


POSTFIRE PLANT ESTABLISHMENT: THE EFFECTS OF ENVIRONMENT, PREFIRE VEGETATION, FIRE SEVERITY, AND LANDSCAPE POSITION



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♦ INTRODUCTION

The initial species composition and conditions following disturbance are crucial to determining the long-term development of vegetation (Egler 1954, Glenn-Lewin et al. 1992). Thus, an understanding of early succession can provide insights into the mosaic of vegetation types that will emerge on a landscape. Observations in the Rocky Mountains and elsewhere indicate that postfire vegetation patterns vary considerably. It is now known that numerous factors simultaneously contribute to the species composition of pioneer vegetation (Stahelin 1943, Cattelino et al. 1979, Glenn-Lewin 1980, Noble and Slatyer 1980, Keever 1983, Walker and Chapin 1987, Pickett 1989, Westoby et al. 1989, Glenn-Lewin et al. 1992), and often different patterns of early succession are possible even on sites that are similar. While research on the distribution of late successional vegetation along environmental and disturbance gradients has been a dominant theme in plant ecology (Daubenmire 1943, Whittaker 1956, Despain 1973, Loope and Gruell 1973, Whipple and Dix 1979, Peet 1981, Romme and Knight 1981, Wentworth 1981, Veblen 1986, Allen and Peet 1990), few studies have directly investigated the factors that affect the distribution of pioneer plant communities. Moreover, the influence of landscape structure on the development of vegetation mosaics

has only recently been considered (Milne and Forman 1986, Turner et al. unpublished manuscript). Studies designed to understand vegetation patterns following disturbance could be improved by considering site history and the character of the surrounding landscape as well as the effects of site features.

We have initiated research to consider the effect of various spatial, historical and site factors on early postfire vegetation in Grand Teton National Park (GTNP) and the adjacent Bridger-Teton National Forest. Specifically, we are studying the relationships between characteristics of early succession and fire severity, geologic substrate, soil characteristics, mean burn patch size, prefire canopy composition, cone serotiny, topographic position, distance to unburned vegetation, and the vegetation composition and fire severity of the surrounding landscape. Our research objectives are to: 1) determine the range of variability in the patterns of early postfire succession; 2) determine which environmental and historical variables are most important in controlling vegetation development following fire; 3) elucidate the importance of landscape position and between-patch interactions during early postfire succession; 4) develop a series of multivariate models that will predict the characteristics of early succession in different situations; 5) project, based on existing literature, the

most probable trajectories of each pioneer community type.

An important component of our research is to examine the influence of landscape context on early successional vegetation. Understanding and predicting the behavior of organisms requires the consideration of a broad environmental matrix, not simply the autecology of the organisms (Rowe 1981). According to Glenn-Lewin and van der Maarel (1992), spatial attributes such as landscape complexity, community isolation, and the spatial scale of disturbance are important factors influencing succession. We will use GRASS-GIS, to better understand the relationship between site characteristics and pioneer vegetation pattern (Davis and Dozier 1990, Davis and Goetz 1990) as well as to elucidate the importance of landscape position in early succession.

♦ STUDY AREA

A large number of geologic, topographic and hydrologic controls occur in close proximity in the Teton region. Much of the variability in site conditions that is characteristic of the Teton region is represented in 6 sites that have burned during the last two decades. The burns we are studying are known as the 1988 Huck Fire, the 1988 Hunter Fire, the 1987 Dave Adams Hill Fire, the 1985 Beaver Creek Fire, the 1981 Mystic Isle Fire, and the 1974 Waterfalls Canyon fire. The fires range in size from a minimum of 400 ha for the Beaver Creek Fire to greater than 32,400 ha for the Huck Fire. Elevation within the various burns ranges from approximately 2040 m to 2900 m. Fire severity within each burn varies from severe crown burning to light surface burns. The majority of the region's major vegetation types are represented within the burns.

A variety of different substrate types are exposed within the six burned areas (Table 1). For example, within the Waterfalls Canyon fire are some of the oldest rocks of the Tetons, Precambrian gneiss, as well as sandstone, limestone and siltstone dating to the Paleozoic Era and glacial deposits dating to the Quaternary. Glacial deposits also are found in the Mystic Isle and Beaver Creek sites. Within the boundaries of the Hunter, Dave Adams Hill, and Huck fires are volcanic substrates, landslide debris, and different Mesozoic sedimentary

rocks (including shales, sandstone, dolomitic siltstone and claystone; Love et al. 1992).

Table 1. Number of stands sampled within each major geologic type for each study area.

Substrate Type	Huck	Hunt	WCF	DAH	Mys	BC	Σ
Glacial Drift/Glacial Debris	4	1	8	3	12	9	37
Landslide Debris	5	4	1	4			14
Sedimentary (non calcareous)	8	1	1				10
Sedimentary (with calcareous layers)	1	3	1	2			7
Volcanic tuff	7			1			8
Precambrian Gneiss			2				2

Huck = Huck Fire; Hunt = Hunter Fire; WCF = Waterfalls Canyon Fire; DAH = Dave Adams Hill Fire; MYS = Mystic Isle Fire; and BC = Beaver Creek Fire.

♦ METHODS

VEGETATION DATA

We have adopted a standard sampling design whereby three rectangular plots (30 m x 5 m) are located within each stand, although the number and size of plots varies depending on seedling density, patch size, and variability within the stand. To sample the composition of the understory, ten quadrants (50 cm x 20 cm) are sampled within each plot. A complete species list has been compiled for each plot and the following plant data have been obtained:

a. Postfire tree establishment and survivorship: The density and height class by species of all live tree seedlings and saplings that established following the fire. For each species, the number of individuals that appear to have survived the fire (based on estimating tree age) have been recorded.

b. Estimate of prefire vegetation: The dbh (at 1.37 m) of all standing dead trees by species. Wood samples have been collected for anatomical analysis to verify the identification of dead trees. Wherever possible, the understory composition of nearby unburned forests (with similar site characteristics) has been recorded.

c. Percent cone serotiny: The prefire serotiny of *P. contorta*, if present, has been estimated

using the techniques developed by Tinker et al. (1994) or by determining percent serotiny in nearby unburned stands that are similar in site characteristics.

d. Percent cover of understory species: The percent cover of all herbaceous and shrub species has been estimated by cover class using the Daubenmire canopy coverage method (Daubenmire 1959), and the percent cover of all large shrub species has been estimated using the line-intercept method (Mueller-Dombois and Ellenberg 1974).

ENVIRONMENTAL DATA

In addition to plant data, the following environmental data have been collected for each plot:

a. Slope, aspect, elevation, and landform type [concave slope, ridgetop etc].

b. Distance to unburned forest, distance to ridgetop, distance to stream [either measured or estimated from topographic maps or aerial photos].

c. Percent of the soil surface that is bedrock, boulders, cobbles, gravel, soil, and dead wood.

d. Geologic substrate and soil type [determined from field inspection and available maps, e.g., Young (1982), Love et al. (1992)].

e. Fire severity, classified as severe, moderate or light [the criteria used to classify fire severity includes the degree to which branches were consumed by the fire, the consumption of leaf litter, charring of logs on the ground, and the density of surviving trees within the stand; See Bradley et al. (1992)].

f. Soil analyses [three soil samples have been collected and pooled for each plot for subsequent analysis of texture and chemical composition].

g. Weather patterns for the years following each fire [compiled from data collected at weather stations in GTNP].

DEVELOPMENT OF GIS DATABASES

A primary goal of our research is to demonstrate the correspondence that exists between early successional vegetation patterns and environmental and landscape features. To understand these relationships and to test our hypotheses, we will use a variety of techniques including GRASS-GIS, multivariate analyses, and statistics.

The following map layers will be included in the GRASS-GIS databases: elevation, aspect, slope (derived from a digital elevation model), geology, soils, hydrology, habitat type (available for all but the Hunter Fire), prefire vegetation type, and burn pattern (digitized from aerial photography). Vegetation and other environmental data from stands that we sample will also be added to the databases. From the original maps, measures of landscape structure will be generated using the *r.le* programs developed by Baker and Cai (1992), including diversity of vegetation types, mean patch size, dominance of burn severity class, distance to streams, distance to ridgetop, and distance to unburned forest.

PROGRESS REPORT

In a previous study (Doyle 1994), we analyzed data collected from permanent plots located in severe and moderate burns of the 1974 Waterfalls Canyon Fire in GTNP. Qualitative differences in species richness, life-history characteristics, percent cover of the understory, and density of postfire tree establishment were observed between areas that burned with different intensity. For both moderately and severely burned areas, the initial floristic composition appears to be important in shaping long-term development of the vegetation. Based on a comparison of the burned areas with older adjacent stands, various pathways of succession could be identified.

While conducting the Waterfalls Canyon study, we realized that a few permanent plots did not represent the wide range of variability in post-fire succession found in GTNP. Thus, during the summers of 1992-1994, we collected data from stands that had burned within the last two decades. These 80 stands represent much of the topographic and geologic variability within the six study areas (Table 1). In 1994, in addition to sampling 17 new stands, we collected additional data from previously sampled stands. These data include information on burn severity, as well as prefire stand characteristics such as percent serotiny and species composition prior to fire.

The following maps have been digitized and encompass most of the area within the six burned areas: geology, habitat type, vegetation cover type, soils, elevation, aspect, slope, and hydrology. Also,

using GRASS-GIS we have completed a preliminary landscape classification of the Dave Adams Hill Fire. Maps of geology, slope, aspect, elevation and burn mosaic were used to classify the landscape and the resulting classification appeared to be ecologically meaningful. We are continuing to digitize the burn mosaic from aerial photos for each of the other five study areas, and will be developing a landscape classification for each of the six study areas using the following map layers: geology, soils, slope, aspect, elevation, burn mosaic, distance to streams, and prefire vegetation.

In 1995 we will finish our data collection and concentrate on data analysis and development of our GIS database. We expect that the results of this research will provide a better understanding of vegetation patterns in the region and the influence of landscape context on early successional vegetation after fire. Our study complements ongoing research being conducted in Yellowstone National Park and will aid resource managers in managing for natural ecosystem processes.

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