how continued N enrichment will influence future N uptake and loss from this system.

B32C MCC: 3014 Wednesday 1340h

The Effects of Forest Disturbance on Watershed Processes: Hydrology, Soils, Biota, and Water Chemistry

(joint with H, GC)

Presiding: **M R McHale,** U.S. Geological Survey**; N Ohte,** Kyoto University

B32C-01 1345h INVITED

Effects of Forest Disturbance on Chronic and Episodic Hydrogeomorphic Processes

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Dominant hydrogeomorphic processes in forest environments differ in relation to climate and biogeography, but also with respect to location within drainage basins. For example, in steep headwaters, episodic geomorphic processes (e.g., landslides, debris flows) are typically the major supplier of sediment to streams, and sediment and woody debris are routed through steep channels by a combination of mass wasting and episodic fluvial processes. Tributary junctions play a key role in storing and releasing materials. In gentler reaches further downstream, such sediment and wood are typically supplied and transported by chronic processes such as surface wash, litter and tree fall, and bedload and suspended sediment transport. Additionally, subsurface flow processes often dominate in upper catchment reaches while saturated overland flow controls much of the storm runoff in lower reaches where riparian corridors are wide. Subsurface and surface hydrologic pathways are strongly affected by antecedent moisture, especially in steep headwaters. Thus, effects forest land uses, such as roads and trails, harvesting, and conversion to agriculture, exert different influences depending on when and where they occur within the catchment. Hydrogeomorphic responses to forest management in steep terrain are compared between temperate catchments, where sediment is supplied largely by landslides, and tropical catchments, where organic horizons are thin and surface erosion follows disturbance. Management effects on chronic versus episodic hydrogeomorphic processes are stressed, including feedback between these processes.

B32C-02 1405h INVITED

Effects of Harvesting Intensity and Herbivory by White-tailed Deer on Vegetation and Nutrient Uptake in a Northern Hardwood Forest

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We quantified the response of vegetation and nutrient uptake in a northern hardwood forest in southeastern New York for three to four years after three intensities of harvesting: clearcutting, heavy timber stand improvement (TSI), light TSI (97, 29, and 10% basal area reductions, respectively). We also quantified effects of white-tailed deer (*Odocoileus virginianus*) herbivory on nutrient retention by vegetation. Total biomass and nutrient accumulation in vegetation was higher after TSI than clearcutting in the first two years but was highest in the fenced clearcut in subsequent years, indicating that TSI or partial harvesting is a viable management tool for harvesting timber while consistently maintaining high rates of nutrient retention. After clearcutting, biomass and nutrient retention were initially dominated by woody stems <1.4 m tall and herbaceous vegetation, but saplings 0.1-5.0 cm DBH became the most important contributors to biomass and nutrient accumulation within four years. However, after both intensities of TSI, trees >5.0 cm DBH continued to account for most biomass and nutrient accumulation whereas understory vegetation accumulated little biomass or nutrients. Heavy TSI resulted in increased regeneration of only two tree species (*Acer pensylvanicum*, *Fagus grandifolia*), but clearcutting allowed these two species, mature forest species (*A. saccharum*, *Betula alleghaniensis*), and the early successional *Prunus pensylvanica* to regenerate. Several early successional shrub and herbaceous species were also important to nutrient retention after clearcutting, including *Polygonum cilinode*, *Rubus* spp., and *Sambucus racemosa*. Herbivory by white-tailed deer dramatically reduced biomass and nutrient accumulation by woody stems <5 cm DBH after clearcutting (5.5 vs. 0.7 Mg biomass/ha and 30.4 vs. 6.3 kg N/ha on fenced and unfenced clearcut sites, respectively, after four years), indicating the important influence this herbivore can have on nutrient retention in recently disturbed forests.

B32C-03 1425h

Biological and hydrological controls of streamwater nitrate concentration in a forested catchment with a natural disturbance

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In Matsu-zawa catchment, central Japan, nitrate concentrations in stream water increased following a small-scale, natural disturbance involving an outbreak of pine wilt disease that affected approximately 25 per cent of the forested catchment. In order to clarify controls of nitrogen dynamics in the soil and its relationship with stream water nitrate, we investigated soil nitrogen transformations and soil water chemistry in disturbed and undisturbed, water-unsaturated and -saturated plots. The highest values for nitrification rate, nitrate concentration in soil solution, and nitrate exported from the root zone were observed for the disturbed plot. The rate of nitrification in surface soil of the disturbed plot increased dramatically compared to prior to the disturbance. Root zone leachate from the disturbed area showed gradually increasing groundwater nitrate concentrations in the temporarily saturated zone during lateral, matrix flow. The catchment's deep soils and associated hydrologic processes limited the degree of plant uptake of the nitrate generated in the disturbed area. It was inferred that the persistent high levels of nitrate observed in the stream water resulted largely from the stable high nitrate concentrations observed in the saturated groundwater of this catchment. Stream water nitrate loads discharged following the disturbance were more than ten times greater than prior to it.

B32C-04 1440h

Upland wildfires and fluvial processes: the response of tree populations along a gravel-bed watershed in the Canadian Rocky Mountains.

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In order to better predict the influence of upland processes on watershed responses, we must first understand how forested systems change along drainage basins. Riparian vegetation studies tend to only consider fluvial disturbances to be of importance and ignore the impact of other disturbances, such as wildfires. This is partly due to the fact that riparian research typically only focus on high-order reaches, while little is known about larger, basin-scale processes. The objective of our research was to determine the relative importance of floods and fires on riparian forests along a drainage basin. The study was conducted along a gravel-bed river in a small mountainous watershed of the Canadian Rocky Mountains. Sites were chosen to represent first, second, and third order reaches. At each site, we constructed flood and fire frequency distributions as well as age structures of the vegetation. The results show that location within the watershed and reach type (straight or meandering) both dictate whether fires or floods dominated. First, fires dominate on all low-order reaches, creating even-aged forests. With an increase in drainage area and the onset of meandering, point bars are formed and the relative importance of floods is increased. Floods dominate on meandering reaches, where bi-modal age distributions are observed, with young trees found on fluvially-disturbed bars and old trees on older, fire-disturbed surfaces. Along straight reaches, even-aged distributions tend to occur since floods are typically not large enough to overflow the banks and fires therefore dominate. The shift in the relative importance of disturbances along the basin indicates that terrestrial processes differ along a basin, causing changes in forest structure and composition. Incorporating these changes in watershed models will lead to better predictions of large-scale hydrological processes.

B32C-05 1455h

Forest Fire Effects on Mercury and Other Trace Metal Concentrations in a Rocky Mountain Forest Ecosystem

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The impacts of forest fires on pools of major elements including carbon, calcium, and sulfur, have been extensively studied while their effects on potentially toxic trace metals are not as well understood. We examined the effect of the summer 2001, 4470 acre Green Knoll Fire (GKF) in northeastern Wyoming on mercury (Hg) and other trace metal concentrations in forest ecosystem pools. A paired watershed study was conducted using a burned and unburned watershed of similar stand age, climate, vegetation, and geology to investigate wildfire effects on the evolution and dispersal of pools of Hg and trace metals in forests. Mercury and other trace metal concentrations were determined through a 15 cm soil profile as well as in vegetation. Atmospheric sampling suggests that possibly due to geothermal inputs, ambient atmospheric and soil mercury concentrations are elevated in this region compared to other rural areas in the US, with typical concentrations of vapor phase mercury >5 ng/m^3. The burned watershed soil profile had much lower mercury concentrations than that of the unburned watershed, suggesting Hg volatilization by wildfires. Previous studies have suggested that leaf litter releases 97-100% of its mercury content, while this study suggests that the Hg release from soil organic matter may not be as complete. Mercury concentrations in the unburned soil column decreased from an average of 158 ppb at the surface to 38 ppb at 10-15 cm. In contrast, average concentrations in the burned soil were near 30 ppb from 0-15 cm. This result indicates the GKF released only $\sim$ 85% of the mercury present in the organic soil horizon, which may be attributed to relatively low fire intensity. Extrapolations from our results indicate that this relatively small fire released $\sim$ 0.1 Mg of Hg from the soil. On average, 4.2 million acres are burned yearly in the US, suggesting that soil burning releases an approximate 100 Mg annual Hg flux into the atmosphere, 70% of the estimated US anthropogenic flux of 144 Mg. Past fire suppression practices in the US have caused a buildup of flammable materials, which combined with the legacy of pollution in the 20^{th} century, suggests that modern fires may release more mercury than in the past. This study reinforces the importance of wildfires to the global mercury cycle and indicates that forests in the Rocky Mountain region may contain large reservoirs of Hg that can be released during fires and add to the global budget of mercury emissions.

B32C-06 1510h

The Effects of Forest Disturbance on Macroinvertebrates in Western Oregon Headwater Streams - Patterns in Existing Databases

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As part of a research project investigating the effects of forest harvest practices on stream macroinvertebrates, we compiled existing data for Western Oregon headwater forest streams. The compiled database consists of 168 sites with watershed areas less than 10 square km that had measurements of stream macroinvertebrates, fish, physical habitat, water chemistry, and watershed land cover. The source of the data is from surveys conducted for EPA's EMAP program, the state of Oregon's Salmon Plan monitoring, and our own sampling efforts between 1994 and 2000. Almost all sites in the database were selected using the randomized EMAP survey design so they constitute a representative sample of all streams in this population. The streams in our dataset typically had mean wetted widths of 1-5 m, mean thalweg depths of 8-34 cm, and channel slopes of 1-15%. Watersheds for these sites were delineated and data on forest condition and logging history were clipped from available GIS layers. There were 189 macroinvertebrate taxa at the 168 sites with richness at individual sites ranging from 7 to 71 taxa. Ordination of the macroinvertebrate assemblages using NMS resulted in a 3 dimensional solution which accounted for 78% of the variation in the similarity among sites and demonstrated clear patterns in taxonomic composition with Baetis, Epeorus and Chironominae having the highest correlations with the ordination axes. Axes 1 and 2 each explained about 30% of the variation and were strongly correlated with substrate size, site slope and elevation. The third axis explained 17% of the variation and was correlated most strongly with watershed indices of forest logging history.

B32C-07 1525h

Forest Disturbance Through Alpine Ski Area Development: Results of a Paired Watershed Study in the Northeastern U.S.

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Disturbance to forested watersheds through suburbanization and resort development is increasingly common, particularly in densely populated regions. We are examining the effects of ski resort development on flow dynamics and water quality through a paired watershed study in northern Vermont. Our watersheds include the West Branch basin (11.7 km2), which encompasses an alpine ski resort, and the Ranch Brook basin (9.6 km2), which serves as our undeveloped control. Our analysis includes empirical interpretation of three years of streamflow and water quality data, as well as model simulations of flow dynamics under current and proposed future conditions, including proposed development of expanded snowmaking, ski trails and slope side village amenities in the West Branch basin. Our results show distinct differences in hydrologic response between the two watersheds, including elevated streamflows and delayed peaks during snowmelt in the developed watershed that may be attributable to trail clearing and snowmaking. Water quality data suggest that runoff from parking lots and other disturbed surfaces result in higher suspended sediment concentrations in the developed West Branch, particularly during the early part of snowmelt and during intense summer rains. Salting of parking lots and roadways within the West Branch basin resulted in elevated chloride concentrations year round (up to 700 ueq L-1 during snowmelt). Nitrate peaked near 70 ueq L-1 in both basins during snowmelt, but generally remained somewhat higher at West Branch. Otherwise, stream chemistry at both sites was dominated by weathering solutes (Ca, Mg, Si). We argue that disturbance to forested watersheds through this form of development may be more persistent than disturbance associated with traditional forest management activities (e.g. forest harvesting) and suggest that the results of our study may provide improved insight into the effects of new forms of human disturbance in the alpine environment.

B32D MCC: 3014 Wednesday 1600h

Isotopic Indicators of Biological Processes: From Soils to the Ocean

(joint with A, H, OS, GC)

Presiding: **J R Brooks,** National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency**; E Sulzman,** Oregon State University

B32D-01 1600h INVITED

Investigating Ecosystem Functional Development Along a Temperate Rainforest Chronosequence Using Stable Isotope Techniques

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Soil chronosequences are valuable systems for investigating ecosystem development by natural substitution of space for time. The Franz Josef chronosequence in New Zealand comprises temperate mixed conifer/hardwood rainforests formed on glacial surfaces of varying age. It is particularly useful as it includes both early build-up and decline phases over a relatively short time period (ca. 120 k years). Along the sequence, soil phosphorus decreases 8-fold, from 778 to 8 mg kg^{-1} soluble P. In contrast, nitrogen availability increases to peak at about 500 years, due to early successional N_2-fixing shrubs, after which it slowly declines. Ecosystem development along the sequence is characterised by marked changes in both plant species richness and tree height, with progression up to 5 k years and retrogression at older sites (ie > 14 k years). The carbon isotope ratio ($\delta^{13}C_L$) of sunlit canopy leaves from three dominant species sampled from within each of six sites, representing the full length of the sequence, decreased from -26.2 to -31.0 per mil with increasing ecosystem age. Independent measurements of photosynthetic capacity confirmed that the decrease was due to declining maximum photosynthetic rate: N_2-fixers > early successional angiosperms > late successional angiosperms > late successional conifers. Stable oxygen and nitrogen isotope ratios of canopy leaves are interpreted in terms of stomatal regulation of water loss and changing nitrogen source, respectively. Carbon isotope analysis of CO_2 sampled at night at different heights within the canopy allowed estimation of ecosystem discrimination ($\delta^{13}C_R$) using Keeling plots. Similarly to $\delta^{13}C_L$, $\delta^{13}C_R$ decreased with increasing soil age, suggesting that in high rainfall environments $\delta^{13}C_R$ is a good integrator of ecosystem photosynthetic capacity.

B32D-02 1615h

Decomposition and Stabilization Dynamics of C and N from Fine Roots Versus Needles

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Do fine roots or needles ultimately produce the most C sequestered as stable soil organic matter (SOM)? How does the soil microclimate/soil horizon influence the efficiency of decomposition and C and N humification dynamics? We present the first 1.5 yr results of a study using ^{13}C- and ^{15}N-labeled *Pinus ponderosa* litter to track the short- and long-term fate of fine root vs. needle C and N inputs to soil. Labeled substrates were placed into either the O or A horizons of an Ultic Haploxeralf in the Sierra Nevada, CA. We determined the amount of label respired as CO_2 and the amount remaining in the soil. The movement of the ^{13}C and ^{15}N into and through the microbial community (PLFA/CFE) and SOM fractions was determined to compare the humification rates and pathways of the added ^{13}C and ^{15}N. Total soil recovery of fine root C far exceeded that of needles after 1 yr (76.9 vs. 52.4%). Twice as much of the needle C was reduced to a smaller size class (less than 2 mm) than for fine roots. Soil ^{15}N retention was high and unaffected by soil depth or substrate type (88%) after 1 yr. The proportion of ^{15}N recovered in microbial biomass was twice as great from needles as from fine roots (10.2 vs. 5.1%). Leaching losses of ^{13}C and ^{15}N were apparently very low with only 1-2% of ^{13}C or ^{15}N transported from the O to the A horizon after 1 yr. Due to moisture limitation in the surface soil during the summer, $^{13}CO_2$ respiration was faster for both substrates in the A horizon, while during the winter and spring, substrates in the O horizon had faster rates of $^{13}CO_2$ respiration than those in the A horizon. Although soil depth and microclimate influenced seasonal C loss by respiration, it did not affect total soil C recovery after 1 yr. The C quality of the substrates appeared to be more important than soil placement depth in affecting C residence time after the first year.

B32D-03 1630h

Refinement of Isotopically Derived Fine Root Lifespans Using A Locally Released Radiocarbon Label in Oak Ridge, TN.

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Isotopic techniques (^{13}C and ^{14}C) are relative newcomers among the approaches used to quantify fine root (< 2 mm diameter) dynamics in a field setting. Direct measurements of the isotopic content of root tissues, used as a proxy for root age, have shown that at least some portion of the fine root system lives for 5-10 years or more. In this work we take advantage of a local radiocarbon (^{14}C) release in Oak Ridge, TN in summer 1999, to examine (1) the influence of stored C in new root growth and (2) the lifespan of fine roots from a mature, temperate deciduous forest. This release provides a local ^{14}C pulse of similar magnitude to the peak of the ^{14}C bomb spike. However, since we have been able to make ecosystem wide measurements within one year of the local ^{14}C release we have much greater time resolution than we do with the standard bomb-^{14}C technique applied today (which is 1-2 years). We have constructed a new multi-compartment model of root growth and decay, whose structure was developed using data from field sampling at Oak Ridge, TN. Model results, constrained with a ^{14}C time series of new root growth, show that fine roots are grown with 10% of their carbon coming from stored C sources. Additionally, a three-year time series of root cores shows that at least two pools are required to account for ^{14}C changes in live and dead fine roots. Testing this ^{14}C data set with our model shows that the shorter-lived root pool has a turnover time (mean lifetime) of a few months and the longer-lived pool has a turnover time of 5 years.

B32D-04 1645h

Decomposition of ^{14}C-Labeled Roots in a Pasture Soil Exposed to 10 Years of Elevated CO_2

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