RODEO-CHEDISKI WILDFIRE: A SUMMARY OF IMPACTS

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The 462,600 acre Rodeo-Chediski Wildfire of 2002 was the largest known in Arizona's history and the ninth largest wildfire in the United States (National Interagency Fire Center 2009) in terms of the 462,600 acres impacted by the burn.. It damaged or destroyed ecosystem resources, disrupted hydrologic functioning, and altered loadings of flammable fuels in much of the ponderosa pine (*Pinus ponderosa*) forests exposed to the burn. An opportunity to study the impacts of this wildfire on ecosystem resources, hydrologic functioning, and flammable fuels presented itself on the Stermer Ridge Watersheds near Heber, Arizona. These watersheds were instrumented as a cooperative endeavor of the School of Natural Resources and the Environment, University of Arizona, Tucson, and the Rocky Mountain Research Station, U.S. Forest Service, to obtain baseline information on watersheds located on sedimentary soils (Ffolliott and Baker 1977). This information complemented the results obtained from "experimental watersheds" located in ponderosa pine forests on basaltic soils. One of the Stermer Ridge Watersheds was exposed to a high severity (stand-replacing) fire and the other to a low severity (stand-modifying) fire (Ffolliott et al. 2008, 2009). This five-year study (2002 through 2007) was initiated shortly after cessation of the wildfire and continued through implementation of salvage cutting and fuel reduction treatments on the watershed burned by a high severity fire.

A more comprehensive report of the impacts of this historical wildfire on ecosystem resources, hydrologic functioning, and loadings of flammable fuels has been prepared (Ffolliott et al. 2010). The purpose of this paper is to present a brief summary of these impacts.

IMPACTS ON ECOSYSTEM RESOURCES

The Rodeo-Chediski Wildfire impacted on the structures of tree overstories on the Stermer Ridge Watersheds, with the changes more drastic on the watershed experiencing a high severity fire than on the watershed burned by a low severity fire (Ffolliott et al. 2008). The pole class of trees (8 to 10 inches dbh) suffered higher mortality than trees in the sawtimber classes (12 inches dbh and larger). Most of the trees surviving the wildfire but severely damaged by the burn died within two years of the burn and many had started falling to the ground at this time. Salvage cutting and fuel reduction treatments imposed on the watershed burned by a high severity fire eliminated most of the remaining standing trees on this watershed. Stocking of ponderosa pine seedlings after the wildfire was insufficient to sustain a ponderosa pine forest on either of the watersheds.

Production of herbaceous plants and the grass and forb components of herbaceous plants were greater on the watershed burned by a high severity fire throughout the study. An earlier study in southwestern ponderosa pine forests found that production of herbaceous plants generally increases when densities of competing tree overstories decrease (Bojorquez-Tapia et al. 1990). Burning intensities that consume the litter and large amounts of the duff layer can also increase the level of herbage production in these forests (Clary et al 1968). Such a fire occurred on the severely burned watershed.

Mullein ((*Verbascum thapsus*) represented almost one-half of the production of the forbs on the severely burned watershed at its peak occurrence, while this early-seral species contributed less to the lower level of forb production on the watershed burned by a low severity fire. Mullein then declined in its occurrence after dominating the forb component on both of the watersheds in the early and middle years after the wildfire.

Impacts of the Rodeo-Chediski Wildfire on indigenous ungulates and small mammals inhabiting the Stermer Ridge Watersheds at the time of the wildfire differed in magnitude and duration. The increased presence of elk on the watershed burned by a high severity fire in the third year after the burn was attributed to the increase in preferred forage plants (Kufeld 1973, Thill et al. 1983), with availability of a cover being a secondary factor of importance. The smaller quantities of browse preferred by mule deer (Severson 1981, Thill et al. 1983) resulted in lower occurrences of this ungulate relative to that of elk on

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both of the watersheds. The limited presence of cottontail on both of the watersheds was a result of the limited availability of preferred forage plants (USDA Natural Resources Conservation Service 1999) available to this mammal. Extirpation of Abert's squirrel from the watershed burned by a high severity fire was caused largely by the loss of preferred feed trees (Ffolliott and Patton 1978). Following their initial disappearance, feeding activities by the squirrel were observed on the watershed burned by a low severity fire two years after the wildfire. This finding was attributed largely to most of their preferred feeding trees surviving the fire.

Not knowing the structure of bird communities on the watersheds before the wildfire precluded comparisons of pre- and post-fire species and numbers. Nevertheless, the numbers of birds in some guilds declined, while birds in other guilds were affected less by the wildfire (Ffolliott et al. 2009). Because of the varying responses of birds to the Rodeo-Chediski Wildfire, a mosaic of habitats on a scale much larger than that of the Stermer Ridge Watersheds seems necessary to sustain a "full suite" of bird species following the burn.

IMPACTS ON HYDROLOGIC FUNCTIONING

One impact of the wildfire on the hydrologic functioning of the Stermer Ridge Watershed burned by a high severity fire, and the limited areas of the watershed exposed to a low severity fire but burned at a high severity, was a decrease in the interception of precipitation with the loss of tree overstories and the litter and duff layers by the burn. Reforestation on these severely burned areas in the near future is unlikely without artificial regeneration. Litter and duff layers cannot re-form on the sites experiencing a high severity fire in the near future because of the absence of trees.

Transpiration is another component of the water budget that was altered by the wildfire. To estimate of the magnitude of this hydrologic component, a set of measurements of transpiration rates were obtained by the sap flow method (Swanson 1994). Three severely damaged and three undamaged ponderosa pine trees 18 to 24 inches in dbh were measured on each of the watersheds shortly after the wildfire. While sap flow was detected in all of the trees, the three repeated measurements of each tree sampled were insufficient to reliably differentiate the magnitude of transpiration losses on the two watersheds with confidence. Nevertheless, it was concluded that the loss of water by transpiration was reduced (to unknown levels) on both of the Stermer Ridge Watersheds, with comparatively higher losses on the watershed experiencing a high severity fire because of the greater loss of trees.

Infiltration of water into the soil was not measured in the study. It has been assumed, however, that the formation of water repellent soils as a result of the wildfire inhibited the infiltration rates, with much of the precipitation reaching the soil surface increasing the flows of overland water and concurrent erosion and deposition of soil particles (Garcia-Chevesich et al. 2004). This phenomenon was more pronounced on the watershed burned with a high severity fire because of the more extensive formation of strong water repellency (Stropki et al. 2005). Water repellent soils persisted up to three years after the wildfire, after which it was likely that infiltration of water into the soil increased toward pre-fire levels, while the accelerated overland flows of water and soil movement declined.

Destruction of the vegetative covers and litter and duff layers coupled with formation of the water repellent soils on the watersheds combined to result in peak stormflows of historical magnitudes following the wildfire (Ffolliott and Neary 2003). The highest of these peak stormflows were observed following high intensity, short-duration rainfall events shortly after cessation of the wildfire. While post-fire stormflows of "exceedingly high peaks" are often characteristic of flooding regimes, downstream flooding following the Rodeo-Chediski Wildfire did not occur. Quality characteristics of the water flowing from the watersheds were not measured in this study. It was (ultimately) determined, however, that the concentrations of sediment, nutrients, and other debris in water flowing from the larger area burned by the wildfire presented few environmental problems.

IMPACTS ON FLAMMABLE FUELS

Measurements made one year following the wildfire indicated that 40 percent of the accumulated pre-fire flammable fuels on the watershed burned by the high severity fire had been consumed in the burn, with most of this loss in standing trees. Nearly 75 percent of the pre-fire trees had died by 2005, three years after the wildfire, with this mortality translating into an additional increase of 15 percent in loadings of standing dead trees in relation to that one year after the fire. Measurements of flammable fuels on the watershed exposed to a low severity fire one year after the wildfire indicated that about 20 percent of the pre-fire loadings of flammable fuels had been consumed by the wildfire. The fire killed less than 5 percent of the pre-fire trees on this watershed. This finding was not surprising, however, as much of this watershed that had been burned was impacted by surface fire. The greater loadings of litter and duff on this watershed at this time was attributed to the litter falling from standing trees surviving the burn with "slightly scorched" crowns, an observation following earlier fires (Davis et al. 1968). In comparison, post-fire litter fall on the watershed burned by a high severity fire was minimal because most of the trees had either been killed by the wildfire or severely damaged and died within two years of the burn.

Salvage cutting and fuel reduction treatments implemented on the watershed burned by a high severity fire impacted the post-fire loadings of flammable fuels. The fraction represented by standing trees was (essentially) eliminated on this watershed by the treatments. However, stem sections, branches, and twigs on the forest floor increased significantly as a result of these interventions. Therefore, while the probability of future crown fire on the watershed has been reduced, the possibility of surface fire remains.

CONCLUSIONS

Recovery of the Stermer Ridge Watersheds from the Rodeo-Chediski Wildfire to date is related to the fire severities that the two watersheds experienced. The watershed burned by a high severity fire underwent a conversion from a southwestern ponderosa pine forest ecosystem to a landscape of grasses, forbs, and a few shrubs. This post-fire cover of plants is likely to persist in varying forms in the absence of artificial tree regeneration. Recovery of the hydrologic functioning on this watershed has begun on a limited scale with elimination of fire-induced water repellent soils and resulting decrease in the magnitudes of overland flows of water; a reduction in soil erosion and deposition and, therefore, sediment accumulations in the stream channel; and a gradual but continuous return of peak stormflows to pre-fire levels. It is anticipated, however, that the overall hydrologic functioning of this watershed will not approach pre-fire conditions for many years. Flammable fuels represented by standing trees have been eliminated as a result of the salvage cutting and fuel reduction treatments, but there has been an increased in the fraction comprised of stem sections, branches, and twigs on the forest floor. Therefore, while the possibility of a future crown fire has declined, the potential for surface fire remains.

Much of the watershed exposed to a low severity fire was either unburned or burned by surface fire at a low severity. The sites that were burned are recovering slowly from the Rodeo-Chediski Wildfire, a progression that is likely to continue into the future in the absence of further wildfire events or other major disturbance. While small areas of this watershed were burned at higher fire severities, these areas were isolated and scattered on the landscape. Much of the hydrologic functioning of the watershed is also returning to its pre-fire level. Post-fire loadings of flammable fuels were largely unchanged from their pre-fire estimates. This watershed remains vulnerable to future wildfire events as a consequence.

MANAGEMENT IMPLICATIONS

Information presented in this paper should be helpful to managers in anticipating the impacts of future wildfire events of varying burning severities on the ecosystem resources, hydrologic functioning, and flammable fuels in southwestern ponderosa pine forests. Duration of these post-fire impacts into the future might also be estimated. Identifying the need for implementing rehabilitation measures to mitigate the impacts when necessary could also possible in some instances.

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REFERENCES

Bojorquez-Tapia, L. A., P. F. Ffolliott, and D. P. Guertin. 1990. Herbage production-forest overstory relationships in two ponderosa pine forests. Journal of Range Management 43:25-28.

Clary, W. P., P. F. Ffolliott, and D. A. Jameson. 1968. Relationship of different forest floor layers to herbage production. USDA Forest Service Research Note RM-123.

Davis, J. R., P. F. Ffolliott, and W. P. Clary. 1968. A fire prescription for consuming ponderosa pine duff. USDA Forest Service Research Note RM-115.

Ffolliott, P. F., and M. B. Baker, Jr. 1977. Characteristics of Arizona ponderosa pine stands on sandstone soils. USDA Forest Service General Technical Report RM-44.

Ffolliott, P. F., and D. G. Neary. 2003. Impacts of a historical wildfire on hydrologic processes: a case study in Arizona. In: Pfeffer, M. J., D. J. Van Abs, and K. N. Brooks, editors. Water management for water supply systems: Proceedings of the 2003 International Congress. American Water Resources, Middleburg, VA. [CD-ROM]

Ffolliott, P. F., and D. R. Patton. 1978. Abert squirrel use of ponderosa pine as feed trees. USDA Forest Service Research Note RM-362.

Ffolliott, P. F., C. L. Stropki, and D. G. Neary. 2008. Historical wildfire impacts on ponderosa pine tree overstories: An Arizona case study. USDA Forest Service Research Paper RMRS-RP-75.

Ffolliott, P. F., C. L. Stropki, H. Chen, and D. G. Neary. 2009. Observations of bird numbers and species following a historic wildfire in Arizona ponderosa pine forest. Journal of the Arizona-Nevada Academy of Science 41(1):18-23.

Ffolliott, P. F., C. L. Stropki, H. Chen, and D. G. Neary. 2010. A historic wildfire in southwestern ponderosa pine forests: Impacts on ecosystem resources, hydrologic functioning, and flammable fuels. Forests. (In process)

Garcia-Chevesich, P. A., P. F. Ffolliott, and D. G. Neary. 2004. Soil losses following the Rodeo-Chediski Wildfire: An initial assessment. Hydrology and Water Resources in Arizona and the Southwest 34:51-56.

Kufeld, R. C. 1973. Food eaten by the Rocky Mountain elk. Journal of Range Management 26:106-113.

National Interagency Fire Center. 2009. Fire information: Wildland fire statistics. (http://www.nifc.gov)

Severson, K. E. 1981. Food habitats and nutritional relationships of mule deer in the Southwestern United States. In: Ffolliott, P. F., and S. Gallina, editors. Deer biology, habitats requirements, and management in Western North America. Instituto de Ecologia, Mexico, DF, pp. 149-164.

Stropki, C. L., P. F. Ffolliott, L. F. DeBano, and D. G. Neary. 2005. Water-repellent soils on the Stermer Ridge Watersheds after the Rodeo-Chediski Wildfire: A preliminary assessment. Hydrology and Water Resources in Arizona and the Southwest 35:47-50.

Swanson, R. H. 1994. Significant historical development in thermal methods for measuring sap flow in trees. Agricultural and Forest Meteorology 72:113-132..

Thill, R. E., P. F. Ffolliott, and D. R. Patton. 1983. Deer and elk forage production in Arizona mixed conifer forests. USDA Forest Service Research Paper RM-248.

USDA Natural Resources Conservation Service. 1999.Eastern cottontail. Fish and Wildlife Habitat Management Leaflet 4.