Fire and Fuels Science Quarterly: Fall 2013

Abstracts of Recent Papers in Fire Ecology and Fuels Management

Compiled by Craig Goodell, Fire Ecologist, USFS Pacific Northwest Region, Portland, OR

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Aquatic Wildlife

HOSSACK, BLAKE R., WINSOR H. LOWE and PAUL STEPHEN CORN, 2013. Rapid Increases and Time-Lagged Declines in Amphibian Occupancy after Wildfire. Conservation Biology Volume 27, Issue 1, February 2013, Pages: 219–228, Article first published online: 14 SEP 2012, DOI: 10.1111/j.1523-1739.2012.01921

Abstract. *Climate change is expected to increase the frequency and severity of drought and wildfire. Aquatic and moisture-sensitive species, such as amphibians, may be particularly vulnerable to these modified disturbance regimes because large wildfires often occur during extended droughts and thus may compound environmental threats. However, understanding of the effects of wildfires on amphibians in forests with long fire-return intervals is limited. Numerous stand-replacing wildfires have occurred since 1988 in Glacier National Park (Montana, U.S.A.), where we have conducted long-term monitoring of amphibians. We measured responses of 3 amphibian species to fires of different sizes, severity, and age in a small geographic area with uniform management. We used data from wetlands associated with 6 wildfires that burned between 1988 and 2003 to evaluate whether burn extent and severity and interactions between wildfire and wetland isolation affected the distribution of breeding populations. We measured responses with models that accounted for imperfect detection to estimate occupancy during prefire (0–4 years) and different postfire recovery periods. For the long-toed salamander (*Ambystoma macrodactylum*) and Columbia spotted frog (*Rana luteiventris*), occupancy was not affected for 6 years after wildfire. But 7–21 years after wildfire, occupancy for both species decreased ≥25% in areas where >50% of the forest within 500 m of wetlands burned. In contrast, occupancy of the boreal toad (*Anaxyrus boreas*) tripled in the 3 years after low-elevation forests burned. This increase in occupancy was followed by a gradual decline. Our results show that accounting for magnitude of change and time lags is critical to understanding population dynamics of amphibians after large disturbances. Our results also inform understanding of the potential threat of increases in wildfire frequency or severity to amphibians in the region*.

Climate Change and Carbon Management

Beever, Erik A., S. Z. Dobrowski, J. Long, A. R. Mynsberge, and N. B. Piekielek, 2013. Understanding relationships among abundance, extirpation, and climate at ecoregional scales. Ecology 94:1563–1571. http://dx.doi.org/10.1890/12-2174.1

Abstract. Recent research on mountain-dwelling species has illustrated changes in species' distributional patterns in response to climate change. Abundance of a species will likely provide an earlier warning indicator of change than will occupancy, yet relationships between abundance and climatic factors have received less attention. We tested whether predictors of counts of American pikas (*Ochotona princeps*) during surveys from the Great Basin region in 1994–1999 and 2003–2008 differed between the two periods. Additionally, we tested whether various modeled

aspects of ecohydrology better predicted relative density than did average annual precipitation, and whether risk of site-wide extirpation predicted subsequent population counts of pikas. We observed several patterns of change in pika abundance at range edges that likely constitute early warnings of distributional shifts. Predictors of pika abundance differed strongly between the survey periods, as did pika extirpation patterns previously reported from this region. Additionally, maximum snowpack and growing-season precipitation resulted in better-supported models than those using average annual precipitation, and constituted two of the top three predictors of pika density in the 2000s surveys (affecting pikas perhaps via vegetation). Unexpectedly, we found that extirpation risk positively predicted subsequent population size. Our results emphasize the need to clarify mechanisms underlying biotic responses to recent climate change at organism-relevant scales, to inform management and conservation strategies for species of concern.

Munson, Seth M., 2013. Plant responses, climate pivot points, and trade-offs in water-limited ecosystems. Ecosphere 4:art109. http://dx.doi.org/10.1890/ES13-00132.1

Abstract. Plant species in dryland ecosystems are limited by water availability and may be vulnerable to increases in aridity. Methods are needed to monitor and assess the rate of change in plant abundance and composition in relation to climate, understand the potential for degradation in dryland ecosystems, and forecast future changes in plant species assemblages. I employ nearly a century of vegetation monitoring data from three North American deserts to demonstrate an approach to determine plant species responses to climate and critical points over a range of climatic conditions at which plant species shift from increases to decreases in abundance (climate pivot points). I assess these metrics from a site to regional scale and highlight how these indicators of plant performance can be modified by the physical and biotic environment. For example, shrubs were more responsive to drought and high temperatures on shallow soils with limited capacity to store water and fine-textured soils with slow percolation rates, whereas perennial grasses were more responsive to precipitation in sparse shrublands than in relatively dense grasslands and shrublands, where competition for water is likely more intense. The responses and associated climate pivot points of plant species aligned with their lifespan and structural characteristics, and the relationship between responses and climate pivot points provides evidence of the trade-off between the capacity of a plant species to increase in abundance when water is available and its drought resistance.

López-Hoffman, Laura, David D. Breshears, Craig D. Allen, and Marc L. Miller, 2013. Key landscape ecology metrics for assessing climate change adaptation options: rate of change and patchiness of impacts. Ecosphere 4:art101. http://dx.doi.org/10.1890/ES13-00118.1

Abstract. Under a changing climate, devising strategies to help stakeholders adapt to alterations to ecosystems and their services is of utmost importance. In western North America, diminished snowpack and river flows are causing relatively gradual, homogeneous (system-wide) changes in ecosystems and services. In addition, increased climate variability is also accelerating the incidence of abrupt and patchy disturbances such as fires, floods and droughts. This paper posits that two key variables often considered in landscape ecology—the rate of change and the degree of patchiness of change—can aid in developing climate change adaptation strategies. We use two examples from the "borderland" region of the southwestern United

States and northwestern Mexico. In piñon-juniper woodland die-offs that occurred in the southwestern United States during the 2000s, ecosystem services suddenly crashed in some parts of the system while remaining unaffected in other locations. The precise timing and location of die-offs was uncertain. On the other hand, slower, homogeneous change, such as the expected declines in water supply to the Colorado River delta, will likely impact the entire ecosystem, with ecosystem services everywhere in the delta subject to alteration, and all users likely exposed. The rapidity and spatial heterogeneity of faster, patchy climate change exemplified by tree die-off suggests that decision-makers and local stakeholders would be wise to operate under a Rawlsian "veil of ignorance," and implement adaptation strategies that allow ecosystem service users to equitably share the risk of sudden loss of ecosystem services before actual ecosystem changes occur. On the other hand, in the case of slower, homogeneous, system-wide impacts to ecosystem services as exemplified by the Colorado River delta, adaptation strategies can be implemented after the changes begin, but will require a fundamental rethinking of how ecosystems and services are used and valued. In sum, understanding how the rate of change and degree of patchiness of change will constrain adaptive options is a critical consideration in preparing for climate change.

Cross, M. S., McCarthy, P. D., Garfin, G., Gori, D. and Enquist, C. A.F., 2013. Accelerating Adaptation of Natural Resource Management to Address Climate Change. Conservation Biology, 27: 4–13. doi: 10.1111/j.1523-1739.2012.01954.x

Abstract. *Natural resource managers are seeking tools to help them address current and future effects of climate change. We present a model for collaborative planning aimed at identifying ways to adapt management actions to address the effects of climate change in landscapes that cross public and private jurisdictional boundaries. The Southwest Climate Change Initiative (SWCCI) piloted the Adaptation for Conservation Targets (ACT) planning approach at workshops in 4 southwestern U.S. landscapes. This planning approach successfully increased participants' self-reported capacity to address climate change by providing them with a better understanding of potential effects and guiding the identification of solutions. The workshops fostered cross-jurisdictional and multidisciplinary dialogue on climate change through active participation of scientists and managers in assessing climate change effects, discussing the implications of those effects for determining management goals and activities, and cultivating opportunities for regional coordination on adaptation of management plans. Facilitated application of the ACT framework advanced group discussions beyond assessing effects to devising options to mitigate the effects of climate change on specific species, ecological functions, and ecosystems. Participants addressed uncertainty about future conditions by considering more than one climate-change scenario. They outlined opportunities and identified next steps for implementing several actions, and local partnerships have begun implementing actions and conducting additional planning. Continued investment in adaptation of management plans and actions to address the effects of climate change in the southwestern United States and extension of the approaches used in this project to additional landscapes are needed if biological diversity and ecosystem services are to be maintained in a rapidly changing world*.

Fire Behavior and Fuels

Scott, Joe H.; Thompson, Matthew P.; Calkin, David E., 2013. A wildfire risk assessment framework for land and resource management. Gen. Tech. Rep. RMRS-GTR-315. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 p.

Abstract. Wildfires can result in significant, long-lasting impacts to ecological, social, and economic systems. It is necessary, therefore, to identify and understand the risks posed by wildland fire, and to develop cost-effective mitigation strategies accordingly. This report presents a general framework with which to assess wildfire risk and explore mitigation options, and illustrates a process for implementing the framework. Two key strengths of the framework are its flexibility—allowing for a multitude of data sources, modeling techniques, and approaches to measuring risk—and its scalability, with potential application for project, forest, regional, and national planning. The specific risk assessment process we introduce is premised on three modeling approaches to characterize wildfire likelihood and intensity, fire effects, and the relative importance of highly valued resources and assets that could be impacted by wildfire. The spatial scope of the process is landscape-scale, and the temporal scope is short-term (that is, the temporal dynamics of succession and disturbance are not simulated). We highlight key information needs, provide guidance for use of fire simulation models and risk geo-processing tools, and demonstrate recent applications of the framework across planning scales. The aim of this report is to provide fire and land managers with a helpful set of guiding principles and tools for assessing and mitigating wildfire risk.

Andrews, Patricia L., 2013. *Current status and future needs of the BehavePlus Fire Modeling System. International Journal of Wildland Fire* http://dx.doi.org/10.1071/WF12167 Submitted: 5 October 2012. Accepted: 16 April 2013. Published online: 6 September 2013.

Abstract. The BehavePlus Fire Modeling System is among the most widely used systems for wildland fire prediction. It is designed for use in a range of tasks including wildfire behaviour prediction, prescribed fire planning, fire investigation, fuel hazard assessment, fire model understanding, communication and research. BehavePlus is based on mathematical models for fire behaviour, fire effects and fire environment. It is a point system for which conditions are constant for each calculation, but is designed to encourage examination of the effect of a range of conditions through tables and graphs. BehavePlus is successor to BEHAVE, which was developed in 1977 and became available for field application in 1984. It was updated to BehavePlus in 2002. Updates through version 5 have added features and modelling capabilities. It is becoming increasingly difficult to expand the system. A redesign will address the need for consolidation with other systems and make it easier to incorporate new research results. This paper describes the development history and application of BehavePlus. The design, features and modelling foundation of the current system are described. Considerations for the next generation are presented.

Stevens-Rumann, Camille, Kristen Shive, Peter Fulé and Carolyn H. Sieg, 2013. Pre-wildfire fuel reduction treatments result in more resilient forest structure a decade after wildfire. *International Journal of Wildland Fire* - http://dx.doi.org/10.1071/WF12216 Submitted: 14 December 2012. Accepted: 30 April 2013. Published online: 15 August 2013

Abstract. Increasing size and severity of wildfires have led to an interest in the effectiveness of forest fuels treatments on reducing fire severity and post-wildfire fuels. Our objective was to contrast stand structure and surface fuel loadings on treated and untreated sites within the 2002 Rodeo–Chediski Fire area. Data from 140 plots on seven paired treated–untreated sites indicated that pre-wildfire treatments reduced fire severity compared with untreated sites. In 2011, coarse woody debris loading (woody material >7.62 cm in diameter) was 257% higher and fine woody debris (woody material <7.62 cm) was 152% higher on untreated sites than on treated sites. Yet, in spite of higher levels of coarse woody debris on untreated sites, loadings did not exceed recommended ranges based on published literature and many treated sites fell below recommendations. By 2011, basal area and stand density on treated sites and stand density on untreated sites met management guidelines for ponderosa pine forests, but untreated sites had basal areas well below recommendations. Snags declined over this period and only three plots had snags that met minimum size and density requirements for wildlife habitat by 2011. The effects of pre-wildfire treatments are long-lasting and contribute to changes in both overstorey and understorey fuel complexes.

Chung, Woodam, Greg Jones, Kurt Krueger, Jody Bramel and Marco Contreras, 2013. Optimising fuel treatments over time and space. *International Journal of Wildland Fire* - http://dx.doi.org/10.1071/WF12138 Submitted: 20 August 2012. Accepted: 29 April 2013. Published online: 25 July 2013.

Abstract. Fuel treatments have been widely used as a tool to reduce catastrophic wildland fire risks in many forests around the world. However, it is a challenging task for forest managers to prioritise where, when and how to implement fuel treatments across a large forest landscape. In this study, an optimisation model was developed for long-term fuel management decisions at a landscape scale. Using a simulated annealing algorithm, the model optimises locations and timing of fuel treatments, while considering changes in forest dynamics over time, fire behaviour and spread, values at risk, and operational feasibility. The model employs the Minimum Travel Time algorithm in FlamMap and the Fire and Fuels Extension to the Forest Vegetation Simulator to assess spatial and temporal effects with and without fuel treatments. The objective function is set to minimise total expected loss from a landscape due to wildfires throughout the planning horizon. The model was applied to a 14 000-ha study landscape located on the west side of the Bitterroot Valley in Montana. Comparisons between the optimised and random solutions show that the model was able to strategically locate and schedule fuel treatments to efficiently reduce expected loss from the landscape.

Forests

Tepley, Alan J., Frederick J. Swanson, and Thomas A. Spies, 2013. Fire-mediated pathways of stand development in Douglas-fir/western hemlock forests of the Pacific Northwest, USA. Ecology 94:1729–1743. http://dx.doi.org/10.1890/12-1506.1

Abstract. Forests dominated by Douglas-fir and western hemlock in the Pacific Northwest of the United States have strongly influenced concepts and policy concerning old-growth forest conservation. Despite the attention to their old-growth characteristics, a tendency remains to view their disturbance ecology in relatively simple terms, emphasizing infrequent, stand-replacing (SR) fire and an associated linear pathway toward development of those old-growth characteristics. This study uses forest stand- and age-structure data from 124 stands in the central western Cascades of Oregon to construct a conceptual model of stand development under the mixed-severity fire regime that has operated extensively in this region. Hierarchical clustering of variables describing the age distributions of shade-intolerant and shade-tolerant species identified six groups, representing different influences of fire frequency and severity on stand development. Douglas-fir trees >400 years old were found in 84% of stands, yet only 18% of these stands (15% overall) lack evidence of fire since the establishment of these old trees, whereas 73% of all stands show evidence of at least one non-stand-replacing (NSR) fire. Differences in fire frequency and severity have contributed to multiple development pathways and associated variation in contemporary stand structure and the successional roles of the major tree species. Shade-intolerant species form a single cohort following SR fire, or up to four cohorts per stand in response to recurring NSR fires that left living trees at densities up to 45 trees/ha. Where the surviving trees persist at densities of 60–65 trees/ha, the postfire cohort is composed only of shade-tolerant species. This study reveals that fire history and the development of old-growth forests in this region are more complex than characterized in current stand-development models, with important implications for maintaining existing old-growth forests and restoring stands subject to timber management.

Halpern, Charles B. and James A. Lutz, 2013. Canopy closure exerts weak controls on understory dynamics: a 30-year study of overstory–understory interactions. Ecological Monographs 83:221–237. http://dx.doi.org/10.1890/12-1696.1

Abstract. Stem exclusion and understory reinitiation are commonly described, but poorly understood, stages of forest development. It is assumed that overstory trees exert strong controls on understory herbs and shrubs during the transition from open- to closed-canopy forests, but long-term observations of this process are rare. We use long-term data from 188 plots to explore patterns and correlates of variation in understory richness and abundance 15–45 years after clear-cut logging and burning of two experimental watersheds in western Oregon, USA. We test whether variation in the temporal dynamics of plots can be explained by topoedaphic factors that influence resource availability (insolation and soil moisture), variation in the pace and intensity of overstory development, or characteristics of the vegetation prior to canopy closure. Changes in forest structure were substantial over the study period; canopy cover increased fourfold, stem density by 75%, and bole biomass by two orders of magnitude, although trends were highly variable among individual plots. In contrast, understory richness, foliar cover, and biomass declined only 30–

40%, driven by loss of early-seral colonists, not residual forest species. Canopy closure occurred earlier on north aspects but declines in understory biomass, reflecting loss of colonizing shrubs (without concomitant increases in forest shrubs), were limited to south aspects. In contrast, variation in effective soil moisture had little influence on the pace of decline. Temporal trends were highly asynchronous among plots: nearly 50% of plots experienced some form of decline, but >35% showed no discernible trend. Declines were more likely in plots with greater tree influence before or at peak overstory development, but also in plots with greater understory development prior to canopy closure. Quantile regression models indicated weak relationships between understory biomass and overstory structure at most points in time. Our long-term data support a model of understory dynamics in which characteristics of the pre-closure vegetation are as important as overstory structure in determining the timing and nature of decline. Long-term studies are critical for elucidating patterns and processes that cannot be inferred from short-term experiments or space-for-time substitutions.

Godoy, Maria M., Guillermo E. Defossé , Lucas O. Bianchi, Miguel M. Davel and Tomás E. Withington, 2013. Fire-caused tree mortality in thinned Douglas-fir stands in Patagonia, Argentina. *International Journal of Wildland Fire* 22(6) 810-814 http://dx.doi.org/10.1071/WF12107 Submitted: 21 December 2012. Accepted: 8 January 2013. Published: 2 May 2013.

Abstract. In 2003 in a municipal park near Esquel, Patagonia, Argentina, plots within a 21-year-old Douglas-fir (*Pseudotsuga menziesii*) afforested area were subjected to three silvicultural treatments (thinning to Reineke's Stand Density Index (SDI) of 900, 700, 500). In March 2007 all plots were burned by a wildfire that presented extreme fire behaviour. Three weeks after the wildfire we assessed mortality, height of scorch and percentage of crown scorch, and during three subsequent growing seasons we measured mortality and growth parameters. At the end of the study, mortality differed significantly among treatments and an untreated control, and ranged from 100% in the untreated control to 25, 10 and 5% in the SDI 900, 700 and 500 treatments. The highest growth parameters and lower mortality rates were achieved at SDI indices of 700 or 500 (i.e. in the least dense plots). Trees thinned to these densities not only appear to withstand extreme fires, at least under the conditions presented, but also to achieve the highest growth rates.

Houtman, Rachel M., Claire A. Montgomery, Aaron R. Gagnon, David E. Calkin, Thomas G. Dietterich, Sean McGregor and Mark Crowley, 2013. Allowing a wildfire to burn: estimating the effect on future fire suppression costs. *International Journal of Wildland Fire* http://dx.doi.org/10.1071/WF12157 Submitted: 22 September 2012. Accepted: 18 January 2013. Published online: 9 May 2013.

Abstract. Where a legacy of aggressive wildland fire suppression has left forests in need of fuel reduction, allowing wildland fire to burn may provide fuel treatment benefits, thereby reducing suppression costs from subsequent fires. The least-cost-plus-net-value-change model of wildland fire economics includes benefits of wildfire in a framework for evaluating suppression options. In this study, we estimated one component of that benefit – the expected present value of the reduction in suppression costs for subsequent fires arising from the fuel treatment effect of a current fire. To that end, we employed Monte Carlo methods to generate a set of scenarios for subsequent fire ignition and weather events, which are referred to as sample paths, for a study area in central Oregon. We simulated fire on the landscape

over a 100-year time horizon using existing models of fire behaviour, vegetation and fuels development, and suppression effectiveness, and we estimated suppression costs using an existing suppression cost model. Our estimates suggest that the potential cost savings may be substantial. Further research is needed to estimate the full least-cost-plus-net-value-change model. This line of research will extend the set of tools available for developing wildfire management plans for forested landscapes.

Postfire Recovery

Herron, Christopher M., Jayne L. Jonas, Paul J. Meiman and Mark W. Paschke, 2013. Using native annual plants to restore post-fire habitats in western North America. *International Journal of Wildland Fire* 22(6) 815-821 http://dx.doi.org/10.1071/WF11179 Submitted: 20 December 2011. Accepted: 19 January 2013. Published: 16 May 2013.

Abstract. Increasing fire frequencies and uncharacteristic severe fires have created a need for improved restoration methods across rangelands in western North America. Traditional restoration seed mixtures of native perennial mid- to late-seral plant species may not be suitable for intensely burned sites that have been returned to an early-seral condition. Under such conditions, native annual plant species are likely to be more successful at becoming established and competing with exotic annual plant species, such as *Bromus tectorum* L., for resources. We used a field study in Colorado and Idaho, USA, to test the hypothesis that native annual plant species are better suited to post-fire restoration efforts compared with perennial plant species that are commonly used in traditional seed mixtures. Replicated test plots at three post-fire sites were assigned one of four treatments: (1) native annual seed mixture, (2) standard perennial seed mixture, (3) combination of annual and perennial and (4) an unseeded control. Seeding native annuals with perennials resulted in a slight reduction in exotic plant cover, suggesting that it is potentially beneficial to include native annual plant species in restoration seed mixtures.

Gray, Erin C., and Patricia S. Muir, 2013. Does *Kochia prostrata* Spread From Seeded Sites? An Evaluation From Southwestern Idaho, USA. Rangeland Ecology & Management: March 2013, Vol. 66, No. 2, pp. 191-203. **doi:** http://dx.doi.org/10.2111/REM-D-11-00177.1

Abstract. Purposeful introductions of exotic species for rehabilitation efforts following wildfire are common on rangelands in the western United States, though ecological impacts of exotic species in novel environments are often poorly understood. One such introduced species, *Kochia prostrata* (L.) Schrad (forage kochia) has been seeded on over 200000 ha throughout the Intermountain West to provide fuel breaks and forage, and to compete with invasive plants. Despite its potential benefits, *K. prostrata* has been reported to spread from some seeded areas, and no studies have addressed its potential interactions with native species. A systematic investigation is needed to increase understanding of the extent to which *K. prostrata*spreads from seeded areas, the environmental conditions under which it spreads, and its interactions with the associated plant communities. We sampled 28 *K. prostrata* postfire rehabilitation and greenstrip seedings in southwestern Idaho, which ranged from 3 to 24 yr since seeding. We analyzed cover of *K. prostrata* and the associated plant community in adjacent seeded and unseeded areas, and quantified extent of spread from seeded areas. Abundance of *K. prostrata* was negatively associated with that of most plant functional groups,

including native species, but was positively associated with abundance of exotic annual forbs. *Kochia prostrata* spread to unseeded areas on 89% of sampled sites; distances of the farthest individual from the seeding boundary were greater than those previously reported, ranging from 0 to 710 m, with a mean distance of 208 m. Further, although the area covered by *K. prostrata* increased with time since seeding, we found no evidence that plant community composition affected spread of *K. prostrata*. Results contribute to current understanding of potential ecological implications of seeding *K. prostrata* and will enhance the ability of land managers to make scientifically based management decisions about its use.

Restoration

Sneeuwjagt, Rick J., Tim S. Kline, and Scott L. Stephens, 2013. Opportunities for Improved Fire Use and Management in California: Lessons from Western Australia. Fire Ecology Volume 9, Issue 2, 2013. doi:10.4996/fireecology.0902014.

Abstract. As the large scale of fuel treatments needed to promote ecosystem health and reduce heavy fuel loads becomes clear in California's mixed conifer forests, managers are beginning to focus on how to scale up prescribed fire use in order to treat a meaningful portion of the landscape. We look at the example of Western Australia's large-scale and highly successful prescribed burning program by their Department of Environment and Conservation as a model for emulation by land management agencies in California. Focusing on: 1) novel management practices, 2) inter-agency collaboration, 3) regulatory collaboration and policy, 4) research integration, 5) cultural acceptance, and 6) political support of prescribed fire, we make recommendations for a new approach to the management and regulation of fire use in California's mixed conifer forests.

Hickman, Laura K., Peggy Ann Desserud, Barry W. Adams and C. Cormack Gates, 2013. Effects of Disturbance on Silver Sagebrush Communities in Dry Mixed-Grass Prairie. *Ecological Rest. September 2013 31:274-282; doi:10.3368/er.31.3.274*

Abstract. Restoration specialists are increasingly interested in re-establishing silver sagebrush (Artemisia cana) communities due to the large number of wildlife species that are partial sagebrush obligates. Energy development within native grasslands can contribute to habitat loss through introduction of invasive species. In this study, pipeline and reclaimed well site footprints were assessed relative to undisturbed sample units to identify management practices that achieve effective restoration of silver sagebrush communities on disturbed sites. Our objectives were to compare silver sagebrush communities on energy disturbances with undisturbed areas in two ecological range sites in dry mixed-grass prairie: blowouts (hard-packed bare ground) and overflows (mesic sedimentation). Our hypothesis was that moisture, greater nutrient values, and potential seed banks found in overflows may benefit silver sagebrush growth. We were also interested in plant communities resulting from of various seeding treatments, hypothesizing that silver sagebrush may be negatively impacted by some seeding treatments. We used a paired transect design to measure variations in plant species cover in each ecological range type. We found similar silver sagebrush cover values to adjacent undisturbed areas following disturbances on both overflow and blowout ecological range types; however, silver sagebrush was significantly reduced in disturbed areas that were seeded with grass

species compared to sites that were allowed to recover naturally. We recommend minimum disturbance practices with natural recovery, avoidance of seeding agronomic cultivars, and in particular preventing introduction of invasive species such as crested wheatgrass.

Egan, Andrew and Vicky Estrada, 2013. Socio-Economic Indicators for Forest Restoration Projects. *Ecological Rest. September 2013 31:302-316; doi:10.3368/er.31.3.302*

Abstract. A model for assessing the socio-economic outcomes of forest restoration projects was developed. Using snowball sampling, eleven experts with backgrounds in the social, economic, and business aspects of forest restoration were identified and agreed to participate in the process. Four iterations of a Delphi process, an iterative approach that systematically aims to achieve consensus among a group of experts who remain anonymous to each other, resulted in a practical, robust model capable of evaluating the social and economic effects and outcomes of a wide range of forest restoration projects. Among the most highly rated indicators in the model were those related to job creation, community stability, economic impacts, and collaborative participation in restoration processes. The relative importance of the indicators was estimated and specific metrics were developed for each indicator in the model. Upon completion of the Delphi process, the model was discussed with forest restoration monitoring practitioners and stakeholders, who offered their perspectives from practitioners' points-of-view and helped to refine the model for a specific forest restoration program in New Mexico. The use of a Delphi process to develop socio-economic indicators for restoration projects may have utility in other, similar efforts. In addition, aspects of the model and the indicators developed by this study may be relevant for any forest restoration efforts with an interest in assessing a project's social and economic outcomes.

Davies, Kirk W., Chad S. Boyd, and Aleta M. Nafus, *2013*. Restoring the Sagebrush Component in Crested Wheatgrass–Dominated Communities. Rangeland Ecology & Management: July 2013, Vol. 66, No. 4, pp. 472-478. doi: http://dx.doi.org/10.2111/REM-D-12-00145.1

Abstract. Monotypic stands of crested wheatgrass (*Agropyron cristatum* [L] Gaertm. and *Agropyron desertorum* [Fisch.] Schult.), an introduced grass, occupy vast expanses of the sagebrush steppe. Efforts to improve habitat for sagebrush-associated wildlife by establishing a diverse community of native vegetation in crested wheatgrass stands have largely failed. Instead of concentrating on a diversity of species, we evaluated the potential to restore the foundation species, Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis* [Beetle & A. Young] S. L. Welsh), to these communities. We investigated the establishment of Wyoming big sagebrush into six crested wheatgrass stands (sites) by broadcast seeding and planting seedling sagebrush across varying levels of crested wheatgrass control with glyphosate. Planted sagebrush seedlings survived at high rates (~70% planted sagebrush survival 3 yr postplanting), even without crested wheatgrass control. However, most attempts to establish sagebrush by broadcast seeding failed. Only at high levels of crested wheatgrass control did a few sagebrush plants establish from broadcasted seed. Sagebrush density and cover were greater with planting seedlings than broadcast seeding. Sagebrush cover, height, and canopy area were greater at higher levels of crested wheatgrass control. High levels of crested wheatgrass control also created an opportunity for exotic annuals to increase. Crested wheatgrass rapidly recovered after glyphosate control treatments, which suggests multiple

treatments may be needed to effectively control crested wheatgrass. Our results suggest that planting sagebrush seedlings can structurally diversify monotypic crested wheatgrass stands to provide habitat for sagebrush-associated wildlife. Though this is not the full diversity of native functional groups representative of the sagebrush steppe, it is a substantial improvement over other efforts that have largely failed to alter these plant communities. We also hypothesize that planting sagebrush seedlings in patches or strips may provide a relatively inexpensive method to facilitate sagebrush recovery across vast landscapes where sagebrush has been lost.

Soils

Busse, Matt D., Carol J. Shestak and Ken R. Hubbert, 2013. Soil heating during burning of forest slash piles and wood piles. *International Journal of Wildland Fire* 22(6) 786-796 http://dx.doi.org/10.1071/WF12179 Submitted: 25 October 2012. Accepted: 17 January 2013. Published: 20 May 2013.

Abstract. Pile burning of conifer slash is a common fuel reduction practice in forests of the western United States that has a direct, yet poorly quantified effect on soil heating. To address this knowledge gap, we measured the heat pulse beneath hand-built piles ranging widely in fuel composition and pile size in sandy-textured soils of the Lake Tahoe Basin. The soil heat pulse depended primarily on fuel composition, not on pile size. Burn piles dominated by large wood produced extreme temperatures in soil profile, with lethal heating lasting up to 3 days. In contrast, the heat pulse was moderate beneath piles containing a mixture of fuel sizes. Considerable spatial variability was noted, as soil temperatures were generally greatest near pile centres and decline sharply toward the pile edges. Also, saturating pile burns with water 8 h after ignition ('mopping up') effectively quenched the soil heat pulse while allowing near-complete fuel consumption. The findings suggest that burning of hand piles will not result in extreme or extensive soil heating except for uncommon conditions when piles are dominated by large wood and occupy a high percentage of the ground surface.

Santín C., S. H. Doerr, C. Preston and R. Bryant, 2013. Consumption of residual pyrogenic carbon by wildfire. *International Journal of Wildland Fire* - http://dx.doi.org/10.1071/WF12190 Submitted: 15 November 2012. Accepted: 25 April 2013. Published online: 13 August 2013.

Abstract. Pyrogenic carbon (PyC) produced during vegetation fires represents one of the most degradation resistant organic carbon pools and has important implications for the global carbon cycle. Its long-term fate in the environment and the processes leading to its degradation are the subject of much debate. Its consumption in subsequent fires is considered a potential major mechanism of abiotic PyC degradation; however, no quantitative data supporting this removal pathway have been published to date. To address this gap, we quantified consumption of residual PyC at the forest floor during an experimental fire, representative of a typical boreal wildfire, complemented by exploratory laboratory heating experiments. Labelled PyC (pinewood charcoal from a slash pile burn), in granular form contained in stainless steel mesh bags and as individual pieces, were placed at ~2-cm depth within the forest floor. The median mass loss of granular charcoal was 6.6%, with 75% of the samples losing <15%, and of individual pieces 15.1% with 75% of the samples losing <25%. The mass losses under laboratory

conditions, although somewhat higher than in the field, confirm an overall low consumption of PyC. The limited losses of PyC found here do not support the widely held notion that wildfire is a major cause of loss for residual PyC.

Gómez-Rey, M. X., S. García-Marco, C. Fernández , A. Couto-Vázquez and S. J. González-Prieto, 2013. Effects of post-fire soil stabilisation techniques on trace elements lost by erosion. *International Journal of Wildland Fire* - http://dx.doi.org/10.1071/WF12196 Submitted: 20 November 2012. Accepted: 5 June 2013. Published online: 10 September 2013.

Abstract. The effect of two post-fire stabilisation techniques (Seeding and Mulching) on trace element (Al, B, Co, Cu, Fe, Mn, Mo and Zn) losses with eroded sediments was evaluated over a 13-month period following an experimental fire in a steep shrubland of a temperate-humid region (north-west Spain). With time, concentration of extractable Mn, Zn and Cu in sediments decreased, Fe tended to increase and Al, Co, B and Mo varied without a clear trend. Most sediments and trace element losses occurred during the first 3 months post-fire. Compared with the available elements in ash + burned topsoil, the fraction lost with sediments was highest for Mo (10–16%), intermediate for Mn (4%) and Zn (3%) and low for the rest (0.4–1.2%). Although minor effects of stabilisation techniques on element concentrations were found, accumulated mass losses of trace elements decreased 6–12 times in Mulching because of its 10-fold lower soil erosion rate; no significant changes were found in Seeding. Sediment nutrient losses are probably more important than those published for smoke, leaching or volatilisation. Our results suggest that the Zn and Cu enrichment in sediments from the first erosion events increase the risk of downslope water and soil contamination. In conclusion, soil stabilisation techniques are useful to prevent post-fire ecosystem damage.

Heckman, Katherine, John Campbell, Heath Powers, Beverly Law and Chris Swanston, 2013. THE INFLUENCE OF FIRE ON THE RADIOCARBON SIGNATURE AND CHARACTER OF SOIL ORGANIC MATTER IN THE SISKIYOU NATIONAL FOREST, OREGON, USA. *Fire Ecology Volume 9, Issue 2, 2013.doi:10.4996/fireecology.0902040*

Abstract. Forest fires contribute a significant amount of CO2 to the atmosphere each year, and CO2 emissions from fires are likely to increase under projected conditions of global climate change. In addition to volatilizing aboveground biomass and litter layers, forest fires have a profound effect on belowground carbon (C) pools and the cycling of soil organic matter as a whole. However, the influence of fire on belowground organic matter cycling is not well defined and varies widely with fire severity. We measured soil organic matter (SOM) characteristics across a range of fire severities two years after the 2002 Biscuit Fire in southwest Oregon, USA, to address the following questions: (1) Which C pools are preferentially volatilized or transformed to charcoal under low-se verity and high-severity fire? (2) How does fire change the distribution of SOM among density fractions and depths? (3) How does fire affect the general character of SOM including such variables as abundance, C:N ratio, 13C abundance, and 14C abundance? We examined soils from a mixed hardwood-evergreen forest across a range of burn severities: unburned, low severity, mixed severity, and high severity. Results indicated that increasing burn severity led to progressive loss of forest floor mass, but not to progressive loss of C from the mineral soil. Although fire significantly increased the charcoal content of the soils, fire did not significantly change the distribution of soil organic matter between heavy and free or light fractions. Other significant changes in soil organic matter

characteristics included a progressive increase in nitrogen (N) with increasing burn severity, possibly due to the encroachment of N-fixing shrubs following the loss of native vegetation. Although qualitative changes in total root abundance following fire were noted, differences among burn severity treatments were not statistically significant. Increased concentrations of rock fragments in burned areas may be suggestive of erosion in these areas, consistent with previous studies documenting varying degrees of soil erosion following fire. In addition, although 13C abundances were similar among severely burned and unburned plots, soils from severely burned plots were significantly depleted in 14C in comparison to soils from unburned plots. This 14C depletion is most likely the combined result of erosion and preferential combustion of organics enriched in 14C relative to the bulk soil, perhaps reflecting a historical pattern of fire occurrence and severity across the landscape.

Terrestrial Wildlife

Baruch-Mordo, Sharon, Jeffrey S. Evans, John P. Severson, David E. Naugle, Jeremy D. Maestas, Joseph M. Kiesecker, Michael J. Falkowski, Christian A. Hagen, Kerry P. Reese, 2013. Saving sage-grouse from the trees: A proactive solution to reducing a key threat to a candidate species. Biological Conservation 167 (2013) 233–241.

Abstract. Conservation investment in management of at-risk species can be less costly than a delay-and-repair approach implemented after species receive legal protection. The United States Endangered Species Act candidate species designation represents an opportunity to implement proactive management to avoid future listing. Such efforts require substantial investments, and the challenge becomes one of optimization of limited conservation funds to maximize return. Focusing on conifer encroachment threats to greater sage-grouse (*Centrocercus urophasianus*), we demonstrated an approach that links species demographics with attributes of conservation threats to inform targeting of investments. We mapped conifer stand characteristics using spatial wavelet analysis, and modeled lek activity as a function of conifer-related and additional lek site covariates using random forests. We applied modeling results to identify leks of high management potential and to estimate management costs. Results suggest sage-grouse incur population-level impacts at very low levels of encroachment, and leks were less likely to be active where smaller trees were dispersed. We estimated costs of prevention (treating active leks in jeopardy) and restoration (treating inactive leks with recolonization potential) management across the study area (2.5 million ha) at a total of US$17.5 million, which is within the scope of landscape-level conservation already implemented. An annual investment of US$8.75 million can potentially address encroachment issues near all known Oregon leks within the next decade. Investments in proactive conservation with public and private landowners can increase ecosystem health to benefit species conservation and sustainable land uses, replace top-down regulatory approaches, and prevent conservation reliance of at-risk species.

Talluto, Matt V. and Craig W. Benkman, 2013. Landscape-scale eco-evolutionary dynamics: Selection by seed predators and fire determine a major reproductive strategy. Ecology 94:1307–1316. http://dx.doi.org/10.1890/12-2058.1.

Abstract. Recent work in model systems has demonstrated significant effects of rapid evolutionary change on ecological processes (eco-evolutionary dynamics).

Fewer studies have addressed whether eco-evolutionary dynamics structure natural ecosystems. We investigated variation in the frequency of serotiny in lodgepole pine (*Pinus contorta*), a widespread species in which postfire seedling density and ecosystem structure are largely determined by serotiny. Serotiny, the retention of mature seeds in cones in a canopy seed bank, is thought to be an adaptation for stand-replacing fire, but less attention has been paid to the potential selective effects of seed predation on serotiny. We hypothesized that spatial variation in percentage serotiny in lodgepole pine forests results from an eco-evolutionary dynamic where the local level of serotiny depends on the relative strengths of conflicting directional selection from fire (favoring serotiny) and seed predation (favoring cones that open at maturity). We measured percentage serotiny, the abundance of American red squirrels (*Tamiasciurus hudsonicus*; the primary pre-dispersal seed predator of lodgepole pine), and several measures of forest structure in Yellowstone National Park, USA. Fire frequency strongly predicted the frequency of serotiny, a pattern that is well-supported in the literature. At sites with high fire frequency (return intervals of ~135–185 years) where fire favors increased serotiny, squirrel abundance was negatively associated with serotiny, suggesting that selection from predation can overwhelm selection from fire when squirrels are abundant. At sites with low fire frequency (return intervals of ~280–310 years), serotiny was nearly universally uncommon (<10%). Finally, forest structure strongly predicted squirrel density independently of serotiny, and serotiny provided no additional explanatory power, suggesting that the correlation is caused by selection against serotiny exerted by squirrels, rather than squirrels responding to variation in percentage serotiny.

Hollenbeck, J. P., Bate, L. J., Saab, V. A. and Lehmkuhl, J. F., 2013. Snag distributions in relation to human access in ponderosa pine forests. Wildlife Society Bulletin, 37: 256–266. doi: 10.1002/wsb.252

Abstract. Ponderosa pine (*Pinus ponderosa*) forests in western North America provide habitat for numerous cavity-using wildlife species that often select large-diameter snags for nesting and roosting. Yet large snags are often removed for their commercial and firewood values. Consequently we evaluated effects of human access on snag densities and diameter-class distributions at nine locations in ponderosa pine forests throughout the interior western United States. We found no relationship between small-diameter (23–50 cm diam breast ht [dbh]) snags and human access measures (i.e., road density, distance to nearest town, and topography). However, large-snag (≥50 cm dbh) density was best predicted by road density, which suggested a decline, on average, of 0.7 large snags/ha for every km of road/km^2. Most locations had relatively high densities of small-diameter snags (<23 cm dbh) and diminishing density as diameter class increased. Idaho and Colorado study locations had higher snag densities in the largest diameter classes compared with remaining locations. These locations experienced minimal commercial timber harvest, were situated far from towns, and had few or no roads. Persistence of large-diameter snags and adequate snag densities for wildlife requires consideration of human access characteristics at coarse spatial scales. Snag management guidelines may need to incorporate these measures and focus more on retention of large-diameter snags than minimum density targets.

Woods, Bonnie A., Janet L. Rachlow, Stephen C. Bunting, Timothy R. Johnson, and Kelly Bocking, *2013*. Managing High-Elevation Sagebrush Steppe: Do Conifer Encroachment and Prescribed Fire Affect Habitat for Pygmy Rabbits?. Rangeland Ecology & Management: July 2013, Vol. 66, No. 4, pp. 462-471. **doi:** http://dx.doi.org/10.2111/REM-D-12-00144.1

Abstract. Both fire and conifer encroachment can markedly alter big sagebrush communities and thus habitat quality and quantity for wildlife. We investigated how conifer encroachment and spring prescribed burning affected forage and cover resources for a sagebrush specialist, the pygmy rabbit. We studied these dynamics at spring prescribed burns in southwestern Montana and eastern Idaho during the summer of 2011. Within each spring prescribed burn, we established plots that described the habitat conditions for pygmy rabbits (forage plant biomass and habitat components that influence predation risk) in areas that were burned, adjacent areas of conifer encroachment, and areas that were neither burned nor encroached. We analyzed the data for significant differences in habitat conditions between the paired reference and encroachment plots and modeled when the burned areas would approximate the conditions on the paired reference plots. Biomass of forage plants and habitat components that reduce predation risk differed between undisturbed reference plots and areas that were either burned or encroached with >30% conifer canopy. Our models estimated that 13–27 yr were required for a spring prescribed burn to provide levels of cover and forage resources similar to sagebrush steppe reference plots. We documented that vegetation composition was associated with the plot designations (burn, reference, or conifer encroachment), but not with other abiotic factors, such as soil texture, aspect, or study site; this suggested that the documented differences in habitat were related to the treatments, rather than being site-specific characteristics. The information from this study can contribute to habitat management plans for high-elevation mountain big sagebrush sites where conifer encroachment is altering habitat for sagebrush-dependent wildlife species.

Watersheds and Hydrology

Malevich, Steven B., Connie A. Woodhouse, David M. Meko, 2013. Tree-ring reconstructed hydroclimate of the Upper Klamath basin. Journal of Hydrology Volume 495, 12 July 2013, Pages 13–22.

Abstract. This work presents the first tree-ring reconstructions of hydroclimate for the Upper Klamath River basin, which stretches from northern California into southern Oregon. The extended record provides a centuries-long perspective on the region's hydroclimatic variability and context for water-related political issues that have erupted in recent years. Reconstructions of water-year precipitation for Klamath Falls, Oregon (extending 1564–2004 and 1000–2010 CE) were developed to compare past drought severity with drought severity of the instrumental record (extending 1896–2011). The reconstructions suggest that variability exhibited during the instrumental period captures extremes of moderate-to-long-duration (6-, 10-, and 20-year) droughts, but not of short (single-year and 3-year) and very long (50-year) droughts, which were more severe during the 11th–13th centuries. The late-16th-century "mega drought" is present in the Klamath River basin, though with less strength than in the neighboring Sacramento River basin. Cool-season storm tracks appear to be a direct driver of hydroclimatic variability, leading to instances of see-saw like relationships with neighboring regions, such as in the mid-14th century. In

contrast, the larger area of drought in the 12th century is suggestive of a long-term northward shift in cool-season storm tracks

Wildland-Urban Interface

Jakes, Pamela J. and Victoria Sturtevant, 2013. Trial by fire: Community Wildfire Protection Plans put to the test. *International Journal of Wildland Fire* http://dx.doi.org/10.1071/WF12156 Submitted: 22 September 2012. Accepted: 30 April 2013. Published online: 13 August 2013.

Abstract. Research has found that community wildfire protection planning can make significant contributions to wildfire mitigation and preparedness, but can the planning process and resulting Community Wildfire Protection Plans make a difference to wildfire response and recovery? In case studies conducted in four USA communities with Community Wildfire Protection Plans in place when wildfires occurred, we saw a range of Community Wildfire Protection Plan projects designed to change the path and intensity of the wildfires. In most of our communities, the Community Wildfire Protection Plan and planning process improved relationships among firefighting agencies, clarified responsibilities and improved communication systems, contributing to fire response efficiency and effectiveness. We found that social learning resulting from the wildfire experience motivated communities to revisit and implement their Community Wildfire Protection Plans, changing the planning frame and scale and increasing the plan's relevance for response and recovery. We conclude that Community Wildfire Protection Plans and experience with wildfire can also result in greater community capacity that builds resilience and increases adaptive capacity for future environmental changes and disasters

Champ, Patricia A., Geoffrey H. Donovan and Christopher M. Barth, 2013. Living in a tinderbox: wildfire risk perceptions and mitigating behaviours. *International Journal of Wildland Fire* 22(6) 832-840 http://dx.doi.org/10.1071/WF12093 Submitted: 14 June 2012. Accepted: 23 January 2013. Published: 31 May 2013.

Abstract. The loss of homes to wildfires is an important issue in the USA and other countries. Yet many homeowners living in fire-prone areas do not undertake mitigating actions, such as clearing vegetation, to decrease the risk of losing their home. To better understand the complexity of wildfire risk-mitigation decisions and the role of perceived risk, we conducted a survey of homeowners in a fire-prone area of the front range of the Rocky Mountains in Colorado. We examine the relationship between perceived wildfire risk ratings and risk-mitigating behaviours in two ways. First, we model wildfire risk-mitigation behaviours as a function of perceived risk. Then, we model wildfire risk-mitigation behaviours and perceived risk simultaneously. The results of the simultaneous model suggest that perceived risk and wildfire risk-mitigating behaviours are jointly determined. By correctly specifying the relationship between risk perceptions and mitigating behaviours, we are better able to understand the relationship between other factors, such as exposure to a wildfire-mitigation program and wildfire risk-mitigating behaviours. We also find that having a wood roof, as well as homeowner age, income and previous experience with living in a fire-prone area, are associated with wildfire risk-mitigating behaviours.

Woodlands and Rangelands

Evers, Louisa B., Richard F. Miller and Paul S. Doescher, 2013. POTENTIAL EFFECTS OF DISTURBANCE TYPES AND ENVIRONMENTAL VARIABILITY ON SAGEBRUSH-STEPPE COMMUNITY DYNAMICS. *Fire Ecology Volume 9, Issue 2, 2013 doi: 10.4996/fireecology.0902057.*

Abstract. While fire is widely recognized as an important factor shaping sagebrush (*Artemisia* spp.) ecosystems, little is known about the role other natural events play in these systems. Using a state-and-transition modeling framework in conjunction with the scientific literature and data for climate (temperature, precipitation, and snow), soils (soil surveys and ecological site descriptions), and modern fire occurrence records, we explored how fire and various other natural events might shape sagebrush ecosystems in eastern Oregon, USA, and whether those events could affect fire rotation. Model results suggested other disturbance events were important in shaping all but the most productive sagebrush communities and influenced fire rotation in drier sagebrush communities. Insects and pronghorn browsing may have been as important as fire in shaping sagebrush-steppe landscapes with freezekill and snow mold locally important. Our study also demonstrated the use of climate, soils, ecological site, and fire occurrence data to derive probabilities of several natural events, providing a more objective approach to estimating reference conditions.

McAdoo, J. Kent, Brad W. Schultz, and Sherman R. Swanson, *2013*. Aboriginal Precedent for Active Management of Sagebrush-Perennial Grass Communities in the Great Basin. Rangeland Ecology & Management: May 2013, Vol. 66, No. 3, pp. 241-253. doi: http://dx.doi.org/10.2111/REM-D-11-00231.1

Abstract. Until recently, most contemporary ecologists have ignored or diminished anecdotal historical accounts and anthropologists' reports about aboriginal fire in the Great Basin. Literature review shows that Indians practiced regular use of fire for many purposes, including the obvious reasons of increasing the availability of desired plants, maintaining habitats for animals used as food, and driving game during hunts. Historical accounts of prehistoric anthropogenic firing, inferences from fire-scar data, and data regarding annual production capability of representative sagebrush (*Artemisia*spp.)-perennial grass ecological sites indicate that prehistoric conditions were neither fuel- nor ignition-limited. According to many sources, this "active management" by Indians was widespread, significant, and more common than lightning-caused fires, resulting in mosaic vegetation patterns that subsequently moderated the behavior of "natural fires." This interaction between Indian-burning and lightning fires may have strongly influenced the pre-Euro-American settlement vegetation of the Great Basin. At the very least, the landscape was a patchwork of areas altered by aboriginal people and areas shaped primarily by bio-physical processes. Based on this prehistoric precedent, current historically unprecedented conditions (fuel load and exotic weed invasion threats), and predicted climate change, contemporary active management of sagebrush-perennial grass communities is paramount. Restoration measures should be scientifically based and tailored to achieve ecological resilience and functionality in specific sites. Prescribed fire is not always ecologically appropriate or judicious, especially in Wyoming big sagebrush (*A. tridentata* spp. *wyomingensis*) communities, so managers should consider using other alternatives where an intentional low severity distubance is deemed necessary. Properly planned active management would disrupt fuel

continuity for lighthning fires, ensure ecological process and successional integrity, and benefit multiple uses on a landscape scale.

Bates, Jonathan D., Robert N. Sharp and Kirk W. Davies, 2013. Sagebrush steppe recovery after fire varies by development phase of *Juniperus occidentalis* woodland. *International Journal of Wildland Fire* - http://dx.doi.org/10.1071/WF12206 Submitted: 4 December 2012. Accepted: 19 June 2013. Published online: 10 September 2013.

Abstract. Woodland ecosystems of the world have been changed by land use demands, altered fire regimes, invasive species and climate change. Reduced fire frequency is recognised as a main causative agent for *Pinus–Juniperus* L. (piñon–juniper) expansion in North American woodlands. Piñon–juniper control measures, including prescribed fire, are increasingly employed to restore sagebrush steppe communities. We compared vegetation recovery following prescribed fire on Phase 2 (mid-succession) and Phase 3 (late-succession) *Juniperus occidentalis* Hook. (western juniper) woodlands in Oregon. The herbaceous layer on Phase 2 sites was comprised of native perennial and annual vegetation before and after fire. On Phase 3 sites the herbaceous layer shifted from native species to dominance by invasive *Bromus tectorum* L. (cheatgrass). After fire, shrubs on Phase 2 sites were comprised of sprouting species and *Ceanothus velutinus* Dougl. (snowbrush). On Phase 3 woodland sites the shrub layer was dominated by *C. velutinus.* The results suggest that Phase 2 sites have a greater likelihood of recovery to native vegetation after fire and indicate that sites transitioning from Phase 2 to Phase 3 woodlands cross a recovery threshold where there is a greater potential for invasive weeds, rather than native vegetation, to dominate after fire.

Evers, Louisa B., Richard F. Miller, Paul S. Doescher, Miles Hemstrom, and Ronald P. Neilson, 2013. Simulating Current Successional Trajectories in Sagebrush Ecosystems With Multiple Disturbances Using a State-and-Transition Modeling Framework. Rangeland Ecology & Management: May 2013, Vol. 66, No. 3, pp. 313-329.
doi: http://dx.doi.org/10.2111/REM-D-11-00220.1

Abstract. Disturbances and their interactions play major roles in sagebrush (*Artemisia* spp. L.) community dynamics. Although impacts of some disturbances, most notably fire, have been quantified at the landscape level, some have been ignored and rarely are interactions between disturbances evaluated. We developed conceptual state-and-transition models for each of two broad sagebrush groups—a warm-dry group characterized by Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) communities and a cool-moist group characterized by mountain big sagebrush (*Artemisia tridentata* Nutt. subsp. *vaseyana* [Rydb.] Beetle) communities. We used the Vegetation Dynamics Development Tool to explore how the abundance of community phases and states in each conceptual model might be affected by fire, insect outbreak, drought, snow mold, voles, sudden drops in winter temperatures (freeze-kill), livestock grazing, juniper (*Juniperus occidentalis* var. *occidentalis* Hook.) expansion, nonnative annual grasses such as cheatgrass (*Bromus tectorum* L.), and vegetation treatments. Changes in fuel continuity and loading resulted in average fire rotations of 12 yr in the warm-dry sagebrush group and 81 yr in the cool-moist sagebrush group. Model results in the warm-dry sagebrush group indicated postfire seeding success alone was not sufficient to limit the area of cheatgrass domination. The frequency of episodes of very high utilization by domestic livestock during severe drought was a

key influence on community phase abundance in our models. In the cool-moist sagebrush group, model results indicated at least 10% of the juniper expansion area should be treated annually to keep juniper in check. Regardless, juniper seedlings and saplings would remain abundant.