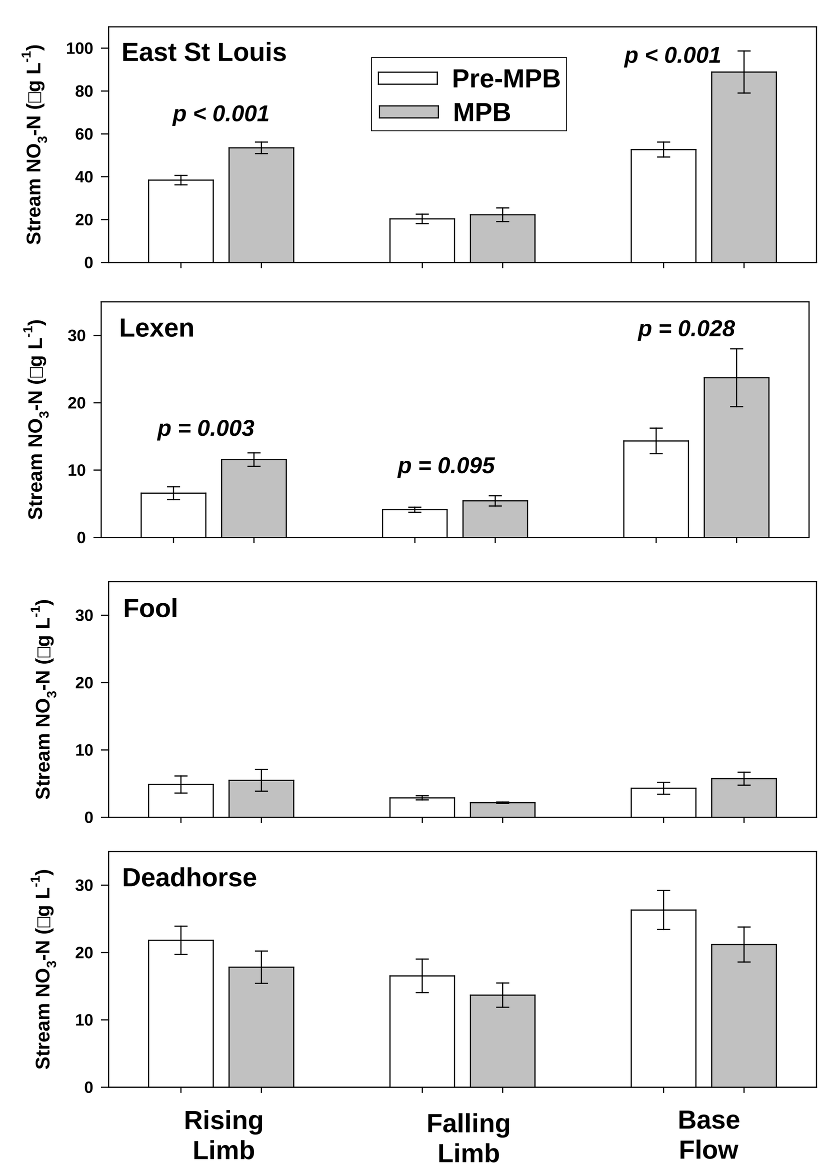
Mountain pine beetles prefer larger diameter lodgepole pine, so areas populated by smaller diameter trees are more resistant to attack at the onset of an outbreak. Fraser basins that were treated in the 1950's & 1970's have less pine basal area and have lost < ¼ of their total basal area to beetles.

Fool Creek: Half the forested area was cut in the mid 1950s to quantify changes in snowpack and water yield.

Soil Nitrogen: Lower water and nutrient uptake by dying trees is expected to increase soil N after bark beetle attack. This was documented under Colorado lodgepole pine (Clow et al. 2011) and in every study where it has been examined (Rhoades *in prep.*). The increase in soil N occurs prior to significant needle drop (red needle phase) or other forest structure or microclimatic change.

Streamwater Nitrate: At Fraser, stream nitrate concentrations were statistically higher in the East St Louis Ck basin the decade after bark beetles killed 75% of lodgepole pine basal area compared to the pre-outbreak period. Nitrate increased in another unmanaged basin (Lexen), but not 2 managed basins (Fool, Deadhorse).

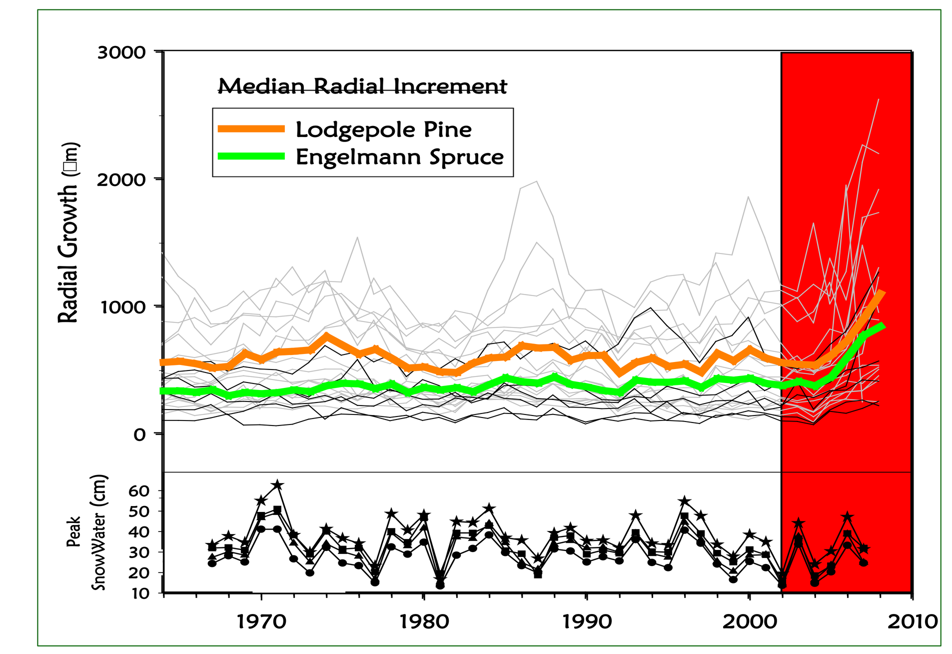


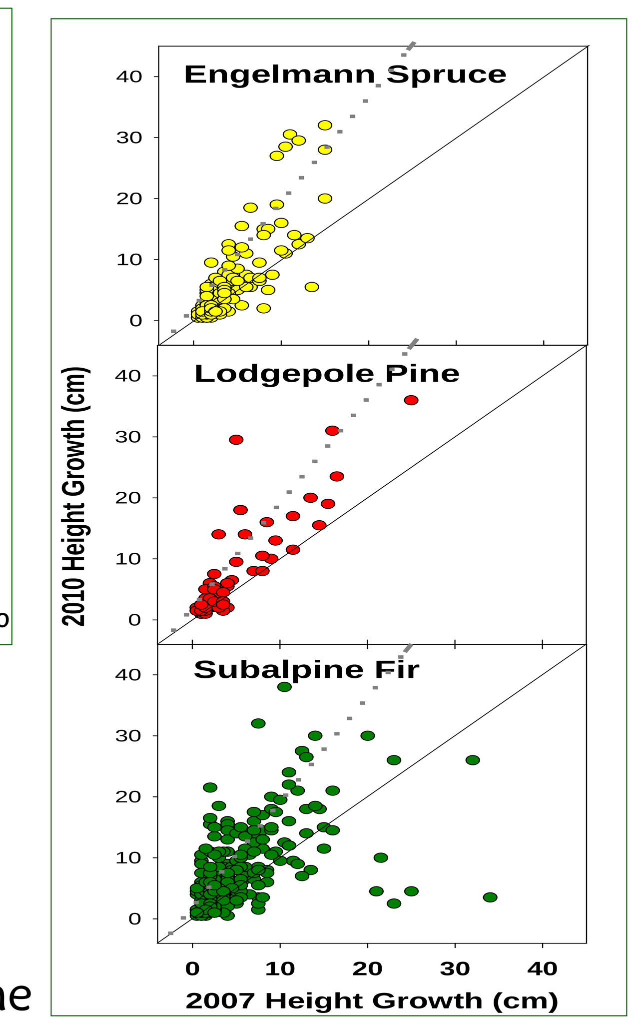


Post-outbreak differences were greatest on the rising limb of the stream hydrograph and during baseflow. On average, monthly nitrate export was 30% higher after beetles entered unmanaged basins; the largest differences were in May and June.

Magnitude of Change: Stream nitrate concentrations remained low (< 0.1 mg NO_3-N L^{-1}); beetle-related change in streamwater N was < 2% of annual deposition. A number of studies in Colorado found that stream nitrate responses to bark beetles were minor compared to harvesting and other disturbances (Rhoades et al. 2013).

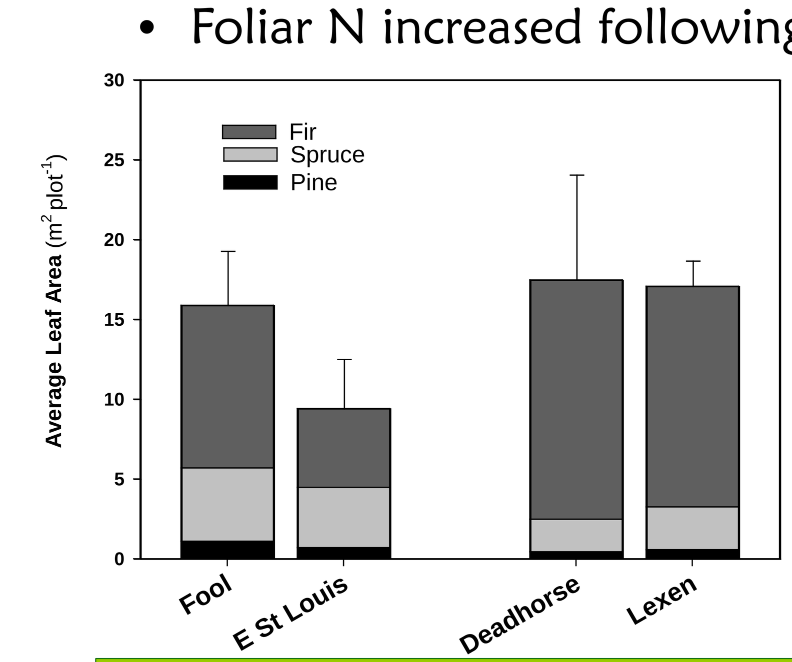
Compensatory Forest Growth





At Fraser there is widespread evidence of stimulated post-outbreak plant growth and nutrient demand. For example, we have found:

- Radial growth higher for 30% of trees
- Abundant new seedlings under dead pine
- Understory tree growth is 2X faster
- Foliar N increased following attack



MPB effect on basal area and LAI
is less in Mixed stands;
>small, young, non-host trees

Young trees use more soil resources
~ 5X more water / unit leaf area
than old trees (Hubbard unpublished)

Related Citations

Biogeochemistry of Beetle Kill: Explaining a weak nitrate response. Rhoades et al. 2013; PNAS

Changes in transpiration and foliage growth in lodgepole pine trees following mountain pine beetle attack and mechanical girdling. Hubbard et al. 2013; FEM

Responses of soil and water chemistry to mountain pine beetle induced tree mortality in Grand County, Colorado, USA. Clow et al. 2011; Applied Geochem

Tree regeneration and future stand development after bark beetle infestation and harvesting in Colorado lodgepole pine stands. Collins et al. 2011; FEM