Fire and Fuels Science Quarterly: Spring 2013

Abstracts of Recent Papers in Fire Ecology and Fuels Management

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Table of Contents

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Aquatic Wildlife

Hossack, Blake R., Winsor H. Lowe, R. Ken Honeycutt, Sean A. Parks, and Paul Stephen Corn. 2013. Interactive effects of wildfire, forest management, and isolation on amphibian and parasite abundance. Ecological Applications 23:479–492. http://dx.doi.org/10.1890/12-0316.1

Abstract. Projected increases in wildfire and other climate-driven disturbances will affect populations and communities worldwide, including host–parasite relationships. Research in temperate forests has shown that wildfire can negatively affect amphibians, but this research has occurred primarily outside of managed landscapes where interactions with human disturbances could result in additive or synergistic effects. Furthermore, parasites represent a large component of biodiversity and can affect host fitness and population dynamics, yet they are rarely included in studies of how vertebrate hosts respond to disturbance. To determine how wildfire affects amphibians and their parasites, and whether effects differ between protected and managed landscapes, we compared abundance of two amphibians and two nematodes relative to wildfire extent and severity around wetlands in neighboring protected and managed forests (Montana, USA). Population sizes of adult, male long-toed salamanders (*Ambystoma macrodactylum*) decreased with increased burn severity, with stronger negative effects on isolated populations and in managed forests. In contrast, breeding population sizes of Columbia spotted frogs (*Rana luteiventris*) increased with burn extent in both protected and managed protected forests. Path analysis showed that the effects of wildfire on the two species of nematodes were consistent with differences in their life history and transmission strategies and the responses of their hosts. Burn severity indirectly reduced abundance of soil-transmitted *Cosmocercoides variabilis* through reductions in salamander abundance. Burn severity also directly reduced *C. variabilis* abundance, possibly though changes in soil conditions. For the aquatically transmitted nematode *Gyrinicola batrachiensis*, the positive effect of burn extent on density of Columbia spotted frog larvae indirectly increased parasite abundance. Our results show that effects of wildfire on amphibians depend upon burn extent and severity, isolation, and prior land use. Through subsequent effects on the parasites, our results also reveal how changes in disturbance regimes can affect communities across trophic levels

Climate Change and Carbon Management

Sander Veraverbeke and Simon J. Hook, 2013. Evaluating spectral indices and spectral mixture analysis for assessing fire severity, combustion completeness and carbon emissions. *International Journal of Wildland Fire.* http://dx.doi.org/10.1071/WF12168 Submitted: 6 October 2012 Accepted: 16 December 2012. Published online: 18 March 2013.

Abstract. We used a Landsat Thematic Mapper (TM) image from the 2011 Wallow fire in Arizona, USA, in combination with field data to assess different methods for determining fire severity. These include the normalised burn ratio (NBR), the differenced NBR (dNBR), the relative dNBR (RdNBR) and the burned fraction (BF)

estimated by spectral mixture analysis (SMA). The Geo Composite Burn Index (GeoCBI) and vegetation mortality data were used as ground truth. Of all the remotely sensed measures evaluated the dNBR had the best performance (GeoCBI–dNBR R^2 = 0.84), which supports the operational use of the dNBR for post-fire management. Of the other remotely sensed measures, the SMA-derived BF also had moderately high correlations with the GeoCBI (R^2 = 0.66). Both approaches demonstrated their usefulness for refining modelled CC values, however, the SMA approach has the advantage of providing transferable quantitative estimates without the need for calibration with field data. The carbon emission estimates that included fire severity were more than 50% lower than the estimate derived from modelling alone. These results suggest that for certain fire types, especially mixed-severity fires, current emission estimates are significantly overestimated, which will affect global carbon emission estimates from wildfires.

Robert E. Keane and Rachel A. Loehman, 2013. Estimating Critical Climate-Driven Thresholds in Landscape Dynamics Using Spatial Simulation Modeling: Climate Change Tipping Points in Fire Management. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Lab, Project and final report number: 09-3-01-17. http://www.firelab.org/firebgcv2-tipping-points.

Abstract. Climate projections for the next 20-50 years forecast higher temperatures and variable precipitation for many landscapes in the western United States. Climate changes may cause or contribute to threshold shifts, or tipping points, where relatively small shifts in climate result in large, abrupt, and persistent changes in landscape patterns and fire regimes. Rather than simulate potential climate-fire interactions using future climate data derived from Global Climate Models (GCMs), we developed sets of progressively warmer and drier or wetter climate scenarios that span and exceed the range of GCM outputs for the western US, including temperature and precipitation combinations that may not be present in GCM projections by may occur at finer (regional or local) scales. These climate scenarios were used to simulate potential future fire and vegetation dynamics in three study areas in the western United States - McDonald watershed, Glacier National Park (MT), the central plateau of Yellowstone National Park (WY), and the East Fork Bitterroot River basin (MT). These landscapes encompass a diverse range of biophysical settings, vegetation species, forest structure, and fire regime, and thus were expected to differ in their sensitivity to climate changes and exhibit unique threshold behavior following climatic and wildfire perturbations. Each of the study areas proved sensitive to simulated changes in temperature and precipitation, as reflected in shifts in mean annual burned area, crown fire area, and fire-caused tree mortality. Sensitivity to climate changes differed across landscapes – for example, a significant decline in basal area occurred at temperature shifts of 3 °C and above for the Yellowstone National Park study area, 4 °C and above for the Glacier National Park study area, and above 5 °C for the East Fork Bitterroot River basin. Moreover, shifts in basal area were strongly related to changes in area burned and fire regime characteristics, suggesting that synergistic interactions of climate and fire will be important in determining future landscape patterns

Lu, Meng, Xuhui Zhou, Qiang Yang, Hui Li, Yiqi Luo, Changming Fang, Jiakuan Chen, Xin Yang, and Bo Li. 2013. Responses of ecosystem carbon cycle to experimental warming: a meta-analysis. Ecology 94:726–738. http://dx.doi.org/10.1890/12-0279.1

Abstract. Global warming potentially alters the terrestrial carbon (C) cycle, likely feeding back to further climate warming. However, how the ecosystem C cycle responds and feeds back to warming remains unclear. Here we used a meta-analysis approach to quantify the response ratios of 18 variables of the ecosystem C cycle to experimental warming and evaluated ecosystem C-cycle feedback to climate warming. Our results showed that warming stimulated gross ecosystem photosynthesis (GEP) by 15.7%, net primary production (NPP) by 4.4%, and plant C pools from above- and belowground parts by 6.8% and 7.0%, respectively. Experimental warming accelerated litter mass loss by 6.8%, soil respiration by 9.0%, and dissolved organic C leaching by 12.1%. In addition, the responses of some of those variables to experimental warming differed among the ecosystem types. Our results demonstrated that the stimulation of plant-derived C influx basically offset the increase in warming-induced efflux and resulted in insignificant changes in litter and soil C content, indicating that climate warming may not trigger strong positive C-climate feedback from terrestrial ecosystems. Moreover, the increase in plant C storage together with the slight but not statistically significant decrease of net ecosystem exchange (NEE) across ecosystems suggests that terrestrial ecosystems might be a weak C sink rather than a C source under global climate warming. Our results are also potentially useful for parameterizing and benchmarking land surface models in terms of C cycle responses to climate warming.

Fire Behavior and Fuels

Daniel C. Donato, Joseph B. Fontaine, J. Boone Kauffman, W. Douglas Robinson and Beverly E. Law. 2013. Fuel mass and forest structure following stand-replacement fire and post-fire logging in a mixed-evergreen forest. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF12109 Submitted: 9 July 2012 Accepted: 6 November 2012 Published online: 15 February 2013.

Abstract. Following severe wildfires, managing fire hazard by removing dead trees (post-fire logging) is an important issue globally. Data informing these management actions are relatively scarce, particularly how fuel loads differ by post-fire logging intensity within different environmental settings. In mixed-evergreen forests of Oregon, USA, we quantified fuel profiles 3–4 years after stand-replacement fire – assessing three post-fire logging intensities (0, 25–75, or >75% basal area cut) across two climatic settings (mesic coastal, drier interior). Stand-replacement fire consumed ~17% of aboveground biomass. Post-fire logging significantly reduced standing dead biomass, with high-intensity treatment leaving a greater proportion (28%) of felled biomass on site compared with moderate-intensity treatment (14%) because of less selective tree felling. A significant relationship between logging intensity and resulting surface fuels (per-hectare increase of 0.4–1.2 Mg per square metre of basal area cut) indicated a broadly applicable predictive tool for management. Down wood cover increased by 3–5 times and became more spatially homogeneous after logging. Post-fire logging altered the fuel profile of early-seral stands (standing material removed or transferred, short-term increase in surface fuels, likely reduction in future large fuel accumulation), with moderate-intensity and

unlogged treatments yielding surface fuel loads consistent with commonly prescribed levels, and high-intensity treatment resulting in greater potential need for follow-up fuel treatments

Jesse K. Kreye, Leda N. Kobziar and Wayne C. Zipperer. 2013. Effects of fuel load and moisture content on fire behaviour and heating in masticated litter-dominated fuels. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF12147 Submitted: 31 August 2012 Accepted: 22 October 2012 Published online: 17 December 2012.

Abstract. Mechanical fuels treatments are being used in fire-prone ecosystems where fuel loading poses a hazard, yet little research elucidating subsequent fire behaviour exists, especially in litter-dominated fuelbeds. To address this deficiency, we burned constructed fuelbeds from masticated sites in pine flatwoods forests in northern Florida with palmetto-dominated understoreys and examined the effects of fuel load and fuel moisture content (FMC) on fire behaviour. Flame lengths (49–140 cm) and fireline intensity (183–773 kJ m^{-1} s^{-1}) increased with loading (10–30 Mg ha^{-1}) and were reduced by 40 and 47% with increasing FMC from 9 to 13%. Rate of spread was not influenced by fuel load, but doubled under drier FMC. Fuel consumption was >90% for all burns. Soil temperatures were influenced by both fuel load and FMC, but never reached lethal temperatures (60°C). However, temperatures of thermocouple probes placed at the fuelbed surface reached 274–503°C. Probe maximum temperature and duration at temperatures ≥60°C (9.5–20.0°C min) both increased with fuel load, but were unaffected by FMC. The fire behaviour observed in these unique litter-dominated fuelbeds provides additional insight into the burning characteristics of masticated fuels in general.

Pamela S. Ziesler, Douglas B. Rideout and Robin Reich, 2013. Modelling conditional burn probability patterns for large wildland fires. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF11185 Submitted: 31 December 2011 Accepted: 27 November 2012 Published online: 18 March 2013.

Abstract. We present a technique for modeling conditional burn probability patterns in two dimensions for large wildland fires. The intended use for the model is strategic program planning when information about future fire weather and event durations is unavailable and estimates of the average probabilistic shape and extent of large fires on a landscape are needed. To model average conditional burn probability patterns, we organized historical fire data from Yellowstone National Park, USA, into a set of grids; one grid per fire. We captured various spatial relationships inherent in the gridded data through use of geometric variables in the main model and by incorporating an autoregressive covariance structure. The final model had 'good' predictive ability with an AUC of 0.81 (1.0 is perfect prediction) and the estimated coefficients are consistent with theory and reflect how fires usually behave on the study site landscape. This technique produces a predictive model with finer detail than most landscape-wide models of burn probability and it has advantages over simulation methods for strategic planning because it does not require multiple runs of spread simulation models or information on fire duration.

Forests

Thompson, Matthew P.; Vaillant, Nicole M.; Haas, Jessica R.; Gebert, Krista M.; Stockmann, Keith, 2013. Quantifying the Potential Impacts of Fuel Treatments on Wildfire Suppression Costs. Journal of Forestry, Volume 111, Number 1, January 2013, pp. 49-58(10).

Abstract. Modeling the impacts and effects of hazardous fuel reduction treatments is a pressing issue within the wildfire management community. Prospective evaluation of fuel treatment effectiveness allows for comparison of alternative treatment strategies in terms of socioeconomic and ecological impacts and facilitates analysis of tradeoffs across land-management objectives. Studies have yet to rigorously examine potential impacts to fire suppression expenditures associated with prior hazardous fuel reduction treatments. Such information would be helpful for federal land-management agencies struggling to contain escalating wildfire management costs. In this article we establish a methodology for estimating potential reductions in wildfire suppression costs. Our approach pairs wildfire simulation outputs with a regression cost model and quantifies the influence of fuel treatments on distributions of wildfire sizes and suppression costs. Our case study focuses on a landscape within the Deschutes National Forest in central Oregon that was selected to receive funding under the auspices of the Collaborative Forest Landscape Restoration Program. Results suggest substantial reductions in distributions of wildfire size and suppression cost on a per fire basis. Furthermore, because fewer ignitions become large fires on the treated landscape, distributions of annual area burned and annual suppression costs also shift downward because of fuel treatments. Results are contingent on four key factors: large-scale implementation of fuel treatments across the landscape, assumed treatment effectiveness over the duration of the analysis period, accuracy of wildfire and cost models, and accuracy of projected changes to fire behavior fuel models resulting from fuel treatments. We discuss strengths and limitations of the modeling approach and offer suggestions for future improvements and applications.

Postfire Recovery

Kashian, Daniel M., William H. Romme, Daniel B. Tinker, Monica G. Turner, and Michael G. Ryan. 2013. Postfire changes in forest carbon storage over a 300-year chronosequence of *Pinus contorta*-dominated forests. Ecological Monographs 83:49–66. http://dx.doi.org/10.1890/11-1454.1

Abstract. A warming climate may increase the frequency and severity of stand-replacing wildfires, reducing carbon (C) storage in forest ecosystems. Understanding the variability of postfire C cycling on heterogeneous landscapes is critical for predicting changes in C storage with more frequent disturbance. We measured C pools and fluxes for 77 lodgepole pine (*Pinus contorta* Dougl. ex Loud var. *latifolia* Engelm.) stands in and around Yellowstone National Park (YNP) along a 300-year chronosequence to examine how quickly forest C pools recover after a stand-replacing fire, their variability through time across a complex landscape, and the role of stand structure in this variability.

Carbon accumulation after fire was rapid relative to the historical mean fire interval of 150–300 years, recovering nearly 80% of prefire C in 50 years and 90% within 100 years. Net ecosystem carbon balance (NECB) declined monotonically, from 160 g $C \cdot m^{-2} \cdot yr^{-1}$ at age 12 to 5 g $C \cdot m^{-2} \cdot yr^{-1}$ at age 250, but was never negative after

disturbance. Decomposition and accumulation of dead wood contributed little to NECB relative to live biomass in this system. Aboveground net primary productivity was correlated with leaf area for all stands, and the decline in aboveground net primary productivity with forest age was related to a decline in both leaf area and growth efficiency. Forest structure was an important driver of ecosystem C, with ecosystem C, live biomass C, and organic soil C varying with basal area or tree density in addition to forest age. Rather than identifying a single chronosequence, we found high variability in many components of ecosystem C stocks through time; a >50% random subsample of the sampled stands was necessary to reliably estimate the nonlinear equation coefficients for ecosystem C. At the spatial scale of YNP, this variability suggests that landscape C develops via many pathways over decades and centuries, with prior stand structure, regeneration, and within-stand disturbance all important. With fire rotation projected to be <30 years by mid-century in response to a changing climate, forests in YNP will store substantially less C (at least 4.8 kg C/m^2 or 30% less).

K. N. Dalldorf, S. R. Swanson, D. F. Kozlowski, K. M. Schmidt, R. S. Shane, and G. Fernandez, 2013. Influence of Livestock Grazing Strategies on Riparian Response to Wildfire in Northern Nevada. Rangeland Ecology & Management: January 2013, Vol. 66, No. 1, pp. 34-42.

Abstract. In 1999–2001 wildfires burned 1.13 million ha across northern Nevada, burning through many grazed riparian areas. With increases in wildfire frequency and extent predicted throughout the Great Basin, an understanding of the interactive effects of wildfire, livestock grazing, and natural hydrologic characteristics is critical. A comparison of pre- and postfire stream surveys provided a unique opportunity to statistically assess changes in stream survey attributes at 43 burned and 38 unburned streams. Livestock grazing variables derived from an extensive federal grazing allotment inventory were used to identify interactive effects of grazing strategies, fire, and natural stressors across 81 independent riparian areas. Differences between baseline and "postfire" stream survey attributes were evaluated for significance using the nonparametric Mann–Whitney test for paired data. Binary logistic regression models evaluated the influence of fire, grazing, and hydrologic characteristics on observed stream survey attribute changes. Grazing attributes contributed most significantly to the bankfull width increase and bank stability rating decrease models. The odds of bankfull width degradation (increase in bankfull width) decreased where there had been rest is some recent years compared to continuous grazing. As the number of days grazed during the growing season increased, the odds of bank stability degradation also increased. The occurrence of fire was not significant in any model. Variation in the riparian width model was attributed primarily to hydrologic characteristics, not grazing. For the models in which grazing variables played a role, stream survey attributes were more likely to improve over time when coupled with a history of rotational grazing and limited duration of use during the growing season. This supports long-term riparian functional recovery through application of riparian complementary grazing strategies.

Restoration

Michael G. Harrington, 2012. Duff mound consumption and cambium injury for centuries-old western larch from prescribed burning in western Montana. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF12038 Submitted: 6 March 2012 Accepted: 24 August 2012 Published online: 22 October 2012.

Abstract. Western larch is one of the most fire-adapted conifers in western North America. Its historical perpetuation depended upon regular fire disturbances, which creates open stand conditions and mineral seedbeds. A stand of 200- to 500-year-old larch in western Montana with deep duff mounds resulting from an unusually long 150-year fire-free period was mechanically thinned and prescribed burned to reduce the probability of high intensity wildfire near a community and increase opportunities for larch regeneration. Little documentation is available regarding basal damage to larch from lengthy duff mound burning; therefore this study was established to assess: duff consumption from prescribed burning and resulting cambial damage and tree vitality. Ninety trees averaging 91-cm diameter at breast height were selected, half with duff mounds measured and burned in autumn and half with mounds removed. Duff depths nearest the bole averaged 20 cm and mound consumption approached 100% including large amounts of the basal bark with smoldering combustion lasting 18–24 h. Cambial mortality ranged from 0 to 36% of the basal circumference but no trees had died after 7 years. The cambium mortality was likely due to the spatially infrequent coincident of deep duff and thinner bark. Under similar site and environmental conditions removal of the potential duff consumption injury hazard appears unwarranted.

Kirk W. Davies, Aleta M. Nafus, and Dustin D. Johnson, 2013. Are Early Summer Wildfires an Opportunity to Revegetate Exotic Annual Grass–Invaded Plant Communities? Rangeland Ecology & Management: March 2013, Vol. 66, No. 2, pp. 234-240.

Abstract. Medusahead (*Taeniatherum caput-medusae* [L.] Nevski) is an exotic annual grass invading western rangelands. Successful revegetation of invaded-plant communities can be prohibitively expensive because it often requires iterative applications of integrated control and revegetation treatments. Prescribed burning has been used to control medusahead and prepare seedbeds for revegetation, but burning has been constrained by liability concerns and has produced widely varying results. Capitalizing on naturally occurring wildfires could reduce revegetation costs and alleviate liability concerns. Thus, our objective was to determine if early summer wildfires and fall drill seeding could be used as a treatment combination to decrease medusahead and increase perennial and native vegetation. Treatments were evaluated pretreatment and for 3 yr post fire at six sites and included 1) an early summer wildfire combined with a seeding treatment (burn and seed) and 2) a nontreated (no burn, no seed) control. Perennial grass density was 4.6- to 10.0-fold greater in the burn-and-seed treatment compared to the control in the first 3 yr post treatment ($P < 0.05$). Exotic annual grass density and cover in the third year post treatment were lower in the burn-and-seed treatment than in the control ($P < 0.05$). However, exotic annual grass density was still >130 individuals$\cdot m^{-2}$ in the burn-and-seed treatment. The density of exotic annual grass is of concern because over time medusahead may displace perennial grasses and annual forbs that increased with the burn-and-seed treatment. Though not directly tested in this study, we suggest

that, based on other research, the burn-and-seed treatment may need to incorporate a pre-emergent herbicide application to further suppress medusahead and increase the establishment of seeded vegetation. However, it appears that early summer wildfires may provide an opportunity to reduce the cost of integrated programs to revegetate medusahead-invaded plant communities

Michelle Buonopane, Gabrielle Snider, Becky K. Kerns, Paul S. Doescher, 2013. Complex restoration challenges: Weeds, seeds, and roads in a forested Wildland Urban Interface. **Forest Ecology and Management,** Volume 295, 1 May 2013, Pages 87–96.

Abstract. Federal policies in the US strongly emphasize reducing hazardous fuels at the Wildland Urban Interface (WUI). However, these areas present restoration challenges as they often have exotic weeds, frequent human disturbance, and the presence of roads. Understanding seed banks is important in planning for desirable post-disturbance community conditions, developing integrated weed management programs, and complying with State and Federal regulations. We characterized the aboveground vegetation and seed bank in a WUI composed of mixed age dry-mixed conifer forest stands in central Washington State, and examined patterns and relationships between aboveground vegetation and seed bank germinant abundance in relation to distance to road, seed bank layer, and herbicide treatments. Noxious weed frequency, as well as exotic weed and annual native forb cover, significantly decreased with distance from road, while native graminoid cover increased, declining beyond 20 m. Herbicides did not affect composition of the aboveground community in the short term. Six hundred and thirty seeds germinated from litter and mineral soil samples over a 5 month trial, and 43 species were identified. Most germinants (77%) and species (36 species) emerged from the litter layer compared to mineral soil, and the majority were annual forbs, followed by perennial forbs, native graminoids and exotic species. Little similarity was found between the extant vegetation and seed bank floras. Fourteen percent of germinants were exotic species, and were found in similar abundances regardless of proximity to road or herbicide treatment. Findings from our study suggest that (1) roads strongly influenced aboveground vegetative cover and species composition; (2) seed bank contributions to desirable post-disturbance understory development may be relatively low, especially if activities remove the litter layer; (3) weed populations were largely confined to near road environments, but the weed seed bank, which is a substantial part of the total seed bank, was not; and (4) herbicide treatments were ineffective and did not impact seed banks in the short term.

Riparian Areas

Adam C. Watts Leda N. Kobziar, 2013. Smoldering Combustion and ground fires: ecological effects and multi-scale Significance. Fire Ecology Volume 9, Issue 1, 2013. doi: 10.4996/fireecology.0901124.

Abstract. Although fires in wetlands would seem to be rare or impossible by definition, these ecosystems do occasionally experience fire. A common feature of fires in wetlands is smoldering combustion in organic soils, such as peat and muck. Increasing occurrence and size of these events from the Arctic to the tropics has been matched by increasing research interest, yet our understanding of smoldering lags behind that of flame-based combustion. Smoldering fires represent hazards to human health and safety locally, and global ecological concerns due to their potential for carbon release. Additionally, ecological effects of smoldering ground fires are

generally perceived to be negative, particularly where their historical frequencies are thought to be low. This synthesis describes some aspects of smoldering combustion, and discusses some of the particular ecological aspects of ground fires, focusing on examples from the southeastern United States. We suggest that despite the well-recognized negative aspects of ground fires, there may exist under-recognized ecological benefits that should be further studied and weighed against known hazards posed by these events.

Soils

M. X. Gómez-Rey, A. Couto-Vázquez, S. García-Marco, J. A. Vega and S. J. González-Prieto. 2013. Reduction of nutrient losses with eroded sediments by post-fire soil stabilisation techniques. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF12079 Submitted: 21 May 2012 Accepted: 13 November 2012 Published online: 15 February 2013.

Abstract. After an experimental fire in steep shrubland in a temperate–humid region (north-west Spain), the effects of two post-fire stabilisation treatments (grass seeding and straw mulching) on the chemical properties of eroded sediments, and the amount of nutrients lost with them, were evaluated relative to control burnt soil, over a period of 13 months. Total C and N concentrations, and $\delta^{13}C$, indicated that sediments were mainly contributed by charred plant and litter material. The highest concentrations of extractable base cations in the sediments occurred during the first 3 months following fire, especially for Na and K. As treatments had little or no effect on nutrient concentration in sediments, differences in nutrient losses were due to the 10-fold lower sediment production in mulching compared with other treatments. In control and seeding treatments, the accumulated amounts of nutrients lost with sediments were 989–1028 kg ha^{-1} (C), 77 kg ha^{-1} (N), 1.9–2.4 kg ha^{-1} (Ca), 0.9–1.1 kg ha^{-1} (Mg), 0.48–0.55 kg ha^{-1} (NH_4^+–N), 0.39–0.56 kg ha^{-1} (K), 0.19–0.34 kg ha^{-1} (Na) and <0.1 kg ha^{-1} (P and NO_3^-–N). These values accounted for 22–25% (total C and N) and 5–12% (NH_4^+–N, Ca, P and Mg) of available nutrients in ash, and 1.0–2.4% of those in ash+topsoil. As nutrient and sediment losses were strongly correlated, the reduction of the latter by mulching application leads to an effective decrease of post-fire nutrient losses.

Stephanie Yelenik, Steven Perakis, and David Hibbs, 2013. Regional constraints to biological nitrogen fixation in post-fire forest communities. Ecology, 94(3), 2013, pp. 739–750_2013 by the Ecological Society of America.

Abstract. Biological nitrogen fixation (BNF) is a key ecological process that can restore nitrogen (N) lost in wildfire and shape the pace and pattern of post-fire forest recovery. To date, there is limited information on how climate and soil fertility interact to influence different pathways of BNF in early forest succession. We studied asymbiotic (forest floor and soil) and symbiotic (the shrub Ceanothus integerrimus) BNF rates across six sites in the Klamath National Forest, California, USA. We used combined gradient and experimental phosphorus (P) fertilization studies to explore cross-site variation in BNF rates and then related these rates to abiotic and biotic variables. We estimate that our measured BNF rates 22 years after wildfire (6.1–12.1 kg N_ha_1_yr_1) are unlikely to fully replace wildfire N losses. We found that asymbiotic BNF is P limited, although this is not the case for symbiotic BNF in Ceanothus. In contrast, Ceanothus BNF is largely driven by competition from other

vegetation: in high-productivity sites with high potential evapotranspiration (Et), shrub biomass is suppressed as tree biomass increases. Because shrub biomass governed cross-site variation in Ceanothus BNF, this competitive interaction led to lower BNF in sites with high productivity and Et. Overall, these results suggest that the effects of nutrients play a larger role in driving asymbiotic than symbiotic fixation across our post-fire sites. However, because symbiotic BNF is 8–903greater than asymbiotic BNF, it is interspecific plant competition that governs overall BNF inputs in these forests.

Terrestrial Wildlife

Buchalski MR, Fontaine JB, Heady PA III, Hayes JP, Frick WF, 2013. Bat Response to Differing Fire Severity in Mixed-Conifer Forest California, USA. PLoS ONE 8(3): e57884. doi:10.1371/journal.pone.0057884

Abstract. Wildlife response to natural disturbances such as fire is of conservation concern to managers, policy makers, and scientists, yet information is scant beyond a few well-studied groups (e.g., birds, small mammals). We examined the effects of wildfire severity on bats, a taxon of high conservation concern, at both the stand (<1 ha) and landscape scale in response to the 2002 McNally fire in the Sierra Nevada region of California, USA. One year after fire, we conducted surveys of echolocation activity at 14 survey locations, stratified in riparian and upland habitat, in mixed-conifer forest habitats spanning three levels of burn severity: unburned, moderate, and high. Bat activity in burned areas was either equivalent or higher than in unburned stands for all six phonic groups measured, with four groups having significantly greater activity in at least one burn severity level. Evidence of differentiation between fire severities was observed with some *Myotis* species having higher levels of activity in stands of high-severity burn. Larger-bodied bats, typically adapted to more open habitat, showed no response to fire. We found differential use of riparian and upland habitats among the phonic groups, yet no interaction of habitat type by fire severity was found. Extent of high-severity fire damage in the landscape had no effect on activity of bats in unburned sites suggesting no landscape effect of fire on foraging site selection and emphasizing stand-scale conditions driving bat activity. Results from this fire in mixed-conifer forests of California suggest that bats are resilient to landscape-scale fire and that some species are preferentially selecting burned areas for foraging, perhaps facilitated by reduced clutter and increased post-fire availability of prey and roosts.

Watersheds and Hydrology

J. Cancelo-González, M. E. Rial-Rivas and F. Díaz-Fierros. 2013. Effects of fire on cation content in water: a laboratory simulation study. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF12178 Submitted: 23 October 2012 Accepted: 6 November 2012 Published online: 29 January 2013.

Abstract. Laboratory experiments were carried out to explore the effect of thermal shocks (as occur during fire) and simulated rainfall events on cation leaching dynamics in an organic rich Leptic Umbrisol soil. The soil samples were collected in the field using specially designed lysimeter boxes that allow sampling and application of thermal shock treatments and simulated rainfall while keeping the soil structure unaltered. The soil temperature during the thermal shocks and degree-hours of accumulated heat were determined, and cation (Na^+, K^+, Ca^{2+} and Mg^{2+}) leaching

was measured in surface runoff (0-cm depth) and subsurface flow (12-cm depth) samples collected from the lysimeter boxes. Important differences were found in cation leaching in relation to thermal shock: monovalent cation leaching from the soil above 200°C (68 degree-hours) and divalent cations leaching above 220°C (195 degree-hours) was higher than that seen in other treatments. In general, the amount of cations leached increased with the severity of the thermal shock; however, under moderate conditions, there was a decrease in cation leaching, mainly of monovalent ions. The exchangeable cation losses by leaching in the intense heat treatments were ~80%.

Wildland-Urban Interface

Patricia H. Gude, Kingsford Jones, Ray Rasker and Mark C. Greenwood, 2013. Evidence for the effect of homes on wildfire suppression costs. International Journal of Wildland Fire - http://dx.doi.org/10.1071/WF11095 Submitted: 8 July 2011 Accepted: 29 August 2012 Published online: 3 January 2013.

Abstract. This paper uses wildfires in the Sierra Nevada area of California to estimate the *relationship between housing and fire suppression costs. We investigated whether* the presence of homes was associated with increased costs of firefighting after controlling for the effects of potential confounding variables including fire size, weather, terrain and human factors such as road access. This paper investigates wildfires in a way that other published studies have not; we analysed costs at the daily level, retaining information that would have been lost had we aggregated the data. We used linear mixed models to estimate the effects of homes on daily costs while incorporating within-fire variation. We conclude that the expected increase in the log daily cost with each unit increase in the log count of homes within 6 miles (~9.7 km) of an active fire is 0.07 (P = 0.005). The findings of this study are in agreement with most other previous empirical studies that have investigated the relationship between fire suppression costs and housing using cumulative fire costs and more generalized data on home locations. The study adds to mounting evidence that increases in housing lead to increases in fire suppression costs.

Hawbaker, Todd J., Volker C. Radeloff, Susan I. Stewart, Roger B. Hammer, Nicholas S. Keuler, and Murray K. Clayton. 2013. Human and biophysical influences on fire occurrence in the United States. Ecological Applications 23:565–582. http://dx.doi.org/10.1890/12-1816.1

Abstract. National-scale analyses of fire occurrence are needed to prioritize fire policy and management activities across the United States. However, the drivers of national-scale patterns of fire occurrence are not well understood, and how the relative importance of human or biophysical factors varies across the country is unclear. Our research goal was to model the drivers of fire occurrence within ecoregions across the conterminous United States. We used generalized linear models to compare the relative influence of human, vegetation, climate, and topographic variables on fire occurrence in the United States, as measured by MODIS active fire detections collected between 2000 and 2006. We constructed models for all fires and for large fires only and generated predictive maps to quantify fire occurrence probabilities. Areas with high fire occurrence probabilities were widespread in the Southeast, and localized in the Mountain West, particularly in southern California, Arizona, and New Mexico. Probabilities for large-fire occurrence

were generally lower, but hot spots existed in the western and south-central United States The probability of fire occurrence is a critical component of fire risk assessments, in addition to vegetation type, fire behavior, and the values at risk. Many of the hot spots we identified have extensive development in the wildland–urban interface and are near large metropolitan areas. Our results demonstrated that human variables were important predictors of both all fires and large fires and frequently exhibited nonlinear relationships. However, vegetation, climate, and topography were also significant variables in most ecoregions. If recent housing growth trends and fire occurrence patterns continue, these areas will continue to challenge policies and management efforts seeking to balance the risks generated by wildfires with the ecological benefits of fire.

Woodlands and Rangelands

Alofs, Karen M., and Norma L. Fowler. 2013. Loss of native herbaceous species due to woody plant encroachment facilitates the establishment of an invasive grass. Ecology 94:751–760. http://dx.doi.org/10.1890/12-0732.1

Abstract. Although negative relationships between diversity (frequently measured as species richness) and invasibility at neighborhood or community scales have often been reported, realistic natural diversity gradients have rarely been studied at this scale. We recreated a naturally occurring gradient in species richness to test the effects of species richness on community invasibility. In central Texas savannas, as the proportion of woody plants increases (a process known as woody plant encroachment), herbaceous habitat is both lost and fragmented, and native herbaceous species richness declines. We examined the effects of these species losses on invasibility in situ by removing species that occur less frequently in herbaceous patches as woody plant encroachment advances. This realistic species removal was accompanied by a parallel and equivalent removal of biomass with no changes in species richness. Over two springs, the nonnative bunchgrass *Bothriochloa ischaemum* germinated significantly more often in the biomass-removal treatment than in unmanipulated control plots, suggesting an effect of native plant density independent of diversity. Additionally, significantly more germination occurred in the species-removal treatment than in the biomass-removal treatment. Changes in species richness had a stronger effect on *B. ischaemum* germination than changes in plant density, demonstrating that niche-related processes contributed more to biotic resistance in this system than did species-neutral competitive interactions. Similar treatment effects were found on transplant growth. Thus we show that woody plant encroachment indirectly facilitates the establishment of an invasive grass by reducing native diversity. Although we found a negative relationship between species richness and invasibility at the scale of plots with similar composition and environmental conditions, we found a positive relationship between species richness and invasibility at larger scales. This apparent paradox is consistent with reports from other systems and may be the result of variation in environmental factors at larger scales similarly influencing both invasibility and richness. The habitat loss and fragmentation associated with woody plant encroachment are two of many processes that commonly threaten biodiversity, including climate change. Many of these processes are similarly likely to increase invasibility via their negative effects on native diversity.

Bukowski, Beth E., and William L. Baker. 2013. Historical fire regimes, reconstructed from land-survey data, led to complexity and fluctuation in sagebrush landscapes. Ecological Applications 23:546–564. http://dx.doi.org/10.1890/12-0844.1

Abstract. Sagebrush landscapes provide habitat for Sage-Grouse and other sagebrush obligates, yet historical fire regimes and the structure of historical sagebrush landscapes are poorly known, hampering ecological restoration and management. To remedy this, General Land Office Survey (GLO) survey notes were used to reconstruct over two million hectares of historical vegetation for four sagebrush-dominated (*Artemisia* spp.) study areas in the western United States. Reconstructed vegetation was analyzed for fire indicators used to identify historical fires and reconstruct historical fire regimes. Historical fire-size distributions were inverse-J shaped, and one fire >100 000 ha was identified. Historical fire rotations were estimated at 171–342 years for Wyoming big sagebrush (*A. tridentata* ssp. *wyomingensis*) and 137–217 years for mountain big sagebrush (*A. tridentata* ssp. *vaseyana*). Historical fire and patch sizes were significantly larger in Wyoming big sagebrush than mountain big sagebrush, and historical fire rotations were significantly longer in Wyoming big sagebrush than mountain big sagebrush. Historical fire rotations in Wyoming were longer than those in other study areas. Fine-scale mosaics of burned and unburned area and larger unburned inclusions within fire perimeters were less common than in modern fires. Historical sagebrush landscapes were dominated by large, contiguous areas of sagebrush, though large grass-dominated areas and finer-scale mosaics of grass and sagebrush were also present in smaller amounts. Variation in sagebrush density was a common source of patchiness, and areas classified as "dense" made up 24.5% of total sagebrush area, compared to 16.3% for "scattered" sagebrush. Results suggest significant differences in historical and modern fire regimes. Modern fire rotations in Wyoming big sagebrush are shorter than historical fire rotations. Results also suggest that historical sagebrush landscapes would have fluctuated, because of infrequent episodes of large fires and long periods of recovery and maturity. Due to fragmentation of sagebrush landscapes, the large, contiguous expanses of sagebrush that dominated historically are most at risk and in need of conservation, including both dense and scattered sagebrush. Fire suppression in Wyoming big sagebrush may also be advisable, as modern fire rotations are shorter than their historical counterparts.