Streamwater Nitrogen During Mountain Pine Beetle Infestation of Subalpine Watersheds at the US Forest Service, Fraser Experimental Forest

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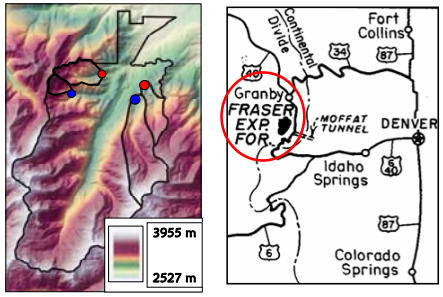
Rapidly Changing Forest Watersheds

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 research watersheds.

The hydrologic, climatic, biogeochemical and vegetation records available at the Fraser Experimental Forest (FEF) provide a unique opportunity to quantify the impacts of this widespread, but poorly understood disturbance in basins relative to a multi-decade pre-disturbance period. Here we compare streamwater chemistry and nutrient export in the six years since the bark beetle outbreak began with the twenty year pre-attack record for Fraser's four main research watersheds.

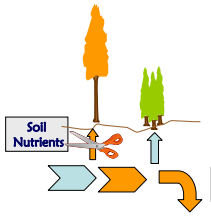


FEF is 100km west of Denver on the western edge of Colorado's Front Range. The 9,300 ha research forest ranges from 2,684 m to 3,903m elevation and contains subalpine and alpine ecosystems. Lodgepole pine dominates the lower elevations and south aspects.

	Watershed Area	Elevation Mean	Elevation Max	Alpine Area		Overstory Composition Pine	Spruce	Fir	Total
	ha	(m)		ha	(%)	m^2 ha^{-1} and (%)			
East St Louis	941.3	3360.9	3847.6	290.9	30.9	32.4 (56.4)	17.1 (29.7)	8.0 (13.9)	57.5
Lexen	129.9	3267.8	3527.6	15.9	12.3	30.5 (47.0)	17.5 (26.9)	16.9 (26.1)	65.0
Fool	307.3	3208.9	3503.3	1.6	0.5	18.7 (39.7)	15.4 (32.6)	13.1 (27.7)	47.2
Deadhorse	319.5	3187.8	3526.3	14.1	4.4	17.0 (35.8)	17.1 (36.1)	13.3 (28.1)	47.4

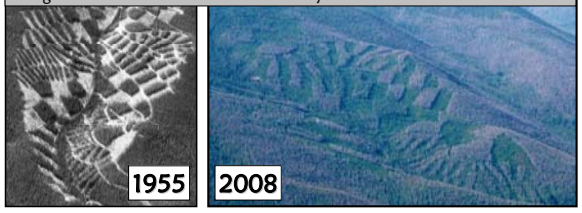
* Treeline averages 3482 m elevation (range: 3242 - 3654) at the Fraser Experimental Forest.

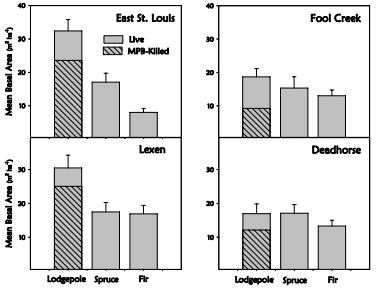
Expected Watershed Responses



The biogeochemical implications of the current MPB outbreak result from the aggregate of short and longer term change in factors that regulate nutrient retention and release. For example, water and nutrient demand by pines cease within weeks after beetles attack and introduce blue stain fungi into the host tree's vascular system and thus may rapidly alter nutrient leaching and streamwater export. In contrast, changes in canopy interception and understory growth following overstory mortality and windthrow will continue for years to decades.

Fool Creek: Half the forested area was clear cut in 1954-55 to study changes in snow accumulation and water yield.





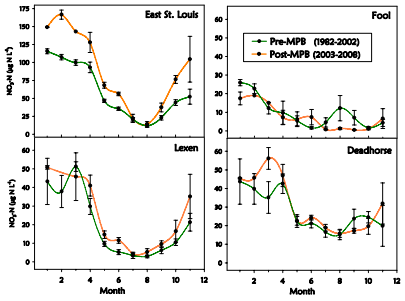
Unmanaged Managed

Bark beetles preferentially attack larger diameter lodgepole pine, so areas populated by smaller diameter trees regenerating after harvesting or wildfire may be resistant to change during the initial outbreak phase. Fraser basins managed in the 50's and 70's have proportionally less pine and have lost < ¼ of total basal area to beetles.

Biogeochemical Patterns

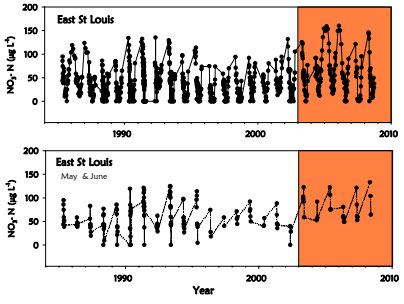
Seasonal hydrochemistry of Fraser streams mirrors spring snowmelt; concentrations are diluted during the period of peak stream runoff for most analytes. Nitrate represents 50-90% of the dissolved inorganic nitrogen in Fraser streams. Nitrate concentrations are highest during late winter and spring and low throughout summer and fall.

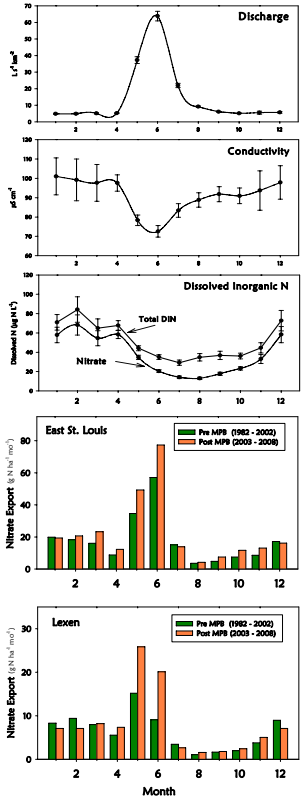
Unmanaged Managed



During six years following the onset of bark beetle activity spring and fall nitrate was higher than pre-outbreak concentrations in unmanaged basins. In these basins, beetle attack killed >75% of the pine and 40% of the total overstory basal area.

On average monthly nitrate export was 30% higher after beetles entered unmanaged basins; the largest differences were in May and June.





Implications

Fraser watersheds responded rapidly to beetle attack. Few physical changes have altered forest structure at this point, so higher nitrate concentration and export are the likely result of decreased nutrient demand following pine mortality.

Streamwater nitrate remains extremely low; change in N export is equivalent to only about 2% of annual N deposition (~2 kg N ha^{-1} yr^{-1}).