Appendix D

Historic range of variability

Introduction

This summary of the natural and human history of the White River National Forest conveys what ecological conditions were like in the region of the forest before European settlement began around 1870. It also shows these conditions have changed in the 130 years since settlement began. Some will be essentially unchanged. Others will have departed significantly from earlier norms. The range of conditions that existed before human influences played a role is the *historic range of variability*, or HRV, of the White River National Forest. For the purposes of this report, the time scale of this range is pre-history to 1870.

Some conditions have changed since the beginning of settlement because such variability is natural for them. Many components of the area's ecosystems evolved on the basis of these fluctuations. These conditions can be said to be within their HRV. Others will have changed to a point that is not within the range of long-term fluctuation that is natural for them, usually because of human influence. These then are considered to be outside their HRV.

The findings summarized in this appendix are based on a number of individual reports by resource specialists that drew upon research findings, forest mapping data, literature reviews, Forest Service files, historical reports, anecdotal accounts, and professional judgment. It should be noted that for each forest resource, descriptions of what was present before European settlement vary greatly by resource and the types of information available for interpretation and analysis. There were two major limitations in this effort. One was the scarcity of scientific information about many of the resources before the middle of the 20th century. The other was the fact that much of the available information addressed broader geographic areas than the forest alone. References used for this study are included with each specialist's report. These individual reports are available to the public at the Forest Supervisor's office in Glenwood Springs.

Development of an ecological history can provide valuable information upon which to base management decisions. It can show how different ecosystems and communities respond to disturbance events, providing a context for long-term planning. It will assist the forest in designing a framework for ecosystem management and for identifying some of the trade-offs implicit in many management activities.

Although knowing what conditions are within or are outside of the HRV provides a reference point for forest managers, it does not necessarily convey desired conditions. In some cases, it may be appropriate to seek to maintain or return to pre-settlement conditions. In other cases, this outcome may not be desirable or possible.

The year 1870 is used to mark the beginning of European settlement of the area of the forest. This settlement period brought about large-scale change in the landscapes and ecosystems of the region. The rapid influx of settlers after 1870 was accompanied by

mining, road and railway development, livestock grazing, logging, water diversions, permanent settlements, and the control or suppression of natural disturbances.

Although explorers and fur traders had penetrated western Colorado in earlier decades, their impact on the area was relatively minor (except for certain animal species seriously depleted by trapping) in comparison to the population growth and resource exploitation of the late 19th century. Of course, Native Americans had occupied or visited the region for millennia, but they did not appreciably alter the role of natural processes in shaping the area's ecosystems.

For simplicity, "European" is used here to represent all non-Indian settlers and not to diminish the fact that other groups were involved in the westward movement.

ADMINISTRATIVE HISTORY

Throughout this report, facts and figures reflect a White River National Forest that has grown over the years in both size and complexity. The forest began as one of the nation's earliest forest reserves before being merged with other forests to reach its current acreage.

The 1880s marked the beginnings of a national conservation movement. People concerned about the rampant and unregulated exploitation of public domain timber and forage, and the threat this use represented to western watersheds, sought a means to protect these resources. They succeeded in March 1891, with the passage of the Forest Reserves Act. This act authorized the president to "set apart and reserve ... any part of the public lands wholly or partly covered with timber or undergrowth, whether of commercial value or not, as public reservations."

President Benjamin Harrison acted quickly, creating the White River Plateau Timber Land Reserve in October, 1891. The White River reserve encompassed 1,198,180 acres of forest land near the towns of Meeker, Blanco, Rifle and Glenwood Springs. Designation of the Battlement Mesa Forest Reserve followed six months later.

Naming of the reserves was not accompanied by provisions to protect them. For six years, unregulated use of the White River reserve continued unabated in the absence of management authority. This authority came with the passage of the Organic Administration Act of 1897, which provided management guidelines for the reserves under the control of the General Land Office of the Department of the Interior. The Act stated that:

> "...no public forest reservation shall be established except to improve and protect the forest within the reservation for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber for the use and necessities of citizens of the United States."

It also directed the Secretary of Interior to:

> "...make provisions for the protection against destruction by fires and depredations upon the public forests ... and he may make such rules and regulations and establish such service as will insure the objects of such reservations, namely, to regulate their occupancy and use and to preserve the forests thereon from destruction."

In 1902, the reserve was renamed the White River Forest Reserve. The Transfer Act of 1905 shifted management of the reserves to the Department of Agriculture's newly

established Forest Service. In the same year, Theodore Roosevelt designated the Holy Cross Forest Reserve, which encompassed lands in the Fryingpan, Roaring Fork, Crystal, Eagle, and Piney River drainages and covered 1,171,409 acres. In 1907, the forest reserves were renamed national forests.

In 1908, parts of the Battlement Mesa, Leadville, and Gunnison National Forests were transferred to the Holy Cross National Forest.

In 1929, 1,392 acres of the Holy Cross National Forest were turned over to the National Park Service, placing Mount of the Holy Cross under its jurisdiction as a national monument. This status was rescinded in 1950 and the land returned to Forest Service management.

Consolidation of the White River and Holy Cross national forests, as well as portions of the Routt National Forest, took place in 1945 to form most of the current White River National Forest. Responsibility for administering the Dillon Ranger District of the Arapaho National Forest was shifted to the White River National Forest in 1973, and the district itself transferred to the forest in 1998, bringing its total acreage to about 2.3 million acres.

BIOGEOGRAPHY

The physical characteristics of the White River National Forest — its climate, geomorphology, potential natural vegetation, and life zones — set the stage for the forms that its ecosystems and natural resources take.

A useful approach for understanding the ecosystems and resources of the forest is to view them in the context of much larger physiographic regions. These ecoregions, defined by the National Hierarchy of Ecological Units, are presented in more detail in Appendix E. This report focuses on the province and section levels of the ecological hierarchy to show how the forest compares to the Southern Rocky Mountains as a whole.

Province

The mountainous area of Colorado as well as the mountains of southern and central Wyoming, northeastern Utah, and northern New Mexico form the province known as *Southern Rocky Mountains Steppe-Open Woodland-Coniferous Forest-Alpine Meadow*, an expanse of nearly 66 million acres. All of the national forests in Region 2 of the Forest Service except those in South Dakota and Nebraska fall within the province.

The Southern Rocky Mountains Province features rugged glaciated mountains and intermontane depressions, or “parks.” Some mountains exceed 14,000 feet in elevation. Local relief varies between 3,000 and 7,000 feet. The climate of the province is a temperate, semi-arid steppe regime. In the higher mountains, a large part of precipitation falls as snow. Annual precipitation ranges from 10-20 inches in the valleys up to 50 inches at higher elevations. The climate of the province is influenced by prevailing west winds and the general north-south orientation of the mountain ranges. East slopes are much drier than west slopes. Average annual temperatures are 35-45° F but reach 50° F in the lower valleys.

Sections

The forest is located on two of the province's nine Ecological Sections. Its western half is within the *North-Central Highlands and Rocky Mountains Section,* while its eastern half is within the *Rocky Mountains and Northern Parks and Ranges Section*. These two sections encompass 19.3 million acres and include all of the mountainous area of the

northern half of Colorado.

The North-Central Highlands and Rocky Mountains Section features steeply sloping to precipitous flat-topped mountains dissected by narrow stream valleys with steep gradients. High plateaus have parks, mountain ridges, and foothills. Elevations range from 5,600 to 12,000 feet. The potential natural vegetation of the section includes western spruce-fir forest, pine-Douglas fir forest, pinyon-juniper woodland, mountain mahogany-oak scrub, and sagebrush steppe. Above timberline, alpine tundra predominates. At higher elevations, types include Engelmann spruce, subalpine fir, Douglas fir, ponderosa pine/Douglas fir, aspen, and meadows of grass and sedge. At lower elevations are pinyon pine, shrubs, and grass. Precipitation on the section ranges from 7 to 45 inches annually, and average annual temperatures from 32° to 45° F. In the mountains, water from streams and lakes is abundant, and ground water is plentiful. Snowfields are found on upper slopes and crests. Major rivers in the section include the Yampa, White, Colorado, Eagle, Arkansas, Taylor, Gunnison, Crystal, Roaring Fork, and Fryingpan rivers. Fire, insects, and disease are predominant sources of natural disturbance.

The Northern Parks and Ranges Section features steeply sloping to precipitous mountains dissected by many narrow stream valleys with steep gradients. The area has gently rolling mountain parks and valleys, with some mountain ridges. Rugged hills and low mountains are found in narrow bands along the eastern slopes of the Rocky Mountains. These hills are strongly dissected and in many places are crossed by large streams flowing eastward from the mountains. Elevations range from 5,575 to 14,410 feet. Potential natural vegetation consists of alpine meadows and barren, fescue-mountain muhley prairie, sagebrush steppe, pinyon-juniper woodland, and Great Basin sagebrush. Precipitation ranges from 5 to 50 inches per year, and annual average temperatures from 32° to 50° F. In the mountains, water from streams and lakes is abundant, and ground water is plentiful. Snowfields are found on upper slopes and crests. In the parks, perennial streams originate from snowmelt; by August, these streams are often short of water. Large reservoirs store water for domestic, power, and irrigation uses outside the mountain park areas. Major streams cross the foothills area, but elsewhere water is scarce. The Arkansas, North Platte, Laramie, Fraser, Yampa, White, Crystal, Roaring Fork, Fryingpan, and Colorado are major rivers in this section. Fire, insects, and disease are predominate sources of natural disturbance.

Table A-54 shows the acreages and percentage of the dominant cover types in the forest, the two sections, and the province, respectively. **Table A-55** shows what percentage of the two sections and the province that the acreages found on the forest represent.

Table A-54
Acres and rank of forest cover types on the forest, the two sections, and the province

Cover type	Acres of Forest	% of Forest	Acres of 2 sections	% of 2 sections	Acres of Province	% of province
Douglas fir	63,100	3	482,000	3	3,702,200	6
Ponderosa pine	1,500	<0.1	1,927,100	10	5,269,300	8
Lodgepole pine	265,100	12	2,980,000	15	9,781,700	15
Spruce-fir	690,000	30	2,583,000	13	8,776,500	13
Brush & shrub	157,200	7	995,800	5	1,601,700	2
Pinyon-juniper	19	1	1,137,900	6	8,115,900	12
Aspen *	448,900	20	2,311,700	12	5,045,400	8
Non-forested	647,800	28	6,888,500	36	23,316,900	35
Water	8,800	0.4	41,700	0.2	241,600	0.4
Total		**100**	**19,347,700**	**100**	**65,851,200**	**100**

** This category includes minor acreages of other hardwoods but is predominantly aspen.*

As **Table A-55** shows, the forest comprises only 3.5 percent of the province, but accounts for about 8 percent of its spruce-fir, 9 percent of its aspen, and 10 percent of its oakbrush and shrub. Similarly, the forest comprises only 12 percent of the two sections, but contains 27 percent of their spruce-fir stands, 20 percent of their aspen, and 16 percent of their oakbrush and shrub. Poorly represented cover types on the forest are ponderosa pine, Douglas fir, and pinyon-juniper.

Table A-55
White River National Forest cover types

Cover type	Acres of Forest	% of the Forest represented by this acreage	% of the 2 sections represented by this acreage	% of the province represented by this acreage
Douglas fir	63,100	3	13	1.7
Ponderosa pine	1,500	<0.1	<0.1	<1.0
Lodgepole pine	265,100	12	9	2.7
Engelmann spruce-subalpine fir	690,000	30	27	7.9
Oakbrush-mountain shrub	157,200	7	16	9.8
Pinyon-juniper	19,600	1	2	0.2
Aspen	448,900	20	19	8.9
Non-forested *	647,800	28	9	2.8
Water	8,800	0.4	21	3.6
Total	**2,307,500**	**100**	**12**	**3.5**

** Includes willow, Krummholz, grasslands, rock, alpine, and non-open-water wetlands.*

Other resources on the forest compare to the province and the two sections as follows:

- The percentage of non-forested vegetation on the forest is about the same as in both the province and two sections.
- Air resources throughout the province generally are of good quality, with isolated exceptions such as along Colorado's Front Range metropolitan corridor.
- No significant differences exist between the climate on the forest and that of the province other than what would normally be expected along a latitudinal gradient.
- No significant differences exist between the fire history and current management on the forest and those of the province and sections.
- No significant differences exist between the insect and disease conditions on the forest and those of the province and sections in general.
- In the area of aquatic resources, the forest has a high percentage of the habitat and population base of Colorado River cutthroat trout in the two sections. Transbasin water diversions are high on the forest. Diversions for seasonal snowmaking by ski resorts are more concentrated on the forest than elsewhere.

Life zones

Landscapes can be characterized by the mix of vegetation, climate, and wildlife found at different elevations. It is useful to view the White River National Forest in terms of these *life zones* to understand how vegetation and wildlife habitats change as elevation increases. **Table A-56** shows the life zones that occur on the forest.

Table A-56
Life zones on the White River National Forest

	Elevation range (in feet)	Acres of forest	% of forest
Arid / semi-arid	5,000-7,000	15,600	>1
Lower montane	7,001-8,500	249,900	11
Montane	8,501-10,500	1,213,200	54
Subalpine	10,501-11,799	562,400	25
Alpine	>11,800	222,600	10

One should note that elevation alone is not always a consistent measure in mountain regions because of "environmental compensation," or the difference between north-facing and south-facing slopes. The elevations given here for each zone are general ranges that may vary depending on site aspect.

The following description of life zones is accompanied by **Table A-57**, which provides climate data for each of the zones.

- The **arid/semi-arid** zone is a mosaic of grassland, shrub (rabbitbrush, Gambel oak, chokecherry, serviceberry, and mountain big sagebrush), pinyon pine, juniper, and barren land that occupies only a small part of the forest. This zone is found along large river basins and the steep side slopes of mesas. A relatively high degree of natural vegetation patchiness is common. As one moves upslope, woodland forest species and shrubs dominate northern aspects while grasses and barren lands dominate southern exposures.
- In the **lower montane** zone, Douglas fir dominates northern exposures at lower elevations and on steep canyon slopes. At higher elevations, aspen favors southern aspects and spruce favors northern aspects or drainage areas. Ponderosa pine occurs in isolated areas near major river corridors.
- The **montane** zone is a blend of forest vegetation, non-forest lands and unique geographical features. Most of the White River National Forest occurs in this zone. Montane lands are dominated by lodgepole pine, aspen, Douglas fir, and Engelmann spruce cover types. Non-forested lands are dominated by Gambel oak, berry shrubs, sagebrush, elk sedge, and Thurber fescue. This zone exhibits a relatively high degree of natural patchiness.
- The **subalpine** zone occurs as a mosaic of forest and non-forest vegetation in which forested types dominate the landscape matrix. Engelmann spruce shares the landscape with subalpine fir in varying ratios. The subalpine landscape often is dotted and swirled with stands of aspen and lodgepole pine depending upon past disturbances, elevation, and aspect. This subalpine forest typically is sculptured by steep drainages, rock outcrops, and contrasting aspects. Southern aspect slopes yield warmer and drier conditions often resulting in more intense disturbances. Some of these slopes are dominated by grasslands or open-canopy woodlands.
- The **alpine** zone is the highest in elevation, with a surprisingly high variety of plant species. The zone is dominated by sedges, kobresia, alpine avens, American bistort, dwarf clover, Rocky Mountain nailwort, and unclassified lichens. This vegetation is found in and around vast fields of rock talus. The alpine zone is naturally open with isolated patches of shrubs and Krummholz. This region is covered with snow for the greater part of the year.

Table A-57
Climate characteristics of life zones on the White River National Forest

Life zone	Air Temp. (°F)	Soil Temp. (°F)	Frost-free Period (days and seasons)	Annual Precipitation (inches)	% of Precip. as Snow	Snowfall Accumu-lation (inches)	Snowmelt Period (on north slopes)	Snowmelt Period (on south slopes)
Arid/ Semi-arid	46-52	48-52	80-110, May to Sept.	10-12		>40	March to April	Feb. to March
Lower Montane	44-48	42-48	70-90, June to mid-Sept.	16-20	50	40-80, Sept. to May	mid-April to May	March to April
Montane	36-42	38-42	60-80, mid-June through Sept.	18-25	50	80-150 Sept. to June	late-April to late-May	mid-March to late-April
Subalpine	34-38	34-38	30-50, July through Aug.	20-40	50	135-350, October to May	late-May to late-June	early May to June
Alpine	32-36	32-36	10-30, late July	>20 to 50	70-80	200-400, Sept. to June	June to August	May to early July

HUMAN USE

Human use before 1870

From around 10,000 B.C.E. (before current era), the forest was frequented by big-game hunters known as Paleo-Indians. Hourglass Cave, at 10,500 feet, has yielded human remains dating to about 6,000 B.C.E. Small bands of people are thought to have moved through the region with the seasons. Most evidence of their passage is limited to isolated finds of large projectile points that were used to hunt such large animals as the mastodon and a now-extinct species of bison.

For several centuries, and perhaps for much longer, the Western Slope of Colorado was the domain of the Ute Indians. Most sources describe the social organization of the Utes as a loose confederation of seven bands. Two of these bands occupied the area of the forest: the Grand River band, (also called the Parianuc), who lived along the Colorado River; and the Yampa band (also called the White River, Yamparika, or Sabuaganas), who inhabited the Yampa River Valley and adjacent areas. The total population of the tribe, before European contact, is thought to have been no more than a few thousand.

The Utes were skillful nomadic hunters who followed herds of bison and elk on their seasonal migrations. They developed an extensive network of foot trails throughout the region. On the forest, one of their most important trails is known as the Ute Trail, which runs from the confluence of the Eagle and Colorado rivers to the White River.

For shelter, the Utes lived in tepees covered in elk or bison hides, and during hunting forays they built wickiups made from the boughs and bark of pinyon, juniper, or aspen. They followed the mountain bison from their summer range in the Flat Tops to their winter range in the Roaring Fork and other valleys. They also used snowshoes to hunt elk

in winter. Other animals that were obtained for hides or food included deer, rabbits, mountain sheep, beaver, ground squirrels, sage grouse, ducks and fish. Their vegetable foods normally included roots, berries, seeds, several kinds of greens, the inner bark of pine, and pine nuts. Plants also were used for basketry, sewing materials, and matting.

The Ute people preferred a diet rich in meat sources. In the region of the forest, fish were a relatively minor food source. Accounts of their fishing methods include shooting with bow and arrow and the use of bone hooks baited with grasshoppers.

Although Indian tribes in other parts of the continent made deliberate use of fire to manipulate vegetation, there is no record of the Utes having done so. Most fires in the pre-settlement period are assumed to have been started by lightning.

Exploration of the region of the forest by people of European origin began with a brief initial foray by Spanish missionaries, who failed to find the route to California they were seeking.

In the 1820s, fur traders traveled throughout western Colorado, searching mainly for beaver to serve the burgeoning market in Europe for beaver hats. The fur trade lasted only a few decades, declining after over-trapping of beaver seriously depleted their population and beaver hats passed out of fashion. Also sought by trappers during this period were mink, wolverines, river otter, and other furbearers. The mountain men were the first Europeans to build permanent settlements and trading posts in the area.

The 1840s and 1850s brought a number of American expeditions, commissioned by the Army to find routes to California, passes across the Rockies for railways, or the headwaters of the area's principal rivers.

Human use after 1870

In the 19th century, the nation's westward expansion came late to Colorado. Its towering mountain ranges were a barrier to travel. For decades, pioneers and traders gave the mountains a wide berth and followed instead the Oregon and Santa Fe trails that delivered them to points further west. When gold fever struck Colorado in 1859, thousands of fortune-seekers came to the Front Range in the 1860s. In that decade, prospectors staked their claims throughout the Eastern Slope of the Rockies, but few ventured very far west of the Continental Divide. The 1870s brought the mining boom into lands of the White River National Forest, starting with the establishment of Breckenridge in 1869, and of Red Cliff and Aspen in 1879. High above these towns were numerous mining camps built near timberline in the drainages of the Blue, Eagle, and Roaring Fork Rivers.

Most of the initial population growth of the area of the forest took place in the 1880s. Aspen grew from a few hundred people in 1879 to more than 11,000 in 1893. The 1880s also marked the coming of farmers and ranchers to settle the river valleys of the region.

Prompted by the demand for meat by local residents as well as to serve Eastern markets, ranchers introduced thousands of heads of cattle to the forest. Herds brought from Texas were turned loose on the mid-elevation meadows; each fall, cowboys would round up the herds and drive them over a network of stock trails to their winter range in lower valleys or to railheads along the Colorado River. Large herds of sheep followed in the 1890s,

sparking a range war between sheep growers and cattlemen in which thousands of sheep and some of the shepherds were killed.

During the mining boom of the 1870s and 1880s, extensive clearing of trees near the mines was done to produce mine props, sluiceways, and related structures, and to build the mining camps and towns that popped up throughout the high country of western Colorado. To construct the narrow-gauge railroads that carried ore to the smelters and supplies to the mining towns, many thousands of rail ties were cut from area timber stands. Also needed was lumber to erect railway trestles and bridges. Ranchers and farmers made use of nearby forests to build fences, corrals, houses, barns, and outbuildings, supplementing their incomes by supplying ties to the rail crews.

In the 1880s and 1890s, when commercial quantities of coal were found in the Roaring Fork and Crystal River valleys, thousands of miners worked the coal seams. Building of the railroads also employed thousands of workers. To fuel the Leadville smelters, hundreds of coke ovens were built near Glenwood Springs. At the same time, the town was rapidly becoming a major tourist attraction as people came by train to bask in its renowned hot springs pool.

Each push by settlers into Western Colorado led to efforts to remove the Ute tribes from their traditional lands. In 1863, after the gold rush spread throughout the Front Range, the Utes ceded the Eastern Slope but retained all of Western Colorado. A second treaty in 1868 gave up more land but kept the western third of the Colorado Territory. When gold and silver were found in the San Juan Mountains in 1870, pressure to remove the Utes mounted, and the tribe agreed to cede much of the area. The Ute presence in what was left of their domain in northwestern Colorado ended in 1881 when the tribe was forced out of most of Colorado and the area of the forest was opened to European settlement.

Much of the mining activity on the forest came to an abrupt end in 1893, when the U.S. Government withdrew its price supports for silver and Colorado's silver mining industry collapsed. Coal mining continued and zinc and other mineral resources were developed to carry a more limited mining industry into the 20th century.

Farming and ranching settlement accelerated after the displacement of the Utes, initially along the river bottoms, where water was needed to support cattle and irrigate hay fields. Ranchers made extensive use of the mid-elevation rangelands of what would become the White River National Forest. A number of Colorado River towns trace their origin to the support of ranching, including Gypsum, New Castle, Rifle, Silt, and Wolcott. Completion of railway access through this river corridor enabled ranchers to ship livestock to eastern markets, boosting demand for use of the public range.

During the settlement period, market hunting of deer and elk brought about their near-extirpation from the forest by about 1910. World War I brought increased demand for livestock, and the forest accommodated this demand by greatly increasing the number of animals permitted to graze. This upward trend continued to about 1930, when the effects of severe overgrazing were seen. Forest managers responded in the 1930s by reducing permitted numbers to much lower levels. The 1920s and 1930s also saw the introduction of protections for deer and elk to restore their numbers.

In these same decades, the forest acquired national significance as the site of Mount of the Holy Cross, which attracted thousands of visitors to viewpoints near the mountain.

A key factor in management of the forest during the Great Depression was the Civilian Conservation Corps, which from 1933 to 1942 built many roads, trails, and structures; fought fires; and treated forests for insects and disease. Improved facilities for access and recreation built by the CCC helped kick off the era of large-scale forest recreation that began after World War II and continues today.

The Army's decision to build its Camp Hale base along the upper Eagle River played a major role in the Forest's future. During the war, some 16,000 troops were trained at this facility in winter mountaineering techniques. After the war, some of these 10th Mountain Division veterans returned to Colorado to establish the downhill ski areas that today have come to represent the White River National Forest to the world and are the source of most of its current recreation use. Another attraction linked to the Camp Hale heritage is the forest's backcountry hut system, which has become very popular for both winter and summer use.

Many of the people exposed to this area during the war returned in the decades that followed to enjoy its recreational attractions or to develop economic ventures. As the ski resorts grew, so did communities near them. The Aspen ski areas came first in the 1940s and 1950s, with Vail following in 1962. The 1960s also saw the development of four ski resorts in Summit County.

In recent years, ski areas operating have evolved into four-season resorts that attract visitors throughout the year. Communities near the forest that once based their economies on skiing alone have moved beyond this base to support a host of other businesses, including second-home development, golf courses, recreation outfitting and guide services, retail stores, and support services for a rapidly growing local population. Significant outcomes of this growth have been greatly increased recreational use and impacts on the forest as well as the loss of wildlife habitat and migration corridors to road building and urban development.

The passage in 1964 of the Wilderness Act, later followed by designation of about 750,000 acres of Wilderness on the forest, has made it a popular destination for hikers, campers, and cross-country skiers. In the fall months it also attracts thousands of hunters drawn by the nation's largest elk herd.

Diversion of water from the forest to supply Front Range communities, along with storage projects to meet Colorado River Compact obligations, has altered flow regimes in many locations of the White River National Forest. Among the projects developed in recent decades are the Green Mountain, Dillon, Ruedi, and Homestake reservoirs.

The interstate highway corridor that bisects the forest represents a major source of impacts to the area's ecosystems. Completion of the Eisenhower Tunnel, Vail Pass, and Glenwood Canyon segments of Interstate 70 has put the White River National Forest within easy reach of the Front Range population as well as other travelers. Widening of Highway 82 from Glenwood Springs to Aspen also has improved public access to the forest. As the volume of traffic has increased on both routes, so has use of the forest's 2,400 miles of forest development roads.

Farming and ranching continue near the forest today, although in many places they are being displaced by rising property taxes, unfavorable markets, and nearby urban growth. Many of the home ranches that once accompanied grazing allotments on the forest have

been sold to developers, their conversion then resulting in the alteration of habitats and the loss of winter range for wildlife.

Human use conclusions

- Human use and occupation of the forest has occurred for thousands of years and will continue.
- Use of the landscape by Native Americans to obtain sustenance, shelter, and clothing had a very limited influence on ecosystems because of their small populations, lack of technology, and non-exploitive philosophies of land use.
- The influx of European exploitation of natural resources that moved a number of forest resources or conditions out of the HRV. This period brought about federal regulation of public lands in the area and the later passage of a range of legislation to protect environmental values.

FORESTED VEGETATION

This section summarizes the HRV status of forest vegetation on the White River National Forest. The stand and landscape level conditions of composition, structure, and pattern for the major cover types on the forest are compared between conditions that existed on the forest prior to the settlement of the area by modern Europeans and those same parameters on the forest today. Where the data permits, conditions specific to the White River National Forest are compared, but when the data is lacking, other, adjacent studies of historic or current conditions were used to make the best interpretations.

The primary components addressed in this section include the composition, structure, and pattern of the spruce fir, aspen, lodgepole pine, Douglas fir, pinyon juniper and ponderosa pine cover types as well as general landscapes found on the White River National Forest. Other forested cover types exist on such limited acreages on the White River National Forest that landscape scale interpretations are difficult to make. Disturbance ecology principles specific to the major cover types are discussed in general terms. More specific and detailed information concerning disturbance ecology for the major cover types can be found in the insect and disease and fire chapters of the HRV document.

Historic conditions are considered to be the range of conditions that occurred on the forest prior to the changes induced by the settlement of the area by modern Europeans. These conditions are referred to as pre-European settlement conditions or pre-settlement. Conditions that resulted from the impacts of European settlement are referred to as post-settlement condition. The influx of European settlement began approximately 1870 when the first miners moved into the area eventually designated as the White River National Forest. Many of the major impacts associated with the settlement period occurred during the first 30 to 40 years of intensive exploration and exploitation of resources. The historic conditions are compared to the current conditions for the landscapes and cover types on the forest. The impacts of early settlement as well as from more modern forest management activities are discussed under the Human Uses Section and the individual cover type sections.

METHODS

The information contained in this report is a synthesis of available historic and current literature, including reports by early explorers to the area and interpretation of recent scientific literature. Where information specific to the White River National Forest was available, it was used to develop interpretations. However, much of the available information was more general in nature, such as studies specific to the general Rocky Mountain area. Also used were unpublished internal Forest Service reports. Funding and timeframes prevented initiating new fieldwork. Recent Historic Range of Variation reports, either finalized, or in draft form were also reviewed for appropriate information. Information concerning site-specific, historic conditions on the forest were available in different forms, and were used when appropriate to the topic of discussion. Most interpretations are qualitative rather than quantitative due to the limitations of the historic literature, descriptions, and mapping. Studies on adjacent forests that have analyzed landscape conditions were used to interpret conditions on the White River National Forest when the cover types and other conditions were similar to the White River National Forest.

Vegetation data used to develop local interpretations regarding composition, structure, and pattern of cover types came from two White River National Forest databases, the RMRIS database and the Common Vegetation Unit of the Integrated Resource Inventory Database currently under development on the forest coupled with the forested vegetation database from the 1984 forest planning effort. The RMRIS database was the most useful in determining stand ages, especially for even-aged stands. For even-aged cover types such as spruce fir, this database averages the ages of trees within the stand, which limits the accuracy of the information concerning stand age by biasing the true stand initiation age downward. The RMRIS database has not been digitized and therefore is not spatial, which severely limited its utilization for making interpretations concerning differing portions of the forest. Approximately 40 percent of the total White River National Forest is covered by the RMRIS database information.

There are some identified limitations of the databases used for this study. The RMRIS database is based on stage II stand exams and covers approximately 40 percent of the forest. The RMRIS database does provide limited age data for individual trees within a stand. This age information is most useful when investigating even aged forested stands, such as aspen and lodgepole pine. Since the ages of a data site are the average of all the ages of the individual trees that were measured at that site, it is less useful when the stand is an uneven-aged stand such as normally occurs in spruce fir cover types. Although this database does provide the most detailed field verified data for specific locations, it has not been digitized and does not provide spatial information.

Assumptions included in the RMRIS database include:

- Polygons must be greater than 5-10 acres
- They are segregated by topographic features (such as ridgelines and streams)
- They are segregated by human development (such as highways, roads, and subdivisions)

- They are segregated by 40 percent slopes (the limit of commercial timber harvest capability)

The Integrated Resource Inventory, Common Vegetation Unit database has not been completed on the forest, which places limitations on its utility. The CVU information is a photo interpreted, ARCINFO, spatial database and covers approximately 83 percent of the total acres of the White River National Forest. The majority of the non-wilderness has been completely mapped, but much of the designated wilderness on the forest (750,000 acres) has not been mapped. The forest combined the mapped portion of the CVU database with a previous mapping effort, which included the wilderness, resulting in what is known as the WR/Veg database. This is the database used for overall vegetation information in this report. TheWR/Veg combined database was completed at a coarser scale and does not allow the same resolution as the CVU information. Advantages of this database are that it is spatial and it covers the entire forest. No specific age data is included in this database, so interpretations are based on size and canopy closure.

FORESTED SETTING

Physiography

The White River National Forest includes steeply sloping to precipitous flat-topped mountains dissected by narrow stream valley with steep gradients. High plateaus have steep walled canyons (McNab and Avers 1994). There are gently rolling mountain parks, mountain ridges, and foothills. Elevations on the forest range from 5,700 feet to over 14,000 feet. The extreme variation in topography on the forest results in natural patchy vegetation patterns across the landscape.

The forest species composition of the eastern portion of the forest differs slightly in comparison to the western portion (Battlement Mesa, Grand Mesa, and White River Plateau RMRIS database). The eastern portion resides in a continental mountain climate (Hogan 1992), which favors lodgepole pine. The western mesa topography favors aspen as middle successional stages of the spruce fir habitat type (Sudworth 1900a; Veblen et al. 1994).

Major Forest Vegetation Types

The major cover types discussed in this section of the HRV report include Engelmann spruce-subalpine fir (spruce fir), Douglas fir, lodgepole pine, aspen, ponderosa pine, and pinyon juniper. Other cover types on the forest, such as limber pine, cottonwood, and blue spruce occur on such limited acreages that information is generally lacking to make any assumptions concerning the HRV conditions for these cover types. Ponderosa pine and pinyon juniper woodlands also occur on relatively limited acreages on the forest, but some discussions about these two cover types are possible based on the information available.

The current acreage and percentage coverage of the various cover types of the White River National Forest are listed in **Table A-58**, below.

Table A-58
Acreage and percentages of the current cover types on the White River National Forest

Cover Type	Percentage Cover	Acres
Spruce/ Fir	28.5	650,700
Douglas-fir	3.1	69,700
Lodgepole pine	11.2	256,600
Pinyon-juniper	0.7	15,100
Aspen	18.7	426,000
Ponderosa pine	< .1	300
Oakbrush/Shrubland	8.0	181,800
Limber pine, blue spruce	0.2	3,900
Non-forested*	29.3	668,500
Water	**0.4**	**9,800**
Totals	**100**	**2,282,400**

*Includes willow, Krummholz, grasslands, rock, alpine, and non-open-water wetlands.

THREATENED OR ENDANGERED FOREST COMMUNITIES

No forested communities on the White River National Forest are officially listed as threatened, endangered, or sensitive. The Colorado Natural Heritage Program list the balsam cottonwood-blue spruce/ alder/red-osier dogwood type as G2, S2, indicating that it is imperiled globally and at the state level due to it rarity. One area of this community occurs on the Eagle District along Brush Creek for approximately 1.1 miles (0.2 miles within the proclamation boundary up E. Brush Creek). This montane riparian forest type was rated as "excellent" in 1988.

LAND USE AND MANAGEMENT HISTORY

Much of the current forest vegetation is directly related to the major disturbance events associated with the early European settlement of the forest, and the consequent demand for resources. Mining in the 1870s to 1890s produced major changes in the forested landscapes through extraction of timber and use of fire. Gold, silver, and coal mining (1870-1890s), farming and ranching (1890-current), federally subsidized access (CCC 1930-40s), fire suppression (most significant from 1920 to the present), and increased forest management technology (1980-current) have all resulted in vegetation change.

Commercial and private logging, market hunting, fur trapping, unregulated fires, and mining during the later part of the 19th century all played significant roles in changing the resources on the lands that became the White River National Forest. Entire mountainsides were burned by prospectors to reveal potential ore bodies; fires were intentionally set to

kill stands of trees for future logging (it was less of a crime to harvest dead trees than live); the construction of railroads and mines necessitated large volumes of sawlogs, mine props, and cross ties; and populations of the larger wildlife of the area were decimated by market hunting to supply the demands of the miners and settlers (Sudworth 1900a and 1900b).

Sudworth (1900b) described the local uses and values of certain tree species at the end of the last century. In the Battlement Reserve, he noted that Engelmann spruce and subalpine fir were the most important timber species on the forest. He also commented on the high amount of dead spruce (25 percent to 40 percent) in the area. He suggested that this dead spruce was the result of landscape scale fires that had occurred during the previous 20 to 30 years. The early settlers preferred dead spruce for most building purposes, but also employed subalpine fir, Douglas fir, aspen, oak, and juniper for various uses.

Intensive use of the forest for lumber by early settlers appears to have been buffered by a preference for dead material rather than green trees (Sudworth 1900a, 1900b) because of their limited ability to haul the heavier green trees, to cure them, or to transport them over wagon roads. In comparison to the amount of early timber harvest, much more of the forest was impacted by the significant, large fires that occurred during the period of early European settlement.

FOREST VEGETATION MANAGEMENT OVER THE LAST 50 YEARS

Changes to natural conditions that result from timber management activities include more than just the removal of trees from a site. Road building results in smaller forest patches and less interior habitats, slash disposal practices concentrate post-treatment slash rather than leave it in place across a cutting unit, site preparation treatments may scarify soils, and the removal of snags from cutting units changes the amount of coarse woody debris on an area. Intermediate cutting treatments such as the initial cuts in shelterwood treatments or thinning treatments result in stands with reduced tree densities and less canopy cover.

On the White River National Forest, clearcutting, sanitation and salvage logging, and overstory-removal silvicultural approaches have dominated over the last 50 to 60 years and have been used to manage stands for insect and disease resistance in addition to the production of marketable timber.

Clearcutting, resulting in complete stand regeneration, was used for most cover types through the 1970s, generally for economic reasons. Practices then shifted towards insect/disease control strategies which involved selective cutting techniques in spruce/fir and clearcutting in aspen and lodgepole cover types.

Table A-59 documents the timber harvest program on the forest from the earliest records (prior to 1955) to the current. Approximately 56 percent of the total harvest has been sanitation/salvage treatment resulting from the spruce beetle epidemic on the Flattop Plateau in the late 1940's and early 1950's; 12 percent has been clearcuts; and the remainder has resulted from various silvicultural treatments. A large portion of the mid-to lower elevation forests on the White River National Forest were regenerated during the late 1800s and are just now reaching ages which result in commercial timber values. It is important to put the acreage of harvest into perspective. The 41,000 acres of timber

harvest (all types) over the past 50 to 60 year period has been less than 2 percent of the entire acreage of the White River National Forest. When computed against the total acreage of forested cover types on the forest, this increases to 3 percent. Approximately one-fourth of the timber management activity on the forest has been clearcut and overstory removal cuts that would have resulted in the largest changes to forest composition and structure.

Table A-59
Recent timber harvest on the White River National Forest

Period	Clearcut	Shelter-wood Prep	Shelter-wood Seed	Overstory Removal	Individual Selection	Group Selection	Sanitation/ Salvage	Commercial Thinning	Total
1984-97	4,332	4,541	799	1,107	330	444	18,196	706	30,455
1975-83	715	349	212	5	82	0	1,034	266	2,663
1965-74	1,852	0	56	498	114	0	26	48	2,594
1955-64	411	0	0	342	0 c	75	1,795	0	2,623
Prior 1955	114	0	0	933	68	0	2,001	0	3,116
Total acres	7,424	4,890	1,067	2,885	594	519	23,052	1,020	41,451
%	18	12	3	7	1	1	56	2	100

**** Figures reflect acres harvested by silvicultural treatment types by decade.***

The existing management plan for the White River National Forest prescribes the following rotation ages for cover types commonly managed on the forest. For clearcuts lodgepole pine, 50 to 140 years; aspen, 80 to 120 years; other species, 70 years; and for two and three stage shelterwood cuts; lodgepole pine, 5 to 140 years; aspen, 90 to120 years, and 70 years for other cover types. All of these rotation ages are shorter than what would be expected for natural disturbance events for the differing cover types. Therefore, in managed areas, the rotation ages would be shorter than expected under natural disturbance patterns.

Although many historical (prior to 1980) spruce-fir clearcuts have regenerated, many of these sites remain relatively open-canopied as a result of poor regeneration of spruce and fir. Where clearcuts have occurred on mixed, spruce-fir/lodgepole sites, stands have often regenerated as pure lodgepole pine. Where clearcuts have occurred on mixed, conifer/aspen stands, they often remain mixed lodgepole/aspen or convert to pure stands of lodgepole or aspen. Coppice cutting in aspen has resulted in regeneration of even-aged

aspen stands. Sanitation/salvage/overstory removal approaches usually select Engelmann spruce to be removed in the spruce-fir forest types.

Table A-60 shows the acres treated by silvicultural treatments by cover type. Spruce-fir has been the predominant species harvested on the White River National Forest and has accounted for about 70 percent of the treatment acres. The majority of the spruce-fir logged on the forest (approximately 75 percent) has been sanitation/salvage, dead material removal, mainly resulting from a late 1940s spruce beetle outbreak on the White River Plateau. Putting this into context of the entire forest, approximately 5 percent of the spruce fir on the forest has had some type of silvicultural treatment, mainly sanitation/salvage, over the past 60-year period.

Approximately .5 percent of the total forested acres of the White River National Forest have been managed by clearcut silvicultural treatments over the past 60 years. Less than 3 percent of the total forested acres of the White River National Forest have been managed by all silvicultural treatments during that time period. Intensive timber management has been concentrated in accessible areas of the forest (21 percent). The younger structural patches (open canopy) are clustered in these managed areas. The dominant landscape on the remaining 79 percent of the forest is largely mature and closed canopy forest.

As the forest industry has increased its production efficiency, from about 1970 to the present, environmental concerns have escalated, resulting in a decrease of the land base affected by intense timber harvest. In addition, the Wilderness Act of 1964 and Colorado Wilderness Bill of 1980 led to 35 percent of the forest being designated as wilderness.

The overall magnitude of human-induced forest structural change is considerably lower than the changes that would be expected from natural change agents, especially fire. While roughly 50 percent to 60 percent of the aspen and lodgepole pine on the forest were regenerated (mainly by large fire events) over a 40 year period during early European settlement, approximately 3 percent of the lodgepole pine and less than 1 percent of the aspen on the forest has been managed by timber harvest activities over the past 60 years.

Table A-60
Acres Treated by Cover Type

Period	Aspen	Ponderosa Pine	Douglas Fir	Spruce-fir	Lodgepole Pine	Misc.	Total
1984-97	2,381	0	189	21,615	5,993	277	30,455
1975-83	188	0	140	1,545	698	92	2,663
1965-74	4	0	0	2,030	550	10	2,594
1955-64	167	0	0	2,369	10	77	2,623
Prior 1955	3	37	236	2,739	90	11	3,116
Total	2,743	37	565	30,298	7,341	467	41,451

Note: The miscellaneous column includes forested lands, shrublands, grasslands and forblands treated by commercial harvest and from fire.

GENERAL PATTERNS OF SPECIES COMPOSITION

Pre-settlement

Information indicative of the forest species composition before human settlement includes tree-ring analysis of existing trees and studies associated with pollen or charcoal analysis for other nearby areas. In addition, understanding climate, disturbance regimes, and species ecology as well as looking at historical accounts and data allows us to make strong inferences about pre-settlement species composition. We can tell a lot about species composition at the time of settlement from GLO survey data. Time prevented the forest from developing this information. Paleo-ecological studies (Feiler and Anderson 1993) show that spruce has been a dominant forest type on the White River Plateau for 10,600 years. Carbon dating of packrat middens (USDA-FS 1986) in the Southwest have shown juniper woodland expansions and retreats occurring for more than 13,000 years. Climatic oscillations between cool-and-moist conditions and warm-and-dry conditions have acted to increase tree stress, making trees more vulnerable to insect infestations or to fire when fuel conditions are appropriate. Warm-and-dry conditions that accelerated around 1850, coupled with the rapid development of resources by European settlers, brought about catastrophic fires that led to an increase in aspen and lodgepole pine. Anecdotal information (USDA-FS 1940) suggests that the occurrence of ponderosa pine and Douglas-fir may have been more than the current incidental distribution and densities in the general areas of the White River National Forest. The longevity of spruce and fir (Alexander 1987), in addition to trees of advanced age currently occurring (RMRIS database; Veblen et al. 1994), suggests that the historic mix of species in the alpine and subalpine elevations across the White River National Forest was likely similar to that found in designated wilderness areas today. Insect epidemics throughout the landscapes have likely shifted the dominance of subalpine forest species between Engelmann spruce

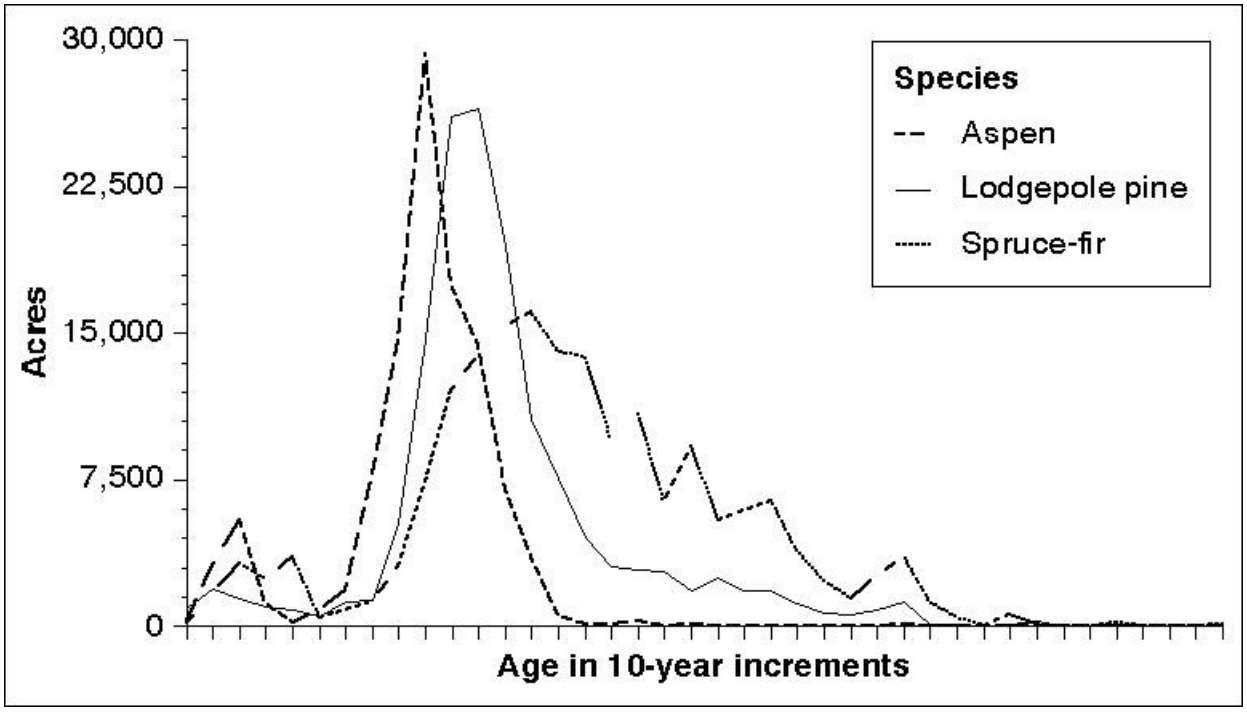
and subalpine fir as subtle patches in the forest matrix (Johnson 1994), especially in the White River plateau region (Veblen et al. 1994).

The RMRIS database reflects many lodgepole, Douglas fir, and aspen stands originating before 1850 and continuing to exist. The earliest stand initiation date for Douglas fir in the database is 1803 with the earliest initiation date for aspen at 1713. According to the RIS database, approximately 24,731 acres (20 percent) of lodgepole pine have their origination between 1706 and 1850

Post-Settlement

A large portion of what is now the White River National Forest was heavily impacted by early European settlement between approximately 1870-1910. This resulted in large areas of forested ecosystems regenerating in a short time period. The current, high percentage of 90 to 120 year old, even-aged stands of seral lodgepole pine and aspen are the result of this disturbance period. The current age class distribution for lodgepole and aspen (Fig. 1) indicates that a large percentage of the current coverage of these species became established during this 30-year period and have not been affected by major disturbance events (natural or man-created) since. It is not known what the original cover type of these areas were prior to the disturbances in the late 1800s that created the seral lodgepole and aspen stands that now exist. Much of it was undoubtedly mature spruce fir, while other areas may have been in seral cover types due to other, previous disturbances.

Figure A-4
Current age class distributions of aspen, lodgepole pine and spruce-fir on the White River National Forest



Much of the aspen and lodgepole pine on the White River National Forest is currently 90-130 years old and was established by the fires associated with the early European settlement of the forest. Although some of the current spruce fir was established during this timeframe, the majority of this cover type predates this period. The spruce-fir cover type is generally made up of uneven-aged stands. The age of a stand for this figure came from the RMRIS database and is an average of the oldest trees in the stand and the young, understory trees. Therefore, the actual age of establishment of a spruce-fir stand is generally much older than the age indicated in **Figure A-4**.

GENERAL INFORMATION CONCERNING FOREST STRUCTURE

Forest structure is a description of the size, and age of the trees in a stand, canopy complexity and canopy closure, and amount of dead and down material included in a stand. Structural stages are the developmental stages of tree stands described in terms of tree age (size), tree density (number per acre) and the extent of the canopy closure that all of the trees create (Formann and Godron 1981; Hoover and Wills 1984; Rebertus et al. 1992; Reice 1994; Roovers and Rebertus 1993; Veblen et al. 1991b; USDA-FS 1982-1992). Structural stages and other forest structural components such as standing dead and down dead material help to define and relate to terrestrial habitats, especially for wildlife (Darveau et al. 1995; Hoover and Wills 1984; Sousa 1984; USDA-FS 1992 1992a 1994a). **Table A-61** lists the current structural stage information for the major cover types on the White River National Forest (based on the CVU/Forest Vegetation Database).

Information regarding impacts to forest structure can also be found in the general discussion about timber harvest activities, above.

Table A-61
Structural stages by tree species, in acres and percent of the White River National Forest

	Aspen		Douglas-fir		Lodgepole		Spruce-fir		Totals	
Structural Stage	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
1 and 2	33,200	8	1,300	2	5,900	3	47,300	8	87,700	7
3A	36,000	9	7,900	11	8,900	4	48,000	8	100,800	8
3B	105,000	25	8,600	12	38,100	17	68,100	11	219,800	17
3C	145,600	34	10,400	15	78,900	35	80,200	13	315,100	24
4A	7,100	2	8,000	12	4,500	2	49,200	8	68,800	5
4B	39,900	9	14,800	21	20,900	9	148,300	24	223,900	17
4C and 5	58,200	14	18,800	27	68,700	30	169,300	28	315,000	24
Total	**425,000**		**69,800**		**225,900**		**610,400**		**1,331,100**	

Pinyon juniper woodlands, ponderosa pine, limber pine and cottonwood make up such small acreages on the White River National Forest that they are not included in the table.

In **Table A-61**, structural stages are identified by number and letter, indicating growth stage and canopy closure, respectively. Stage 1 is grass/forb; stage 2 is shrub/seedling; stage 3 is sapling/pole; stage 4 is mature; and stage 5 is old growth. Within each stage, canopy closure is given as A = 0 to 40 percent canopy closure; B = 41percent to70 percent; and C = 71percent to 100 percent. Due to database limitations with the CVU database, structural stages 1 and 2 have been combined into structural stage 1, and 4C and 5 into structural stage 5.

Pre-settlement

Fire ecology studies (Crane 1982; Jones and DeByle 1985; Veblen et al. 1991b, 1994; Rebertus et al. 1992; Peet 1981; Romme and Knight 1981) and historic accounts provide the most useful information to describe historic landscape structure on the White River National Forest, however, quantitative amounts of forest structure are limited. Spruce fir stands were predominantly mature stands (Veblen et al. 1994). Sudworth (1990) and others commented on the high amount of standing dead material in the area of the White River National Forest around the turn of the past century, due to past fires and other disturbance events. This indicates that high level of snags and other coarse woody debris were likely common in the spruce fir landscapes.

Understanding climate, disturbance regimes, and species ecology as well as looking at historical accounts and data allows us to make strong inferences about pre-settlement structural conditions on the forest. Fire ecology studies (Crane 1982; Jones and DeByle 1985; Veblen et al. 1991b, 1994; Rebertus et al. 1992; Peet 1981; Romme and Knight

1981) provide the most useful information, however, quantitative amounts of forest structure cannot be estimated. Spruce fir stands were predominantly mature stands (Veblen et al. 1994). Sudworth (1990) and others commented on the high amount of standing dead material in the area of the White River National Forest around the turn of the past century, due to past fires and other disturbance events. This indicates that high level of snags and other coarse woody debris were likely common in the spruce fir landscapes.

A high degree of structural variety occurred in lodgepole, Douglas fir, and aspen cover types, dependent upon slope aspect and elevation. Ponderosa pine cover types favored mature structure assuming relatively frequent low-intensity fire occurrence (Romme 1997 (Draft), Spies and Turner 1999, Averrill et al. 1994). Pinyon juniper woodlands typically have an infrequent, stand-replacing fire regime which may have resulted in large, even-aged stands following disturbances.

Mortality of trees either through disturbance or old age results in standing dead trees (snags) and down dead trees (woody debris). The higher density occurrence of these structures is exhibited in the cover types (e.g., aspen, spruce, fir, and lodgepole pine) that experience less frequent (100-200 year) and less intense change. Insect activities result in high occurrences of standing dead and down dead material. Lower density dead material occurs on warmer-and-drier cover types (e.g., ponderosa pine) where more frequent and moderate-to-low-intensity fires occur. Tree age data reflects many older forests existing on the forest since 1666 (lodgepole), 1662 (Douglas-fir), and 1725 (aspen). At least one spruce-fir stand has existed since 1605.

Post-settlement

Existing even-aged (lodgepole pine and aspen) forest stands can give an indication of historic natural or human-induced disturbance events. Unfortunately, natural disturbance factors are difficult to separate from human-induced factors. Regardless of cause, many forest stands were often ready for regeneration due to their maturity, density, and the existing climate. The stand ages for spruce, fir, aspen and lodgepole pine stands included in the RMRIS database are displayed in **Figure A-4**. Approximately 54 percent of the total lodgepole-dominant stands on the forest regenerated during the period of early European settlement from 1870-1910. A period of low disturbance is indicated in the data between 1706 and 1870, however, it increases steadily between 1870 and 1910. This was common across most Central Rocky Mountain areas, as this period marked the height of the mining era and the movement of European settlers into forest landscapes. Disturbance in lodgepole pine declined after 1908 to near pre-1870 levels. The curve of the data closely follows human events such as railroad construction that began in 1879; the mining era; initial management of forest reserves in 1891; fire suppression that started in the early 1900s; World War I; work done by the CCC during the Great Depression; and World War II.

Woodland structural characteristics can appear to be somewhat simplistic. The pinyon juniper structure is more open-canopied largely because of the arid nature of the woodland landscapes. Gambel oak woodlands often occur with very dense canopy closure. The early structural stages of the pinyon-juniper types persist for relatively long periods (USDA-FS 1986) when compared to shrub or other forest types. Ponderosa pine

and pinyon-juniper age class data is limited, but the limited data indicates that both types are completely mature structural stages.

Large portions of the forest were significantly impacted by disturbance resulting from the early European settlement of 1870-1910. Approximately 50 percent to 60 percent of the current aspen and lodgepole pine on the forest was regenerated by the fires and other disturbances that occurred during this period. Only limited disturbances, either natural or man-caused, have occurred in the past 80 years. More details on the disturbance history can be found in the Fire and Insect and Disease sections of the forest HRV document. Due to the lack of recent disturbances, the forest is trending towards increased maturity and more dense canopy density for most cover types. Early structural stages (grass/forb, seedling/shrub, sapling) of forest ecosystems are in limited quantities (See table 4) and are not dispersed across the landscapes. Recent forest management (1946-1990s), has resulted in some highly contrasting patches (e.g., clearcut surrounded by mature forest), and a decrease in overall forest maturity within the most intensively managed areas. These managed areas result in forest perforation and are normally associated with Forest road systems (USDA-FS 1984).

Much of the White River National Forest has fire regimes that result in low frequency/high intensity, stand replacing fires (see fire section of HRV). These events are bound to occur; it's only a matter of when fuel and weather conditions allow these events to occur. Nearly 60 percent of the spruce fir cover type on the forest is classified as mature and old growth. These stands have higher susceptibility to disturbance events such as insect outbreaks or stand replacing fires (Rebertus et al 1992). Many seral aspen and lodgepole pine stands that regenerated in the mid-1880s to 1920s have not been at high risk for intense fire because of their relative immaturity during and following that period, but are now in moving into age and structural classes that lend themselves to stand replacing disturbances.

Historical management of forested lands has obviously resulted in shifts in forest structure. Sanitation/salvage, clearcut, and overstory removal silvicultural approaches have dominated throughout recent years (USDA-FS 1940).

Sanitation/salvage/overstory removal approaches usually result in the shift of tree stand diameters (large to medium), shift from dense canopy to more open canopy stands, reduced stand age, reduced stand height and reduced snags and woody debris. Clearcut approaches result in complete stand regeneration and, for many years, removed all standing dead trees and a moderate amount of down woody material (Hoover and Wills 1984).

GENERAL INFORMATION CONCERNING FOREST PATTERNS-

Forest pattern is described as the “arrangement or structural pattern of patches and corridors ... to aid in discussion of functional flows and movements through the landscapes...(Forman 1995)” The forest landscape matrices, as previously discussed, are predominantly conifer and mixed conifer/deciduous forest species. These landscapes can be extensive, limited, continuous, perforated, aggregated, or dispersed (Forman 1995) much depending upon change intensity, change frequency, topography, aspect, elevation and soil types. Thus the smaller vegetation mosaics or forest stands in these landscapes are very random and wide-ranging. The vegetation mosaics or patches vary from large to

small, round, elongated, smooth to convoluted with corridors varying from wide to narrow, high or low connectivity, and straight or meandering (Forman 1995). Vegetation structure determines the flows and movement of elements through it, as well as, the disturbance flows and movement creating the structure, thus, changing the land mosaic over time (Forman 1995).

Pre-settlement

Pre-European settlement pattern relationships on the White River National Forest are best inferred from historic accounts and by studying existing landscape patterns in relationship to topography, climate and disturbance ecology for a particular cover type. In 1900, George Sudworth described vegetation conditions for the Battlement Mesa and White River Plateau areas (Sudworth 1900a, 1900b).

"The entire upper surface of Battlement Mesa east of the headwaters of Wallace Creek was originally covered with Engelmann spruce and alpine fir in scattered bodies, interspersed with grassy parks," Sudworth reported.

He found "red fir" (Douglas-fir) as "often greatly isolated groups and single trees" which were "so widely separated as to have no visible connection in their origin."

Sudworth described ponderosa pine as being of "...very limited occurrence" and noted a "thin, often widely-scattered stand on the east slope and rocky ledges of the Crystal River," a stand which had "been greatly thinned in numbers by numerous fires."

Post-settlement

Although there were undoubtedly significant impacts to stand and landscape patterns during the period of early European settlement, it is not possible to quantify pre-settlement conditions on the White River National Forest with any assurance. Changes associated with the past 60 years of active timber management can be more easily documented. Comparison of the unmanaged and intensively managed land for the major cover types on the forest is summarized below. **Table A-62** displays the patch classifications based on the RMRIS database, while **Table A-63** displays the average patch sizes for managed versus reference areas from the CVU/Forest Vegetation database. The comparison in **Table A-64** was developed using the FRAGSTATS model comparing areas of the forest that have been the most heavily impacted by timber harvest over the past 60 years with adjacent unmanaged reference areas. **Table A-62** displays the RMRIS information concerning overall patch size information by cover type for the entire forest. These figures should be used with care as the RMRIS database biases towards smaller patches sizes due to mandatory splitting of some patches on topographic and other features.

Table A-62
Number of patches* by forest cover type on the White River National Forest based on the RMRIS database

Patch size	0-5	6-50	51-200	201-500	501+	Total
Aspen	194	3,655	1,767	340	103	6059
%	3	60	29	6	2	
Douglas-fir	29	958	350	20	3	1360
%	2	70	26	1	<1	
Lodgepole pine	216	3,630	1,294	162	19	5321
%	4	68	24	3	<1	
Pinyon/juniper	0	116	114	143	0	373
%	0	31	31	38	0	
Ponderosa pine	0	6	3	3	0	12
%	0	50	25	25	0	
Spruce-fir	189	5,647	2767	477	133	9213
%	2	61	30	5	1	
Forest totals	**62**	**13,012**	**6295**	**1145**	**258**	**22,308**
Forest %	**2%**	**58%**	**28%**	**4%**	**1%**	

Patches are in acres.

Table A-63
Total acreage by patch category by forest cover type on the White River National Forest based on the RMRIS database

Patch size	0-5	6-50	51-200	201-500	501+	Total
Aspen	738	90,700	170,098	104,785	82,150	448,471
%	<1	20	38	23	18	
Douglas-fir	105	23,497	31,552	5,633	2,442	63,229
%	<1	37	50	9	4	
Lodgepole pine	759	85,863	116,306	46,494	14,527	263,949
%	<1	32	44	18	6	
Pinyon/juniper	0	387	11,414	3748	8,415	22,964
%	0	2	48	16	35	
Ponderosa pine	0	194	368	931	0	1,493
%	0	13	24	62	0	
Spruce-fir	823	140,974	264,130	137,629	145,717	689,273
%	<1	20	38	20	21	
Forest totals	**2425**	**341,615**	**593,868**	**299,220**	**253,251**	**1,489,379**
Forest %	**<1**	**23**	**40**	**20**	**17**	

Note: Figures in first row for each cover type are in acres and reflect the total number of acres included in the RMRIS database within the specified patch category.

Table A-64
Comparison of FRAGSTATS assessment of average patch sizes between managed and reference areas for the major cover types on the White River National Forest by structural class

	Cover type					
	Spruce Fir		Aspen		Lodgepole Pine	
	Managed	Reference	Managed	Reference	Managed	Reference
Structural Class 1	35	42	24	39	30	23
Structural Class 2	28	46	11	23	12	23
Structural Class 3	51	56	63	74	71	71
Structural Class 4	19	42	19	17	16	28
Structural Class 5	72	104	42	36	47	51

Due to database limitations, structural stages 1 and 2 have been combined into structural class 1, structural stages 3A and 3B into structural class 3 and 4C and 5 into structural class 5.

Table A-62 indicates that the majority of the patches for all cover types on the White River National Forest are between 6 to 50 acres in size (62 percent of all forested patches), with the next largest category 51 to 200 acres (28 percent). Only 1 percent of the forested patches on the forest are larger than 500 acres, mainly in the aspen and spruce fir cover types.

Table A-63 gives a somewhat different picture of the importance of various stand or patch categories. The overall percentage of patches on the forest is heavily weighted to the 5-200 acre patch categories, with only 5 percent of the patches larger than 200 acres. However, 37 percent of the total acres of forested stands on the forest are found in patches larger than 200 acres. Only 4 percent of the patches are in the 201 to 500 acre category, but they contain 20 percent of the total acres of the forest; 1 percent of the total forest patches on the White River National Forest are larger than 500 acres, but those patches contain 17 percent of the total acres. This highlights the potential importance of the relatively few large patches to species dependent upon large blocks of relatively homogeneous habitat.

Table A-64 details potential impacts to average patch size from recent timber management activities in the three major cover types on the forest. Road impacts were analyzed separately and are discussed in the following paragraph. Analysis of the data for this table indicated in a very high amount of variability in the overall class size

distribution for all cover types. The average patch size in spruce fir appears to be smaller in managed stands in structural classes 2, 4, and 5. In aspen stands, the managed stands have smaller patches in classes 1 and 2. The average patch size is larger in managed aspen stands in class 5, contrary to what would be expected where coppice or clearcutting of blocks of 40 acres or less has been the primary management tool. In lodgepole pine, the average patch size appears to be smaller in classes 2 and 4. Considering the potential impacts that would result from silvicultural activities to the differing cover types, it is difficult to relate many of these patch size differences to past management activities.

Changes to average patch sizes induced by the construction of roads on the forest were analyzed as part of the wildlife section of the 2002 Forest Plan effort. This analysis focused on managed portions of the forest and compared average patch sizes prior to, and after, road building. Before roads were built, late-successional forest habitat patches of Douglas fir ranged from 5-49 acres with an average patch size of 26 acres; spruce fir from 10-252 acres with and average patch size of 100 acres; lodgepole pine from 37-111 acres with an average patch size of 62 acres; and aspen ranged from 2 to 94 acres with an average patch size of 57 acres. After road building, the average patch size for Douglas fir was reduced 16 percent to 26 acres; spruce fir was reduced 36 percent to 64 acres; lodgepole pine was reduced 32 percent to 47 acres; and aspen was reduced 34 percent to 38 acres.

This information suggests that patches between six to 200 acres are dominant on the forest. Past vegetation management, especially with maximum clearcuts of 40 acres, has likely accelerated forest patches in the 6 to 50 acre category in the small percentage of the forest that has been intensively managed. However, the topography of the White River National Forest results in a natural dominance of moderate-size patches, which is suggested by the data.

Forest species composition changes as one compares the western portion of the forest with the eastern portion. This appears to hold true for patch size. The steep, highly dissected terrain of the Continental Divide appears to be fire-disturbance dominant, and thus, has more moderate-sized forest patches. The less steep, mesa-type terrain of the Flat Tops appears to be more insect-disturbance dominant, resulting in larger and more blended patches of aspen and spruce-fir.

The above patch size comparisons include specified-constructed roads as portions of patch boundaries, but is not all-inclusive. Therefore, patch sizes are trending to a higher number of smaller sized. Other less-developed, currently used and non-used roads may not be included. Forest plan standards for spruce and fir direct management on units less than 500 acres in size, thus providing some guidance to maintain a relatively large patch size through time from the existing plan.

Forest patch changes have occurred based upon historical trees species demanded by industry and historical silvicultural approaches. Patch changes occur based on mixed forest patches being manipulated into single species patches in even-aged clearcutting, or selecting spruce over subalpine fir for harvest.

Forest areas that have been accessed by management (recently 1946-1990s), the forest has moved in a direction away from structural variation towards high contrasting patches (e.g., clearcut surrounded by mature forest), and a decrease in maturity. These situations are a relative “shotgun-pattern” associated with road access systems.

Patch sizes in pinyon-juniper woodlands have not been significantly affected by vegetation management, but the construction of roads and activities such as fire wood cutting have likely resulted in smaller average patches in some areas.

Information specific to the major cover types on the White River National Forest

PINYON-JUNIPER WOODLANDS

Composition- The pinyon-juniper cover type is generally found between 6,400 and 7,900 feet (Hess and Wasser 1982). The pinyon-juniper woodlands of the forest currently occur as a dominant cover type over approximately 15,100 acres or 0.7 percent of the forest. These woodlands occur between 5,900 and 8,500 feet in elevation in stands ranging between six and 666 acres. These sites are predominantly along the major river corridors. Hess and Wasser (1982) describe three pinyon-juniper types dependent on site location and elevation. Juniper is more prevalent on lower elevation sites that are more xeric. Pinyon and juniper mixed woodland occurs at mid-elevations, and pinyon is dominant on higher-elevation, mesic sites. Fire suppression, domestic livestock grazing, and fuelwood cutting all occur on many of these sites, but the overall impacts on these communities is relatively unknown on the forest. Other areas in the West (USDA-FS 1986; 1991; 1993; 1994e Peet 1988) are experiencing dramatic increases in juniper over pinyon, and a general increase in overall coverage of the pinyon-juniper cover type. These increases are often in the mixed shrub and sagebrush ecotones and are at the expense of these shrub types. Specific information concerning potential composition changes for pinyon-juniper on the White River National Forest is not available, but it is assumed that they would be similar to those occurring elsewhere in the West.

Due to the combined impacts of grazing and fire suppression, pinyon pine and juniper have increased their distributions throughout much of their range in the West and may also have increased on the White River National Forest. There is inadequate information available to determine if this amount of increase is outside the HRV, but the increase has been at the expense of shrublands and particularly sagebrush. Fire suppression and continued livestock grazing in these cover types may have altered the composition and overall coverage of stands capable of producing a grassy understory in which low-intensity fires occasionally occurred. Reproduction and spread of these stands was often limited by these low-intensity fires. Fires and grazing likely have not significantly altered the unproductive stands which historically did not support grassy understories. These stands rarely burned either in crown or surface fires.

Structure- Little information is available regarding the historical structure of pinyon-juniper woodlands on the forest. The lower elevations in which this type is generally found were highly impacted during early European settlement by fuelwood and fencing material gathering, fires and grazing by domestic livestock (Sudworth 1900a and Sudworth 1900b). All existing stands of pinyon-juniper in the RMRIS database are mature stands indicating that there has been little stand regeneration from disturbance within the past 50-80 years. The total lack of any younger aged stands on the forest indicates that this type is on the low end of HRV for structural stage diversity.

Pattern- The pinyon-juniper cover type has not been subjected to silvicultural treatment in recent time, i.e., the past 60 years. However incidental fuelwood harvest, fence post cutting and other miscellaneous activities have occurred within this type in some areas of the forest. Patch sizes in pinyon-juniper woodlands have not been significantly affected by vegetation management, but the construction of roads and activities such as fire wood cutting have likely resulted in smaller average patches in some areas. The patch sizes for pinyon-juniper are felt to be within the HRV at the landscape level.

PONDEROSA PINE

Composition- The two databases available for documenting vegetation on the forest differ in the amount of ponderosa pine coverage. Regardless, ponderosa currently occurs on relatively few acres on the White River National Forest. The CVU database reveals that ponderosa pine occurs as a dominant cover type on approximately 300 acres of the forest. The RMRIS database indicates that ponderosa occurs as a dominant type on approximately 1,493 acres. These apparent differences result from the various differences in mapping of the databases and overall dominance of the species within a stand. Ponderosa stands occur between 7,800 and 9,400 feet in elevation (Hess and Wasser 1982). The locations of the larger stands include the Burns, Buford, Basalt, and Redstone areas. These stands are predominantly open-canopy (less than 41 percent). They are mature, thus are more susceptible to insects and disease than stands and landscapes of mixed ages. A recent outbreak of mountain pine beetles has impacted the stands near Burns. Only 37 acres of ponderosa pine have been silviculturally treated over the past 60 years (**Table A-60**). However, one sale is in preparation at this time to treat the insect outbreak in the Burns area.

Ponderosa pine occurs more widely across the forest as a subdominate species. Only limited regeneration has occurred in these scattered locations, likely due to competition with shrubs and lack of low-intensity fire occurrence. There are anecdotal indications that ponderosa pine may have been more common prior to European settlement (Sudworth 1900b and UDSA-FS 1940).

Douglas-fir, ponderosa pine, and cottonwood may have seen the highest levels of reduction during European settlement because of logging, grazing, and settlement in the lower elevations where they historically occurred (Sudworth 1990a and 1990b, USDA-FS 1940).

Overall coverage of ponderosa pine is at the low end of the HRV for the species due to the lack of regeneration of many ponderosa stands following the disturbances associated with European settlement. The stands that still exist are generally open-canopied stands with limited understory regeneration and are likely within the HRV for species composition. Although some stands are being impacted by mountain pine beetle, this species of tree and the beetle evolved together and there is no indications that these outbreaks are outside the HRV.

Structure- Very little active management has occurred in the ponderosa pine cover type over the past 60 years. Many ponderosa areas across the west have experienced significant changes in structural components due to the increase in understory. However, the stands on the White River National Forest have not had the same high level of understory regeneration. Therefore, the mature stands on the forest are within the HRV

for within-stand structure. Since all the stands identified on the forest are mature, it is likely that this cover type is at the low end, if not outside of, the HRV in regards to structural stage distribution. This needs to be tempered with the information that this cover type is extremely limited on the forest and small acreage changes may appear large.

Pattern- There are too few patches of ponderosa pine on the forest to make any assumptions concerning the HRV for pattern.

DOUGLAS FIR

Composition- Approximately 70,000 acres of Douglas fir is found on the forest, mainly on low elevation, mesic, north-facing slopes in the montane zone. These areas are often mixed with mountain shrub communities on the south facing slopes. Anecdotal information (Sudworth 1900b) indicates that some of the areas currently dominated by Douglas fir may have been more common as mixed Douglas fir-ponderosa pine stands prior to European settlement. Logging preferences and widespread fires during the settlement period may have led to dominance of these sites by Douglas fir to the detriment of ponderosa pine. Douglas fir remains as a relatively common cover type, but ponderosa pine is very limited on the forest.

Due to its location on the forest in lower elevations and its value as commercial timber, much of the Douglas fir on the forest was regenerated during the early European settlement period. Although Douglas fir was a preferred species for timber during early European settlement (Sudworth 1900 b and UDSA-FS 1940), its use on the forest has been only incidental in recent years. Only 565 acres of the cover type (less than 1 percent of the total Douglas fir cover type on the forest) has been harvested in the past 60 years (**Table A-60**). Undoubtedly, it has also been cut as an incidental species when it occurs in mixed stands with other species. Roughly half of the existing Douglas fir occurs as late successional forest.

Recent management activities have not played a major role in changing composition of the Douglas fir forests on the White River National Forest (see **Table A-60**). Although there may currently be slightly more Douglas fir due to the reduction of ponderosa pine during early European settlement, there is no indication that the overall composition of Douglas fir on the landscape is outside its HRV.

Structure- Overall impacts to the Douglas fir cover type during the European settlement period have not be quantified, but is thought that disturbances to these areas would have been significant due to their proximity to heavily settled areas. The CVU database indicates that Douglas fir stands on the forest have a good distribution of structural stages and it is felt that this cover type is within HRV for structural stage distribution.

Pattern- Detailed information concerning reference patch sizes for Douglas fir is not available. Existing information indicates that although 70 percent of the patches in this cover type are in the 6-50 acre category, one half of the total Douglas fir acreage is found in the 51-200 acre patch category. A high number of relatively small patches would be expected for this cover type, based on the lower elevation, rough topography where the majority of the acreage for this type is found on the White River National Forest. Less than 1 percent of the current Douglas fir cover type has been silviculturally treated over the past 60 years. There are no indications that the overall pattern for Douglas fir is outside the HRV.

Summary of historical and current disturbances and patterns and the ecological implications of changes

Historical Conditions

Historical disturbance processes which affected the Douglas fir on the White River National Forest:

- Armillaria root rot has been present in Douglas fir for several hundred years.
- Fire in Douglas fir often resulted from fires spreading from adjacent cover types, such as shrublands and grasslands.
- Fires were variable, but often stand-replacing.
- Fires return intervals were generally long from 200 to 400 years.
- Budworm was an historic disturbance in late-successional stands.

Historical patterns that resulted from those disturbances were:

- Douglas fir generally occurred with patchy distribution, due to the natural physiography. Douglas fir generally occurs on the cooler, moister, north-facing slopes, with grass and shrublands occurring on the warmer aspects.
- Douglas fir occurred across a wide distribution of the lower elevations.
- Most stands occurred in even-aged stands.

Current Conditions

Current disturbance processes, which are affecting Douglas fir, are:

- Most of the disturbances are generally the same as historic.
- Fire generally does not have the same opportunity to move into Douglas fir stands with the same frequency as would be expected due to the development of the lower elevation lands removing or changing fire regimes on those lands. With the long return interval for this type, this has not significantly affected the disturbance regimes at this time.
- Budworm outbreaks may be more synchronous than historic.

Current patterns resulting from those disturbances are:

- The Douglas fir is relatively homogeneous in age, due to the heavy impact on these areas during the early settlement period. Many of these stands were burned or logged during the period from 1870 to 1910 resulting in regeneration of many of these stands during a relatively short time period.
- Although this homogeneity of stands resulted from human-caused disturbances, these same levels of disturbances may have occurred naturally in historic times.

- There is some indication that Douglas fir is less common as a cover type than existed historically.

Ecological Implications

- Where feasible, fire should be reintroduced into Douglas fir ecosystems in its characteristic intensity and frequency.
- The forest should maintain all existing Douglas fir stands.
- There is a need for a better understanding of the Douglas fir ecosystem and its disturbance ecology.

ASPEN

Composition-The White River National Forest, along with portions of the Routt National Forest and the Grand Mesa National Forest, forms the "heart" of the aspen country in the Southern Rocky Mountains Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Ecological Province. Approximately 425,000 acres of aspen is found on the White River National Forest. This amounts to 19 percent of the total acreage of the forest. Hess and Wasser (1982) identified four major habitat types associated with this cover type. Together, these 4 types represent a significant proportion of the middle to high elevation landscapes of the forest.

In the portions of the forest not significantly impacted by the major disturbance events associated with European settlement, fire suppression over the last 80 years has allowed many aspen stands to proceed through natural succession into spruce and fir. This is a normal successional pathway for these cover types. Stands of pure aspen can be difficult to burn under climatic conditions found during most years, and fire return interval of 100-300 years have been documented. It is likely that fire suppression over the past 80 years has affected individual aspen stands that might have burned and regenerated during dry seasons. Due to the long fire return interval possible for this type, it is doubtful that relatively short period of intensive fire suppression would have reduced disturbances enough to have moved these aspen landscapes outside of the HRV for composition.

Several authors have differed on the ecology of stable vs. seral aspen in a landscape. Ryer and Murray (1992) indicated that aspen occurring on mollisol, Argic Pachic Cryoborolls, and Pachic Cryoboroll soil types are generally considered stable, while Pfister (unpublished dissertation, cited in Meuggler 1976) and Harper (personal communication, cite din Mueggler 1985) indicated that stable aspen may be an artifact of elevational and aspect relationships. Romme (1999) postulates that the stable aspen on the San Juan National Forest may be related to low-elevation sites in association with frequent, low intensity fires adjacent to ponderosa pine areas. Regardless, the White River National Forest has many large aspen stands that show no historic or current conifer invasion. These stable aspen areas are felt to be within their HRV for species composition on the landscape.

As a result of the high level of disturbance that occurred in the 1870 to 1910 period, a high percentage of the aspen regenerated in a relatively short period of time. Approximately 50 percent to 60 percent of the seral aspen stands for which age data is available (RMRIS database) regenerated between the years of 1850 to 1910. This is a

higher percentage than would be expected based on the natural disturbance regimes for these species. It is impossible to determine the pre-disturbance species composition of the areas that were regenerated approximately 90 to 120 years ago. It is highly likely that many of these areas were mature spruce fir, but many may have been seral aspen from previous disturbances. Based on the high magnitude of the disturbances that occurred within a relatively short period of time at the end of the last century, existing seral aspen is thought to be at the high end of HRV for overall coverage of the landscapes of the White River National Forest. Because of the relative immaturity of the stands that regenerated between the mid-1880s to 1920s, most have not significantly changed from even-aged, single species stands of aspen, and they have not been high risks for natural disturbance events. Species composition of these stands is considered to within the HRV for the cover type.

Structure- As a result of the high level of disturbance that occurred in the 1870 to 1910 period, a high percentage of the aspen on the White River National Forest regenerated in a relatively short period of time. Approximately 50 percent to 60 percent of the seral aspen stands for which age data is available (RMRIS database) regenerated between the years of 1870 to 1910. This is a higher percentage of one age class than would be expected based on the natural disturbance regimes for these species. Based on fire return intervals of from 100-300 years (see references for stand replacing events in Knight's report), the expected percentage of stand replacing events during this 40-year timeframe for large landscapes would have been from 6 percent to 40 percent. The large acreage of regeneration that occurred in the last part of the 19th century coupled with the lack of regenerating fires in the past 80 years has resulted in a more homogeneous age and size structure than existed prior to European settlement.

Many seral aspen stands that regenerated in the mid-1880s to 1920s have not been at high risk for intense fire because of their relative immaturity during and following that period. Many of these stands are now moving into age and structural classes that lend themselves to stand replacing disturbances.

In managed areas of the forest, the within-stand structure has been modified by the removal of tree boles for commercial timber, changes in dead, down and snags components by slash policies, and prescribed burning for site treatment. Clearcut areas may be on the low end of HRV for coarse woody material, but likely are not outside what might be found in the hotter areas of a stand replacing fire event.

Pattern- Detailed information concerning the historic pattern of aspen is not available. Currently the majority of the aspen stands on the forest are between 6 to 50 acres in size; however there are a significant number of stands in the 51 to 200 acre size class and approximately 1.5 percent of all aspen stands are larger than 500 acres. Comparison of **Tables A-61** and **A-62** reveals that 60 percent of all aspen patches on the forest are less than 50 acres in size, but 79 percent of the total acreage is found in patches that are over 51 acres each. Analysis of potential impacts of the past 60 years of vegetation management indicates that there have been very limited changes to patch size classes based on timber management alone**. Table A-64** displays that there may have been some reduction in average patch size in Structural Classes 1 and 2, but that classes 4 and 5 are larger in the managed areas than in the reference areas, contrary to what would be expected in a cover type managed by relatively small clearcuts. Road construction across the forest has reduced the average patch size of aspen in roaded areas by 34 percent, from

an average of 57 acres to 38 acres. There is a high degree of natural variability in patch sizes for aspen on the forest. Approximately 55 percent of the aspen on the forest is included within the inventoried roadless or designated wilderness classifications where roadbuilding and silvicultural treatments have had no impacts to landscape pattern. Due to the wide variability of the size of aspen stands across the forest and the limited acreage of aspen that has been managed on the forest (less than 3,000 acres of the 425,000 acres), it is doubtful if the past 60 years of vegetation management has significantly changed the HRV for aspen on the forest. Roading of aspen areas may have reduced the average patch size of stands in managed areas. Due to the natural wide variability in the size of aspen stands, the fact that one third of the forest is designated wilderness, and the fact that road densities are less than one mile of road per square mile on the remaining two thirds of the forest it is doubtful if roading has significantly affected the HRV for patch size of aspen at the landscape scale.

Summary of historical and current disturbances and patterns and the ecological implications of changes

Historic Conditions

Historic disturbances that affected aspen on the White River:

- Fire was variable with return intervals from 70 to 200 years. Most fires were very low intensity and small in extent if they were only burning in aspen.
- Aspen historically was disturbance dependent for maintenance of the stand.
- Canker and decay were both common in aspen.
- Ungulate grazing may have impacted regeneration, especially in areas such as winter ranges where native ungulates congregated.

Historic patterns that resulted from those disturbances:

- Aspen has historically been a common species.
- Stands were generally even-aged.
- Stands were clonal.
- Much of the aspen on the forest was early seral, resulting from disturbance, and was replaced by spruce-fir through natural succession.
- Some portions of the forest historically maintained stable, self-replacing aspen stands, and landscapes, over long periods of time.
- Patch size was variable, but could be very large.
- The amount of aspen on the landscape varied over time, due to the influence of large-scale disturbances both within the aspen type as well as within the coniferous cover types.

Current Conditions

Current disturbances that are affecting aspen on the White River:

- The major disturbances still predominate.
- Increased logging in the last 10 to 15 years has influenced localized areas.
- Conifer invasion that is currently observed is largely a result of the natural succession of stands disturbed at the turn of the century during the early settlement by Europeans.
- There are some localized areas on the forest where regeneration is struggling due to the impacts of browsing by native herbivores and domestic livestock.

Current patterns resulting from those disturbances:

- Aspen continues to be a very common cover type. Approximately 17 percent of the Forest is currently covered by aspen cover types.
- Many of the aspen sites have been in aspen for hundreds of years.
- There is an increasing amount of conifer succession in aspen stands due to the high amount of aspen that regenerated approximately 100 years ago during the settlement by Europeans. This is what would be expected to occur within 100-year-old aspen stands.

Ecological Implications

- Aspen-conifer mix cover types are an important ecological type; conifer encroachment is natural, will continue, and is desirable from a species or biodiversity perspective.
- Aspen stands that have little or no conifer component are also important from a species and biodiversity perspective.
- There is no indication of a current, significant aspen decline; therefore management actions should not be based on a presumption of a current aspen decline.
- The forest should allow natural processes to manage for aspen where feasible. Specifically, stand-replacing fires within conifer types in areas that would regenerate to aspen are desirable.
- If stand-replacing fires are removed from the landscape, then eventually the landscape may be on a trajectory where aspen distribution would be reduced from levels expected under natural disturbance regimes.
- Because of the ecological and social importance of aspen forests, the forest should emphasize the maintenance and recruitment of the aspen cover type.

LODGEPOLE PINE

Composition- Lodgepole pine occurs across the White River National Forest, but is much more concentrated in the eastern half of the forest. Lodgepole pine is typically a seral species, however, where shade-tolerant conifer species are absent from an area, it can form self-perpetuating stands (Peet 1988, Hess and Wasser 1982). Approximately 50 percent to 60 percent of the lodgepole pine that exists on the White River National Forest was regenerated between 1850 and 1910. From 1870 to 1910 was a period of rapid resource development by European settlers and this settlement activity resulted in large fires across much of the forest. It is not known how much of the area that was regenerated during this 40-year period was originally in spruce fir and how much was in seral lodgepole pine at the time of the disturbance. The stands of lodgepole that regenerated during this period have been relatively immature during the 20th century and have not been subjected to large-scale disturbances, either man-caused or natural. However, these large landscapes of single-species, relatively even-aged stands are nearing the stage in development when increases in disturbances can be expected, especially from mountain pine beetle outbreaks. Increases in pine beetle activity have been noted in the Vail area where local concern over forest health has been expressed by residents of the area.

A much higher percentage of the lodgepole pine on the forest resulted from regeneration disturbances in the period from 1870 to 1910 than would be expected based on the natural disturbance regimes for these species. Based on fire return intervals of from 200 to 700 years (see references for stand replacing events in Knight's report), the expected percentage of stand replacing events during this 40-year timeframe for large landscapes would have been from 6 percent to 20 percent. More 90- to 120-year-old lodgepole pine occurs than would be expected under the HRV. It is impossible to determine the pre-disturbance species composition of the areas that were regenerated approximately 100 years ago. It is highly likely that many of these areas were mature spruce fir, but many may have been seral lodgepole pine from previous disturbances. Based on the high magnitude of the disturbances that occurred within a relatively short period of time at the end of the last century, existing lodgepole pine is thought to be at the high end of HRV for overall coverage of the landscapes of the White River National Forest.

In areas not significantly impacted by European settlement, many lodgepole pine sites are slowly being replaced through succession by spruce and subalpine fir. Due to the long fire return history in these types, it is doubtful that the past 80 years of fire suppression have significantly affected the HRV conditions of these stands.

Structure- Fire suppression for the last 80 years has allowed natural succession to proceed from lodgepole pine to spruce and fir in those areas not significantly impacted by the major disturbance events associated with European settlement. In those areas, fire suppression may have prevented some stand level regeneration, but due to the long fire return interval in these forest types, it is doubtful if significant changes to HRV structural stage distribution conditions have occurred over the past 80 years.

Many seral lodgepole pine stands that regenerated in the mid-1880s to 1920s have not been at high risk for intense fire because of their relative immaturity during and following

that period, but are now in moving into age and structural classes that lend themselves to stand replacing disturbances.

A high percentage of the lodgepole pine on the forest is 100 to 130 years old. Lodgepole pine is generally not prone to disturbance events of fire or insects and disease until it matures at approximately 100 to 150 years of age (Alexander 1987; Debyle and Winokur, Eds. 1985; Jones and Debyle 1985; Lotan and Perry 1983). A major regenerating period may start within the next 50 years in these lodgepole pine stands. In the Vail area, increases in mountain pine beetle infestation of lodgepole pine have been noted in the past several years. As these disturbances occur, forest structure will start to shift to a more single species (by stand) and early structural ecological status. Overall forest structure will likely be in a more balanced and more dispersed distribution.

A much higher percentage of 90 to 130 year old lodgepole pine currently occurs on the forest than would be expected based on the natural disturbance regimes for these species. Based on fire return intervals of from 100 to 700 years (see references for stand replacing events in Knight's report), the expected percentage of stand replacing events during this 40-year timeframe for large landscapes would have been from 6 percent to 40 percent. The high percentage of regeneration that occurred in the last part of the 19th century coupled with the lack of regenerating fires in the past 80 years has resulted in a more homogeneous age and size structure for lodgepole pine on the White River National Forest than existed prior to European settlement. Due to the lack of disturbance on stands regenerated between the mid-1880s to 1920s, they have not significantly changed from even-aged, single species stands of lodgepole pine, and they have not been high risks for natural disturbance events. However, these large acreages of mature lodgepole pine are becoming increasingly at risk for future insect and fire disturbances, specifically due to their homogeneity.

In managed areas of the forest, the within-stand structure has been modified by the removal of tree boles for commercial timber, changes in dead, down and snags components by slash policies, and prescribed burning for site treatment. Clearcut areas may be on the low end of HRV for coarse woody material, but likely are not outside what might be found in the hotter areas of a stand replacing fire event.

Pattern- Detailed information concerning the historic pattern of the lodgepole pine on the forest is not available. Many landscape scale fire occurred during the late 1800, which regenerated into even-aged, single species lodgepole pine stands. Approximately 60 percent of the lodgepole pine stands currently on the forest regenerated during this 40-year period. The majority of the lodgepole pine stands on the forest are between 6 to 50 acres in size with a considerable number of patches in the 51 to 200 acre category (table 5). Table 6 indicates that the majority of the acreage of lodgepole pine on the forest also occurs in these smaller patch categories. An analysis of the potential impacts to patch size from vegetation management and from roading was completed as part of the 2002 Forest Plan effort. **Table A-64** displays the patch sizes by structural class for areas intensively managed for timber versus reference areas. The managed stands in Structural Class 1 are larger than in the reference areas, in contrast to what would be expected in stands heavily managed by relatively small clearcuts. (The forest average for clearcuts is less than 20 acres). Structural Class 5 indicates no differences between managed and reference landscapes. The possible explanations for these discrepancies are the wide variation in the natural patch size and the relatively limited amount of timber management (less than

3 percent of the total lodgepole pine on the forest has been harvested) that has occurred on the forest. There is a high degree of natural variability in patch sizes for lodgepole pine on the forest. Approximately 55 percent of the lodgepole pine on the forest is included within the inventoried roadless or designated wilderness classifications where roadbuilding and silvicultural treatments have had no impacts to landscape pattern. Due to the wide variability of the size of lodgepole pine stands across the forest and the limited acreage of lodgepole pine that has been managed (less than 7,500 acres of the 226,000 acres), it is doubtful if the past 60 years of vegetation management has significantly changed the HRV for lodgepole on the forest. Roading of lodgepole areas may have reduced the average patch size of stands in managed areas. Due to the natural wide variability in the size of lodgepole stands, the fact that one third of the forest is designated wilderness, and the fact that road densities are less than one mile of road per square mile on the remaining two thirds of the forest it is doubtful if roading on the White River National Forest has significantly affected the HRV for patch size of lodgepole pine at the landscape scale. Landscape pattern for lodgepole pine at the landscape level is within the HRV.

Summary of historical and current disturbances and patterns, and the ecological implications of changes

Historic Conditions

Historic disturbances that affected the lodgepole pine forests of the White River:

- Fire regimes were similar to spruce/fir; fire has an infrequent return interval from 200 to 400 year range. When fires occur, they are mainly climatically driven and are high intensity, large scale, stand-replacing events.
- Mountain pine beetle is a native species that has historically influenced lodgepole pine stands.
- Dwarf mistletoe is a native species that has historically influenced lodgepole pine stands. Stand replacing fires historically played a role in determining the distribution and impacts of dwarf mistletoe by affecting stand composition and sanitizing infected stands.

Historic patterns that resulted from those disturbances:

- Lodgepole pine has historically been a common cover type.
- Historic lodgepole pine stands were even-aged stands.
- Historically, most lodgepole pine stands were early seral resulting from stand-replacing disturbance events. These stands progressed through natural successional pathways and were eventually replaced by spruce/fir.
- It is likely that there was less lodgepole pine historically, than currently exists on the forest. Approximately 60 percent of the current lodgepole pine regenerated during from disturbances during the compressed time period of early European

settlement. Stand replacing disturbances that impacted spruce/fir stands during that period resulted in regeneration into lodgepole pine.

Current Conditions

Current disturbances that are affecting lodgepole pine forests on the White River:

- The major natural disturbance processes still predominate.
- Logging has targeted the oldest age class of lodgepole pine.
- There is a common age class due to the effects of fire and logging during early European settlement.

Current patterns resulting from those disturbances:

- Lodgepole pine continues to be a very common cover type. It is currently the third most abundant cover type with approximately 10 percent of the forest covered by lodgepole pine.
- The 90 to 130 year age class dominates the lodgepole pine on the forest due to the regeneration that occurred during the period of early European settlement. This has resulted in a more homogeneous age structure across the stands on the forest.
- There is less structural complexity in managed stands.

Ecological Implications

- Allow natural process to continue where feasible.
- Emphasize the maintenance of existing lodgepole pine.
- The oldest age class stands with complex structure are an important feature of lodgepole pine landscapes and should be maintained. Pay special attention to maintaining spatial distribution of these stands, without initiating a preserve system.

SPRUCE FIR

Composition- The spruce fir cover type encompasses the major high elevation forestlands of the White River National Forest. Hess and Wasser (1982) identified four major habitat types for spruce fir on the forest. More than 28 percent of the forest is covered by spruce fir and nearly one half of all forested acres on the White River National Forest are spruce fir. It occurs from 9,000 feet to over 12,000 feet, and the majority of the forests above 9,200 feet on the forest are spruce fir.

Tree ring evidence suggests that the earliest known spruce beetle outbreak on the White River Plateau occurred in the early 1700's (Miller 1970; Veblen et al. 1994). In the mid 1870s, Sudworth (1900a) found that 10 percent to 25 percent of the mature spruce on the White River Plateau and the Grand Mesa was dead. Hopkins (1909) later confirmed that spruce beetles caused this mortality. Photographic and tree-ring analysis by Baker and Veblen (1990) suggest that mortality in the Flat Top area observed by Sudworth and

Hopkins occurred in the 1850s and 1880s and affected forests from central New Mexico to north-central Colorado. More recent work in the Marvine Valley described several forest stands as being affected near the years 1716, 1827, and 1949 (Veblen et al. 1994). The major forest response to the 1940's spruce beetle outbreak that affected approximately 250,000 acres on the White River Plateau was the shift in species composition from 90 percent spruce/10-percent fir, to 20 percent spruce/80-percent fir with the resultant release of previously suppressed fir and spruce (Schmid and Hinds 1974; Veblen et al. 1991). Establishment of new spruce and fir seedlings was not evident approximately 40 years later (Veblen et al. 1991). Because fir is more abundant than spruce in the understory (in areas susceptible to spruce beetle outbreaks), more of the former species can be expected to grow into the larger size classes following an outbreak (Peet 1981; Veblen 1986). However, over time, the greater longevity of spruce will result in stands being co-dominated by both tree species. Peet (1988) displays the wide variation possible in species composition between spruce and fir based on local site conditions.

Much of the White River National Forest has fire regimes that result in low frequency/high intensity, stand replacing fires (see fire section of HRV). These events are bound to occur; it's only a matter of when fuel and weather conditions allow these events to occur. Nearly 60 percent of the spruce fir cover type on the forest is classified as mature and old growth. These stands have higher susceptibility to disturbance events such as insect outbreaks or stand replacing fires.

Paleo-ecological studies (Feiler and Anderson 1993) show that spruce has been a dominant forest type on the White River Plateau for at least 10,400 years. The historic mix of spruce and fir in the undeveloped and wilderness portions of the White River National Forest are likely similar to what would have existed across the forest prior to European settlement. Due to differences in susceptibility to various insects, diseases and disturbances, these two species fluctuate over time within a stand and over landscapes (Johnson 1994 and Veblen et al 1994).

There is evidence of several major spruce beetle outbreaks on the White River Plateau over the past 300 years with the earliest report from the early 1700s and the most recent from 1949. These outbreaks result in the mature spruce dying and the composition shifting heavily to subalpine fir within the landscapes involved (Veblen et al 1991).

The spruce fir cover type has fire regimes which are characterized by high intensity/low frequency, stand replacing events. Veblen et al (1994) documented fire return intervals on the White River Plateau of more than 350 years. Return intervals of 700 years have been recorded for other spruce fir studies (Billings 1969).

Spruce, especially dead spruce, was preferred by early European settlers for a variety of values, including house logs, fencing, timbers, and fuel wood.

The lower elevations and areas with high mineral potential were subjected to intensive disturbances by European settlers beginning around 1870. Mining, ranching, logging and uncontrolled use of fire all were common throughout this timeframe. This resource exploitation extended into the early part of the 20th century and resulted in vegetation changes across large areas of what is now the White River National Forest. Many areas, which are now covered by seral lodgepole pine and aspen, were undoubtedly mature spruce fir dominated landscapes prior to these disturbances.

Much of the forest currently dominated by spruce/fir occurs in areas that were not easily accessible to early settlers and did not have the mineral and other resource values that led to concentrated settlement and heavy disturbance that occurred in other areas. The age distribution of spruce-fir (**Figure A-4**) indicates that much of the current spruce-fir was not heavily impacted over the past 150 years. It is likely, as noted above, that much of the current seral lodgepole pine and aspen was mature spruce fir prior to disturbances associated with the European settlement period.

Modern logging (the past 60 years) on the forest has centered on the values of Engelmann spruce. Approximately 70 percent of the total timber harvest has been spruce. Early harvests were mainly clearcuts and although many of these cuts have regenerated, either back to spruce fir or seral aspen or lodgepole, some have still not regenerated adequately and still remain relatively open.

More recent logging in the spruce fir types have focused on sanitation/salvage and shelterwood approaches. Over half of the total volume of sawlogs that have come off the forest in the past 60 years have been dead material from this area. The sanitation salvage harvest has centered on the eastern portion of the White River Plateau and removal of beetle killed dead spruce. The shelterwood removals have occurred across the forest on suitable lands. Less than 5 percent of the total acreage of spruce has been logged during the past 60 years.

Species composition within the spruce fir cover type is quite variable due to the wide variability in effects of natural disturbances. Fires, insects, and the natural differences in life spans of the Engelmann spruce and subalpine fir result in ebbs and flows of species composition within stands and landscapes. There are no indications that recent logging has changed species composition outside the natural variability of the spruce fir type.

Due to the major concentrated disturbance events, both in time and space, that occurred associated with European settlement period of 1880 to 1910, the spruce fir cover type likely covers less acreage than would be expected under historic disturbance regimes on the White River National Forest. Most of these acres are currently occupied by seral stands of lodgepole pine and/or aspen.

Spruce fir stands not impacted by early European settlement activities are mainly within their HRV for species composition. Disturbance regimes that impact this type occur over such long temporal scales that the last 80 years of fire suppression would have had only minor impacts. In areas of concentrated management, such as timber harvest and road building areas, minor changes to species composition may have occurred, mainly to seral aspen and lodgepole pine. Over the past 60 years, approximately 75 percent of the vegetation management on the White River National Forest has occurred within the spruce fir cover type. Approximately 5 percent of the total existing spruce fir has been managed over this period, with approximately 75 percent of that management resulting from sanitation/salvage removal of dead material. In “green tree” sale areas, some increase in fir over spruce may have occurred due to the increased focus on the more valuable spruce. Overall, due to the small acreages involved on the forest and the wide natural variability in species composition in spruce fir stands, it is felt that the species composition within the spruce fir cover type is within HRV for the forest.

The traditional demand by industry for spruce and lodgepole pine in tandem with traditional silvicultural techniques for maximizing wood fiber production (the favoring of

some species combined with the removal of dead, sick, deformed, and damaged trees) has resulted in more uniform, single-species stands in managed areas. In recent years, however, higher costs of doing business and changing land management allocations have resulted in increased acres treated while the volume of tree removal has decreased (a result of fewer clearcuts and more treatment activities that cover more acres).

Structure- Spruce fir landscapes are historically made up of high percentages of late successional stands with low percentages of acreages of early successional stands from recent stand-replacing disturbances (Veblen 1994 and Sudworth 1900). At least one spruce fir stand on the White River National Forest has existed since 1605. Age information concerning spruce fir is only available from the RMRIS database. This information can be misleading due to the averaging of ages in the uneven aged stands. Regardless, a high number of spruce fir stands on the forest are older than 200 years (**Figure A-4**).

In managed areas, the within-stand structure has been modified by the removal of tree boles for commercial timber, changes in dead, down and snags components by slash policies, and prescribed burning for site treatment. The clearcut areas from prior to 1980 may be out of HRV on the low end for coarse woody material. However, changes in forest vegetation management since 1980 have focused more on maintaining uneven-aged stands and more coarse woody material has been left on site. These areas may be on the low end of HRV for coarse woody material, but likely are not outside what might be found in the hotter areas of a stand replacing fire event.

The sanitation/salvage and shelterwood approaches that have been dominant in spruce fir cover types since the middle of the 1970s, usually result in the reduction of the average tree diameters, a shift to more open canopies, reduced average stand age, reduced stand height, and reduced snags and other coarse woody debris. These treatments generally maintain the stand as an uneven-aged, multistoried stand.

It is important to remember that less than 5 percent of the spruce fir on the forest has been managed through silvicultural treatments and most of those were sanitation/salvage removal of standing dead trees. Most of the downed material from these sales was left on site. Snag numbers may be less than in surrounding areas, but 2002 Forest Plan standards required retention of some snags, even in salvage operations. Although some spruce fir stands may be on the low end of HRV for within stand coarse woody debris and snags, spruce fir landscapes across the forest are within the HRV for structural components of coarse woody debris and snags.

Veblen (1994) found that spruce fir cover types on the White River Plateau had a fire return interval greater than 350 years. Fire suppression efforts over the past 80 years have likely had very limited impacts to the structural components within the spruce fir cover types. The existing spruce fir cover type on the Forest is within the HRV for structural stage distribution.

Pattern- Over 60 percent of the spruce fir patches on the forest in the RMRIS database are between 5 to 50 acres in size. An additional 30 percent are between 51 to 200 acres. Only 7 percent of the spruce fir stands are larger than 200 acres with only one percent larger than 501 acres. **Table A-63** indicates that almost 80 percent of the total acreage of spruce fir on the forest occurs in patches larger than 51 acres. Over 20 percent of the total Forest acreage is found in the one percent of the patches that are larger than 501 acres in

size. Although there are not many of these large patches on the forest, they do comprise a significant percentage of the overall spruce fir. The FRAGSTATS assessment completed for the 2002 Forest Plan indicated that there were generally smaller patch sizes in all structural classes of the managed areas than in the reference areas (**Table A-64**). Since less than 5 percent of all the spruce fir on the forest has been actively managed by silvicultural treatments over the past 60 years, it is doubtful if all of the reduction in patch size can be explained by this past management. A high degree of variability was found in patch size in both managed and reference landscapes that were analyzed. Road construction has reduced the average patch size in managed areas of spruce fir from 100 acres to 64 acres. Silvicultural treatments and road building over the past 60 years have likely reduced patch sizes for some stands in managed areas of the forest. Approximately 60 percent of the White River National Forest is currently considered either designated wilderness or inventoried roadless. According to the CVU/Forest Vegetation database, 68 percent of all the spruce fir on the forest is included within these "protected" designations and have not been significantly impacted by post-settlement silvicultural treatments or roadbuilding. The small scale of active management on the forest has not lead to landscape scale changes in the HRV for pattern within the spruce fir on the White River National Forest.

Summary of historical and current disturbances and patterns, and the ecological implications of changes

Historic Conditions

Historic disturbances that affected spruce-fir forests of the White River National Forest:

- Armillaria root disease historically impacted White River National Forest stands of spruce-fir.
- Spruce beetle epidemics have been documented for several hundred years (since the early 1700's). These epidemics can occur over large landscapes (over 250,000 acres).
- Blowdown has occurred irregularly throughout the range of spruce fir
- Fire has an infrequent return interval of from the 200 to 400 year range. One study in the Flattops indicated a return interval of over 500 years. When fires occur, they are mainly climatically driven and are high intensity, large scale, stand-replacing events.

Historic patterns that resulted from those disturbances:

- Spruce-fir has been the most common cover type on the White River National Forest over a long history.
- Most spruce fir stands were uneven-aged stands with multiple canopy layers.
- Spruce fir stands were slow to re-establish following stand-replacing disturbances such as fire, blowdown, or insect and disease epidemic. They

generally have been late in the successional cycle, replacing the early successional cover types of lodgepole pine, aspen, or grassland.

- Spruce fir covered many, large, contiguous areas on the White River National Forest.
- Insect epidemics resulted in very large expanses of dead spruce.
- Mature spruce fir stands historically had large amounts and complexities of dead and/or down materials.

Current Conditions

Current disturbances that are affecting the spruce-fir forests on the White River National River:

- Fire impacts at the broad scale have not changed significantly within this type. Fire frequency within spruce fir is so long that modern fire suppression efforts have not been in effect long enough to result in major changes to landscape conditions.
- Spruce beetle epidemics, Armillaria infection, and blowdown are similar to historic conditions.
- Human-caused disturbances, logging and road-building, have resulted in small localized changes, but natural disturbance processes continue to dominate the overall spruce fir landscapes of the White River National Forest.

Current patterns resulting from those disturbances:

- Spruce/fir landscape patterns are similar to historic conditions at the broad scale. Approximately one fourth of the White River National Forest is spruce fir. However, logging, road-building, and other recent disturbances have influenced structure and distribution on localized portions of the forest.
- Dead and down materials have been reduced on the managed portions of the forest.
- There has been increased access by humans into the forest due to the construction of roads and trails.

Ecological Implications

- Uneven-aged silviculture management activities more closely align with natural processes in the spruce fir cover type.
- The natural rotation cycle in spruce fir is longer (by a factor of two to three times) than what is generally used in intensely managed spruce fir stands on the White River National Forest.
- Natural processes of fire, blowdown, and insects and disease result in more structure within stands (dead and down material) and across landscapes than has resulted from modern silviculture treatments.

OTHER FOREST COVER TYPES

Due to the very small acreages of limber pine and blue spruce types on the forest, and the limited information available concerning the historical occurrence of these species, it is not possible to make inferences concerning the HRV status of these species.

NON-FORESTED VEGETATION (RANGELAND)

Non-forested vegetation (rangeland) before 1870

Knowledge of the grassland, forbland, and brushland plants of the White River National Forest before 1870 is limited. Unlike trees, herbaceous vegetation leaves no record of its passing in tree rings and fire scars. Early photographs show little detail about these plants and historical reports provide little meaningful information. Drawing on fossil data, investigators have concluded that the same families, genera, and sometimes species of plants have been present in the area for the last two million years, and that much of the existing vegetation has not changed significantly during this period. Regarding this conclusion, however, some authors caution that one should not infer that elevational, latitudinal, or longitudinal ranges of taxa were similar to contemporary ranges, nor that assemblages of taxa were similar.

Most native rangeland plants have evolved under the influence of grazing by animals. Fossil records indicate that grazing herds of elephants, mammoths, rhinos, camels, horses, burros, ground sloths, and many other grazers and browsers, including a prehistoric species of cattle, roamed throughout western North America for several million years. Selective pressures for millennia favored the success of plants that had or developed a tolerance of browsing, grazing and trampling.

One source of information about the non-forest vegetation of the forest before settlement began is the diary of Jedediah Smith, a trapper who worked the "White River region" from 1824 to 1826. He described it as a "...high, rugged, barren mountain, the summits of which are either timbered with pine, quaking-asp [aspen] or cedar, or in fact almost entirely destitute of vegetation."

A U.S. government report on the condition of Western rangelands summarized the pre-settlement era:

> "Before white settlement the range was used only by wild game. Although these animals were present in very large numbers, occasionally overgrazing local areas, and variations in forage production were caused by droughts, some of which undoubtedly were as severe as those experienced in recent years, the range by and large was able to maintain itself. It would have continued to do so if the white man had not upset its natural and fairly stable equilibrium."

This report went on to describe sagebrush types before settlement as featuring an abundance of palatable grasses and weeds that grew under and between the shrubs. Prominent among these were the wheatgrasses, bluebunch fescue, needlegrasses, wild-rye, Indian ricegrass, wild geranium, balsamroot, and yarrow. Of lesser importance as forage but of frequent occurrence were hawksbeard, phlox, sunflower, lupine, and many other species. Occasional very dense stands of sagebrush were found, but as a rule the individual plants were several feet apart, forming open diminutive forests from two to

seven feet in height. Mingled with the silvery gray foliage of the sagebrush were other browse species such as bud sagebrush, bitterbrush, and rabbitbrush.

Exotic plant species, including noxious weeds and Kentucky bluegrass, were not present before the settlement period.

Non-forested vegetation after 1870

The major non-forested cover types of the forest were mapped in 1994. **Table A-65** shows the acreage of each type.

Table A-65
Acres of non-forested vegetation types on the White River National Forest

Cover type	Acres within cover type
Shrubland	174,000
Alpine	168,500
Grassland	108,100
Willows	71,100
Sagebrush	68,900
Pinyon pine-juniper	20,800
Mixed shrub (riparian)	4,200
Krummholtz	100

Changes in rangeland types and plant composition

District files indicate that reseeding of degraded areas was a common practice in the 1930s and 1940s, both in abused rangelands and in areas disturbed by fire. A number of these plots were sewn with Kentucky bluegrass, which is not thought to be native to the region, and with other species.

Species used in these projects included mountain brome, intermediate wheatgrass, slender wheatgrass, crested wheatgrass, smooth brome, orchard grass, hard fescue, timothy, meadow foxtail, Dutch white clover, perennial wildrye, cicer milkvetch, alfalfa, and yellow sweet clover. It is common today to see these species growing along roads and trails.

In later years, the Forest Service noted that Kentucky bluegrass had been very successful in establishing dominance in many of the upland parks of the forest, including areas that have never been seeded with it. Bluegrass is likely to remain dominant in these areas for the foreseeable future.

An estimated 89,000 acres of the forest currently are occupied by plant species considered to be noxious weeds, which are alien plants that aggressively invade native plant communities and are detrimental to them. Twelve species of noxious weeds are known to occur on the White River National Forest. These include leafy spurge, yellow toadflax, dalmation toadflax, Canada thistle, plumeless thistle, musk thistle, scotch thistle, Russian knapweed, spotted knapweed, diffuse knapweed, hound's tongue, and hoary cress. Several of these species were introduced into the U.S. as long ago as the early 1800s.

Although many existing noxious weed infestations are believed to result from abusive grazing practices, their current rate of spread is linked mainly to areas that have been

disturbed or is credited to transport by livestock, wildlife, or vehicles. Noxious weeds also have been seen to invade rangelands that have not been disturbed.

Early abuses of rangelands

In 1936, a federal review of rangeland conditions in Western public lands stated that widespread, continuous, and exhaustive use of the forage had changed the entire character of the virgin range. Included in these changes were (1) a tremendous decrease in the quantity and quality of the forage, and (2) deterioration of the basic resource, the soil itself. Many valuable forage species had disappeared entirely. Palatable plants were being replaced by unpalatable ones. Noxious weeds introduced from other countries were invading every type. And throughout the entire western range the vegetation had been thinned out until even conservative estimates place the forage value at less than half of what it was a century before. The loss in forage values from virgin range conditions was described as "range depletion."

Grazing by domestic livestock

The first livestock to be grazed on the forest were cattle brought from Texas into the Eagle River valley during the summer of 1878 or 1879. In 1884, ranchers brought some 25,000 head of cattle into the area of Meeker. The nearest railhead was Dotsero, so large herds were trailed eastward across the Flat Tops each fall.

During Sudworth's 1898 field inventory, he found cattle on nearly all the watercourses penetrating the interior of the White River Reserve and described overgrazing of the area's brushlands. In 1906, the Forest Supervisor found that large tracts of lower-elevation land had been severely overgrazed while much of the high-mountain grassland had not been used at all.

The first year of recorded permitting for livestock use was 1918, when 68,000 cattle and 130,000 sheep were authorized. Since that time, there has been a significant downward trend in permitted livestock numbers, as **Table A-66** shows:

Table A-66
Numbers of domestic livestock permitted to graze the White River National Forest

	NUMBER PERMITTED	
Year Permitted	Cattle	Sheep
1918	68,000	130,000
1940	36,000	160,000
1950	25,000	150,000
1960	28,000	102,000
1970	29,000	88,000
1980	29,000	76,000
1990	25,000	57,000
1995	23,000	51,000

Grazing by wildlife

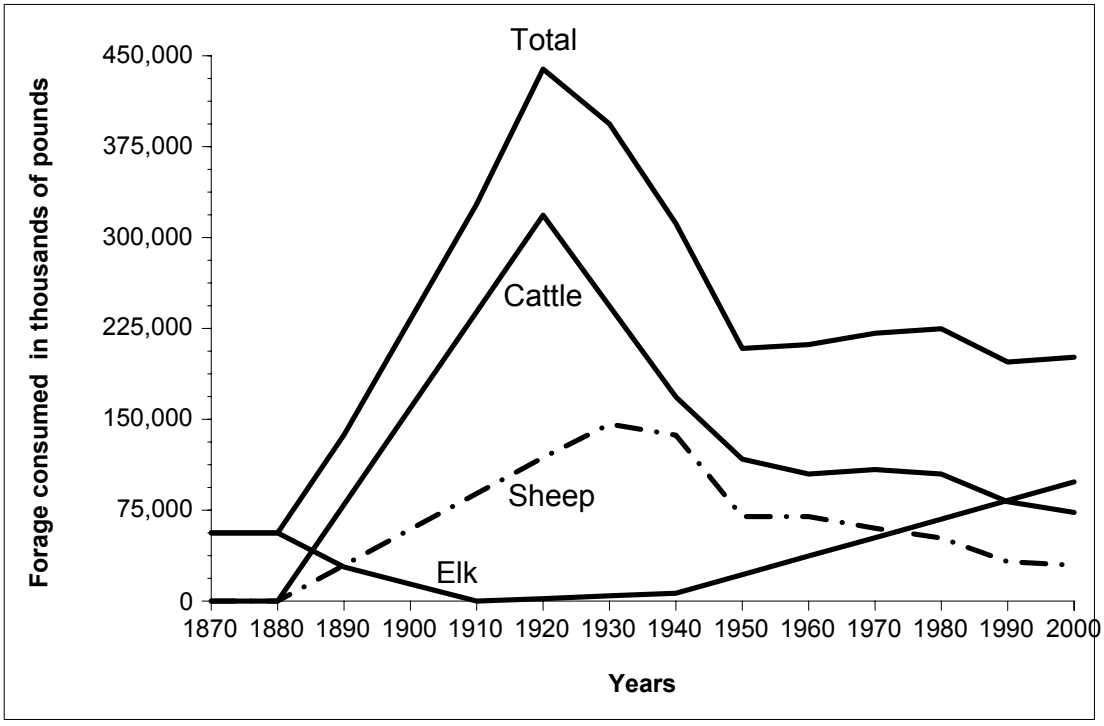
An estimated 35,000 elk were present on the forest at the time of settlement, or about the same as today. Unregulated hunting reduced them to as few as 1,000 animals in all of Colorado. Game management has since restored the herd to its historic level. Deer also were greatly reduced by market hunting in the settlement period, but have rebounded on the forest to about 115,000 animals. There is no good estimate of the number of mountain bison present before and during settlement, but it is believed that their population already was significantly reduced by 1870.

To compare the affects of grazing or herbaceous vegetation by domestic and wild animals, it is useful to plot their respective forage consumption to illustrate trends for each grazing species between 1870 and the present. Estimated levels for different species incorporate the following broad assumptions about how much forage each species consumes each season:

- The average grazing season for elk is six months
- The average grazing season for cattle was five months until 1950, and four months after 1950
- The average grazing season for sheep was four months until 1950, and three months after 1950
- An elk consumes about 60 percent as much forage as a cow
- A sheep consumes about 20 percent as much forage as a cow
- There were no cattle or sheep on the forest in 1870.

Figure A-5 indicates the overall trend of forage consumption for each species (as well as the combined total consumption). Deer are not included because for much of the year their diet consists primarily of browse species rather than herbaceous vegetation. Mountain bison were not included because, as mentioned, there are no good estimates of their numbers.

Figure A-5
Trends in forage consumption by elk, cattle, and sheep from 1870 to 1995 in thousands of pounds of forage



This figure illustrates the following events: (1) the near-extirpation of elk, and their recovery after 1930; (2) the increase of cattle during the settlement period, and continued rise to 1930; and (3) the decline in permitted grazing after 1930.

Non-forested vegetation conclusions

- Early journals and records give an incomplete picture of non-forest communities; and there are no records of pre-settlement species composition or landscape pattern to compare to current information.
- The current appearance of many non-forest communities is assumed to be very similar to before settlement, except for areas containing bluegrass or noxious weeds.
- Noxious weeds are out of the HRV.
- Kentucky bluegrass will continue its dominance of many areas for the foreseeable future.
- Before 1870, larger species can be assumed to have overgrazed local areas of rangeland from time to time, and levels of forage production on the forest varied with the occurrence of droughts. However, the current grazing habits of wildlife species indicate that rangeland communities were able to maintain themselves.
- Starting in the 1880s, cattle were introduced to lands now part of the forest. Their presence was generally continuous from green-up to first snowfall. Use was severe enough in some areas to change the character of the vegetation. Changes included (1) a tremendous decrease in the quantity and quality of the forage, and (2) deterioration of the basic soil resource. However, the heaviest grazing use occurred in areas with a steady supply of water, while areas distant from water received either light or no use.
- Starting in the 1930s, efforts were made to reseed areas that had been depleted by overgrazing. Species used in the seed mixtures are still evident on many of these areas. These species are expected to remain part of the plant composition for the foreseeable future, regardless of whether these areas are currently grazed by domestic livestock.
- It is believed that there currently are fewer acres of shrub- and sedge-dominated riparian vegetation than were present before settlement. Many of these riparian areas historically have been overgrazed.
- The acreage and density of brush species have increased since pre-settlement as a result of fire suppression and other factors.
- There is no evidence to indicate that any of the plant species on the forest listed as threatened or sensitive have been negatively affected by livestock grazing, or that their ranges, or population levels have changed.

AIR RESOURCES

Air resources before 1870

Within the forest, significant sources of air pollution in pre-settlement times are assumed to have been almost exclusively generated by fires. The only other source of air pollution would have been violent volcanic eruptions. Fire emissions include particulate matter and carbon monoxide, the latter being hazardous only to those within close proximity to the fire. Soil cover is assumed to have been sufficient in the forest to prevent significant dust storms. Evidence indicates that significant fires occurred in Colorado in 1676, 1707, 1722, 1753, and 1781, although the acreages involved cannot be quantified. Emissions of particulate matter from these fires probably were also significant.

Air resources after 1870

During the initial settlement period after 1870, a significant source of pollution was smoke from forest fires. Anecdotal reports of fires sweeping through large areas of the forest date from this era. A 1912 report described an occurrence called “dark days” that could prompt the lighting of lamps in the daytime, presumably due to smoke from fires. The study also noted that a smoky haze was commonplace in the autumn months of many of the settlement years, apparently from seasonal fires. A forest fire in Idaho in 1910 that consumed two million acres inundated much of the northern U.S. in a pall of smoke, including the northern half of Colorado. For much of this period, however, smoke may not have been worthy of more than brief mention in local newspapers, and communities may have taken for granted the smoke from stoves, trains and coke ovens as well as from occasional forest fires. They also endured the dust kicked up by people and horses on unpaved streets.

Aggressive fire suppression for the last 80 years has greatly reduced the incidence of smoke in the forest area, although this will change if intense fires occur as a result of the increased fuel loading.

The primary air pollution concern on the forest today is particulate matter. Other pollutants more prevalent today than in the settlement period are nitrogen oxides, sulphur dioxide, carbon monoxide, and tropospheric ozone, stemming from such sources as coal-fired power plants and vehicle and lawnmower emissions. Additional modern pollutants originate from such sources as solvents, propellants, and insecticides.

No air pollution standards have been violated on or near the forest except PM10, which refers to fine particles less than 10 microns in diameter. Violations occurred in Aspen in 1988 and 1991. A study found that 58 percent of this particulate matter came from dust stirred up by vehicles after roads are sanded, and 38 percent from wood stoves and fireplaces. In the summer months, dust is a byproduct of the urban construction going on in many locations near the forest.

PM10 has the potential to affect human populations downwind of a fire. Impacts to people include respiratory problems that can bring on short-term or long-term health problems. Particulate matter from fire also can temporarily reduce visibility in an area. The magnitude of particulate matter's impact on human health and on visibility depends

on the distance from the smoke source, the volume of smoke, and meteorological conditions.

Another concern on the forest is protection of air quality in Class I Wilderness. Such areas were designated by the Clean Air Act as areas of pristine air quality that must be given stricter protection measures. Current monitoring by the forest is limited to programs that assess the affects of regional air quality on Class I areas within the forest boundary. Instruments on Aspen Mountain collect visibility and ambient air data, others on Sunlight Park and at Fourmile Park monitor precipitation for acid deposition, and a camera on Vail Mountain assesses visibility. Also done is water sampling of wilderness lakes to assess the affect of air quality on lake chemistry. Details on these programs are provided in the forest's Air Resources Management Plan.

Data collected to date indicate that air quality is good to excellent in wilderness on the forest, and also show no evidence of acid deposition in alpine lakes.

There is the potential for smoke impacts to increase in the future. Because fire suppression has increased fuel loadings in many parts of the forest, larger acreages have burned in recent years and intense wildfires have become more likely. The higher level of fuel consumed per acre will produce a correspondingly higher level of smoke. One management option is the use of prescribed fire to circumvent the occurrence of uncontrollable wildfires, but these too will contribute to PM10 pollution and reduced visibility, although usually with less impact.

In many cases, prescribed burning is most needed in areas near the forest boundary in which wildfire poses a threat to life and property on adjacent private lands. These areas, however, are where recreationists and residents may object to the smoke impacts that would ensue. By regulation, forest managers must employ effective smoke management techniques to reduce the concentration of fine particulates in downwind sensitive areas such as population centers, highways, airports and hospitals.

Air resources conclusions

- The concentration of smoke in forest airsheds may be out of the HRV, being lower than what occurred before the cycle of fires in the area was interrupted by fire suppression efforts.
- Many present-day pollutants did not exist in pre-settlement days. These include emissions from fossil-fuel extraction and burning, solvents, aerosol propellants, etc. The forest is outside the HRV for these pollutants.

CLIMATE

Climate before 1870

Most climate variables are cyclical, and change along several different time scales. Cooler or warmer overall conditions may prevail for centuries, although individual decades or years may diverge from the norm within these longer spans. Long-term climatic changes can cause boundaries of ecotones to migrate in response to changing temperature or moisture regimes.

Across the Rocky Mountain region, each mountain range and intermontane basin influences local climate. Topographic features such as elevation, aspect and slope, prevailing winds and storm tracks determine distribution of solar radiation, temperature, precipitation and local winds. To an extent, these factors help determine formation of the natural environment.

Examination of tree ring data allows reconstruction of climatic conditions in the West from about 1600 to the present. This data shows the effect of a cool period that lasted from 1600 to the late-1800s. The year 1880 marks the beginning of a warming trend that continues today. Within each cool or warm period, however, were anomalous decades. Four of the five coldest decades in this 400-year span occurred in the 1600s. But two of the warmest decades occurred in the 1600s as well. The same variability can be seen in later centuries.

The El Niño climate event can increase precipitation levels in the western United States. Years with strong El Niños correspond with high water yields and flooding. Documented strong El Niños occurred 19 times from 1763 to 1995 at intervals of about 12 years. This cycle has repeated for at least the last 200 years.

Reconstructed data from before settlement and later measurements illustrate the long-term precipitation pattern for the region of the White River National Forest. Although extremes occur from time to time, the overall pattern has not changed for centuries. During the winter months (November through April), the area is influenced by moist low-pressure air masses that originate over the Pacific, and by high-pressure systems centered in the Great Basin. Snow accumulations begin to mount in the high country in late-October and reach their maximum by mid-April. During the summer months (May through October), stable high-pressure systems over the area draw moist Gulf air northward into Colorado; these fuel convective showers and thunderstorms across the mountains. On the forest as a whole, annual precipitation varies from less than 12 inches on its western margin to more than 40 inches at higher elevations.

Climate after 1870

There are no indications that current precipitation and snowfall accumulations have varied significantly from historic levels. A general warming trend began around 1880. **Table A-67** illustrates the general reduction in water yields recorded at different gauging stations during two periods (the 1910s and the 1990s), showing the effect of diversions from the forest on measured streamflows.

Table A-67
Measured water yields on the White River National Forest

	WATER YIELD (acre feet)		
Station	**1911-1915**	**1990-1994**	**% Reduction**
Blue River at Dillon	100,620	59,612	41
Ten Mile Creek at Dillon	112,050	67,130	40
Homestake Creek at Redcliff	77,422	25,392	67
Blue River near Green Mountain	447,600	239,750	46
Eagle River at Redcliff	51,764	24,954	52
Turkey Creek at Redcliff	25,540	14,240	44
Colorado River at Glenwood	2,268,200	1,170,140	48
Roaring Fork at Glenwood	1,292,900	732,360	43
Maroon Creek in Aspen	64,134	48,462	24
Roaring Fork at Aspen	128,520	63,500	51
White River at Meeker	439,600	342,060	22
North Fork White River at Buford	247,400	141,160	43
South Fork White River at Budge's	194,800	138,200	29

The use of storage impoundments, transbasin diversions, and possibly increased overall basal area of timbered stands has created conditions outside of the HRV in the Colorado River basin. Overall measured water yield is down, peak flows (except in major flood years) are reduced, and baseflows have been altered. Stream systems with significant diversions, storage impoundments, or alterations have resulted in changes in measured water yields, timing of flows, and frequencies of flooding.

Cyclic events that substantially reduce "green" basal area, such as bark beetle epidemics or extensive stand-replacement fires, can result in an increase in water yield and streamflow. These changes usually are short-lived, however, as forest stands regenerate.

Climate conclusions

- Streamflows are out of the HRV due to water diversions and impoundments.
- A general warming trend that occurred in the late 1800s triggered changes in erosion rates. While these changes are within the HRV, recovery and or rates have been influenced by human activities.

FIRE

Fire before 1870

Many of the vegetation types and ecosystems on the White River National Forest are a direct result of fire's defining role in the landscape in the form of periodic stand-replacement fires. Although limited knowledge is available of the forest's fire history before settlement, the consensus is that about 400 to 500 fires were ignited each year by lightning. Most of these fires burned very small areas before going out, so that the total burned acreage each year, on average, was less than 100. Every 10 to 15 years, however, drought conditions would bring about larger fires that consumed 5,000 to 10,000 acres or more. Most of these larger fires can be assumed to have occurred at mid-elevations either in shrublands or conifer forests.

Fire regimes

This frequency and extent of fire on the forest is thought to be what occurs when there is no human intervention in natural fire regimes. Different fire regimes reflect different historic interactions of weather, fuel supplies, and ignition sources. Each regime also features a return interval, which describes the period within which wildfire can be expected to return to the same location.

On the forest, three regimes are present:

- Lower-elevation areas vegetated by oakbrush, sagebrush, and pinyon-juniper experience frequent fires of low-to-moderate intensity, with a return interval of less than 50 years. About 9 percent of the forest falls within this regime.
- Higher-elevation zones vegetated by lodgepole pine and spruce-fir experience infrequent fires of high intensity, with a return interval in the range of 50 to 300 years. About 52 percent of the forest falls within this regime. Periodic severe droughts produce deep drying of dead and downed fuels and live vegetation, setting the stage for intense fires. A modifying factor is that during droughts there is less lightning to ignite these fires.
- The alpine tundra and Krummholz typical of the higher reaches of the forest experiences infrequent fires of low-to-moderate intensity, with a long return interval of 300 to 500 years (although some areas may never burn at all). About 10 percent of the forest is within this regime.
- Another 19 percent of the forest is in aspen, in which frequent low-intensity fires and occasional high-intensity fires occur. The remaining 10 percent of the forest is unvegetated.

Within these three regimes, some plant communities are fire-dependent because fire is an integral part of their life cycle. If fire is suppressed, the health, composition, and diversity of this plant community may be altered. Fire dependency is further classified in terms of how fire affects the ecosystem:

- When light or low-intensity fires thin the vegetation and remove dead and downed surface fuels, reducing the threat of severe wildfire that could kill the stand, the stand is fire-maintained.
- When a high-intensity fire simultaneously kills the resident forest stand and initiates its regeneration, the stand is fire-initiated.

Fire behavior

Within the fire regimes described for the White River National Forest, dominant cover species respond to fire in different ways:

- Engelmann spruce is very fire-sensitive and often is killed even by low-intensity fires due to its thin bark, shallow rooting pattern, resinous bark, low-growing branches, tendency toward dense stands, and moderately flammable foliage.
- Subalpine fir cohabitates sites with Engelmann spruce, and like spruce, is very fire-sensitive. Both species are slow to regenerate after a fire.

- Lodgepole pine is found in the forest in varying percentages of closed-cone and open-coned trees, allowing it to regenerate quickly following both high-intensity and low-intensity fires, high intensity being necessary to open serotinous (closed) cones and release seed.
- Aspen generally depends on major disturbances such as fire for regeneration; fire kills the above-ground portion of the tree but not the roots, which regenerate the stand through root crown or stump sprouting.
- Pinyon pine and Utah juniper are very sensitive to fire in any intensity and are slow to regenerate after a stand is burned.
- Gambel oak (oakbrush) is extremely fire-tolerant and generally sprouts vigorously from stembases or from underground lignotubers and rhizomes following fire; it can flower a second time after a summer fire, increasing the biomass of a stand significantly.
-

Fire season

The fire season on the forest corresponds to summer climate patterns. After green-up of vegetation in late May to early June, a drying trend occurs until the July monsoons. Once the monsoon pattern breaks down in August, a second drying trend occurs until snow starts falling in September or October. Average temperatures (in degrees Fahrenheit) during this fire season of June 1 to November 1 range from the 60s to 80s during the day and 30s to 50s at night. Relative humidities (in percent) during the day range from the mid teens to mid-20s while nighttime humidities recover to the high 60s to low 80s. Prevailing winds for the forest are out of the west/southwest, shifting to the northwest in the fall. Wind speeds average 5-12 miles per hour. Windy periods in mid-to-late June, mid-to-late September, and mid-to-late October, lasting one to three days, may spark the spread of an intense fire event.

Fire after 1870

The movement of people throughout the region of the forest after 1870 was accompanied by a marked increase in the number of fires set intentionally or accidentally. During the mining boom, fires were set by prospectors, perhaps to make ore-producing veins easier to see, or were ignited by passing trains. Although actual fire records are limited, newspaper and anecdotal reports from this era indicate that widespread, large-acreage fires burned throughout Colorado and Wyoming before the turn of the century. The number of lightning-ignited fires was minor compared to the number of human-caused fires. Prolonged periods of smoky or hazy air were commonplace in the late summer and early fall, and settlers evidently were unfazed by the extent of fires burning in the nearby forest. Fires rarely were suppressed unless they threatened ranchland or settlements and often were left to burn or smolder for days and even months.

In the early days of the White River Plateau Timber Reserve, before federal timber agents had been dispatched to the area, a number of lumber mills operated both on and off the reserve. In his survey, Sudworth remarked on the apparent setting of fires by mill operators to kill the trees in timber stands because it was less of a crime to harvest dead trees illegally than live ones. In the same period, the reserve had been publicized in eastern cities as a sportsman's paradise. Sudworth noted that most of the fires of the 1890s probably were sparked by neglected campfires left by “the large number of

reckless, lawless hunters and fishermen that invade the reserve." On the Battlement Timber Reserve, he thought it likely that some fires were started by ranchers to clear land for grazing or to locate stray cows.

The size and intensity of fires in the settlement era would have been influenced by whether they were human-caused or lightning-ignited. Fires started by people usually begin in lowlands or at the base of drainages, where they can, under the right conditions, move upslope and burn considerable acreages. In contrast, lightning fires most often occur higher up on ridges, from which their spread may be limited.

Disruption of natural fire regimes in this era should be seen more as an alteration of when fires occurred rather than in terms of their extent. Given these regimes, most of the areas that people ignited eventually would have burned. The human influence was to shorten the occurrence intervals, which would have been more spread out under natural conditions. Because large areas of the forest were burned, an abundance is seen today of stands of relatively even age that regenerated during this period. Had natural fire regimes not been interrupted, more variation would be seen currently in forest age classes. Also present is an abundance of aspen, which colonizes areas that have burned.

The effects humans have had on fire regimes and cycles during the "Suppression Era" (about 1910 to the present) are less obvious than those of early settlers, but potentially more damaging. This is especially true in forest communities that are conditioned by the occurrence of low-intensity surface fires at frequent intervals. These fire-initiated ecosystems include aspen, lodgepole pine, and Gambel oak communities.

After the Forest Service was established in 1902 and the White River Reserve put under its supervision, aggressive fire suppression activities began to limit the amount of acreage burned on the forest. According to fire reports, only 4,800 acres burned on the forest between 1909 and 1930, or about 218 acres per year. From 1945 to 1949 the average number of detected fires a year was 12 with an average annual burn of 19 acres. From 1950 to 1954 the average went up to 25 fires per year burning an annual average of only 90 acres. A surge in the number of fires from 1955 to 1959 moved the average to 39 per year, burning an annual average of 210 acres. In the 1930s and 1940s the White River National Forest grew in size substantially by merging with the Battlement, Sopris, and Holy Cross national forests, making the decline in fire frequency and extent even more striking.

This major drop can be attributed to the "total warfare" concept of fire suppression waged against wildfire after World War II. Partly responsible for this policy were the widespread insect epidemics of the 1930s and 40s. These greatly increased fuel loading in outbreak areas, prompting forest managers to contemplate the possibility of a catastrophic fire burning most of the forest and producing devastating losses of timber and property. Aggressive suppression methods were undertaken to forestall this event.

From 1971 until 1995, the number of detected and suppressed fires was about 45 per year but the annual acreage burned rose substantially to 1,236. A single large fire in a span of years can skew these figures and give a false picture of the average size of fires in this period. Also worth noting is the fact that changes in the forest's administrative boundaries before 1971 make direct comparison of averages from fire records less meaningful.

Although the number of fires on the forest is about the same today as it was before settlement, the zones in which fires occur has changed. From the 1910s to the 1970s, most fires were seen in lower-elevation rangelands. In recent decades fire increasingly is seen in higher-elevation spruce-fir and lodgepole, reflecting the fact that after many years of effective fire suppression the stands here are older and have a higher build-up of fuels present. Also at work is the speed, mobility, and efficiency of modern fire control, which keeps acreages burned in lower elevations to a minimum. At higher elevations, firefighters are less able to bring about the same level of control.

After around 1975, land management agencies began to use prescribed fire as a management tool. On the forest, this has been done mainly in lower-elevation brushlands, on a limited scale of about 3,000 acres a year, to improve rangeland and wildlife habitat. No prescribed burning has been done in upper-elevation conifer forests.

Prolonged and very successful suppression of fire on the forest has altered fuel profiles in a number of ways. Prevention of fire in lower-elevation shrublands has increased the biomass of vegetation in these zones, creating a "ladder-fuel" profile that increases the potential for fire to spread to conifer stands at higher elevations. Aspen stands that have not seen low-intensity fires for many years are being replaced by conifers, which have a more flammable profile. Within upper-elevation conifer stands, the lack of fire has led to increased fuel loadings in the form of snags and downed woody debris as well as many larger trees of advanced age. These stands are more likely to burn intensely and for long durations once they are ignited. Moreover, such fires will be difficult if not impossible to control with existing suppression methods. The threat to life and property in these areas has been heightened in recent years by the building of homes along the forest boundary or in private inholdings.

Fire conclusions

- The number of fires that occur each year is within the HRV.
- The number of human-caused fires is out of the HRV, being higher than before settlement.
- In terms of natural fire cycles, lodgepole pine and aspen stands are within the HRV but are trending out.
- Oakbrush and sagebrush similarly are trending toward being out of the HRV.
- The frequency of low-intensity fires is within the HRV.
- The frequency and extent of high-intensity fires are out of the HRV.
- In many forest stands the accumulation of litter, standing dead trees, and downed-dead material is out of the HRV.
- The current subalpine landscape is more homogenous than before settlement due to the synchronizing effect of numerous disturbances that occurred in the settlement period.

INSECTS AND DISEASES

Insects and diseases before 1870

Several insects and diseases have stood out in modifying the area's forest stands. In lodgepole pine stands, these include the mountain pine beetle and the lodgepole pine dwarf mistletoe. In spruce-fir forests, the most important insects and diseases are the spruce beetle and Armillaria root disease. In aspen ecosystems, various insects and diseases are normal components, including canker diseases; stem, root and butt decays; and several wood-boring insects. All of these insects and diseases have co-evolved with their tree hosts in a complex interaction that also provides food and habitat for other species.

Mountain pine beetle

Mountain pine beetle is a native bark beetle with a persistent outbreak history. It kills both lodgepole and ponderosa pines. Severe outbreaks in lodgepole develop almost exclusively in stands that have been undisturbed for many years and contain many older trees growing in crowded conditions. At endemic beetle population levels, bark beetles attack and kill weaker trees that are less able to compete for available light, nutrients, and moisture. Under outbreak conditions, the mountain pine beetle population expands to the point of attacking and killing nearly all of the trees in stand, even the healthy ones.

In doing so, the beetle exploits a niche otherwise filled by fire in the regeneration of lodgepole. As a stand reaches an advanced age, its dense canopy, snags, and downed woody material make it more vulnerable to an intense fire. If fire does not occur, however, these crowded stand conditions prove favorable to mountain pine beetles, which kill the larger trees, creating openings in the forest canopy. Lodgepole seedlings then can emerge. The new open areas also invite the growth of forbs and grasses, providing forage for grazing animals, while snags may provide habitat for cavity-nesting birds.

Lodgepole pine dwarf mistletoe

Lodgepole pine dwarf mistletoe is a parasitic flowering plant that reduces lodgepole growth rates, kills trees directly, or predisposes them to attack by insects. The first symptom of infection is a swelling of the host tree's tissues. These then enlarge and produce dense masses of distorted branches called witches' brooms. As the parasite spreads through the crown, tree growth is reduced; eventually the top weakens and dies and growth of the tree ceases. Earlier death may occur when bark beetles attack weakened, heavily infected trees, while other organisms such as decay fungi can enter wounds and swellings created by the mistletoes. The mistletoes themselves may provide a food source for birds, rodents, and elk, and mistletoe brooms may provide bird nesting sites and cover, although the extent of these roles is not well known.

Spruce beetles

Spruce beetles infest all species of spruce in North America, and have been native to the White River National Forest for thousands of years. Spruce beetles generally prefer to attack green windthrown trees or other recently downed spruce. Endemic beetle populations are always present, breeding in scattered fallen trees. Outbreaks generally occur after a major disturbance (such as a windstorm) creates an abundance of suitable breeding material. Populations increase rapidly in fallen trees and then readily attack standing spruce if no fallen spruce is available. The thinning of stands by spruce beetles may improve summer forage for deer and elk, while increased numbers of standing dead

trees may benefit snag-dependent animals.

Tree ring evidence suggests that a major outbreak occurred on the White River Plateau in the early 1700s, and another between 1850 and 1880. In his 1898 survey of the White River Plateau Timber Reserve, George Sudworth found up to 25 percent of the mature spruce in the reserve to be dead.

Armillaria root disease Armillaria root disease, caused by a fungus, is the most common and widespread root disease on the forest. The fungus commonly is observed on subalpine fir, lodgepole pine, and ponderosa pine. It affects trees by weakening their structural support, making them more likely to be windthrown, or kills them directly by girdling their roots. Root disease infection also slows growth and may stress host trees to the point at which they become susceptible to mortality by other agents such as bark beetles or drought. The fungus lives for many years on dead organic material such as old stumps, then can spread through the soil to the roots of living hosts. Beneficial effects of root diseases include the creating natural openings and wildlife habitat as well as helping to decompose woody material on the forest floor.

Insects and diseases in aspen Insects and diseases in aspen perform several important roles, including the recycling of nutrients, the thinning of newly regenerating stands, and the creation of openings and nesting sites for wildlife. Because of aspen's thin bark, wound-invading fungi are particularly important pathogens. These include the canker-causing fungi, such as black target canker, sooty bark canker, Cryptosphaeria canker, and Cytospora canker. Also seen are stem decay fungi such as white trunk rot, and root and butt decay fungi such as white mottled rot. The most widespread canker-causing fungi are probably sooty bark and Cryptosphaeria cankers. Studies have attributed more than half of aspen mortality to sooty bark canker and one-fourth to Cryptosphaeria canker. Also very common is Cytospora canker, which is not a vigorous parasite on healthy trees although it can hasten the death of trees weakened by other insects or disease.

Foliage diseases Several foliage diseases also are common in aspen. These include ink spot, Marssonina blight, and aspen leaf rust. During outbreak years, these diseases can cause widespread leaf bronzing and defoliation, although they seldom cause any permanent damage to their hosts. For climatic reasons, these diseases seldom appear in consecutive years.

Wood borers Two major wood borers are found in aspen on the forest: the poplar borer and the bronze poplar borer. Wood borers often are associated with stressed, damaged, or insect and disease-infested trees. Attack by wood borers frequently hastens the death of the host tree. In addition, the action of wood borers may also create entrance courts for wood decay and canker-causing fungi and encourage woodpecker excavations, leading to further tree breakage and damage.

Insects and diseases after 1870

Mountain pine beetle — Widespread outbreaks of mountain pine beetle occurred on the White River National Forest in 1910 to 1912, 1944 to 1945, and 1980 to 1985. Since 1996, new outbreaks of mountain pine beetle have been seen in several areas. Forest entomologists observed in the 1960s that lodgepole pine stands were becoming increasingly favorable to a beetle outbreak, largely because prolonged fire suppression had increased the abundance of dense, even-aged stands of older trees. A 1967 study found the potential for a major epidemic and recommended stepped-up monitoring and

treatment. Outbreaks in lodgepole pine forests did occur in Summit County and in the Vail and Eagle areas in the early 1980s. A series of measures were adopted to reduce damage in the ongoing infestation as well as the potential for future epidemics. These included direct treatment of infested trees with ethylene dibromide and removal by sanitation logging. Silvicultural treatments consisted of regeneration harvesting of susceptible stands, precommercial thinning, and overstory removal.

By 1985, a significant decline in mountain pine beetle populations was noted throughout the project area. However, a 1991 study that examined 85,000 acres in the Piney River/Red Sandstone area found an estimated 96 percent of lodgepole stands to be at moderate-to-high risk for a substantial outbreak. Aerial surveys in 1996 identified numerous mountain pine beetle sites in lodgepole in the Vail Valley area, in ponderosa pine on Derby Mesa, and in both tree species near Keystone Resort. In recent years, the presence of beetle-killed trees very close to the towns of Vail and Minturn has focused public concern about beetle activity, especially where it was perceived to degrade scenic values or threaten trees on nearby private lands.

Lodgepole pine dwarf mistletoe — Suppression of wildfire has led to increased distribution of this species on the forest. Past practices such as the incomplete removal of infested trees in timber harvest areas and the perpetuation of uneven-aged stand conditions have promoted its spread. Surveys conducted in 1979 indicated that 36 percent of the forest's lodgepole pine was infested.

Dwarf mistletoe is regarded by forest managers as negatively affecting timber, recreation, and scenic values. It may produce significant losses in merchantable timber volume. In developed recreation sites, falling limbs weakened by fungi associated with mistletoe may pose a hazard to visitors. From 1981 to 1995, more than 14,000 acres were surveyed and 2,600 acres treated with overstory removal, sanitation thinning, and stand replacement. Additional acres of control have been accomplished through timber harvests.

Spruce beetle — In the 1940s, the White River, Arapaho, Grand Mesa, Routt, San Juan, and Uncompahgre national forests were the core of the most widespread and severe spruce beetle outbreak ever recorded in the lower 48 states. In the White River, more than 250,000 acres were affected. The outbreak was triggered in 1939 by a violent windstorm that leveled large expanses of subalpine forest in western Colorado. Most of the mortality on the White River Plateau occurred between 1943 and 1946. By the time it subsided in 1952, nearly all spruce eight inches or more in diameter on the plateau had been killed. A portion of this dead spruce was harvested by salvage logging during the 1980s and 1990s, but many dead trees remain standing.

One aftermath of the epidemic was a shift in species composition from 90 percent spruce/10 percent fir to 20 percent spruce/80 percent fir. Because subalpine fir is more abundant than spruce in the understory, fir can be expected to dominate in the decades following a beetle outbreak. Given spruce's greater longevity, however, it is likely to regain dominance of the stand over time. The 1940s outbreak also created a high fuel load for fire (more than 100 tons of dead fuel per acre), although large fires in these stands on the White River Plateau are rare because of moist conditions during much of the fire season.

Because of the very long fire return interval in the spruce-fir type, it is unlikely that fire suppression in this century has affected the susceptibility of spruce stands to spruce beetle infestation.

Armillaria root disease — Very little is known about the past or present distribution of Armillaria root disease on the forest. The only landscape-level survey to be done was performed recently in lodgepole pine in the Piney Analysis Area, which found the disease in 53 percent of acres surveyed. Fire control and selective logging practices often promote its spread by favoring reproduction of more susceptible tree species and by providing stumps, which become new food sources for the fungi. Factors that increase stress in trees such as drought and defoliation by insects also increase the occurrence of root disease.

Insects and diseases of aspen — Disruption of the natural fire cycle in many aspen ecosystems has led to the aging and decline of the aspen cover type on the forest. This increase in age, coupled with a decrease in stand vigor, has undoubtedly led to an increase in the incidence, distribution, severity and impacts of aspen cankers, wood borers and root, butt and stem decays. Additional factors contributing to stress in aspen include soil compaction (by logging operations and heavy use by grazing animals), animal damage (by wild and domestic animals), and the invasion by aspen of marginal sites. Invasion of aspen stands by conifers in the absence of fire has reduced the acreage of aspen on the forest, increasing the concentration of stress and subsequent insect and disease activity in the trees that remain.

Insects and diseases conclusions

- The potential for large-scale insect epidemics is somewhat out of the HRV because fire suppression has promoted the growth of dense stands of older trees.
- Armillaria root disease is trending out of the HRV to the degree that timber harvests and fire suppression have provided food resources for it.
- Lodgepole pine dwarf mistletoe is out of the HRV because of fire suppression and some silvicultural practices that promote its spread.
- The numbers of pre-settlement and post-settlement spruce beetle outbreaks are probably the same, although human activities may make future outbreaks more frequent.
- Disruption of natural fire cycles has produced higher ratios of aspen in older age classes, favoring insects and diseases of aspen to a point that is out of the HRV.

WILDLIFE

Wildlife before 1870

The long-term ecological history of wildlife species for the most part relates to the mix of habitat types present throughout time. However, humans have had an effect on the populations and distributions of some species, regardless of natural habitat changes (i.e., succession, fire and insect disturbances, etc.). This discussion will primarily focus on the time period of pre-settlement (1800s) to present, as that time period provides the only documentation available as to wildlife species presence, abundance and distribution.

Some prehistoric information could be drawn from vegetative history as well as fossil remains, but primarily only species composition conclusions could be made.

Before 1820, Colorado was a land of plentiful game, according to early explorers. The following assumptions and observations can be made about wildlife populations in the area of the forest before the settlement period:

- Elk and mule deer are thought to have had populations on the forest of approximately 35,000 and 115,000 animals, respectively. The White River Plateau elk herd has been known as one of the healthiest and most productive in the nation. At the beginning of the settlement period, deer were found in high numbers.
- Mountain bison once were relatively abundant in northwest Colorado, although they are assumed to have been greatly diminished by 1870; they moved in small herds from the Flat Tops in summer to lower country in winter.
- Bighorn sheep formerly were abundant throughout the state.
- There is no evidence that a resident moose population occurred on the forest historically, although it is likely that moose, especially young males, wandered across the forest from time to time.
- There is no scientific documentation or specimens of mountain goats from Colorado prior to their introduction to the state in the 1940s. Some speculate, however, that this species did exist in the state before 1800, based on historical sightings of "goats," which could have been mistaken for a female bighorn sheep.
- Coyotes, black bears, and mountain lions were common on the forest.
- Wolves and grizzly bear occurred on the forest, but were relatively uncommon.
- The lynx and wolverine, both on the southern end of their range, are thought never to have been very numerous. Lynx probably were always rare in Colorado. Wolverines were likely a peripheral population in Colorado and had sparse populations on the forest historically.
- River otters occurred in the major waterways in and near the forest, but early mammologists reported them to have always been rare in the state.
- Beaver were common until being seriously depleted by trappers in the mid 1800s.
- Peregrine falcons, bald eagles, goshawks, ospreys, and other birds of prey were present on the forest.
- Greater sandhill cranes were found in some areas on the western half of the forest, with breeding grounds from 9,000 to 9,500 feet.
- Harlequin ducks were historically listed as a resident of Colorado. A small breeding population occurred in the Blue River area.
- White-tailed ptarmigan were common in the alpine zone of the forest.

- Sage grouse and blue grouse were very abundant, and Columbian sharptailed grouse of uncertain abundance.

Wildlife after 1870

Many wildlife species were profoundly affected by demands made on them during the settlement period. Market hunting, mining, farming, livestock grazing, and more recent activities such as housing developments have contributed to loss of habitat, changes in population numbers and/or distributions, and extirpation (or near-extirpation) of a few species. In addition, the development of major transportation systems — the interstate highway corridor in particular — has changed, disrupted, or totally blocked traditional migratory pathways and reduced the effectiveness of habitat for many of the species traditionally found near or along these roads and railways.

Each of the species for which significant changes have been seen is summarized in this section.

Elk By 1910, unrestricted hunting had reduced Colorado's elk population to 1,000 or fewer animals. It is believed that they were never completely extirpated from the Flat Tops, although they were thought to be eliminated from what was then the Holy Cross National Forest. Market hunting accelerated in the late-1880s when railway access reached Glenwood Springs. Elk were reintroduced to the Roaring Fork Valley after 1912 and game management programs have since returned them to their historic numbers.

Mule deer Mule deer also were hunted commercially and greatly reduced in number, although they are not thought to have been completely extirpated from the forest. Like the elk they recovered after several decades of game management. Recent estimates of about 115,000 animals are believed to be comparable to the pre-settlement population on the forest.

Bison The extirpation of bison in North America is mainly attributed to market hunting. The last wild bison in Colorado are believed to have been killed in 1904.

Bighorn sheep Between 1859 and 1959 there were a number of major declines in bighorn sheep populations in Colorado. One such decline in 1885 was brought on by a combination of scabies infestation, market hunting, and reduction of their winter habitat. Sheep numbers decreased so drastically by 1885 that the hunting season was closed in 1887 and not reopened until 1953. Further fluctuations indicate an ongoing cycle of bighorn populations, with highs and lows falling about 30 years apart. The overall trend in Colorado in this century has been downward, presumably because of diseases transmitted to them from domestic sheep, as well as habitat succession. An estimated population of 7,230 bighorn sheep in Colorado in 1915 fell to 2,200 in 1970 but currently is estimated at 6,000. On the forest the current bighorn population is estimated at 720. Today's herds are remnants that persist in isolated portions of their pre-settlement range. Only three endemic herds (those that have not been either supplemented with transplants or reintroduced) remain on the forest: the Battlement, Gore Range, and Maroon Bells/Snowmass herds.

Moose Moose have been expanding their range southward in North America since the late 1800s. The forest does not have a known resident population, but has seen an increase in the numbers of moose in the Piney Creek/Sheephorn area, which may support a small breeding population.

Mountain goats The Gore Range herd of mountain goats was introduced from 1968 to 1971, while the Maroon Creek goat population is probably a pioneer group from the Collegiate Peak transplants of the late 1940s.

Wolves Aggressive fur trapping and bounty hunting during the first quarter of the 1900s led to a marked reduction in the number of wolves. Federal campaigns in this era actively sought their extermination. Reports indicate that wolves existed on the forest and surrounding area through the early 1920s at least, but probably were gone from Colorado by the 1930s.

Lynx This feline predator prefers high-elevation coniferous forests with large amounts of downed trees interspersed with meadows or younger stands of forest that provide abundant numbers of snowshoe hare, its primary prey. Its decline from earlier numbers was noted in 1911, mainly due to trapping. A 1910 report described its range as all of the Colorado Rockies at higher elevations, "but nowhere particularly common." The status of this population currently on the forest is undetermined, but if it exists, it is in extremely low numbers.

Wolverine The wolverine, much like the lynx, is considered to be on the southern extent of its range, with a habitat preference for densely forested high mountains. A few sightings in northwestern Colorado have been reported in recent years. The forest historically had sparse populations of wolverine, which likely was always peripheral in Colorado. If it exists on the forest, it is in extremely low numbers.

Grizzly bears Several confirmed reports exist of grizzly bears or "silvertips" on or near the forest in the 1880s through the 1920s, but none are recorded in annual reports after 1923. Grizzlies most likely were extirpated from the forest by the 1930s or 1940s. The last known grizzly bear in Colorado was killed in the San Juan National Forest in 1979.

River otters The river otter was rare in the state by 1910, although early Colorado mammologists believed them to always have been rare in the state. Some believe the species became extirpated from Colorado in the early 1900s through a combination of direct trapping, incidental kills associated with beaver trapping, water quality/quantity reductions, and riparian habitat destruction. No known populations of river otters have been re-established as yet on the forest.

Beaver Beaver were nearly exterminated in Colorado by the 1930s, primarily due to overtrapping. They were reintroduced into the Fryingpan River in 1937 and more than likely into other drainages as well during this period. Beaver were protected by state regulation in 1939 and populations have since rebounded very successfully and are stable today, although there may be changes or reductions in their distribution due to the loss of willow habitat in some areas.

Peregrine falcons Historic records indicate that the peregrine falcon occurred, probably nesting in some of its many high precipitous cliffs and river canyons. Population declines were caused by eggshell thinning linked to pesticide use, especially DDT. Since the U.S. ban of some of the more harmful of these chemicals, populations recently have increased and historic range slowly is being reoccupied by peregrines. There now are several pairs of peregrines newly established on or near the forest.

Bald eagles Bald eagles primarily use habitat on or near the forest for wintering and fall migration stopovers. There are some nesting pairs on the White River (outside the forest boundary)

that summer in the Flat Tops. Several historical records describe bald eagles nesting on the forest in the late 1800s and early 1900s.

Greater sandhill cranes Greater sandhill cranes have historically nested in Northwest Colorado, specifically from the White River north to the Wyoming border. Their populations and distributions have declined since the early 1900s, the species being intolerant of human disturbance during nesting and because of past poor riparian conditions and excessive hunting pressure at that time. Populations now are slowly but steadily increasing and expanding their range back into some historical nesting areas.

Grouse Grouse hunting was very popular in the late 1910s and early 1920s, as the automobile brought people into previously remote locations. As a result, grouse populations were hunted to near extirpation in some areas. Overgrazing that reduced nesting cover and conversion of sagebrush lands to farmland were additional factors.

Sage grouse were very numerous in the early 1900s but populations were decimated by habitat changes and over-hunting until 1916, when bag limits were established. Sage grouse have been extirpated from approximately 45 percent of the historically occupied counties in Colorado. They have been extirpated in two ranges adjacent to and on the forest since 1980. Current sage grouse populations have become smaller and more fragmented.

Columbian sharptailed grouse, also known in the past as willow or pintail grouse, has been observed in many of the counties in or near the forest. Due to the number of common names, however, it is difficult to determine how abundant these birds were historically in Colorado. Its current population and distribution is thought to be much reduced from pre-settlement times.

Ptarmigan Ptarmigan occur throughout the alpine tundra areas of Colorado in areas dominated by willow, primarily on northeast or southeast exposures. Buds and twigs of willow provide the majority of winter food, thus flocks seldom are found where willow is absent. Records indicate that this species currently occupies the same general range as historically although the total usable habitat has been reduced by road building, impoundment of rivers, mining, and the removal of willow, thus populations are lower than they were pre-settlement.

Waterfowl Most of the species of waterfowl that currently migrate through or breed on the forest most likely occurred in higher numbers before the settlement period. Loss of wetland habitat in their breeding grounds, along with hunting pressure has undoubtedly reduced the population levels of most species. Harlequin duck currently is listed as “accidental” on the forest.

Songbirds Many songbirds are neotropical migrants that breed in the U.S. in the spring and summer, and then migrate to Mexico and Central American to winter. These birds appear to have experienced population declines in many areas as a result of chemical use or habitat changes on their wintering grounds. Some songbirds (migratory and non-migratory) found on the forest are declining in population because of loss of habitat. Less common today than historically are the sage sparrow, sage thrasher, purple martin, olive-sided flycatcher, and others. Cowbirds, meanwhile, have expanded their range, and are partly responsible for the decline in other species.

Wildlife summary

1. Changes in species composition — Six species have been extirpated from the forest since pre-settlement times: wolf, grizzly bear, mountain bison, river otter, Columbian sharp-tailed grouse, and harlequin duck. Not surprisingly, two of these are large carnivores, which were purposely exterminated as "undesirable" livestock predators – the wolf and grizzly bear. Four of these species were on the fringes of their range and were mostly likely scarce prior to 1850, and were inadvertently extirpated from the forest through hunting, trapping and habitat changes -- the river otter, harlequin duck and possibly the wolverine and lynx. The Blue River near Breckenridge was dredged for gold in the late 1800s, making the river completely subterranean afterwards, which may be the reason harlequin duck and Barrows goldeneye no longer breed in that particular location. The creation of Green Mountain and Dillon reservoirs has also most likely resulted in a change in species composition, possibly attracting some new species, and extirpating others. Lynx and wolverine are on the southern fringe of their range in Colorado and most likely were never very abundant historically. However, this is not to say the loss of these species from the forest or Colorado would not be significant. Some biologists believe that the distributions of some species, especially those at the edge of their range, are especially dynamic. Perhaps it may be that the populations of a species on the fringe of their range is potentially where more evolutionary changes and adaptations are made. This is not a conclusion, however, but one possible interpretation. Another interpretation could be that when a species is on the fringe of their range, those populations may be good indicators of the health of the species as a whole, as fringe populations would most likely be the first to be extirpated, if the species is declining.

Conclusion: Populations and function of the large carnivores – wolf, grizzly bear, wolverine, and lynx – are outside the HRV.

Conclusion: Populations and function of the river otter are outside the HRV.

The remaining two species, the Columbian sharp-tailed grouse and the bison, both grassland/low shrubland species, were extirpated from the forest through unregulated over-hunting, and changes in land use and management. The sharp-tailed grouse habitat has changed both due to the introduction of livestock grazing, which reduced the quality of their nesting habitat, as well as the advent of fire suppression, and the resulting later successional stages of vegetation. The bison was extirpated primarily from over-hunting.

Conclusion: Populations and function of the mountain bison and the Columbian sharp-tailed grouse are outside the HRV. Habitat for the mountain bison (grassland) is within the HRV, and habitat for the sharp-tailed grouse is on the low end of the HRV, due to fire suppression.

Three terrestrial species have been introduced into the forest. Mountain goat was either introduced or reintroduced into the forest in the late 1940s and there do not seem to be conflicts at the present time with the niche or distribution of other native species. Rock doves have been documented in Glenwood Canyon and starlings may exist in the lower elevation habitat on the west end of the forest.

Moose were never known to be common on the forest, but populations are increasing due to recent transplants in adjacent areas.

2. Changes in distribution — Actual previous and present distribution of a species is not exact, and as such is open to interpretation. Of the species known to currently exist on the forest, at least eight species have had changes in distribution since the 1850's. Lynx, sage grouse, bighorn sheep, bald eagle, peregrine falcon and sandhill crane all have reductions in the size of their ranges on the forest. Reasons for the reduction in distributions include introduced diseases, pesticide use, habitat degradation from livestock overgrazing, human developments and activities, and fire suppression. Cowbirds have possibly expanded their ranges due to the introduction of cattle grazing in higher elevation meadows. Elk and deer may have expanded their ranges in some parts of the forest due to the water developments for livestock also increasing the usable habitat for elk and deer. Merriam's turkey may have expanded ranges since pre-settlement times due to transplants into areas where there is no previous documentation of their occurrence.

Conclusion: Due to the extirpation of sage grouse from the majority of historical ranges on or near the forest, the populations and functions of the sage grouse are outside the HRV of the forest.

Conclusion: Due to bighorn sheep herds persisting only in isolated portions of their pre-settlement ranges, bighorn sheep populations and function are at the low end of the HRV.

3. Changes in population levels — Along with numerous neotropical migratory bird species, at least nine other species have experienced long term reduced population levels in and near the forest since the early 1800s. All six of the above listed species with range reductions are also at lower population levels than historically. Many of the neotropical birds are likely at lower population levels due to changes in their wintering habitats in Mexico and Central America, with a notable exception of the southwestern willow flycatcher, which has been drastically reduced on its breeding range in the southwest United States from habitat degradation and increased cowbird parasitism. White-tailed ptarmigan may be reduced in population levels (but not necessarily in overall distribution), due to human developments (ski resorts and highways) encroaching on habitat. Waterfowl population levels are reduced from the early 1800s due to loss of breeding habitat in the United States, as well as a reduction in habitat quality in some breeding areas on the forest. Cowbird numbers have likely increased, due to expanded distributions related to livestock (cattle and horses) presence. Bald eagles, peregrine falcons, and sandhill cranes have been recently on the increase, but are likely at or below historical population levels. Elk and mule deer may be at similar population levels as in the early 1800s, but the herds most likely consist of different age and sex ratios within the population than occurred pre-settlement. Mortality causes have changed from predator and starvation mortality, to primarily hunting mortality (human predation). This switch in mortality causes may result in the stronger animals being taken out of the population instead of the weaker animals. It also results in different sex and age ratios than might occur with the former mortality causes. However, populations historically most likely fluctuated more than they do under today's intensive management, due to starvation during severe winters. These fluctuations likely caused wide variation in sex and age ratios as well.

Conclusion: Elk and deer populations and distributions are within the HRV.

4. Changes in habitat — Vegetation sections of this report can be used to relate wildlife species dependent on specific habitat types to changes in their populations.

Populations of species that are dependent on late-successional conifer species are most likely at the high end of population level fluctuations over time, due to the fact that current stand conditions are primarily mature to late successional stage. One exception from the above list would be the pygmy nuthatch, which is dependent on primarily ponderosa pine stands. The forest has very little ponderosa, and many of the historical ponderosa stands along the Colorado and Crystal Rivers were logged in the early to mid-1900s and have not been reestablished. The pygmy nuthatch may be at lower population levels now than it was pre-settlement, due to loss of some of its preferred habitat.

Conclusion: Most species dependent on mature conifer habitat are on the high end of the HRV in regards to population numbers.

Grassland species are all peripheral populations or migrating species in the forest area, and were most likely uncommon in the area historically. Loggerhead shrikes have been documented in the large grasslands at 9,000 feet elevation on Clinetop Mesa and the GV Park area of the western White River Plateau. Ferruginous hawks have also been seen on the western White River Plateau during fall migration, and merlin have been documented during spring migration near West Divide Creek. All three of these species are on the Region 2 Sensitive Species List. The large grassland parks and meadows on the forest have not changed significantly since the late 1800's.

Conclusion: Grassland habitat dependent species on the forest are within the HRV.

A conclusion of the Forested Vegetation section was that early structural stages of forested ecosystems are in limited quantities and are not as evenly distributed across the landscape as they might be under “natural” condition, due to fire suppression primarily. This could be interpreted to mean that the species associated with early structural stages of vegetation might be at the low end of their range of variability.

Conclusion: Species associated with an early successional stage of vegetation as a portion of their habitat requirements may be at the low end of the HRV, as this stage is not well distributed.

Sagebrush communities as an entire ecosystem (all lands) are declining. This directly relates to declines in sagebrush-associated species such as sage grouse, sage thrasher and sage sparrow.

Conclusion: Sagebrush dependent species, in and near the forest, are on the low end of the HRV, due to the reduction of sagebrush habitats.

Species dependent upon caves, cliffs, and rocky habitats have most likely either remained stable or increased based on their habitat needs. There has been an increase in mine tunnels and buildings for the bats to use, and no decline in cave, crevice, or cliff habitat for all the above species. There has been, however an increase in recreational use of caves, which has likely led to abandonment or reduced habitat effectiveness for bats in some caves.

Conclusion: Cave, cliff, and rocky habitats are within the HRV.

Wildlife conclusions

- Populations and function of the large carnivores — wolf, grizzly bear, wolverine and lynx — are outside the HRV.
- Populations and function of the river otter are outside the HRV.
- Populations and function of the mountain bison and the Columbian sharp-tailed grouse are outside the HRV. Habitat for the mountain bison (grassland) is within the HRV, and habitat for the sharp-tailed grouse is on the low end of the HRV, due to fire suppression.
- Due to the extirpation of sage grouse from the majority of historical ranges on or near the forest, the populations and functions of the sage grouse are outside the HRV.
- Due to bighorn sheep herds persisting only in isolated portions of their pre-settlement ranges, bighorn sheep populations and function are at the low end of the HRV.
- Elk and deer populations and distributions are within the HRV.
- Most species dependent on mature conifer habitat are on the high end of the HRV in regard to population numbers.
- Grassland habitat dependent species on the forest are within the HRV.
- Species associated with an early successional stage of vegetation as a portion of their habitat requirements may be at the low end of the HRV, as this stage is not well distributed.
- Sagebrush dependent species, in and near the forest, are on the low end of the HRV, due to the reduction of sagebrush habitats.
- Cave, cliff, and rocky habitats are within the HRV.

AQUATIC RESOURCES

Aquatic resources before 1870

The forest lies in the upper Colorado and White River drainage basins. This section of the HRV discusses the Colorado River drainage above its confluence with the Gunnison River and the entire White River drainage in Colorado.

There were 500 natural lakes in the two basins before settlement. They range in size from 0.1 acre to 506 acres. Most occur above 10,000 feet. Many of these lakes were naturally fishless. The earliest recorded fish collections were done in the late 1880s. Only two lakes from the area were included in the collections and both yielded only cutthroat trout.

There were approximately 6,500 miles of streams in the basins. Headwater streams in the region are generally small, cold, well-oxygenated, clear, and steep. As they proceed downstream they become larger, warmer, and flatter. Fish collections in the streams in rivers in the area were done along with the lake collections. Cutthroat trout and speckled dace were the only fish present in the highest reaches. Further downstream mottled

sculpin joined them. As cutthroat trout began to become rare in the larger streams, suckers (bluehead, flannelmouth, and razorback), roundtail chubs and Colorado squawfish became common. Bonytail and humpback chubs became common in the lowest areas. Colorado squawfish, razorback sucker, humpback chub, and bonytail are collectively known as the Big River Fish because they are the dominant natives in the lower Colorado River.

Native Americans did catch and use fish, but not in great numbers. No evidence exists of substantial modification of stream channels or lakes.

Four species of amphibian were widely distributed across the forest. They are tiger salamander, northern leopard frog, western chorus frog, and boreal western toad.

Aquatic resources after 1870

Since settlement, approximately 150 lakes have been constructed. Many of these are large reservoirs, which provide water for communities on the Eastern Slope. The total acreage of lakes has increased fourfold. Many of the lakes that were naturally fishless have been stocked and now support reproducing fish populations. More than 35 non-native species of fish have been stocked in the lakes and many are well established.

Reservoir construction inundated some streams converting them from lotic to lentic habitats. However, the slight loss of stream miles is not substantial. Almost 40 non-native species of fish have been stocked in the streams and rivers and most are now well established. Rainbow, brook and brown trout are the most common of these non-natives. The first two have greatly contributed to the decline of the native cutthroat trout. Stream habitats are generally intact throughout the area and especially on the forest. There are some localized habitat changes, which have occurred, but the only broad-scale changes are due to water diversions in all of their various forms.

Water is an important commodity for developing areas. A few irrigation ditches were present even before intensive settlement began and by 1890 there were more than 7,000 miles of ditches in the state. Water diversions reduce streamflows of fish-producing streams and limit fish habitats. In addition to irrigation within the basin, each year 600,000 acre feet of water is transported out of the Colorado River basin and through the Continental Divide for use on the Front Range. Many of the previously mentioned reservoirs were constructed to store water prior to export or as compensation for exported water.

There have been some localized changes to fish habitat within the area. Mining was widespread in Colorado, but only a few places on the forest had extensive operations. Water quality in a few streams is seriously degraded as a result of acid runoff from abandoned mines. Railroad lines were built to access mines. They were placed in the valley bottoms alongside the streams. Channelizing and armoring the streambanks were often necessary. Most of the railroad lines have been removed, but some of the impacts remain. Timber harvesting has had very little impact on the streams.

Big river fish Water developments and diversions have altered habitat conditions in the main stem of the Colorado River. The harsh habitat conditions in which these species evolved have been greatly ameliorated. This has allowed for numerous non-native species to establish themselves. The non-natives now thrive in the altered habitats and the big river fish have declined as a result.

Cutthroat trout The Colorado River cutthroat is the only trout native to the upper Colorado River Basin. They now occur only in 1 percent of their historic range. Stocking of non-native trout species, especially brook and rainbow trout, has led to their decline through competition and hybridization. Although the native trout are in decline, their habitat niche has been filled with other species from the same family. The ecological role of these species is similar to that of the natives.

Water flows Storage impoundments, transbasin diversions and irrigation ditches have altered water flows and yields in the Colorado River Basin. Overall, measured water yield is down, peak flows are reduced and baseflows have been altered. Channel geometry is most likely adjusting to these reductions in streamflows, but high peak flows still occur and allow for channel readjustment. Water yields in the White River Basin have not changed significantly on National Forest System lands.

Amphibians Of the four species of amphibian, two are in severe decline in the area. There are several isolated populations of boreal western toad on the forest and only one population of northern leopard frog. There were populations of amphibians in many of the naturally fishless lakes. Many of these were lost when fish were introduced. This mechanism is not adequate to explain the overall decline of these two species and the other factors have not been determined. Tiger salamanders and chorus frogs remain common.

Aquatic resources conclusions

- The Colorado River and its native fish community are outside the historic range of variability.
- Distribution of the Colorado River cutthroat trout is outside the historic range of variability, but the habitats and ecological processes are functioning within the HRV.
- Channel geometry is within the HRV, but frequency of adjustment has been reduced.
- Water flows in the Colorado River Basin are outside the HRV.
- Water flows in the White River Basin are within the HRV on the forest, but outside of it downstream.
- Distribution of boreal western toad and northern leopard frog are outside their HRV.