The Latest Science

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Forests and Woodlands

Bowles, Marlin L.; Jacobs, Karel A.; Mengler, Jeffrey L. 2007. Long-term changes in an oak forest's woody understory and herb layer with repeated burning. The Journal of the Torrey Botanical Society 134(2): 223-237.

Abstract. Although fire exclusion is thought to be linked with declining plant diversity in oak forests, few studies have examined long-term changes in their shrub and ground layers resulting from repeated burning. In this study, we compare the composition and structure of woody understory and ground layer vegetation in burned and unburned oak forest after 17 years of annual dormant season low-intensity burns. Over time, burned forest had 97% reduction of shrubs and small saplings, but only 38% loss of stems in the > 5–10 cm size class. Canopy openness was similar in burned and unburned forest plots prior to the onset of burning, but it was significantly greater in burned forest after 17 years of fire. Ground layer vegetation structure also changed significantly, with responses differing by guilds. Spring herbs were the dominant guild before burning and did not change over time. However, cover and abundance of summer herbs increased over time in burned forest, probably in response to greater light assimilation under the more open canopy. This resulted in greater overall species richness in burned plots without loss of the spring herbs. Burning eliminated most alien shrubs, although common buckthorn persisted in small numbers. The alien herb garlic mustard also persisted and had greater abundance in burned plots, apparently by re-colonizing from unburned micro-habitats and adjacent forest. These results indicate that long-term burning can eliminate shrub and small sapling canopy cover, thereby increasing canopy openness and promoting greater richness and cover of summer forbs. Fire also probably had a positive effect on seedling establishment through removal of litter. Resulting tradeoffs to this gain in diversity include loss of native vines, shrubs, understory trees and forest interior bird habitat, as well as persistence of alien plants.

Carroll, Matthew S.; Blatner, Keith A.; Cohn, Patricia J.; Morgan, Todd. 2007. Managing fire danger in the forests of the US inland Northwest: a classic "wicked problem" in public land policy. Journal of Forestry 105(5): 239-244.

Abstract. In their classic article Allen and Gould (Allen, G.M., and E.M. Gould. 1986. Complexity, wickedness, and public forests. *J. For.* 84(4):20-24) stated that the most daunting problems associated with public forest management had a "wicked" element: "Wicked problems share characteristics. Each can be considered as simply a symptom of some higher order problem.... The definition is in the mind of the beholder.... Furthermore, there is no single correct formulation for a wicked problem, only more or less useful ones" (p. 22). This description seems to fit the difficulties associated with managing the increasing risk of wildland fire in the United States. Using the Inland Northwest region of the United States as an example, we explore the dynamics of this issue as they relate to possible improvements and the inherent dilemmas. We conclude that any "solutions" to the problems associated with fire danger are best thought of in terms of long-term system improvements rather than short-term fixes.

Colombaroli, Daniele; Marchetto, Aldo; Tinner, Willy. 2007. Long-term interactions between Mediterranean climate, vegetation and fire regime at Lago di Massaciuccoli (Tuscany, Italy). Journal of Ecology 95: 755-770.

1 A Holocene sedimentary sequence from a coastal lake in the Mediterranean area (Lago di Massaciuccoli, Tuscany, Italy, 0 m a.s.l.) was sampled for pollen and microscopic charcoal analyses. Contiguous 1-cm samples represent an estimated time interval of *c.* 13 years, thus providing a high-resolution sequence from 6100 to 5400 cal. years BP.

2 Just before 6000 cal. years BP, sub-Mediterranean and Mediterranean forests were present together with fir (*Abies alba*), a submontane species that is today absent at low altitudes in the Mediterranean. A sharp vegetational change occurred after 6000 cal. years BP involving a drastic decline of *Abies alba* around the site.

3 Time-series analyses suggest that increased fire activity at this time caused a strong decline in *Abies alba*, a highly fire-sensitive species. During 100 years of higher fire incidence, diverse (predominantly evergreen) forest communities were converted to low-diversity fire-prone shrub communities.

4 Cross-correlations reveal that fire during the mid-Holocene hindered the expansion of holm oak (*Quercus ilex*), the most common tree species today in Mediterranean environments. While the factors that triggered the Holocene expansion of this species in the Mediterranean area are unclear, our results do not support the hypothesis that fire was key for holm oak expansion.

5 Diatom analyses of the same sediment core provide an independent palaeoenvironmental proxy for palaeoclimatic reconstruction. A change in the eutrophy and salinity of the lake occurred just before 6000 cal. years BP, suggesting that a climatic shift towards aridity may have triggered the observed change in hydrology and possibly also in fire regime.

6 Over the millennia fire has decisively contributed to the establishment of the present fire-adapted vegetation type (macchia). Native fire-sensitive species were displaced or repressed, and arboreal vegetation became less diverse. Combined ecological and palaeoecological data may help to assess possible future scenarios of biosphere responses to global change. Our results imply that the forecasted global warming and fire increase may trigger irrecoverable biodiversity losses and shifts in vegetational composition within a few decades or centuries at most. In particular, fire and drought-sensitive vegetation types, such as the relict forests of *Abies alba* in the Apennines, seem particularly threatened by large-scale displacement.

Freeman, Jonathan P.; Stohlgren, Thomas J.; Hunter, Molly E.; Omi, Philip N.; Martinson, Erik, J.; Chong, Geneva W.; Brown, Cynthia S. 2007. Rapid assessment of postfire plant invasions in coniferous forests of the western United States. Ecological Applications 17(6): 1656-1665.

Abstract. Fire is a natural part of most forest ecosystems in the western United States, but its effects on nonnative plant invasion have only recently been studied. Also, forest managers are engaging in fuel reduction projects to lessen fire severity, often without considering potential negative ecological consequences such as nonnative plant species introductions. Increased availability of light, nutrients, and bare ground have all been associated with high-severity fires and fuel treatments and are known to aid in the establishment of nonnative plant species. We use vegetation and environmental data collected after wildfires at seven sites in coniferous forests in the western United States to study responses of nonnative plants to wildfire. We compared burned vs. unburned plots and plots treated with mechanical thinning and/or prescribed burning vs. untreated plots for nonnative plant species richness and cover and used correlation analyses to infer the effect of abiotic site conditions on invasibility. Wildfire was responsible for significant increases in nonnative species richness and cover, and a significant decrease in native cover. Mechanical thinning and prescribed fire fuel treatments were associated with significant changes in plant species composition at some sites. Treatment effects across sites were minimal and inconclusive due to significant site and site × treatment interaction effects caused by variation between sites including differences in treatment and fire severities and initial conditions (e.g., nonnative species sources). We used canonical correspondence analysis (CCA) to determine what combinations of environmental variables best explained patterns of nonnative plant species richness and cover. Variables related to fire severity, soil nutrients, and elevation explained most of the variation in species composition. Nonnative species were generally associated with sites with higher fire severity, elevation, percentage of bare ground, and lower soil nutrient levels and lower canopy cover. Early assessments of postfire stand conditions can guide rapid responses to nonnative plant invasions.

Fulé, Peter Z.; Roccaforte, John P.; Covington, W. Wallace. 2007. Posttreatment tree mortality after forest ecological restoration, Arizona, United States. Environmental Management 40(4): 623-634.

Abstract. Pine–oak forests are of high ecological importance worldwide, but many are threatened by uncharacteristically severe wildfire. Forest restoration treatments, including the reintroduction of a surface fire regime, are intended to decrease fire hazard and emulate historic ecosystem structure and function. Restoration has recently received much management attention and short-term study, but little is known about longer-term ecosystem responses. We remeasured a replicated experimental restoration site in the southwestern United States 5 years after treatments. Basal area, tree density, and canopy cover decreased in the treated units at a faster rate than in controls. Delayed mortality, not evident right after treatment, decreased density modestly (13% in treated units and 10% in controls) but disproportionately affected large trees ("large" ponderosa pines were those with diameter at breast height [dbh] ≥37.5 cm; other species dbh ≥20 cm). In treated units, 10.9 large trees ha^{-1} died, whereas 6.2 trees ha^{-1} died in control units. Compared with reference conditions, the experimental blocks remained higher in pine density and, in three of the four blocks, in basal area. Pine trees grew significantly faster in treated units than in controls, enough to reach the reference level of basal area in 6 years. Although mortality of large trees is a concern, the treated units have vigorous growth and low density, indicating that they will be relatively resistant to future drought and fire events. Similar treatments may be beneficial in many areas of the United States and in related pine-oak ecosystems elsewhere.

Gough, Christopher M.; Vogel, Christoph S.; Harrold, Katherine H.; George, Kristen; Curtis, Peter S. 2007. The legacy of harvest and fire on ecosystem carbon storage in a north temperate forest. Global Change Biology 13(9): 1935-1949.

Abstract. Forest harvesting and wildfire were widespread in the upper Great Lakes region of North America during the early 20th century. We examined how long this legacy of disturbance constrains forest carbon (C) storage rates by quantifying C pools and fluxes after harvest and fire in a mixed deciduous forest chronosequence in northern lower Michigan, USA. Study plots ranged in age from 6 to 68 years and were created following experimental clear-cut harvesting and fire disturbance. Annual C storage was estimated biometrically from measurements of wood, leaf, fine root, and woody debris mass, mass losses to herbivory, soil C content, and soil respiration. Maximum annual C storage in stands that were disturbed by harvest and fire twice was 26% less than a reference stand receiving the same disturbance only once. The mechanism for this reduction in annual C storage was a long-lasting decrease in site quality that endured over the 62-year timeframe examined. However, during regrowth the harvested and burned forest rapidly became a net C sink, storing 0.53 Mg C ha^{-}

^{1} yr^{-1} after 6 years. Maximum net ecosystem production (1.35 Mg C ha^{-1} yr^{-1}) and annual C increment (0.95 Mg C ha^{-1} yr^{-1}) were recorded in the 24- and 50-year-old stands, respectively. Net primary production averaged 5.19 Mg C ha^{-1} yr^{-1} in experimental stands, increasing by < 10% from 6 to 50 years. Soil heterotrophic respiration was more variable across stand ages, ranging from 3.85 Mg C ha^{-1} yr^{-1} in the 6-year-old stand to 4.56 Mg C ha^{-1} yr^{-1} in the 68-year-old stand. These results suggest that harvesting and fire disturbances broadly distributed across the region decades ago caused changes in site quality and successional status that continue to limit forest C storage rates.

Irvine, J.; Law, B.E.; Hibbard, K.A. 2007. Postfire carbon pools and fluxes in semiarid ponderosa pine in Central Oregon. Global Change Biology 13(8): 1748-1760.

Abstract. Forest fire dramatically affects the carbon storage and underlying mechanisms that control the carbon balance of recovering ecosystems. In western North America where fire extent has increased in recent years, we measured carbon pools and fluxes in moderately and severely burned forest stands 2 years after a fire to determine the controls on net ecosystem productivity (NEP) and make comparisons with unburned stands in the same region. Total ecosystem carbon in soil and live and dead pools in the burned stands was on average 66% that of unburned stands (11.0 and 16.5 kg C m^{-2}, respectively, P<0.01). Soil carbon accounted for 56% and 43% of the carbon pools in burned and unburned stands. NEP was significantly lower in severely burned compared with unburned stands (P<0.01) with an increasing trend from −125±44 g C m^{-2} yr^{-1} (±1 SD) in severely burned stands (stand replacing fire), to −38±96 and +50±47 g C m^{-2} yr^{-1} in moderately burned and unburned stands, respectively. Fire of moderate severity killed 82% of trees <20 cm in diameter (diameter at 1.3 m height, DBH); however, this size class only contributed 22% of prefire estimates of bole wood production. Larger trees (> 20 cm DBH) suffered only 34% mortality under moderate severity fire and contributed to 91% of postfire bole wood production. Growth rates of trees that survived the fire were comparable with their prefire rates. Net primary production NPP (g C m^{-2} yr^{-1}, ±1 SD) of severely burned stands was 47% of unburned stands (167±76, 346±148, respectively, P<0.05), with forb and grass aboveground NPP accounting for 74% and 4% of total aboveground NPP, respectively. Based on continuous seasonal measurements of soil respiration in a severely burned stand, in areas kept free of ground vegetation, soil heterotrophic respiration accounted for 56% of total soil CO_2 efflux, comparable with the values of 54% and 49% previously reported for two of the unburned forest stands. Estimates of total ecosystem heterotrophic respiration (R_h) were not significantly different between stand types 2 years after fire. The ratio NPP/R_h averaged 0.55, 0.85 and 1.21 in the severely burned, moderately burned and unburned stands, respectively. Annual soil CO_2 efflux was linearly related to aboveground net primary productivity (ANPP) with an increase in soil CO_2 efflux of 1.48 g C yr^{-1} for every 1 g increase in ANPP (P<0.01, r^2 = 0.76). There was no significant difference in this relationship between the recently burned and unburned stands. Contrary to expectations that the magnitude of NEP 2 years postfire would be principally driven by the sudden increase in detrital pools and increased rates of R_h, the data suggest NPP was more important in determining postfire NEP.

Lafon, Charles W.; Waldron, John D.; Cairns, David M.; Tchakerian, Maria D.; Coulson, Robert N.; Klepzig, Kier D. 2007. Modeling the effects of fire on the long-term dynamics and restoration of yellow pine and oak forests in the southern Appalachian Mountains. Restoration Ecology 15(3): 400-411.

Abstract. We used LANDIS, a model of forest disturbance and succession, to simulate successional dynamics of forests in the southern Appalachian Mountains. The simulated environments are based on the Great Smoky Mountains landscapes studied by Whittaker. We focused on the consequences of two contrasting disturbance regimes—fire exclusion versus frequent burning—for the Yellow pine (*Pinus* L., subgenus *Diploxylon* Koehne) and oak (*Quercus* L.) forests that occupy dry mountain slopes and ridgetops. These ecosystems are a conservation priority, and declines in their abundance have stimulated considerable interest in the use of fire for ecosystem restoration. Under fire exclusion, the abundance of Yellow pines is projected to decrease, even on the driest sites (ridgetops, south- and west-facing slopes). Hardwoods and White pine (*P. strobus* L.) replace the Yellow pines. In contrast, frequent burning promotes high levels of Table Mountain pine (*P. pungens* Lamb.) and Pitch pine (*P. rigida* Mill.) on the driest sites and reduces the abundance of less fire-tolerant species. Our simulations also imply that fire maintains open woodland conditions, rather than closed-canopy forest. For oaks, fire exclusion is beneficial on the driest sites because it permits oaks to replace the pines. On moister sites (north- and east-facing slopes), however, fire exclusion leads to a diverse mix of oaks and other species, whereas frequent burning favors Chestnut oak (*Q. montana* Willd.) and White oak (*Q. alba* L.) dominance. Our results suggest that reintroducing fire may help restore decadent pine and oak stands in the southern Appalachian Mountains.

Marozas, Vitas; Racinskas, Jonas; Bartkevicius, Edmundas. 2007. Dynamics of ground vegetation after surface fires in hemiboreal *Pinus sylvestris* forests. Forest Ecology and Management 250(1-2): 47-55.

Abstract. The aim of this work was to investigate the changes of ground vegetation (field layer: mosses, lichens; ground layer: herbs, shrubs, tree seedlings and saplings) and regeneration of tree species in pine forests after surface fires. The study area was located in Southern part of Lithuania in hemiboreal zone of Europe. The field and ground vegetation was recorded in forest stands burned in 1992 and 1994–2002 and compared with the nearby control fire untouched areas.

We selected five burned areas for each year (total 50 burned stands). Vegetation sampling was conducted during July and August 2003. For vegetation description in each stand we systematically placed twenty 1 m × 1 m plots. Mann–Whitney nonparametric test was used to identify significant differences in vegetation between burned and untouched areas. It was determined that species richness increased after fire. Early successional species such as *Agrostis capillaris* L., *Calamagrostis epigejos* (L.) Roth, *Chamerion angustifolium* (L.) Holub, *Festuca ovina* L. and *Melampyrum pratense* L. invaded in burned areas immediately after fire. Abundance of dominant species (*Vaccinium myrtillus* L. and *Vaccinium vitis-idaea* L.) recovered after 5 years. Pioneer moss species (*Polytrichum piliferum* Hedw. and *Polytrichum juniperinum* Hedw.) replaced late successional mosses (*Dicranum polysetum* Sw., *Dicranum scoparium* Hedw., *Hylocomium splendens* (Hedw.) Schimp. and *Pleurozium schreberi* (Brit.) Mitt.). Species number in the shrub layer decreased. *Juniperus communis* L. was killed by fire. Amount of undergrowth decreased first 4 years after fire. Saplings of *Picea abies* (L.) Karst., disappeared at all. Fire stimulated regeneration of *Pinus sylvestris* L., especially first 4 years after fire. Herbaceous and dwarf shrubs recovered 5–6 years after fire, moss cover—9 years after fire. Differences in moss species composition still remained 11 years after fire. Main finding suggest that fire is favourable to biodiversity of pine forest ecosystems. Fires induce regeneration of pine trees and can be used for restoration of pine forest.

McEwan, Ryan W.; Hutchinson, Todd F.; Long, Robert P.; Ford, D. Robert; McCarthy, C. Brian. 2007. Temporal and spatial patterns in fire occurrence during the establishment of mixed-oak forests in eastern North America. Journal of Vegetation Science 18(5): 655–664.

Question: What was the role of fire during the establishment of the current overstory (ca. 1870-1940) in mixed-oak forests of eastern North America?

Location: Nine sites representing a 240-km latitudinal gradient on the Allegheny and Cumberland Plateaus of eastern North America.

Methods: Basal cross-sections were collected from 225 trees. Samples were surfaced, and fire scars were dated. Fire history diagrams were constructed and fire return intervals were calculated for each site. Geographic patterns of fire occurrence, and fire-climate relationships were assessed.

Results: Fire was a frequent and widespread occurrence during the formation of mixed-oak forests, which initiated after large-scale land clearing in the region ca. 1870. Fire return ranged from 1.7 to 11.1 years during a period of frequent burning from 1875 to 1936. Fires were widespread during this period, sometimes occurring across the study region in the same year. Fires occurred in a variety of climate conditions, including both drought and non-drought years. Fires were rare from 1936 to the present.

Conclusions: A variety of fire regime characteristics were discerned. First, a period of frequent fire lasted approximately 60 years during the establishment of the current oak overstory. Second, fire occurred during a variety of climate conditions, including wet climates and extreme drought. Finally, there was within-site temporal variability in fire occurrence. These reference conditions could be mimicked in ongoing oak restoration activities, improving the likelihood of restoration success.

Moghaddas, Emily E.Y.; Stephens, Scott L. 2007. Thinning, burning, and thin-burn fuel treatment effects on soil properties in a Sierra Nevada mixed-conifer forest. Forest Ecology and Management 250(3): 156-166.

Abstract. More than a century of fire exclusion and past timber management practices in many Sierra Nevada mixed-conifer forests have led to increased stand densities and fuel accumulation, with a corresponding risk of large, high severity wildfires. To reduce hazardous fuel accumulations and restore the health and natural processes of forest ecosystems, fuel management programs often employ thinning and prescribed fire treatments, both alone and in combination. We evaluated forest floor and mineral soil chemical and physical characteristics following these treatments in a managed Sierra Nevada mixed-conifer forest using a fully replicated study design with four separate treatments: THIN, BURN, THIN + BURN, and an untreated CONTROL. Compared to the CONTROL, the BURN and THIN + BURN treatments consumed a large amount of the forest floor, reducing the mass and depth by more than 80%. These treatments reduced the forest floor C and N pools by more than 85%, resulting in reductions of 25 Mg C ha^{-1} and more than 700 kg N ha^{-1} from the forest floor. Despite these large losses from the organic horizons, no significant differences in mineral soil total C and N pools were detected among treatments. Compared with the CONTROL and THIN treatments, the BURN and THIN + BURN significantly increased the mineral soil NO_3-N concentration, pool of inorganic N, pH, and exposed bare soil. The THIN + BURN treatment significantly increased the concentrations of NH_4-N and exchangeable Ca relative to the CONTROL. No significant differences in the net rates of nitrification, N mineralization, or bulk density were detected among the four treatments. The BURN treatment reduced mineral soil C concentration and CEC, while the THIN + BURN treatment had the greatest increase in inorganic N. Fire effects on soil pH and inorganic N were moderated in skid trails due to reduced fuel continuity and consumption. In light of the current management emphasis on hazardous fuels reduction, we recommend that researchers investigating fire effects in harvested stands include skid trail influences in their study design.

Neill, Christopher; Patterson, William A., III; Crary, David W., Jr. 2007. Responses of soil carbon, nitrogen and cations to the frequency and seasonality of prescribed burning in a Cape Cod oak-pine forest. Forest Ecology and Management 250(3): 234-243.

Abstract. Fire is an important component of the historic disturbance regime of oak and pine forests that occupy sandy soils of the coastal outwash plain of the northeastern US. Today prescribed fire is used for fuel reduction and for restoration and maintenance of habitat for rare plant and animal, animal species. We evaluated the effects of the frequency and seasonality of prescribed burning on the soils of a Cape Cod, Massachusetts's coastal oak-pine forest. We compared soil bulk density, pH and acidity, total extractable cations and total soil carbon (C) and nitrogen (N) in unburned plots and in plots burned over a 12-year period, along a gradient of frequency (every 1–4 years), in either spring (March/April) or summer (July/August). Summer burning decreased soil organic horizon thickness more than spring burning, but only summer burning every 1–2 years reduced organic horizons compared with controls. Burning increased soil bulk density of the organic horizon only in the annual summer burns and did not affect bulk density of mineral soil. Burn frequency had no effect on pH in organic soil, but burning every year in summer increased pH of organic soil from 4.01 to 4.95 and of mineral soil from 4.20 to 4.79. Burning had no significant effect on organic or mineral soil percent C, percent N, C:N, soil exchangeable Ca^{2+}, Mg^{2+}, K^{+} or total soil C or N. Overall effects of burning on soil chemistry were minor. Our results suggest that annual summer burns may be required to reduce soil organic matter thickness to produce conditions that would regularly allow seed germination for oak and for grassland species that are conservation targets. Managers may have to look to other measures, such as combinations of fire with mechanical treatments (e.g., soil scarification) to further promote grasses and forbs in forests where establishment of these plants is a high priority.

Pausas, Juli G.; Lloret, F. 2007. Spatial and temporal patterns of plant functional types under simulated fire regimes International Journal of Wildland Fire 16(4) 484–492

Abstract. In spite of enormous fire suppression advances in Mediterranean countries, large high-intensity fires are still common. The effects on vegetation structure and composition of fire and fire regime changes at large spatial and temporal scales are poorly known, and landscape simulation models may throw some light in this regard. Thus, we studied how the abundance, richness, and spatial distribution of the different plant types are sensitive to the frequency, extent and spatial distribution of wildfires, using a landscape simulation model (FATELAND). We simulated the dynamics of 10 plant functional types (PFTs) defined as combinations of post-fire persistence strategies and life forms, under the following fire scenarios: No Fire, Suppressed (one large fire every 20 years), Prescribed (small fuel reductions every year), Unmanaged-1 (two small fires every year) and Unmanaged-2 (four small fires every year). The results suggest that the different fire regimes generate different spatial fire-recurrence patterns and changes in the proportion of the dominant species. For instance, with increasing fire recurrence, seeder shrubs (i.e. those recruiting new individuals after fire from persisting seed bank) with early reproduction increased and seeder trees decreased, while little variation was found for resprouters. Fire also increased the spatial aggregation of plants, while PFT richness decreased with increasing fire recurrence. The results suggest patterns of changes similar to those reported in field studies, and thus they provide consistent hypotheses on the possible vegetation changes due to different fire scenarios.

Ritchie, Martin W.; Skinner, Carl N.; Hamilton, Todd A. 2007. Probability of tree survival after wildfire in an interior pine forest of northern California: effects of thinning and prescribed fire. Forest Ecology and Management 247(1-3): 200-208.

Abstract. A wildfire at Blacks Mountain Experimental Forest provided the opportunity to observe fire severity at the point of transition between treated and untreated stands. At several locations in the forest, the wildfire burned from a dense stand of largely pole-size trees, into an area that had been recently treated with combinations of thinning and prescribed fire. These treatment areas are part of a large-scale experiment designed to evaluate stand structure, grazing and prescribed fire in an interior ponderosa pine (*Pinus ponderosa* P.&C. Lawson) forest.

Tree survival and damage were sampled on strip plots arranged perpendicular to the treatment plot boundary. Logistic regression was used to develop a model relating the probability of initial mortality (within 9 months after the fire) to distance from treatment plot boundary, and treatment history (thinning and prescribed fire). Fire behavior simulation was used to evaluate the effectiveness of the pre-fire stand treatments.

The model shows that probability of survival was greatest in those areas that had both thinning and prescribed fire prior to the wildfire event. Survival was near zero for the untreated areas. Survival in thinned-only areas was greater than untreated areas but substantially less than the areas with both treatments.

Tercero-Bucardo, Norlan; Kitzberger, Thomas; Veblen, Thomas T.; Raffaele, Estela. 2007. A field experiment on climatuc and herbivore impacts on post-fire tree regeneration in north-western Patagonia. Journal of Ecology 95: 771-779.

1 Wildfires are predicted to increase in many ecosystems in relation to globally increasing temperatures but future patterns of post-fire vegetation change are largely unknown, particularly when there are synergistic effects from introduced

biota. In the late 1990s northern Patagonia, Argentina, experienced extreme droughts which led to severe wildfires affecting a range of Andean ecosystems.

2 We experimentally examined how variations in moisture, temperature and herbivory by livestock affect post-1999 fire patterns of the three main tree species. Over two years we monitored, in three forest types, the survival and growth of tree seedlings in a factorial warming (+2˚C)/livestock exclosure/watering experiment.

3 Seedling survival in the warmed treatments and in the controls was nil for the evergreen *Nothofagus dombeyi* and the conifer *Austrocedrus chilensis* at the two low elevation experimental sites. Survival of the subalpine *Nothofagus pumilio* in the warmed treatments at high elevation tended to be lower than in the control; for all treatments of warming alone there were no significant differences compared with the controls.

4 In all three forest types, increased water availability was essential for higher rates of tree seedling survival. Doubling water availability during the growing season resulted in up to fourfold increases in seedling survival and up to threefold increases in seedling biomass.

5 In the subalpine forest, livestock reduced seedling survival by *c.* 30% in non-watered treatments compared with watered treatments, probably due mainly to soil desiccation and to consumption of or damage to facilitating plants. In contrast, at lower elevation, where livestock pressure was lower, seedling survival of *N. dombeyi* and *A. chilensis* tended to be higher in unfenced sites, possibly due to reduced competition from highly palatable shrub species.

6 General circulation models predict a warming–drying trend in northern Patagonia during the twenty-first century. The resulting increase in wildfire is likely to be followed by inadequate tree regeneration and conversion from forest to shrubland cover types. This and similar studies suggest that under relatively slight changes in regional climate, increased fire occurrence interacting synergistically with moisture limitations will result in long-lasting displacements of forest by more xeric vegetation shrublands.

Vanha-Majamaa, S. Lilja; Ryömä, R.; Kotiaho, J.S.; Laaka-Lindberg, S.; Lindberg, H.; Puttonen, P.; Tamminen, P.; Toivanen, T.; Kuuluvainen, T. 2007. Rehabilitating boreal forest structure and species composition in Finland through logging, dead wood creation and fire: The EVO experiment. Forest Ecology and Management 250(1-2): 77-88.

Abstract. This paper reviews an ongoing, large-scale multidisciplinary experiment designed to study the possibilities of rehabilitating forest structure and species composition through logging, dead wood creation and fire in managed Norway spruce (*Picea abies*) forests in southern Finland. These forests have been utilized for several centuries with intensive management and clear-cut harvesting, which has been the dominant practice in Finland since World War II. During this era, the forest structure has become relatively even-aged, and the amount of dead wood has been reduced considerably. Simultaneously, due to an effective fire suppression policy, the role of fire in Finnish nature has been almost completely eliminated. One of the key species in biodiversity, aspen (*Populus tremula*), has also been actively removed from the forests in the past. Forest restoration activities, such as the creation of dead wood and the reintroduction of fire to forest management, have been suggested in conservation and restoration programmes. So far we have studied the immediate effects of restorative actions on forest structure, regeneration, soil nutrient status, understorey and epixylic vegetation, lichens and beetles. In the larger EVO research area we have also studied the population structure of aspen in both protected and managed forests. Our early results show that it is possible, through active forest restoration, i.e. the creation of dead wood and prescribed burning, to rehabilitate boreal forest diversity, even when a significant part of the wood volume is harvested for commercial use. Despite the fact that the immediate effects of fire on many species groups were negative, the long-term effects are expected to be predominantly positive. There is currently a decline in aspen populations in Finnish forests. The absence of large aspens in managed forests and the absence of younger trees/cohorts in conservation areas, combined with high mortality, is a significant threat to aspen-dwelling species. We conclude that studies on active restoration treatments, together with long-term inventories of several species groups, are necessary in order to assess the impacts of varying restoration practices for cost-efficient large-scale applications.

Varner, J. Morgan, III; Hiers, J. Kevin; Ottmar, Roger D.; Gordon, Doria R.; Putz, Francis E.; Wade, Dale D. 2007. Overstory tree mortality resulting from reintroducing fire to long-unburned longleaf pine forests: the importance of duff moisture. Canadian Journal of Forest Research 37(8): 1349-1358.

Abstract. In forests historically maintained by frequent fire, reintroducing fire after decades of exclusion often causes widespread overstory mortality. To better understand this phenomenon, we subjected 16 fire-excluded (ca. 40 years since fire) 10 ha longleaf pine (*Pinus palustris* Mill.) stands to one of four replicated burning treatments based on volumetric duff moisture content (VDMC): wet (115% VDMC); moist (85% VDMC); dry (55% VDMC); and a no-burn control. During the first 2 years postfire, overstory pines in the dry burns suffered the greatest mortality (mean 20.5%); pine mortality in the wet and moist treatments did not differ from the control treatment. Duff reduction was greatest in the dry burns (mean 46.5%), with minimal reduction in the moist and wet burns (14.5% and 5%, respectively). Nested logistic regression using trees from all treatments revealed that the best predictors of individual pine mortality were duff consumption and crown scorch ($P < 0.001$; $R^2 = 0.34$). Crown scorch was significant only in dry burns, whereas duff consumption was significant across all

treatments. Duff consumption was related to moisture content in lower duff (Oa; $R^2 = 0.78$, $P < 0.001$). Restoring fire to long-unburned forests will require development of burn prescriptions that include the effects of duff consumption, an often overlooked fire effect.

Wallenius, Tuomo Hemrik; Lilja, Saara; Kuuluvainen, Timo. 2007. Fire history and tree species composition in managed *Picea abies* stands in southern Finland: implications for restoration. Forest Ecology and Management 250(1-2): 89-95.

Abstract. We studied the fire history of 24 managed *Picea abies*-dominated stands in southern Finland using dendrochronological dating of fire scars in old stumps. Forests in the study area have been heavily utilized in many ways for centuries for swidden cultivation, tar burning, forest pasturage and pasture burning. Old charred stumps of *Pinus sylvestris* were found in every stand although in nine of them the stumps were too decayed to provide a sample that could be dated. In the 17th and 18th centuries, forests burned at intervals of ca. 50 years on average. The last fires in the study plots occurred in the latter half of the 19th century. Based on the presence of the old *Pinus* stumps, past frequent fires and historical documents, it can be judged that forests were *Pinus*-dominated in the 17th and 18th centuries. Around the middle of the 19th century a gap occurred in the annual tree ring chronologies of all study plots. This suggests that large coniferous trees were absent at that time. The currently dominating *Picea* populations regenerated at the beginning of the 20th century. Our results demonstrate that in an area where human impact on forests has been variable, pervasive and long-lasting, the goal of forest restoration can be very different depending on the choice of reference period. We conclude that for defining restoration goals, knowledge of local forest history is needed.

Whitlock, Cathy; Moreno, Patricio I.; Bartlein, Patrick. 2007. Climatic controls of Holocene fire patterns in southern South America. Quaternary Research 68(1): 28-36.

Abstract. Holocene fire–climate–vegetation linkages are mostly understood at individual sites by comparing charcoal and pollen records with other paleoenvironmental proxy and model simulations. This scale of reconstruction often obscures detection of large-scale patterns in past fire activity that are related to changes in regional climate and vegetation. A network of 31 charcoal records from southern South America was examined to assess fire history along a transect from subtropic to subantarctic biomes. The charcoal data indicate that fire activity was greater than present at ca. 12,000 cal yr BP and increased further and was widespread at 9500 cal yr BP. Fire activity decreased and became more spatially variable by 6000 cal yr BP, and this trend continued to present. Atmospheric circulation anomalies during recent high-fire years show a southward shift in westerlies, and paleoclimate model simulations and data syntheses suggest that such conditions may have prevailed for millennia in the early Holocene when the pole-to-equator temperature gradients were weaker and annual temperatures were higher than present, in response to orbitaltime-scale insolation changes.

Woodall, C.W.; Nagle, L.M. 2007. Downed woody fuel loading dynamics of a large-scale blowdown in northern Minnesota, U.S.A. Forest Ecology and Management 247 (1-3): 194-199.

Abstract. On July 4, 1999, a large-scale blowdown occurred in the Boundary Waters Canoe Area Wilderness (BWCAW) of northern Minnesota affecting up to 150,000 ha of forest. To further understand the relationship between downed woody fuel loading, stand processes, and disturbance effects, this study compares fuel loadings defined by three strata: (1) blowdown areas of the BWCAW ($n = 34$), (2) non-blowdown areas of the BWCAW ($n = 55$), and (3) the greater forest ecosystem in which the BWCAW lies ($n = 228$). Further, relationships between downed woody fuel estimates and standing tree attributes (stand basal area and trees per hectare) were compared among study strata. Results indicate that mean 100 and >1000 h timelag fuel loadings in blowdown areas of the BWCAW (13.0 and 22.9 tonnes/ha, respectively) were substantially higher than those in both the non-blowdown areas of the BWCAW (5.8 and 16.3 tonnes/ha, respectively) and the greater forest ecosystem (6.5 and 11.3 tonnes/ha, respectively). There was no relationship between fuel loadings and trees per hectare or stand basal area. However, there did appear to be defined limits to maximum observed fuel loadings in relation to stand density attributes. This study suggests that relationships between a forest ecosystem's standing live and downed dead tree attributes are obscured by two contrasting events: widespread mortality from large-scale disturbances and the limited mortality from gradual stand development/small-scale disturbances.

Grasslands and Shrublands

Bock, Carl E.; Kennedy, Linda; Bock, Jane H.; Jones, Zach F. 2007. Effects of fire frequency and intensity on velvet mesquite in an Arizona grassland. Rangeland Ecology and Management 60(5): 508–514.

Abstract. Increases of velvet mesquite (*Prosopis velutina* Woot.) in southwestern grasslands might have been caused by livestock consumption of fuels that once burned with sufficient frequency and intensity to kill the trees. However, attempts to control mesquite with fire usually have failed. We measured fire damage and 5 years of postfire recovery for 225

mesquite trees > 1 m tall, following a 2002 wildfire that included grasslands differing in fire history, presence vs. 34-year livestock exclusion, and predominance of native vs. exotic grasses. The fire burned 100% of ground cover in ungrazed areas and 65% on grazed lands. Top-kill was 100% for trees in exotic ungrazed grasslands (the areas with highest fuel loads), 79% for trees in ungrazed native grasslands, and 28% for trees in grazed grasslands. Most top-killed trees produced ground sprouts, so that by 2006 the combined foliage volume from ground sprouts and surviving branches was 78% (± 3.2 SE) of preburn foliage volume in grazed areas, 66% (± 3.3) in ungrazed exotic grasslands, and 57% (± 4.0) in ungrazed native grasslands. Fire damage was greater among surviving trees in ungrazed areas that had burned twice (1987 and 2002) than among those that had burned only once since 1968 (in 2002), especially in native grasslands where postfire foliage recovery for twice-burned trees was only 47% (± 6.3) by 2006. Only 1 of 84 trees died in the area burned once, whereas 12 of 66 (18.2%) died in the area burned twice, including several individuals > 3 m tall. These results suggest that repeated fires likely could have prevented the historic spread of velvet mesquite into southwestern grasslands, but probably could be used to control mesquite today only in areas where abundant herbaceous growth provides sufficient fine fuels.

Davies, Kirk W.; Bates, Jonathan D.; Miller, Richard F. 2007. Short-term effects of burning Wyoming big sagebrush steppe in southeast Oregon. Rangeland Ecology and Management 60(5): 515–522.

Abstract. Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis* [Beetle & A. Young] S.L. Welsh) plant communities of the Intermountain West have been greatly reduced from their historic range as a result of wildfire, agronomic practices, brush control treatments, and weed invasions. The impact of prescribed fall burning Wyoming big sagebrush has not been well quantified. Treatments were sagebrush removed with burning (burned) and sagebrush present (control). Treatments were applied to 0.4-ha plots at 6 sites. Biomass production, vegetation cover, perennial herbaceous vegetation diversity, soil water content, soil inorganic nitrogen (NO−3, NH+4), total soil nitrogen (N), total soil carbon (C), and soil organic matter (OM) were compared between treatments in the first 2 years postburn. In 2003 and 2004, total (shrub and herbaceous) aboveground annual biomass production was 2.3 and 1.2 times greater, respectively, in the control compared to the burned treatment. In the upper 15 cm of the soil profile, inorganic N concentrations were greater in the burned than control treatment, while soil water, at least in the spring, was greater in the control than burned treatment. Regardless, greater herbaceous aboveground annual production and cover in the burned treatment indicated that resources were more available to herbaceous vegetation in the burned than the control treatment. Exotic annual grasses did not increase with the burn treatment. Our results suggest in some instances that late seral Wyoming big sagebrush plant communities can be prescribed fall burned to increase livestock forage or alter wildlife habitat without exotic annual grass invasion in the first 2 years postburn. However, long-term evaluation at multiple sites across a larger area is needed to better quantify the effects of prescribed fall burning on these communities. Thus, caution is advised because of the value of Wyoming big sagebrush plant communities to wildlife and the threat of invasive plants.

Harmoney, K. R. 2007. Grazing and burning Japanese brome (*Bromus japonicus*) on mixed grass rangelands. Rangeland Ecology and Management 60(5): 479-486.

Abstract. Japanese brome (*Bromus japonicus* Thunb. ex Murr.) is an introduced, annual cool-season grass adapted to the central and northern Great Plains. Japanese brome has negatively impacted perennial grasses and decreased seasonal animal gains. Prescribed spring burning and defoliation have been effective in reducing brome density or cover, but little information directly compares the two common strategies. The objectives of this study were to 1) compare annual spring burning and grazing to reduce Japanese brome populations; and 2) evaluate trends of vegetative composition and biomass in burned, grazed, and unburned rangelands infested with Japanese brome. Paddocks with Japanese brome were assigned to one of four treatments: 1) annual prescribed spring burning, 2) spring grazing, 3) a combination of annual spring burning and grazing, and 4) an idle control. Treatments were applied annually from 2000 to 2004. Japanese brome density was greatest in the idle control in all years, even when low winter and spring precipitation limited Japanese brome recruitment. Late spring Japanese brome density was similar in all treatments with grazing or burning in four of the five seasons. Spring burning resulted in less than 65% litter cover the last 3 years, whereas the idle control and spring grazing had over 80% litter cover the last 4 years. Western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Löve) decreased with spring grazing in burned and unburned paddocks. Buffalograss (*Bouteloua dactyloides* [Nutt] J. T. Columbus) composition decreased in the idle control treatment. Blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. ex Griffiths) and sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.) composition varied by year. Even though annual burning and spring grazing were equally effective in limiting Japanese brome density and biomass compared to the idle control, Japanese brome was still present after 5 years, which indicates the difficulty of eradicating Japanese brome from ecosystems where it has become naturalized.

Morgan, Jack A.; Milchunas, Daniel G.; LeCain, Daniel R.; West, Mark; Mosier, Arvin R. 2007. Carbon dioxide enrichment alters plant community structure and accelerates shrub growth in the shortgrass steppe. Proceedings of the National Academy of Sciences 104(37): 14724-14729.

Abstract. A hypothesis has been advanced that the incursion of woody plants into world grasslands over the past two centuries has been driven in part by increasing carbon dioxide concentration, [CO_2], in Earth's atmosphere. Unlike the warm season forage grasses they are displacing, woody plants have a photosynthetic metabolism and carbon allocation patterns that are responsive to CO_2, and many have tap roots that are more effective than grasses for reaching deep soil water stores that can be enhanced under elevated CO_2. However, this commonly cited hypothesis has little direct support from manipulative experimentation and competes with more traditional theories of shrub encroachment involving climate change, management, and fire. Here, we show that, although doubling [CO_2] over the Colorado shortgrass steppe had little impact on plant species diversity, it resulted in an increasingly dissimilar plant community over the 5-year experiment compared with plots maintained at present-day [CO_2]. Growth at the doubled [CO_2] resulted in an ≈40-fold increase in aboveground biomass and a 20-fold increase in plant cover of *Artemisia frigida* Willd, a common subshrub of some North American and Asian grasslands. This CO_2-induced enhancement of plant growth, among the highest yet reported, provides evidence from a native grassland suggesting that rising atmospheric [CO_2] may be contributing to the shrubland expansions of the past 200 years. Encroachment of shrubs into grasslands is an important problem facing rangeland managers and ranchers; this process replaces grasses, the preferred forage of domestic livestock, with species that are unsuitable for domestic livestock grazing.

Preece, Noel. 2007. Traditional and ecological fires and effects of bushfire laws in north Australian savannas. International Journal of Wildland Fire 16(4): 378-389.

Abstract. Landscape fires are common and frequent across the north Australian savannas, and are arguably an essential component of regional ecosystem dynamics. Seasonal biases in fire regimes and the high frequency of late dry season fires in a large proportion of the region have been presented as an impediment to appropriate land management. Legislation regulating the lighting of fires applies to the whole of the savannas. The legislation seeks to control the lighting of fires, provides for permit systems to operate in each jurisdiction, and is supported by policies and guidance manuals. The present paper argues that the legislation fails to address prescribed burning, the biophysical and social realities of contemporary regimes, and management needs. The policies and legislation are in need of some fundamental changes, including recognition of the concept of prescribed burning, mechanisms to promote regional fire management strategies and plans, and recognition of indigenous traditional practices.

Russell-Smith, Jeremy; Yates, Cameron P.; Whitehead, Peter J.; Smith, Richard; Craig, Ron; Allan, Grant E.; Thackway, Richard; Frakes, Ian; Cridland, Shane; Meyer, Mick C. P.; Gill, A. Malcolm. 2007. Bushfires 'down under': patterns and implications of contemporary Australian landscape burning. International Journal of Wildland Fire 16(4): 361-377.

Abstract. Australia is among the most fire-prone of continents. While national fire management policy is focused on irregular and comparatively smaller fires in densely settled southern Australia, this comprehensive assessment of continental-scale fire patterning (1997–2005) derived from ~1 km^2 Advanced Very High Resolution Radiometer (AVHRR) imagery shows that fire activity occurs predominantly in the savanna landscapes of monsoonal northern Australia. Statistical models that relate the distribution of large fires to a variety of biophysical variables show that, at the continental scale, rainfall seasonality substantially explains fire patterning. Modelling results, together with data concerning seasonal lightning incidence, implicate the importance of anthropogenic ignition sources, especially in the northern wet–dry tropics and arid Australia, for a substantial component of recurrent fire extent. Contemporary patterns differ markedly from those under Aboriginal occupancy, are causing significant impacts on biodiversity, and, under current patterns of human population distribution, land use, national policy and climate change scenarios, are likely to prevail, if not intensify, for decades to come. Implications of greenhouse gas emissions from savanna burning, especially seasonal emissions of CO_2, are poorly understood and contribute to important underestimation of the significance of savanna emissions both in Australian and probably in international greenhouse gas inventories. A significant challenge for Australia is to address annual fire extent in fire-prone Australian savannas.

Wetlands, Riparian Areas and Hydrology

McMichael, Christine E.; Hope, Allen S. 2007. Predicting streamflow response to fire-induced landcover change: implications of parameter uncertainty in the MIKE SHE model. Journal of Environmental Management 84(3): 245-256.

Abstract. Fire is a primary agent of landcover transformation in California semi-arid shrubland watersheds, however few studies have examined the impacts of fire and post-fire succession on streamflow dynamics in these basins. While it may seem intuitive that larger fires will have a greater impact on streamflow response than smaller fires in these watersheds,

the nature of these relationships has not been determined. The effects of fire size on seasonal and annual streamflow responses were investigated for a medium-sized basin in central California using a modified version of the MIKE SHE model which had been previously calibrated and tested for this watershed using the Generalized Likelihood Uncertainty Estimation methodology. Model simulations were made for two contrasting periods, wet and dry, in order to assess whether fire size effects varied with weather regime. Results indicated that seasonal and annual streamflow response increased nearly linearly with fire size in a given year under both regimes. Annual flow response was generally higher in wetter years for both weather regimes, however a clear trend was confounded by the effect of stand age. These results expand our understanding of the effects of fire size on hydrologic response in chaparral watersheds, but it is important to note that the majority of model predictions were largely indistinguishable from the predictive uncertainty associated with the calibrated model—a key finding that highlights the importance of analyzing hydrologic predictions for altered landcover conditions in the context of model uncertainty. Future work is needed to examine how alternative decisions (e.g., different likelihood measures) may influence GLUE-based MIKE SHE streamflow predictions following different size fires, and how the effect of fire size on streamflow varies with other factors such as fire location.

Pettit; Neil E.; Naiman, Robert J. 2007. Postfire response of flood-regenerating riparian vegetation in a semi-arid landscape. Ecology 88(8): 2094-2104.

Abstract. Piles of large wood (LW) deposited by major floods in river corridors can interact with naturally occurring wildfires from uplands to impact the regeneration of riparian vegetation. This study examines the spatial and short-term temporal response of riparian vegetation and soil nutrients to fire along the Sabie River, South Africa, with special emphasis on the effects of burned LW piles. At the study site there were 112 species of plants recorded with 28% of species restricted to the burned plots. As expected, vegetation cover was significantly lower in burned plots as compared with the unburned plots 12 months postfire. There was a significant influence of LW on species richness with fewer species recorded in the LW plots. For both fire and LW treatments, plant cover showed a significant change over three years. After an initial increase from 12 to 24 months (postfire) there was a decline in plant cover after 36 months. Species community composition was distinctly different between burned and unburned plots 12 months postfire, and the presence of LW affected species composition for burned plots but not for unburned ones. Time series ordination of LW plots highlighted the changes in species composition over the three years of sampling. Of trees with accumulations of LW within 5 m of their base, 48% had been killed by fire as compared to only 4% with no LW accumulations in close proximity. Soil-available P was significantly higher in the burned plots and even higher with burned LW while there were no effects on soil total N. There was also a significant positive trend between available P in soils and plant vegetation cover. Soil-exchangeable K was also significantly higher and total C significantly lower in the burned and LW plots. Burned plots also had significantly higher soil electrical conductivity (EC) and soil pH. The patchy nature of the studied fire, whose complexity is exacerbated by the distribution of flood deposited LW, acted to create a mosaic of alternate successional states as the riparian community recovers from flooding and the subsequent fire. We suspect that the resultant heterogeneity will increase ecosystem resilience by providing flexibility in the form of more options for a system response to subsequent disturbances.

Terrestrial and Aquatic Wildlife

do Rosário, Inês T.; Mathias, Maria da Luz. 2007. Post-fire recolonisation of a montado area by the endangered Cabrera vole (*Microtus cabrerae*). International Journal of Wildland Fire 16(4): 450-457.

Abstract. The Cabrera vole is an endangered species frequently found in the montado, a savannah-like ecosystem well adapted to fire. Although it is assumed that regular burning is not very prejudicial to this vole, the impact of fire is unknown. This research studied, for the first time, recolonisation by the Cabrera vole after wildfire. Colonies were monitored over one year after a wildfire and the most relevant ecological features in their reestablishment were identified. During the first eight months, all the 18 surveyed colonies remained unoccupied. However, after one year, 11 were recolonised. Vegetation structure and composition in the colonies (vegetation height, plant families diversity, percentage of bare ground and cover of shrubs before the fire), which are important features in offering protection and nutrition, were closely related to reoccupation of the colonies. Surprisingly, fire intensity did not influence recolonisation. Distance from unburned areas proved to be a factor that delayed recolonisation. The importance of the montado for this species was reinforced by the evidence that recolonisation occurred preferentially in colonies surrounded by this habitat type.

Greenberg, Cathryn H.; Tomcho, Aimee Livings; Lanham, J. Drew; Waldrop, Thomas A.; Tomcho, Joseph; Phillips, Ross J.; Simon, Dean. 2007. Short-term effects of fire and other fuel reduction treatments on breeding birds in a southern Appalachian upland hardwood forest. Journal of Wildlife Management 71(6): 1906-1916.

Abstract. We compared the effects of 3 fuel reduction techniques and a control on breeding birds during 2001–2005 using 50-m point counts. Four experimental units, each .14 ha, were contained within each of 3 replicate blocks at the Green River Game Land, Polk County, North Carolina, USA. Treatments were 1) prescribed burn, 2) mechanical understory

reduction (chainsaw-felling of shrubs and small trees), 3) mechanical + burn, and 4) controls. We conducted mechanical treatments in winter 2001–2002 and prescribed burns in spring 2003. Tall shrub cover was substantially reduced in all treatments compared to controls. Tree mortality and canopy openness was highest in the mechanical + burn treatment after burning, likely due to higher fuel loading and hotter burns; tree mortality increased with time. Many bird species did not detectably decrease or increase in response to treatments. Species richness, total bird density, and some species, including indigo buntings (*Passerina cyanea*) and eastern bluebirds (*Sialia sialis*), increased in the mechanical + burn treatment after a 1-year to 2-year delay; eastern wood-pewees (*Contopus virens*) increased immediately after treatment. Hooded warblers (*Wilsonia citrina*), black-and-white warblers (*Mniotilta varia*), and worm-eating warblers (*Helmitheros vermivorus*) declined temporarily in some or all treatments, likely in response to understory and (or) leaf litter depth reductions. Densities of most species affected by treatments varied with shrub cover, tree or snag density, or leaf litter depth. High snag availability, open conditions, and a higher density of flying insects in the mechanical + burn treatment likely contributed to increased bird density and species richness. In our study, fuel reduction treatments that left the canopy intact, such as low-intensity prescribed fire or mechanical understory removal, had few detectable effects on breeding birds compared to the mechanical + burn treatment. High-intensity burning with heavy tree-kill, as occurred in our mechanical + burn treatment, can be used as a management tool to increase densities of birds associated with open habitat while retaining many forest and generalist species, but may have short-term adverse effects on some species that are associated with the ground- or shrub-strata for nesting and foraging.

Meyer, Marc D.; Kelt, Douglas A.; North, Malcolm P. 2007. Effects of burning and thinning on lodgepole chipmunks (*Neotamias speciosus*) in the Sierra Nevada, California. Northwestern Naturalist 88: 61-72.

Abstract. Prescribed burning and mechanical thinning are widely used to manage fuels in North American forests, but few studies have examined the relative impacts of these treatments on wildlife. Using a fully factorial and completely randomized design, we examined the short term effects of prescribed burning (no burn vs. burn), mechanical thinning (no thin, light thin, and heavy thin), and combinations of these treatments on the capture rate and demographic parameters of Lodgepole Chipmunks (*Neotamias speciosus*) in mixed-conifer forests in the southern Sierra Nevada of California. Chipmunks were sampled in eighteen 4-ha treatment plots during the summer of 1999 and 2000 (pre-treatment) and 2002 and 2003 (post-treatment). Although burning and thinning caused significant changes in forest structure, neither treatment had a significant effect on the capture rate or most demographic parameters of *N. speciosus*. Body mass of males (2002 and 2003) and the ratio of males to females (2003) decreased following burning. Body mass and percentage reproductive females were positively correlated with the total number of White Fir (*Abies concolor*) cones produced across treatments and years, possibly reflecting a positive association between chipmunk reproduction and food availability. These results suggest that prescribed burning and mechanical thinning may have minor or no short-term effects on the capture rate and demography of *N. speciosus* in mixed-conifer forests of the SierraNevada, but effects over longer periods have not been investigated.

Stratman, Marty R.; Pelton, Michael R. 2007. Spatial response of American black bears to prescribed fire in northwest Florida. Ursus 18(1): 62-71.

Abstract. Little is known about the effects of prescribed burning on American black bears (*Ursus americanus*) in the Southeastern Coastal Plain. In Florida, Eglin Air Force Base is home to 1 of 8 relatively disjunct populations of black bears (*U. a. floridanus*) in the state. Prescribed burning has been used on Eglin since the late 1980s to reduce the dense oak (*Quercus* spp.) midstory that occupies the longleaf pine (*Pinus palustris*)–wiregrass (*Aristida beyrichiana*) community. We studied black bear habitat use during 1994–96 to determine if temporal and spatial relationships existed between prescribed fire and black bear habitat use from 9 years of burning data. Within all habitat types, our results showed that black bears used unburned areas more than burned areas, both annually and seasonally. Among burned areas, black bear use was greatest in 3- and ≥5-year-old burns, both annually and seasonally, for most habitat types. Our results are consistent with published reports on timing of peak soft mast production following prescribed fire, and we conclude that higher use of particular burn ages was related to production of several soft-mast species. We suggest that longer burning cycles be applied within and adjacent to important habitats, like riparian zones, in the Southeastern Coastal Plain. Planning for juxtaposition of various successional post-fire stages is the best approach for managing habitats to maintain cover and availability of primary bear foods and effectively minimize the area needed to satisfy the needs of black bears.

Insects and Arthopods

Cobb, T.P.; Langor, D.W.; Spence, J.R. 2007. Biodiversity and multiple disturbances: boreal forest ground beetle (Coleoptera: Carabidae) responses to wildfire, harvesting, and herbicide. Canadian Journal of Forest Research 37(8): 1310-1323.

Abstract. Rising societal demands for forest resources along with existing natural disturbance regimes suggest that sustainable forest management will increasingly depend on better understanding the cumulative effects of natural and anthropogenic disturbances. In North America, for example, there is increasing economic pressure to salvage log burned forests, although the ecological consequences of combining fire and harvesting on the same sites are unclear. We examined the short-term (2 year) responses of boreal forest ground beetles (Coleoptera: Carabidae) to the individual and combined effects of wildfire, harvesting, and herbicide. Ground beetle responses to wildfire and forestry-related disturbances differed strongly and suggested that, although some species may appear to benefit from disturbance combinations (e.g., *Sericoda quadripunctata* (DeGeer)), these effects are detrimental to others (e.g., *Sericoda bembidioides* Kirby). Species compositional variability was significantly reduced by disturbance combinations suggesting that multiple disturbances may lead to a simplification of this entire assemblage. In addition, ground beetle responses were correlated with changes in several key habitat parameters such as amount of woody debris, exposed ground, and plant species richness suggesting avenues for future study. Overall, however, our results suggest that efforts to avoid compounding disturbances on any site should be considered when developing current and future forest management guidelines.

Jonas, Jayne L.; Joern, Anthony. 2007. Grasshopper (Orthoptera: Acrididae) communities repond to fire, bison grazing and weather in North American tallgrass prairie: a long-term study. Oecologia 153(3): 699-711.

Abstract. Because both intrinsic and extrinsic factors influence insect population dynamics, operating at a range of temporal and spatial scales, it is difficult to assess their contributions. Long-term studies are ideal for assessing the relative contributions of multiple factors to abundance and community dynamics. Using data spanning 25 years, we investigate the contributions of weather at annual and decadal scales, fire return interval, and grazing by bison to understand the dynamics of abundance and community composition in grasshopper assemblages from North American continental grassland. Each of these three primary drivers of grassland ecosystem dynamics affects grasshopper population and community dynamics. Negative feedbacks in abundances, as expected for regulated populations, were observed for all feeding guilds of grasshoppers. Abundance of grasshoppers did not vary in response to frequency of prescribed burns at the site. Among watersheds that varied with respect to controlled spring burns and grazing by bison, species composition of grasshopper assemblages responded significantly to both after 25 years. However, after more than 20 years of fire and grazing treatments, the number of years since the last fire was more important than the managed long-term fire frequency per se. Yearly shifts in species composition (1983–2005), examined using nonmetric multidimensional scaling and fourth-corner analysis, were best explained by local weather events occurring early in grasshopper life cycles. Large-scale patterns were represented by the Palmer Drought Severity Index and the North Atlantic Oscillation (NAO). The NAO was significantly correlated with annual mean frequencies of grasshoppers, especially for forb- and mixed-feeding species. Primary grassland drivers—fire, grazing and weather—contributing both intrinsic and extrinsic influences modulate long-term fluctuations in grasshopper abundances and community taxonomic composition.

Dead Wood and Fuels

Arseneault, Dominique; Boucher, Étienne; Bouchon, Élodie. 2007. Asynchronous forest-stream coupling in a fire-prone boreal landscape: insights from woody debris. Journal of Ecology 95: 789-801.

1 We used dendrochronology to reconstruct the transfer of coarse woody debris across a forest–stream interface in a fire-prone boreal landscape. A sequence of regulating factors was considered from source to sink of in-stream woody debris (SWD), including fire history at the landscape scale, patterns of post-fire recovery of riparian forest and inputs of SWD at the scale of a stream reach and its associated floodplain, and burial of SWD at an excavated site.

2 Fires occurred repeatedly in the studied landscape (at least in 1708, 1733, 1791, 1811, *c.* 1838, *c.* 1850, 1882, 1941 and 1998), and were generally patchy on the floodplain because of the firebreak effect of the riparian corridor. Unburned forest remnants were regularly generated at the stream margin, thus permitting temporally continuous but spatially localized transfer of woody material across the forest–stream interface. These remaining forest patches also increased forest resilience by dispersing seeds and promoting conifer re-establishment in burned areas.

3 Because of higher severity compared with previous fires, the 1941 fire burned almost everywhere on the floodplain, creating only a few widely isolated unburned forest remnants. Consequently, following an abrupt post-fire increase, SWD inputs almost completely ceased. In addition, post-fire recovery of the riparian wood source is slow because of the spatially restricted seed source.

4 In this alluvial stream, wood burial is faster than decay and largely determines the residence time of SWD. Because the residence time is about 150 years, the current density of SWD is high and contrasts sharply with the very low tree density at the stream margin. Although this long residence time helps maintain stream integrity while the forest is recovering from the 1941 fire, it is unlikely that SWD inputs would resume extensively before burial of the current SWD pool.

5 Our research exemplifies the potentially complex impacts of disturbances on material transfer between a source and a sink ecosystem. We conclude that when certain components of ecosystems are coupled by unidirectional flow, those components will behave asynchronously if a disturbance impact at the source ecosystem does not propagate rapidly to the sink and the source and the sink recover at different rates.

de Chantal, Michelle; Granström, Anders. 2007. Aggregations of dead wood after wildfire act as browsing refugia for seedlings of *Populus tremula* and *Salix caprea*. Forest Ecology and Management 250 (1-2): 3-8.

Abstract. In the European boreal forest, early successional tree species in the genera *Salix* and *Populus* are among the most favoured by browsers, often causing poor regeneration. It is frequently assumed that the fast height growth rate of these species on favourable sites can increase their chances to outgrow browsers. Spatial or temporal variation in browsing pressure could be important mechanisms for escape too, but there are few examples of this. In 1999 a large area of old-growth mixed *Pinus sylvestris* L. and *Picea abies* L. Karst. forest burned in Tyresta National Park in central Sweden. In the following year, an abundance of *Populus tremula* L. and *Salix caprea* L. seedlings regenerated naturally. Four years later we analyzed seedling height and browsing history for the tallest seedlings inside and outside natural aggregations of dead wood formed by windthrow of fire-killed trees. All seedlings outside the aggregations had been browsed (on average three times) and average height was 60 ± 9 cm for *P. tremula* and 54 ± 12 cm for *S. caprea*. Inside aggregations, only 33% of the tallest seedlings had any evidence of browsing, and in most cases only from one episode. Average height for *P. tremula* was 153 ± 41 cm and for *S. caprea* 167 ± 27 cm. Stem base diameter was also wider for seedlings growing in dead wood aggregations than in open areas. Droppings of moose, roe deer, and hare were abundant in the area, but judging from bite marks, most browsing damage was due to the ungulates. For seedlings inside dead wood aggregations, backward regression analysis showed that both the structure of the aggregations and the spatial position of seedlings influenced seedling height: for *P. tremula* seedlings, there was a significant association with increasing height of the dead wood aggregation, increasing distance to the edge of the aggregation, and decreasing distance to the nearest dead wood stem. For *S. caprea* seedlings there was a significant association only with the height of the aggregation. The results show that the legacy of the pre-fire tree stand can allow seedlings of palatable early successional trees to escape browsers. The effectiveness of this mechanism depends on both the quality of the pre-fire stand and on the fire behaviour generating the dead wood. A fire regime of long fire-intervals (allowing for wide-crowned trees to develop) followed by a stand-replacing fire (allowing for large aggregates of dead wood) would be optimal.

Soils

Huang, Jianjun; Boerner, Ralph E. 2007. Effects of fire alone or combined with thinning on tissue nutrient concentration and nutrient resorption in *Desmodium nudiflorum*. Oecologica 153(2): 233-243.

Abstract. This study examined tissue nutrient responses of *Desmodium nudiflorum* to changes in soil total inorganic nitrogen (TIN) and available phosphorus (P) that occurred as the result of the application of alternative forest management strategies, namely (1) prescribed low-intensity fire (B), (2) overstory thinning followed by prescribed fire (T + B), and (3) untreated control C), in two *Quercus*-dominated forests in the State of Ohio, USA. In the fourth growing season after a first fire, TIN was significantly greater in the control plots (9.8 mg/kg) than in the B (5.5 mg/kg) and T + B (6.4 mg/kg) plots. Similarly, available P was greater in the control sites (101 lg/g) than in the B (45 lg/kg) and T + B (65 lg/kg) sites. Leaf phosphorus ([P]) was higher in the plants from control site (1.86 mg/g) than in either the B (1.77 mg/g) or T + B plants (1.73 mg/g). Leaf nitrogen ([N]) and root [N] showed significant site–treatment interactive effects, while stem [N], stem [P], and root [P] did not differ significantly among treatments. During the first growing season after a second fire, leaf [N], stem [N], litter [P] and available soil [P] were consistently lower in plots of the manipulated treatments than in the unmanaged control plot, whereas the B and T + B plots did not differ significantly from each other. N resorption efficiency was positively correlated with the initial foliar [N] in the manipulated (B and T + B) sites, but there was no such relation in the unmanaged control plots. P resorption efficiency was positively correlated with the initial leaf [P] in both the control and manipulated plots. Leaf nutrient status was strongly influenced by soil nutrient availability shortly after fire, but became more influenced by topographic position in the fourth year after fire. Nutrient resorption efficiency was independent of soil nutrient availability. These findings enrich our understanding of the effects of ecosystem restoration treatments on soil nutrient availability, plant nutrient relations, and plant–soil interactions at different temporal scales.