Appendix 30

Fire Effects on Key Ecological Processes in Forested Ecosystems

The following paragraphs on fire effects on forest succession are from Stickney (1982)

Forest Succession

…the severity of the disturbance…directly affects the representation of the survivor component in the post-fire vegetation. Since survivors derive from plants already established at the time of disturbance, it is possible…to determine the potential composition for the survivor component. For this reason it also follows that forest stands with little undergrowth vegetation could be expected to have a sparse or limited survivor component following disturbance. In addition, if the colonizer component is composed mostly of shade-tolerant climax-like species the rate of survivor recovery can be expected to be slow. Nearly all of our native forest shrub species are capable of surviving burning, and they can therefore be expected to function as survivors. A majority of the pre-disturbance forest herb species also demonstrated the ability to survive fire, particularly those species with underground stems (rhizome) or root crowns (caudex). As a generalization, the more severe the fire treatment to vegetation, the less the survivor component. In the drier, more open forest types this usually results in a reduction of amount, but not major changes in composition. However, in the moister forest types, where the undergrowth is made up of more mesic shade-tolerant species, marked changes in pre-fire composition can occur as increasing severity reduces survivor representation.

The severity of disturbance… (particularly fire) influences the potential for colonizer presence in two ways: (1) the degree of severity creates the character of the ground surface on which colonizer seedlings germinate, and (2) it activates onsite stored seed. Generalizing, the more severe the disturbance treatment, the more favorable the site becomes for colonizers. As the extent of exposed mineral soil increases, the ground surface becomes more favorable as a site for germination and establishment of colonizer plants. Increases in treatment severity also favor germination of ground-stored seeds by increasing their exposure to light or heat.

Predicting the occurrence of colonizers in post-disturbance vegetation is much less certain than predicting for survivors, but knowledge of the previous succession history can provide the potential composition of residual colonizers. Least predictable is the offsite colonizer component, for its occurrence is dependent on the timing of the disturbance to the availability and dispersal of offsite airborne seed.

The following paragraphs on decomposition and fuel accumulation have been adapted From Paysen et al. 2000

Decomposition Fire, insects, and pathogens are responsible for the decomposition of dead organic matter and the recycling of nutrients (Olson 1963; Stoszek 1988). Fire directly recycles the carbon of living and dead vegetation. The relative importance of fire and biological decomposition depends on site and climate (Harvey 1994). In cold or dry environments biological decay is limited, which allows accumulation of plant debris. Fire plays a major role in recycling organic matter in these environments. Without fire in these ecosystems, nutrients are tied up in dead woody vegetation. In forests, tree density and understories thicken causing increased competition and moisture stress. In turn, this increases the likelihood of mortality from insects and diseases leading to increased dead fuels, higher intensity fires, and possibly volatilization of more nutrients.

Fire both creates and consumes fuel. It increases available fuel by killing shrubs and trees, which leads to "falldown" of dead material into the surface fuel complex. Moisture contents of dead fuels average much lower than live fuels, which also increases fuel availability. Insects and diseases perform similar roles. They both kill vegetation, which creates available fuel, and decompose organic matter. Fire in some circumstances enhances the opportunity for insect and disease attack. For example, bark beetles may overwhelm fire-injured conifers, and wood rotting organisms may invade fire-scarred deciduous trees. A complex interaction that is not well understood exists between insects and disease organisms, fire, and the environment. However, we do know that fire, insects, and pathogens evolved together as vital components of ecosystems.

Fuel Accumulation Fuel accumulation is a term often used loosely to indicate an increasing potential for fire to start, spread, and intensify as the time since the last fire increases. Generally, in ecosystems where annual biomass increment exceeds decay, total vegetative biomass increases steadily with time because photosynthesis is an ongoing process. Fuels accumulate but not necessarily in a steady fashion (Brown 1985a). On forested sites much of the annual biomass increment is tied up in live tree boles where it is unavailable for combustion. In grasslands and forests having short fire intervals, fuels increase regularly over time as biomass increases. However, in medium to long fire interval conifer forests, available fuel, and fire potential may decrease as a post-fire stand develops, then increase as the stand becomes old and overmature (Brown and See 1981).

Fuel accumulation and associated fire potential depend on fuel quantity as well as other important fuel properties such as compactness and continuity (vertical and horizontal)…In a given vegetation type, fuel quantity, size distribution, dead-to-live ratio, and continuity are the important properties that change as succession progresses. Generally, fuel quantities accumulate to greater levels on the more productive sites in grassland, shrubland, and forest ecosystems (Brown and See 1981; Wright and Bailey 1982). In forest ecosystems much of the dead fuel exists as coarse woody debris, which includes pieces larger than 3 inches in diameter and sometimes larger than 1 inch in diameter (Harmon and others 1986). The more productive sites grow larger trees, which eventually become coarse woody debris.

An important consideration in management of temperate ecosystems is that coarse woody debris be recognized for the many roles it plays. It contributes to biodiversity by being part of the life cycle of macroinvertebrates, soil mites, insects, reptiles, amphibians, birds, and mammals (McMinn and Crossley 1996). It is a source of nutrients, habitat for terrestrial and aquatic life, and fuel for wildfire (Harmon and others 1986). As a fuel its most significant feature is that it becomes rotten wood, which prolongs burnout and allows fire to persist on site for long periods. Historically, large fires occurred because fire remained smoldering in rotten wood and duff for extended periods until low fuel moistures combined with high wind speeds to support intense, fast spreading fires.

Flammability increases as dead-to-live ratios increase. As fuels accumulate through growth and mortality of plants, flammability thresholds may be reached that allow fires to increase greatly in intensity. Surface fires become crown fires in conifer forests, and shrub communities burn intensely as a single fuel complex.

Fuel continuity is important because it partly controls where a fire can go and how fast it travels…In forests, existence of ladder fuels from understory vegetation allows surface fires to reach into the crown canopy. If the canopy is mostly closed, crown fire can readily develop under adequate wind speeds. Open canopies do not support crown fires. Increased fuel continuity can account for changes in fire severity from understory to mixed and from mixed to stand-replacement. Effects of fire on fuel arise basically two ways: first, reducing fuel through consumption, and second, increasing fuel by killing vegetation. Both processes affect several properties of fuel and fire potential. Initially dead surface fuel loadings are reduced, also lowering the dead-to-live ratio. If substantial amounts of shrubs, small conifers, and limbs and foliage of larger conifers are killed by fire but not consumed, they will contribute to surface fuels in the years ahead as they accumulate on the ground. Fire greatly influences fuel continuity by creating vertical and horizontal gaps within and between surface fuels and crown fuels.

Accumulation in Forests—Live and dead fuels, as well as small and large diameter fuels, can follow different patterns of accumulation. Typically, live herbaceous and shrub fuels increase following fire during early stages of stand development. Then as tree canopies close, live herbaceous and shrub fuel quantities tend to decrease on mesic sites (Habeck 1976; Lyon and Stickney 1976). However, a decrease in biomass may not occur where understories contain shade tolerant species. Fine dead fuels from foliage, bark flakes, twigs, and cured herbaceous vegetation become incorporated in the forest floor. Once crown canopies close, the amount of litter fuel remains fairly constant as newly fallen litter is offset by older litter moving into the duff layer. Duff quantities continue to increase for some time until equilibrium with decay is reached. This period varies widely from approximately 5 years in Southeastern United States (McNab and others 1978) to well over a hundred years in some boreal ecosystems.

Dead branches and tree boles accumulate on the ground in response to natural mortality and factors causing downfall (Brown 1975). Mortality factors such as fire, insects, disease, canopy suppression, and wind and snow damage impact stands in a rather haphazard manner. Thus, accumulation of downed dead fuel often occurs in an irregular pattern that is correlated poorly with stand age (Brown and See 1981).

Conifer crown fuels increase regularly; however, likelihood of crown fire may increase then decrease as the lower canopy level grows further above surface fuels. Eventually, crown fire potential increases again when surface fuels increase and understory conifers become ladder fuels. Shade tolerant species tend to have more foliar biomass than intolerant species due to their longer needle retention and higher crown densities (Brown 1978; Keane and others 1999). Because of their shade tolerance they can fill in crown canopy gaps and develop into understory ladder fuels.

Fuels critical to fire spread differ considerably between short and long fire interval fire regime types (Brown 1985a). In short fire interval forests, fine fuels such as grass, live shrubs, and needles create flammable understory fuels even in forests with vastly different decomposition rates such as in longleaf pine and ponderosa pine. The substantial quantity of fine fuels coupled with long periods of suitable burning conditions largely account for the understory fire regime. In long fire interval forests the forest floor and accumulated coarse woody debris are critical fuels. They burn with considerable heat release over a relatively long duration resulting in extensive mortality to overstory trees. They ignite other surface and aerial fuels and serve as excellent receptors of spotting embers that often allow fire to move in a leap frog fashion. Fire intervals and environments differ considerably between long fire interval types such as cedar-hemlock forests on warm moist sites and subalpine and boreal forests on cold, dry sites. Nevertheless, in both cases accumulated forest floor and downed woody fuels support stand-replacement fire particularly during extended dry periods (Romme and Despain 1989).