Appendix Eight

Fire Ecology of Major Cover Types

The purpose of this appendix is to provide additional background information on the ecology and role of fire in each of the major cover types on National Forest lands in Utah.

Acreage Estimates and Trends of Major Cover Types

We used data from two statewide assessments of major vegetation cover types to estimate the number of acres in each cover type. The strength of O'Brien et al. data (O'Brien and Brown 1998; O'Brien and Collins 1997; O'Brien and Pope 1997; O'Brien and Tymcio 1997; O'Brien and Waters 1998; O'Brien and Woudenberg 1998) is the consistent wall-to-wall sampling of all forested lands in the state, regardless of ownership, and a statistically valid systematic grid sampling pattern . The disadvantage of the FIA (Forest Inventory Analysis) dataset for this analysis is that nonforest lands were not sampled. Because the data from O'Brien et al. came from actual plots on the ground, we used those data for all of the forested lands (woodland and timberland) on the six forests. Sagebrush/grass/forb and other nonforested types are derived from the GAP dataset. An advantage of using GAP data is that it was designed for use at the broad scale.

We determined the presettlement acreages of each cover type with the professional judgment of several specialists and the best interpretive data available. The historical acres for each cover type are intended to reflect respective abundances 150 to 300 years ago. These estimates are subjective, but demonstrate in a programmatic broadscale assessment the *trends and shifts* in the amounts of various cover types since the historical role of fire as an ecosystem process has changed in the past 150 years. Each forest was estimated separately and then we aggregated the data for all National Forest System (NFS) lands in the state. We rounded estimates of the historical abundance of each cover type to the nearest 10,000 acres. We did this to reinforce the notion that these are gross acreage estimates that are intended to illustrate trends in cover type over time. To report acres at a smaller scale would be to imply a false sense of accuracy.

Comparisons of historical acreages by cover type with existing condition for each cover type projects a trend of vegetation changes during the past 100 to 150 years (Tables/Figure). The pie chart provides a format to display trends for changes in the abundance of various cover types. To read the pie chart, the order of vegetation cover types in the legend starts at the top with "aspen" at 12:00 and goes clockwise back to 12:00 ending with "other". It has taken 150 years to get to this point. Correcting this trend will require decades of thoughtful management.

Figure A-1 displays the major plant communities found in Utah and the historic and current number of acres of each type.

Indirect evidence exists to reinforce the hypothesis that historically fires frequented these landscapes repeatedly and that they prevented most young trees from growing to maturity. Evidence for the absence of mature trees on Utah landscapes 200 years ago is found in Figure A-2 (O'Brien 1999a; O'Brien 1999b). This table covers a much greater area than the NFS lands in Utah. However, it shows a statewide increase in the area occupied by relatively young trees. For the nearly 15 million acres displayed, more than 87% of acres have trees with stand ages less than 200 years old. Some of these species are capable of living more than 200 years. Although harvests occurred in the past 150 years, it is unreasonable to think that 80%+ of the 15 million acres were harvested.

FIGURE A-1
Major cover types in Utah and the historic and current number of acres of each type.

Vegetation Cover Type	Historical Acres	Existing
Aspen	2,070,000	860,000
Lodgepole pine	470,000	470,000
Mixed conifer	430,000	1,990,000
Ponderosa pine	920,000	410,000
Pinyon-juniper	320,000	1,410,000
Mountain shrub	240,000	200,000
Gambel oak	310,000	270,000
Sagebrush/grass/forb	2,260,000	1,500,000
Other*	1,100,000	1,010,000
Total**	8,120,000	8,120,000

* Indicates these cover types are not fire-adapted.

** Analysis based on net NFS acres from FIA data. Acres rounded to nearest 10,000.

FIGURE A-2
Stand-Age Classes

STAND-AGE CLASSES																
Forest Types	Non stocked/ Unclassified	1-50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550	551-600	601-650	651-700	All Classes
ACRES																
Aspen	12,017	348,038	925,799	120,766	2,997											1,409,617
Blue Spruce		3,069	14,209	3,542												20,820
Cottonwood		3,550		21,706	3,542											28,798
Douglas-fir	97,871	131,057	378,902	264,424	57,259	63,584	18,426	17,348								1,028,871
Engel. spruce		6,320	85,182	168,143	55,164	12,113	16,015	3,300								346,237
Juniper	10,253	155,725	675,684	288,391	97,880	45,006	17,536	27,274	14,390	7,252		5,691			11,383	1,356,465
Limber pine	8,908		10,166	28,173	4,173	6,833		2,321								60,574
Lodgepole pine		70,932	159,609	114,520	30,964	6,019										382,044
Maple woodland		80,476	52,478	3,550												136,504
Mtn. mahogany		126,256	157,211	26,865	5,691	5,634	3,542									325,199
Oak		342,956	290,440	93,252	7,332											733,980
Pinyon-juniper	24,959	800,685	2,562,515	1,543,582	1,043,211	586,260	482,600	251,250	93,592	68,607	35,795	20,236	3,760	5,436		7,522,488
Ponderosa pine	110,165	59,799	214,201	82,503	50,195	19,096	8,597	6,040	3,020							553,616
Spruce/fir		64,973	316,716	230,936	49,071	16,265										677,961
White fir	8,534	40,092	172,828	86,941	38,140	8,297	5,648									360,480
All Types	272,707	2,233,928	6,015,940	3,077,294	1,445,619	769,107	552,364	307,533	111,002	75,859	35,795	25,927	3,760	5,436	11,383	14.9 mm

Fire-Adapted Cover Types

Aspen Aspen differs from other cover types because it regenerates from suckers that arise from the parent root system. Generally, disturbance or dieback is necessary to stimulate regeneration. These self-regenerating clones have existed for thousands of years. If they are lost from the landscape, they will not return through normal seeding processes as do other tree species (Bartos and Campbell 1998).

Patch size is variable and dependent upon site quality and competing vegetation. Patch sizes tend to be larger where aspen is associated with subalpine fir and mixed conifer forests. Patches become smaller on drier sites associated with ponderosa pine and Gambel oak and colder sites associated with spruce/fir and lodgepole pine.

On sites where aspen is stable (no conifer encroachment), the mechanisms that keep aspen dominant have not been thoroughly studied and may be variable and site dependent. It may be that aspen dominance is related to soils and moisture conditions where conditions are not favorable to conifer establishment and growth. A viable conifer seed source may not be close enough to germinate in these sites. Many stable aspen stands are uneven-aged where regeneration is a gradual, continual process. Other stable stands are two-aged or even-aged without any substantial regeneration. Stable aspen burns infrequently or as a result of fires burning in other vegetation types that carry into the aspen.

Loss, or potential loss of aspen can be attributed primarily to a combination of successional processes, fire exclusion, and overgrazing. The absence of fire, coupled with excessive browsing of young aspen trees by livestock and wildlife, has led to rapid replacement of aspen communities by conifer forests (Bartos 1998). Some of the aspen clones in Utah are in a mid to old structural stage (O'Brien 1999) and seral aspen areas are being overtopped by conifers through plant succession.

Brown and Simmerman (1986) found that livestock grazing reduces fine fuels so that fire intensity and rates of spread may be as low as one-tenth that of ungrazed stands. Surface fuels in pure aspen stands are not typically conducive to prolonged flaming or burnout due to a lack of intermediate fuels (.4 to 3 inches in diameter). The presence of conifers increases stand flammability and therefore may be essential to carry the fire to regenerate aspen on the site.

Although aspen often depends on fire for successful regeneration, individual stems are extremely fire-sensitive. Even low-intensity fires can cause mortality because of aspen's thin bark. Trees not killed outright by the heat often suffer mortality by the second or third growing season, succumbing to disease or other stress. A low intensity fire may kill the overstory but it takes a very high intensity, high severity fire to kill the root system.

Lodgepole Pine These forests are characterized as heavily stocked, growing in pure stands, on cold sites, and in large patches (often exceeding 200 acres). Where lodgepole is associated with shade-tolerant species, the shade-tolerant species will replace lodgepole without fire or other disturbance because of its intolerance for shade and a bare mineral seedbed requirement. Lodgepole characteristically regenerates after disturbance.

Stand development, vegetation mortality, and fuel accumulation interact dynamically with fire. The type and degree of vegetation mortality affects the fuel buildup, which in turn determines the severity of later

fires and subsequent stand regeneration. Historically, fire may have generated the most surface fuel. Competition between dense seedlings and saplings often results in further fuel buildup from suppression mortality.

Fire frequency varies with summer dryness and lightning occurrence, and it also depends on slope, aspect, elevation, and natural fire barriers. Fires tend toward one of two extremes. They may smolder and creep slowly on the soil surface consuming litter and duff, or act as a severe, stand-replacing crown fire. Most are low-intensity fires due to the generally sparse undergrowth. Cool, moist conditions prevail under a dense, closed canopy, and fires that start here usually remain on the ground, smoldering for days or even weeks before extinguishing.

A fire history in the subalpine fir zone in northern Utah found more frequent fire during European settlement favored the establishment of disturbance-related species lodgepole pine and aspen. The long fire return interval now being experienced by the area due to attempted fire exclusion favors more shade tolerant species, allowing them to eventually overtop the shade intolerant lodgepole pine. (Wadleigh and Jenkins 1996). Historically, low-intensity fires would have reduced both down woody and ladder fuels in the lodgepole pine type.

Mixed Conifer A wide range of fuel conditions exist in this cover type since it ranges across different kinds of stand conditions. Forest composition varies with elevation, exposure, and latitude. Fire frequency varies with summer dryness and lightning occurrence and also depends on slope, aspect, elevation and natural fire barriers. Associated species include most of the conifer species represented in Utah. Douglas-fir is most important in northern Utah, while lodgepole pine is the most dominant species on many sites in the Uintas. White fir, blue spruce, and limber pine may be common in stands in the central and southern mountains and high plateaus. Sometimes subalpine fir and Engelmann spruce may be the only tree species present.

In the dry, ponderosa pine/Douglas-fir type, ground fuels tend to be discontinuous with deep needle mats possible. Poor stocking rates and the resulting open stands make these stands less likely to experience widespread fire than more productive sites. On cooler, more moist sites where lodgepole, aspen, and Douglas-fir grow, the fuels are heavier since these are more productive sites. Closed stands with dense Douglas-fir understories present the highest fire hazard. Stands may have large amounts of downed twigs and small branchwood. Dense overstory trees and the presence of dead branches near the ground create a crown fire potential under severe burning conditions. Downed as well as standing dead trees resulting from dwarf mistletoe mortality may add greatly to fuel loads.

The white fir, spruce, and aspen type occupies the coolest, wettest sites of the mixed conifer zone. This zone is the most productive and consequently has the highest fuel loading. Ladder fuels and down woody material contribute to hazardous fuel conditions during drought years. Dense overstory canopies prevent shrub and herbaceous species from surviving underneath. Blue spruce is a component of the mixed conifer type type, found primarily in riparian and lowland areas. Some of the most extensive areas of blue spruce are on the Dixie National Forest.

Due to selective logging practices over the last 100 years, favoring the removal of ponderosa pine and Douglas-fir, and attempted fire exclusion, these stands are now dense and even-aged, with a larger component of fire sensitive white fir and subalpine fir. Once adapted to a frequent fire regime, they are now

predisposed to high intensity fires from the development of ground and ladder fuels. Stand replacement fires, outside the historical range of intensity and severity are likely.

Ponderosa Pine The geographic distribution of ponderosa pine appears to be limited to areas with adequate moisture in the early growing season. They cover extensive areas of the plateaus and mountains in the central and southern portions of the State. The absence of disturbance has encouraged a conversion to a higher proportion of shade-tolerant species such as Douglas-fir and white fir. These stands are in the mid- to mature-age classes, are overly dense, and more susceptible to insect and disease epidemics (Fule et al. 1997).

The steady accumulation of tree biomass has contributed to progressively declining herbaceous productivity. Ladder fuels are well developed and contribute to unwanted wildland fires outside the historical range of intensity and severity. Additionally, there has been a build up of forest litter and down woody fuels increasing potential fire hazard and lethal effects of fires on vegetation by concentrating heat on the upper soil layers and around the stems of trees and shrubs.

Pinyon/Juniper Stand composition varies with climatic and topographic location. Both pinyon and juniper have broad ecological amplitudes. They occur from the upper fringe of the Mojave Desert to the lower fringes of alpine forests. This wide tolerance of environmental conditions has affected migration by providing these species with the ability to establish into and dominate a wide range of communities. Juniper has wider ecological amplitude than pinyon and dominates lower or drier sites. More moderate higher elevation sites favor pinyon.

Pinyon-juniper stands that are most likely to burn have small-scattered trees with abundant herbaceous fuel between the trees, or have dense, mature trees capable of carrying crown fire during dry, windy conditions. Such stands are often located just below the ponderosa pine belt. Stands of moderate tree density, where overstory competition reduces the herbaceous fuel, and the trees are more widely spaced, are unlikely to burn.

Closed pinyon/juniper stands do not have understory shrubs to carry a surface fire, and do not burn until conditions are met to carry a crown fire. Many woodland sites in the Great Basin are not productive enough to produce this amount of fine fuel, especially if they have an overstory of trees. Trees taller than 4 feet in open pinyon/juniper are difficult to kill unless there are heavy accumulations of fine fuel beneath the trees. Sites with a good growth of cheatgrass are at higher risk for large fires. Livestock grazing reduces fine herbaceous fuels and lowers fire probability but not necessarily fire severity. Grazing tends to favor woody species, which burn hotter. Grazing encourages the spread of exotic species, such as cheatgrass. When exotic annuals, like cheatgrass, take hold after disturbance, it is unknown what will happen to the plant community. There is no past example by which to judge these circumstances.

On dry sites, fire may never have been as important an influence as climatic fluctuations in governing the rate of tree replacement of shrubland or grassland because of the lack of undergrowth to act as fuel. Moister, more productive sites probably had more extensive and frequent fires when droughty periods occurred. The steady increase in crown fuels has allowed burning through areas with deep soils (formerly sagebrush communities) at higher than normal intensities. These sites had never experienced such intensities and therefore are not adapted to this new fire regime.

Mountain Shrub The range of mountain shrub has been shrinking due to fire exclusion and overgrazing by ungulates. Pinyon-juniper and sagebrush have encroached into sites where fires would have historically prevented their spread into the mountain shrub community. Mountain maple has been an exception, increasing in some areas in northern Utah (Wasatch National Forest). Many maple areas are so dense, herbaceous cover is reduced (USDA Forest Service 1997).

Gambel Oak Gambel oak is a broadleaf, deciduous white oak which typically forms dense stands or thickets. On drier sites, it is a slow-growing shrub, but on relatively moist sites, oak often assumes a larger, treelike growth form. The treelike form is much more common at the southern end of its range. Oak typically grows from 3 to 20 feet in height in spreading thickets connected by underground rhizomes.

The range of oak is estimated to be greater today than it was historically (Brown 1958; Christensen 1949; Christensen 1957). Fire exclusion and livestock grazing may be responsible for the expansion of oak on benchlands and lower slopes. Despite the lack of fire, stand structures and conditions are sustainable and viable statewide (USDA Forest Service 1997).

Oak is a fire-adapted species since it resprouts prolifically following a fire. Only extremely severe fires with maximum fuel consumption at the base of the tree would produce enough heat to kill the buried rhizomes. Oak is seldom killed by fire. Fire may stimulate the growth of many dormant buds on rhizomes (McKell 1950).

Sagebrush/Grass/Forb The amount of precipitation a site receives will dictate the amount of herbaceous cover that exists beneath and between sagebrush plants. Grass and forb species associated with these communities assist with the spread of fire. When sagebrush communities are heavily grazed by domestic livestock, the herbaceous understory becomes sparse and can prevent the spread of fire. Fuels in these communities are light due to the lack of an overstory of trees to contribute down woody material.

Cheatgrass may become dominant on overgrazed sites with sparse herbaceous understories and the fire regime may be altered to one where fire burns more frequently (every 2 years). On high elevation sites where cheatgrass is unable to survive, sagebrush stands are dense and decadent with little or no understory vegetation. In some locations, sagebrush grows in large, homogeneous stands. These sites have more than 15 percent sagebrush cover (USDA Forest Service 1997) which indicates these communities are not functioning properly. Ignition probabilities have declined substantially due to the lack of fine grass fuels. When these newer communities burn, it is typically only during very dry conditions, rather than during the fire intervals and intensity levels common for the native system. These fires may burn more severely than they did historically due to the increased amount of woody fuels (USDA Forest Service 1996).

Fire exclusion has allowed pinyon/juniper to encroach onto adjacent sagebrush sites. The result has often been reductions in the production and diversity of associated understory communities. This has reduced the suitability of the affected sites for many species of wildlife and for livestock grazing. Associated alteration of the hydrologic regimes has the potential to change nutrient cycling, and increase soil loss (Tausch and West 1995).

Nonfire-Adapted Cover Types

The results of the properly functioning assessments indicated that several ecosystems in Utah are not adapted to or are not dependent on the presence of fire to maintain them in a properly functioning condition. They include: alpine, high elevation spruce/fir, tall forb, desertscrub, and riparian. The role of fire in the ecology of these ecosystems has been minimal, and it is assumed these ecosystems are within their historic range of variation (Evers 1998; USDA Forest Service 1997).

Alpine Alpine communities occupy relatively small areas at high elevations above tree line. They are restricted to the Tushar and Uinta Mountains. These communities grow under extremely harsh conditions, and recovery is slow after the slightest disturbance (USDA Forest Service 1997). Fire is not a disturbance common to this cover type. Therefore, this community is not fire-dependent.

High Elevation Spruce/fir This cover type ranges from pure Engelmann spruce to pure subalpine fir forests. In most instances it occurs as a mixed species forest. Subalpine fir is similar in ecology to spruce but is shorter-lived (100 to 150 years). It regenerates readily in shaded conditions on humus and duff as well as bare mineral soil. Spruce is characterized as long-lived (>300 years), found on cool moist to wet sites or in riparian areas. Conifer patches intermingle with subalpine meadows.

Due to the high elevation, short snow-free growing season, and moist environment, these ecosystems have relatively few fires. Grasses and forbs cure in August or September; about the time late summer storms often begin, effectively ending the fire season. Summer lightning is generally accompanied by rain, making fire spread unlikely. When an ignition occurs, it usually goes out on its own or stays small (< 1 acre). Only under specific conditions (long periods of drought combined with dry, windy conditions when an ignition occurs) will these sites burn. These specific conditions are unusual and infrequent but they are possible and within the historic range of variability. In this case, a fire could become large (> 1,000 acres). While this ecosystem may occasionally burn, fire does not play a significant role in the ecology of spruce/fir (Bradley et al. 1992).

Timberline stands are frequently discontinuous, separated by talus, rocky cliffs, or expanses of herbaceous vegetation. Fire has its greatest impact when occasional large high-intensity fires spread from lower elevation forests during dry, windy conditions. Periods of high wind and low fuel moistures present the greatest fire hazard. Low-intensity smoldering fires of restricted area probably occur most often. This type of fire may remove single trees or a small group of trees rather than an entire stand. In subalpine forests opened otherwise dense stands, and created a mosaic of different ages and species compositions.

Specific fire history information in subalpine fir and spruce forests is lacking. Stand-replacing fires may have burned every 200 to 400 years (Jenkins et al. 1998).

The role of fire in the ecology of these forests has been localized and small in scale. On drier sites, small fires may have created small openings that have filled in with spruce/fir. The loss of these openings over large landscapes has resulted in the creation of homogeneous stands of spruce/fir. Similarly, fire exclusion may have allowed the encroachment of spruce/fir into adjacent meadows or grasslands.

Tall forb Historically, tall forb communities were common at elevations above 7,000 feet in annual precipitation zones greater than 35 inches (USDA Forest Service 1997). It is found on all aspects and slope gradients where soils are greater than 18 inches and where soil moisture is adequate for nearly season-long plant growth. Typical sites include areas near springs, along streams, in small openings in forest, and in larger open parklands within Douglas-fir and spruce/fir forest zones. The effects of fire in the

tall forb cover type have not been studied. Moist conditions generally inhibit fire spread from wind-driven fires burning in surrounding vegetation types. This community is not considered fire-dependent.

Desertscrub The desertscrub community is located in southern Utah and occupies dry sites at low elevations. It is dominated by low shrubs and grasses. A single or a few species dominate large areas, creating homogeneous landscapes. Major shrubs include: blackbrush, greasewood, creosotebush, bursage, hopsage, pickleweed, and saltbush. Exotic annual grasses have invaded parts of this community. Several other nonnative grasses have been widely planted through the years to improve grazing, and these plants may reduce the potential for invasion by the annual grasses (Evers 1998).

The desert scrub community is not a fire-adapted community because most shrub species are fire sensitive. Even low-intensity fires can kill most species since most do not resprout or resprout weakly. The plant communities that may follow a fire in black brush community vary widely and rarely include species considered more desirable than black brush. The cryptogamic crust associated with blackbrush is very sensitive to disturbance (DeBano et al. 1998). This crust is very important to the hydrologic and nutrient cycling mechanisms of these harsh sites. Saltbush communities are considered fire tolerant, primarily because saltbush and many of its grass associates resprout vigorously and recover quickly (Evers 1998).

Riparian Riparian communities are composed of sites dominated by deciduous trees, shrubs, or herbaceous vegetation adjacent to seasonal or perennial free-flowing streams or open bodies of water. They are often found in a narrow strip along drainage bottoms or between streambeds and upland forest vegetation. Overstory dominants include cottonwoods, aspen, willows, maples, and alders. The understory may be lush and includes a diverse assemblage of forb and graminoid species.

The effects of fire in these communities have not been studied. Although riparian communities are productive and frequently have large amounts of live and woody fuels, moist conditions generally inhibit fire spread. Wind-driven fires originating in surrounding forests can carry in riparian communities during extended drought conditions. While many riparian species may resprout following a fire, this community is not considered a fire-dependent ecosystem.