DIAMOND FORK AREA ASSESSMENT

Final/September 2000

A Cooperative Project between the Mitigation Commission & U.S. Forest Service

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INTRODUCTION AND OVERVIEW OF THE AREA ASSESSMENT

Area assessments are designed to give us an opportunity to stand back and look at the big picture. For years Diamond Fork has been managed for water delivery, grazing, recreation and other uses - all with consequences for the natural resource base of Diamond Fork. However, until this assessment the opportunity was not available to study the cumulative impact of these activities across the entire watershed. This assessment provides that more comprehensive overview.

The Need for the Assessment In 1992, Congress created the Utah Reclamation Mitigation and Conservation Commission (Mitigation Commission) and charged the Mitigation Commission with the responsibility of mitigating impacts to fish, wildlife and recreation caused by the Central Utah Project (CUP). The CUP is a major water development project that transfers water from the Colorado River Basin to the Bonneville Basin. Diamond Fork has and will serve as a major focus for CUP water transport. The Commission and Forest Service agreed to jointly develop the area assessment in order to determine priorities for fish, wildlife and recreation mitigation and management activities. This is consistent with the Forest Service's approach to ecosystem management and the Uinta National Forest's efforts to assess natural resource conditions on a watershed scale. Similar efforts have been completed or are in progress in White River, American Fork Canyon, Vernon, North End (Soapstone-Wolf Creek) and the Strawberry Valley.

Purpose and Scope of the Project This assessment's purpose is to aid in future management decisions by the Mitigation Commission regarding CUP mitigation activities, as well as overall resource management activities by the Forest Service within the landscape. This assessment is NOT a decision-making document. Its scope is to review the interrelationships between the biological, physical, and social and economic components associated with the landscape, identify causes and effects associated with historical land uses, and describe the properly functioning condition for these components. The information is then synthesized to describe the current situation, and opportunities to move Diamond Fork towards the properly functioning condition in instances where resources are outside of a properly functioning condition.

How the Assessment Was Developed This assessment was developed through an interdisciplinary process involving Forest Service and Mitigation Commission specialists.

Assistance and additional information was provided by biologists from the Utah Division of Wildlife Resources and U.S. Fish and Wildlife Service.[1]

The area assessment uses a step-by-step process that focuses on answering the following questions:

- What was Diamond Fork's "ecosystem" (streams, soils, plants, wildlife, human influences, etc.) like before the 1800's and European influences? What impact did post-1850 human use have on Diamond Fork and what is Diamond Fork like today? (***See Chapter 2***)

- What is considered a properly functioning condition[2] for each resource and what is the status of resources today compared to the properly functioning condition? Additionally, what caused some resources to fall outside a functioning condition (assessment), what is the anticipated change over time to the resource given existing management (trend), and what is the consequence of this change if the trend continues (risk)? (***See Chapter 3***)

- What are the primary resource issues in Diamond Fork and what steps can be taken to resolve these issues? Statements of issues were developed by synthesizing the information developed in Chapter 3 (i.e., assessment, trend, and risk for those resources functioning outside of a properly functioning condition). Following the issues, management opportunities are listed as the potential means to help resolve the issues. (***See Chapter 4***)

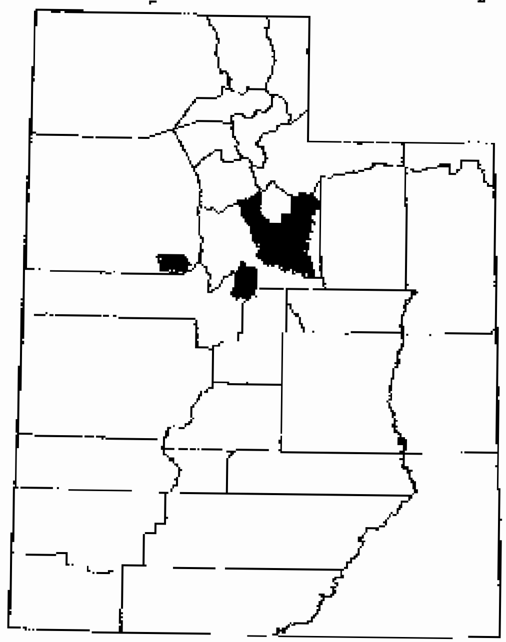
Area Included in the Assessment The landscape identified for this assessment includes the Diamond Fork drainage watershed, including First through Sixth Water, Halls Fork, Little Diamond, Wanrhodes and all tributaries associated with these streams.[3] It covers roughly 154 square miles (99,869 acres) and is the largest headwater tributary of the Spanish Fork River. It lies generally 10 miles east of the city of Spanish Fork (see Map 1). The highest point in the

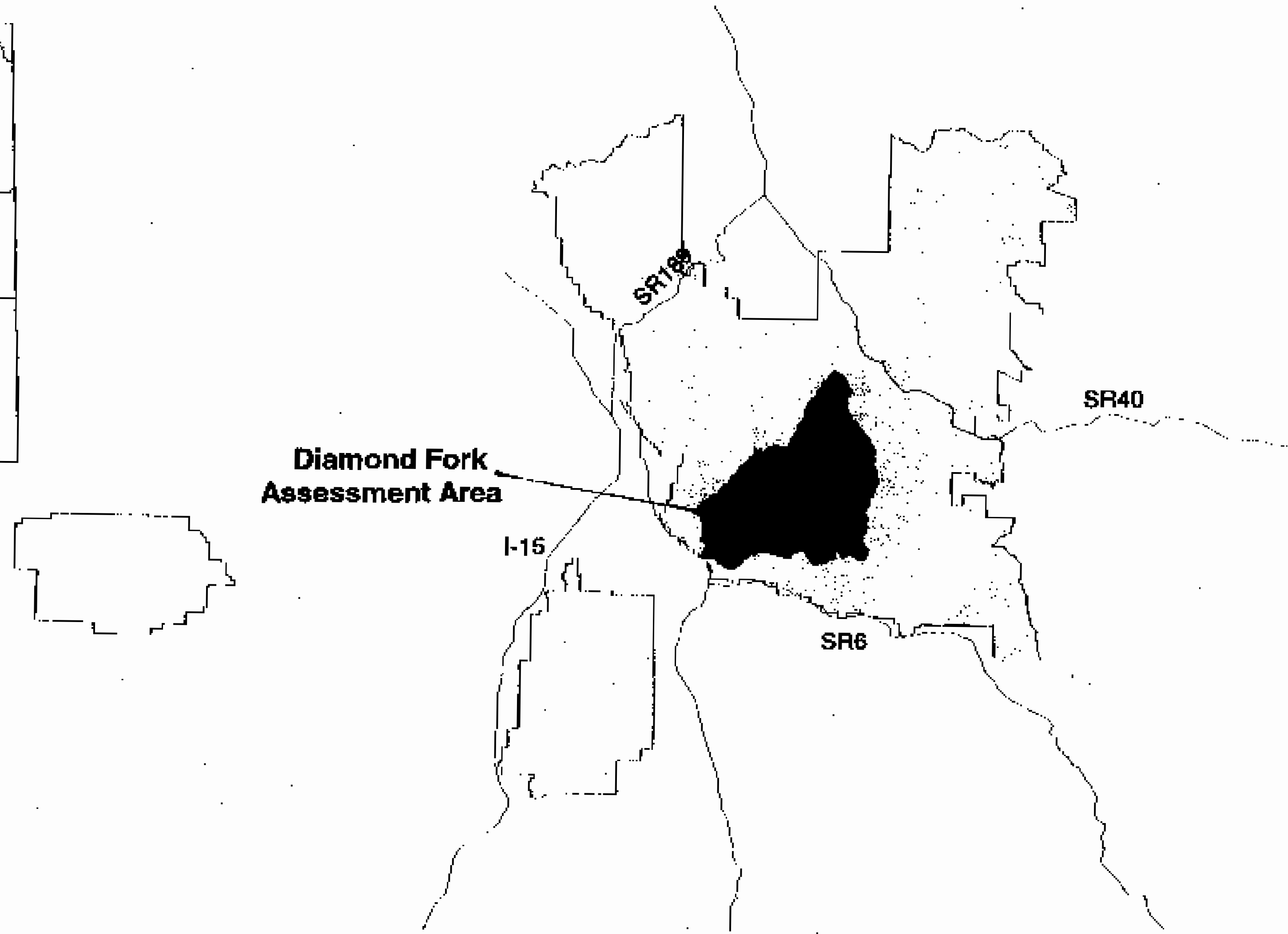
[1]Note that the assessment process is designed to achieve the purpose and scope by compilation and analysis of existing information and/or data. No additional information or data was collected as part of this effort, although some members did participate in observational field trips to various portions of the assessment area. Data was assembled from Uinta National Forest files as well as from outside sources (e.g. stream gage records). Where quantitative data was not available, specialists relied on their personal knowledge of the area, as well as discussions with colleagues from the Forest Service, other agencies, and the public who are familiar with Diamond Fork.

[2] An ecosystem that is "properly functioning" is one that is dynamic and resilient to disturbance to its biological or physical structure, composition and processes.

[3] Some consideration was given to including the Tie Fork and Sheep Creek drainages as part of the landscape. However, because Tie Fork and its tributaries drain directly into Soldier Creek and not Diamond Fork, and the vegetation types are dominated more by pinyon-juniper and oakbrush, Tie Fork was not included in this Assessment.

Map 1 Location and Vicinity Map





watershed, Spanish Fork Peak, is 10,197 feet above sea level. The Diamond Fork drainage is separated from the Hobble Creek drainage by Pump House Ridge on the north and from Strawberry Valley and headwater streams of the Strawberry River by Strawberry Ridge on the east. Elevations on Pump House Ridge range between 7,400 - 9,400 feet. Elevations on Strawberry Ridge range between about 8,500 and 9,400 feet. The landscape area covers approximately 89,734 acres of National Forest System lands. The area also includes 10,135 acres of private and non-National Forest System land, which constitutes 10% of the total area.

A General History, A Short Timeline of the Area The Diamond Fork area has been utilized by man for centuries. Native American peoples hunted and gathered food stuffs well into the early 20th century. Travel routes through the area were initially developed in the mid-1800s to access timber resources in order to relieve timber shortages in Utah Valley. As roads were developed, European settlers began moving into the area, homesteading and utilizing the area for summer grazing operations as well as for agricultural activities. Livestock grazing use in the late 1800s and early 1900s resulted in significant impacts to vegetation and resulted in soil losses and watershed damage. Watershed restoration activities were initiated in the 1930s, coupled with large scale reductions in livestock use. Agricultural activities are ongoing, although on fewer acres. Livestock grazing also continues, but with fewer animals, and under much more intensive management. Diamond Fork had been used by local church groups and families as a group recreation destination, which led to development of facilities in the 1930s, which later became the existing Camp Diamond and Palmyra Campgrounds. With the increased population of Utah Valley, recreation use activities have increased and are still on the rise. Recreation activities have expanded from the traditional camping/hunting/hiking to include mountain biking and ATV use of trail facilities. These non-traditional activities have caused some vegetation and stream resource impacts from off-road/trail use.

Agricultural activities along the Wasatch Front led to development of the transbasin water diversion facilities from Strawberry Reservoir in 1916. Irrigation water was delivered through the Strawberry Tunnel, down Sixth Water and lower Diamond Fork Creeks to the Spanish Fork River, and subsequently to various irrigation users in Utah Valley. In 1990, the Syar Tunnel, designed for higher flow capacity and to replace the old Strawberry Tunnel, was completed. The release of irrigation flows into Sixth Water and lower Diamond Fork Creeks over the past 80 years has resulted in significant changes in channel morphology, stream gradient, and loss of associated riparian vegetation. In 1996, Phase 1 of the Diamond Fork System of the Central Utah Project was initiated in Diamond Fork. This phase involved installation of a major pipeline system designed for delivery of irrigation water from the then-proposed Monks Hollow Dam to the Spanish Fork River. The pipeline was completed in 1997. Because of environmental, operational and cost concerns, plans for construction of the Monks Hollow Dam were abandoned. Phase 2 of the CUP will involve construction of tunnel(s) and pipeline facilities to transport water from the Syar Tunnel to the existing Diamond Fork Pipeline. This phase is scheduled to be completed by 2003.

CHAPTER 2

PHYSICAL, BIOLOGICAL AND SOCIAL ASSESSMENT OF THE WATERSHED

The physical, biological and social elements of the watershed are inter-related. The physical domain provides the water and soil that supports the biological domain in its production of vegetation. Together the water, soil and vegetation create habitat that supports both wildlife and human life. Our goal in this assessment is to understand these systems and how it is thought they have changed through time. Our method to achieve this goal is to describe how it is thought the system functioned before European settlement (pre-European settlement[1]), how it changed after accelerated human use (historic), and what it is like today (present condition).

PHYSICAL DOMAIN

STREAM CHANNEL STRUCTURE, FLOODPLAIN STRUCTURE AND THE HYDROLOGIC REGIME

PRE-EUROPEAN SETTLEMENT

The lower Diamond Fork valley is a broad alluvial plain, averaging close to 900 feet in width at the lowermost end and gradually narrowing upstream. During the Ice Ages of the Pleistocene epoch, Lake Bonneville reached elevations of 5,130 to 5,230 feet (Bissell 1963; Stokes 1968), which inundated the lower valley of Diamond Fork up to the present-day Diamond Campground. The broad form of the lower valley of Diamond Fork likely represents the extent of lateral, or sideward, migration of the Diamond Fork river since late Pleistocene time (approximately 10,000 years before present). High terraces that border lower Diamond Fork valley reflect the amount of uplift and erosion that has occurred along the Wasatch Front over the same period of time. The surfaces of these high terraces are remnants of the larger valley that existed during the wetter climate of the late Pleistocene. Alluvial fans and landslides, which post-date the terraces, encroached on the floodplain and locally altered the position and gradient of the channel. One ancient landslide, in particular, appears to have strongly influenced the channel and floodplain

[1] This era gives an approximation of the range of landscape conditions that may have existed prior to accelerated human influence in Diamond Fork. This range provides a frame of reference, not necessarily a condition or circumstance we are trying to replicate.

shape of lower Diamond Fork, just above the mouth of the canyon (see the discussion below for Lavanger Hollow under the "present condition" and Map 2-1 for the location of streams).

The river was primarily a single-thread, meandering channel from its mouth upstream to a point near Brimhall Canyon, probably with minor backwater channels. The channel width averaged about 30 feet and was bordered by an almost continuous cottonwood and box elder covered riparian fringe. More than half the riparian fringe consisted of mature cottonwood, which mainly occupied an active floodplain 200 to 300 feet in width.

Tributary drainages in Diamond Fork Creek, beginning at Spanish Fork Peak and continuing clockwise, include Little Diamond Creek, Wanrhodes Creek, Red Hollow, Sawmill Hollow, Shingle Mill Creek, Chase Creek, Hall's Fork, Dip Vat Creek, Sixth Water, Fifth Water, Fourth Water, Third Water, Second Water, First Water (collectively referred to as The Waters), Cottonwood Creek, Dry Canyon, Monk's Hollow, and Brimhall Canyon. For purposes of discussion later in this document, these drainages are divided into three categories which are generally distinguished based on their physical and biologic characteristics.

Runoff from Diamond Fork was dominated by spring snowmelt, normally peaking in early to mid-May and receding to base levels by late July. Summer thunderstorms occurred frequently and may have produced significant floods in the tributaries of Diamond Fork, but the volume of runoff was probably smaller than was produced by snowmelt.[2] Beaver may have occupied much of the river, especially the backwater channels.

HISTORIC

Historic land uses, which began in the late 1800's and continued through the mid 1900's, have affected Diamond Fork. Heavy livestock grazing and subsequent erosion occurred in the watershed during the late 1800's and early-to-mid 1900's. Farming of the Diamond Fork valley bottom below Monk's hollow and along Wanrhodes began around 1900 and increased steadily for several decades. Irrigation releases from Strawberry Reservoir through the Strawberry Tunnel began in 1915. These land uses undoubtedly affected the channel and floodplain structure and hydrologic regime in Diamond Fork. By 1939, the earliest date aerial photography of Diamond Fork is available and therefore the earliest date a baseline can effectively be established, the river was still bordered by a nearly continuous riparian fringe averaging up to 250 feet in total width. At this time agriculture was the dominant use of lower Diamond Fork and occupied 70 to 80 percent of the valley floor. Clearing of ground for farming probably affected the extent of total

[2] These assumptions are based on 1) the highest peak flows in the watershed have been snowmelt floods; and, 2) the volume of thunderstorm floods, as measured at the stream gages on lower Diamond Fork, is smaller than that produced by snowmelt. For comparison, the highest recorded thunderstorm peak in Diamond Fork was about 630 cfs at the Red Hollow gage site (the mean daily flow at Red Hollow on that date was 432 cfs and the release from Strawberry Tunnel 309 cfs, so the natural flood peak was probably in the range of 580-630 cfs) compared to the maximum estimated spring snowmelt flood in 1984 of over 2,400 cfs.

riparian area in the valley, as it is apparent from photographs that the river formerly meandered over most (roughly 80%) of the valley floor. The channel of lower Diamond Fork has widened and/or entrenched (eroded downward) significantly, depending upon the location along the valley. This widening and entrenchment occurred primarily in response to irrigation releases from Strawberry Reservoir through the Strawberry Tunnel into Diamond Fork.

Since 1915, the annual hydrographs of Diamond Fork and Sixth Water have been dominated by irrigation releases from Strawberry Reservoir. Gaging station records for the period 1908-1915 show that the average of annual flood peaks, or mean annual flood, was approximately 250 cubic feet per second (cfs) near Brimhall Canyon and 200 cfs near Red Hollow prior to the initiation of irrigation flows. In contrast, peak flows under the irrigation flow regime since 1915 have averaged over 450 cfs and are sustained through the duration of the irrigation season, depending on demand. This altered flow regime has affected the form and stability of Diamond Fork. For example, Bartos (1973) estimated that flows needed to transport a particle 0.5 inches in diameter occurred, on average, for 7 days each year under natural conditions, but up to 110 days on average under the irrigation flow regime. The irrigation flows have therefore been far more erosive than the natural flow pattern would have been. As a result, channel migration rates have increased from approximately 1-3 feet/year to 40-60 feet/year.

Changes have occurred in the magnitude, duration and timing of peak flows which have caused significant changes to the channel system and the adjacent riparian zone. In Sixth Water, channel and bank erosion have occurred over the length of the stream and have locally caused the channel to downcut by an average of approximately 12 to 15 feet. Sections of lower Diamond Fork have also downcut by two to four feet in areas where the channel is confined, but in most other areas, especially where the valley is wide, the channel has become braided in response to the higher flows and sediment loads of the irrigation flow regime. The impacts of the irrigation flow regime have been compounded by agricultural development in lower Diamond Fork, which resulted in the removal of large areas of former riparian forest.

PRESENT

By 1971, the majority of riparian forest in lower Diamond Fork had disappeared and the channel had changed from a predominantly single-thread meandering channel to a multiple-channel, braided stream that migrated over an area up to 200 feet wide. Most of the loss of riparian forest since 1939 is due to lateral migration of the channel, which was induced by high sediment load and subsequent bank erosion caused by the irrigation flow regime. At one site, the channel moved over 450 feet between 1939 and 1984. The large flood events of 1952, 1983 and 1984 also contributed to this change. However, these floods had a much larger impact than they would have had if the channel had not already been damaged. In conjunction with these changes, the channel has become 50 to 400 percent wider, and is both steeper (gradient change from 0.6 percent to 0.8 percent in the lower 3 miles) and straighter at present than it was in 1939. The floodplain that existed in 1939 is largely gone and has been replaced by a series of migrating and relatively unstable gravel bars.

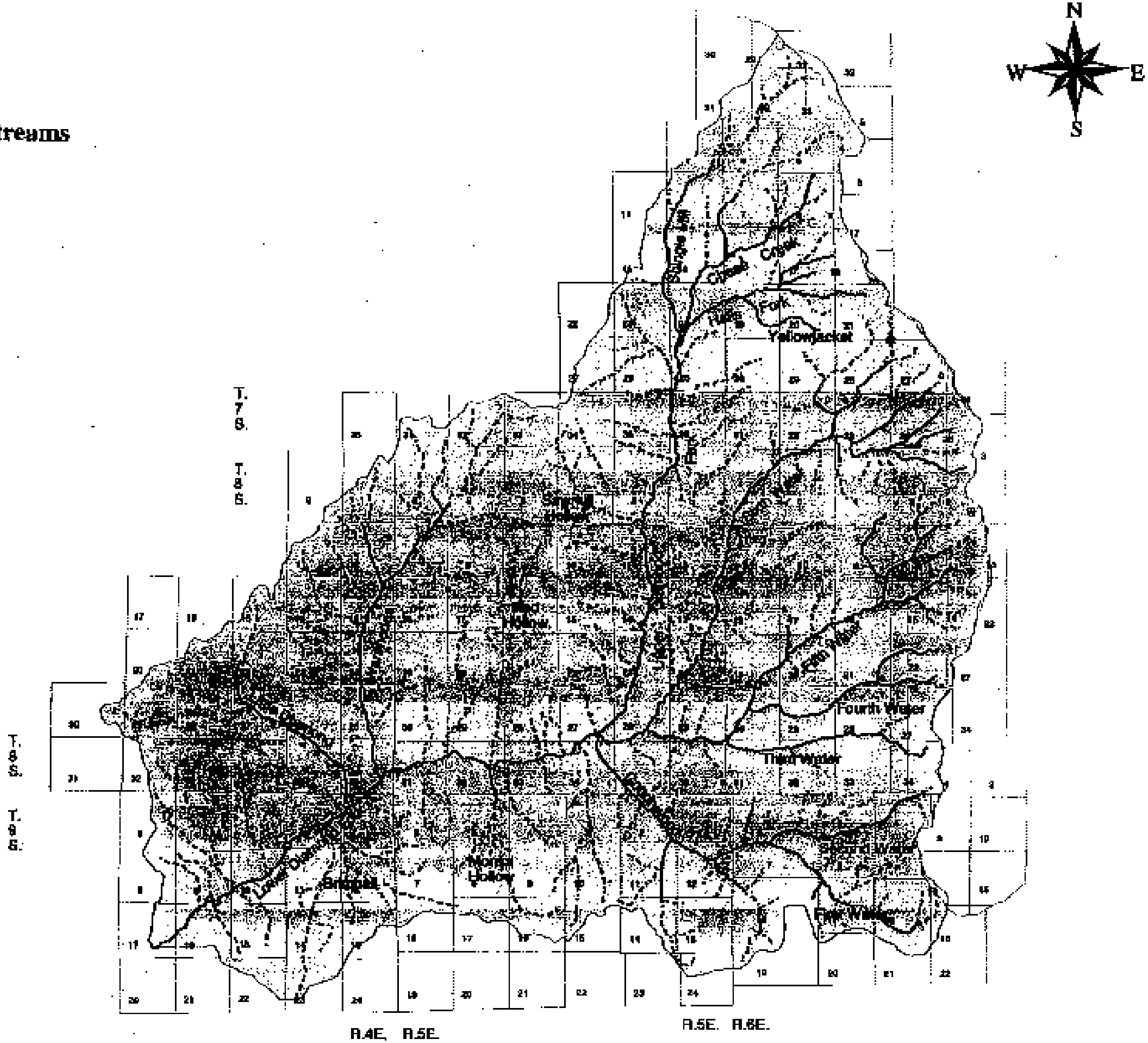
At Lavanger Hollow, a large ancient landslide encroaches on the channel and floodplain from the east while an alluvial fan extends from the mouth of Lavanger Hollow and pinches against the base of the landslide confining the channel. The valley and former floodplain are broad upstream and downstream of this site and the channel is now strongly braided. Within the short reach where the channel is confined, it is restricted from moving laterally and instead has downcut by

Map 2-1 Area Assessment Streams

Diamond Fork Landscape Area

Perennial stream

Intermittant stream



four to six feet. Most of the degradation has occurred within the last 50 to 75 years accelerated by the irrigation flows. It appears to be significant that the largest remaining segment of cottonwoods in lower Diamond Fork, between the mouth of the canyon and Brimhall Canyon, is at the only location along the channel that has not moved since 1939. See Appendix A for annotated aerial photographs of lower Diamond Fork from 1939, 1956, 1971, 1984 and 1995 which graphically illustrate the changes described above. Similar, although less drastic, changes have also occurred in Diamond Fork upstream of Little Diamond Creek. In this reach, the river is more confined. Sediment load has increased, as evidenced by the formation of mid-channel bars. The channel is wider, as in the lower reach and the cottonwood forest has declined although not to the same extent as in the lower reach.

Alterations of the timing and magnitude of streamflows in Sixth Water and Diamond Fork Creeks have not just affected the survival of mature cottonwoods bordering these streams but have also impacted the processes by which cottonwoods establish. For example, it appears that high summer flows have limited cottonwood establishment, at least in lower Diamond Fork, to three main events in the years between 1915 and the present. This is discussed further in the Biological Domain section.

SOILS AND HILLSLOPE PROCESSES

PRE-EUROPEAN SETTLEMENT

Soils Derived predominantly from sandstone and shale and - to a lesser extent - limestone, soils in the Diamond Fork watershed vary greatly in their physical properties.[3] Glacial features and glacially derived soils are generally absent in the watershed except at the highest elevations of Spanish Fork Peak. The soils of greatest interest in this assessment are those derived from the Green River Shale and Uinta Formation that underlie much of the watershed and are the predominant soils in the east half of the watershed. These soils are characterized by moderately slow to very slow permeabilities and high to very high erosion hazards. Physically, the soils are generally shallow, highly erodible and subject to surface sheet and rill erosion as well as being the sites of numerous small slumps, landslides, and debris flows. These soils also often have heavy clay layers which can impede root growth. Chemically, the soils are moderately alkaline and locally highly saline and support less vegetation than other soils in the watershed.

Hillslope Processes Natural areas of hillslope instability in the Diamond Fork watershed are most common in the Green River and Uinta Formations but also occur in areas underlain by the Price River and North Horn Formations. Landslides are most frequent where bedding planes (layers) are parallel with hillslopes or where toe slopes have been undercut (Olson 1968 as cited in Pashley 1975). Landslides of different sizes occur in the Uinta Formation near Billies

[3] Soils maps were completed for the Diamond Fork area in 1976 (Uinta National Forest 1976). See Appendix B for a detailed description of the geologic history of the area.

Mountain and in Wanrhodes Canyon (Pashley 1975). The landslides along Red Mountain near Sawmill Hollow appear to be propagating slowly headward based on analysis of a time series of air photographs dated 1939 to 1984 and may be centuries old. Other slide features exist that are prominent features of the local landscape but are largely stable at present.

Debris flows and debris torrents were also common and periodically contributed significant amounts of sediment to the channel system. These features occurred in all geologic formations on steeper slopes and in headwater draws, but appear to have occurred more frequently in the eastern half of the watershed in areas underlain by shaley layers of the Price River, Green River and Uinta Formations. They were more frequent following large runoff years in which storms or floods with return intervals greater than 10-20 years occurred, such as occurred in 1952, 1983 and 1984; but, they may also have been triggered by summer thunderstorms, which are common to the area.

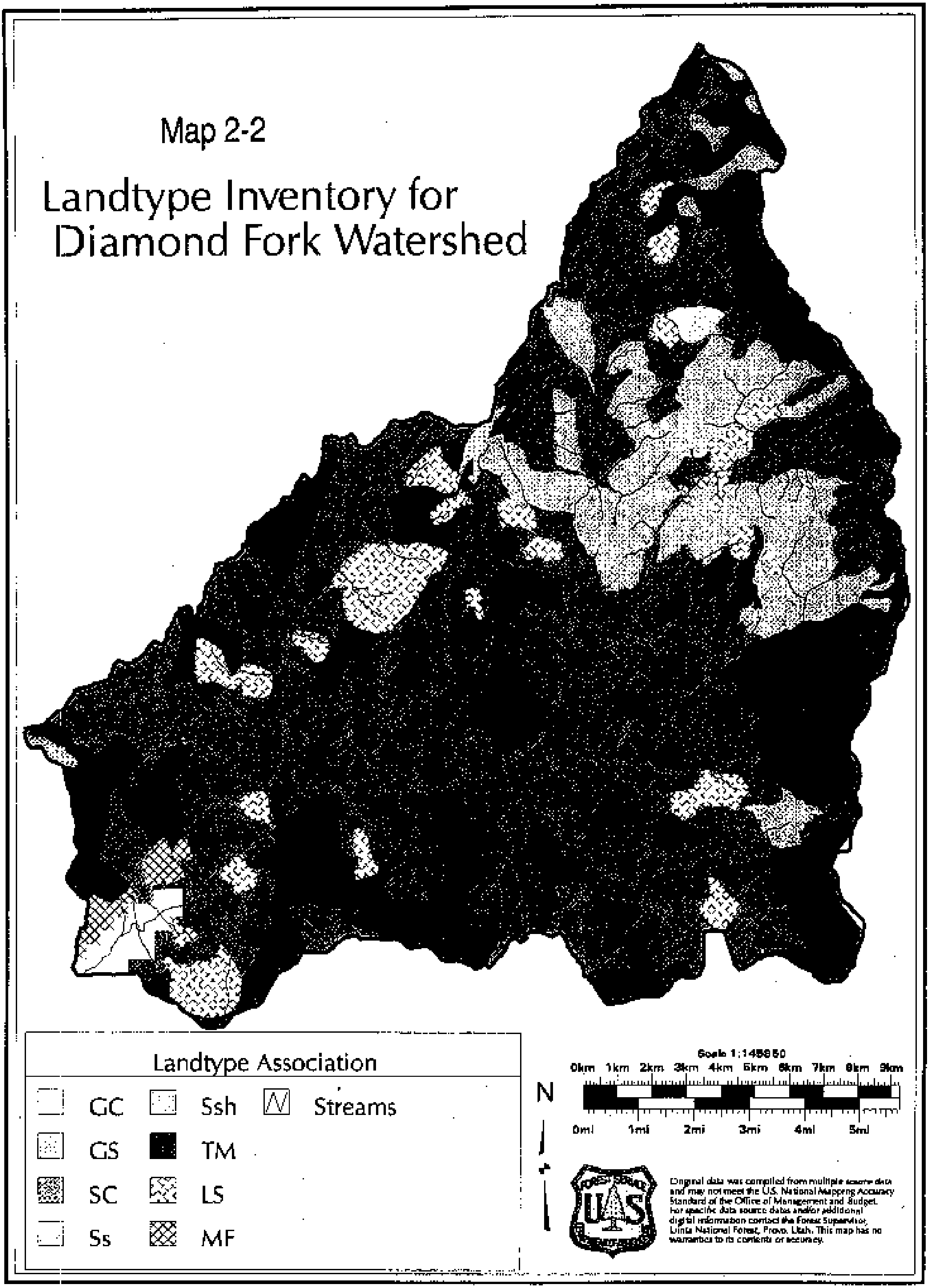
HISTORIC

Examples of instability in the Green River and Uinta Formations are found on the east flank of Red Mountain near Sawmill Hollow (Uinta) and at the large earth flow on Sixth Water Creek below Dip Vat Creek (Green River Shale) where Sixth Water has downcut in response to irrigation releases from Strawberry Reservoir. Several small landslides were triggered in the upper tributaries of Diamond Fork during the 1984 floods in areas underlain by the Green River Shale (Skabelund, personal communication). Erosion rates have been greatest when these soils are disturbed as, for example, by grazing. Heavy sheep grazing in the first few decades of the 1900's (Holmes 1990) resulted in considerable soil loss in upper Diamond Fork, Red Hollow and Wanrhodes Canyon due to loss of vegetative cover. This loss was a principal reason for changes in grazing management strategies and implementation of watershed restoration measures in the 1950's, '60's and '70's (e.g. Kimball and Savage 1977).

PRESENT

Some areas may still not have recovered from early grazing impacts. Surface soil erosion rates are locally high and the Diamond Fork watershed is a moderately high sediment producer when compared to other areas of Utah (Jeppson, et. al. 1968). As with landslides and debris flows, the areas of greatest concern are those underlain by the Tertiary formations, especially the Green River and Uinta Formations. The lower productivity of these soils, presence of restrictive clay layers at shallow depths and lower initial vegetative cover all lead to higher erosion rates.

Skabelund (1977) estimated that soil erosion in the Diamond Fork watershed totaled approximately 128,000 tons per year, or roughly 1.4 tons per acre per year. This estimate was prepared after soil and vegetative treatments in the watershed, totaling more than 13,000 acres in the years between 1942 and 1970, were completed. Actual erosion rates in Diamond Fork prior to these treatments can only be guessed at, but available documentation suggests that soil erosion rates were extremely high prior to the early 1940's and have fallen sharply since then, mainly in response to changes in grazing management and the above-mentioned range improvement measures. High erosion rates at localized sites in the Diamond Fork drainage can still be observed. It is likely that present erosion rates are higher than in pre-settlement times and prior to the advent of roads and the onset of grazing. A complete inventory of actively eroding sites in the watershed would be needed in order to characterize current erosion rates. Map 2-2 and Tables 2-1 and 2-2 identify and describe the landtypes for the Diamond Fork assessment area.



Map 2-2
Landtype Inventory for Diamond Fork Watershed
Landtype Association
GC
Ssh
Streams
GS
TM
SC
LS
Ss
MF
N
0km 1km 2km 3km 4km 5km 6km 7km 8km 9km
0mi 1mi 2mi 3mi 4mi 5mi
Original data was compiled from multiple source data and may not meet the U.S. National Mapping Accuracy Standard of the Office of Management and Budget. For specific data source dates and/or additional digital information contact the Forest Supervisor, Uinta National Forest, Provo, Utah. This map has no warranties to its contents or accuracy.

Table 2-1 Landtype Associations Descriptions

Landtype Association	Description
GC - Glacial Canyon	Consists of landforms in which alpine glaciation processes were dominant and generally confined to areas above 7,000 feet elevation. Includes areas of ground and lateral moraines, cirque basins, and U-shaped valleys.
GS - Glacially Scoured Uplands	Consists of cirque headwalls, cirque basin floors, cirque thresholds, aretes, horn ridges and smaller nivation cirques and hollows.
SC - Stream Canyon	Landforms where stream-forming processes are dominant. Typically includes V-shaped canyon, with or without floodplains and tributary, or side canyons.
S - Structurally Controlled Limestone	Areas strongly influenced by outcrops of limestone bedrock.
Ss - Structurally Controlled Sandstone	Areas where thicker sandstone formations are exposed and consisting of cliff faces and dip slopes.
Ssh - Structurally Controlled Shale	Areas underlain by interbedded shale, siltstone, mudstone, sandstone and limestone of the Green River, Colton, Uinta and Price River Formations.
TM - Tectonic Mountain	Consists of unglaciated upper mountain tips, ridges and sideslopes
LS - Landslide	Includes all active, inactive and paleo-landslides
MF - Mountain Foothill	Consists of fan and pediment surfaces at the interface between upper mountain slopes and valley floors

Erosion hazard for a particular landtype can vary based on differences in shape, aspect, and other topographic factors. Erosion hazard ratings for landtypes found within the Diamond Fork drainage are summarized in Table 2-2.

Table 2-2 Narrative Soil Erosion Hazard Ratings by Landtype

Landtype	Undisturbed Soil Erosion Hazard	Disturbed Soil Erosion Hazard
GC - Glacial Canyon	Variable: Low to High	High
SC - Stream Canyon	Variable: Low to High	Variable: Low to High
S - Structurally Controlled Limestone	Low to Moderate	High
Ss - Structurally Controlled Sandstone	Low to Moderate	Moderate to High
Ssh- Structurally Controlled Shale	Variable: Low to High	Moderate to High
TM- Tectonic Mountain	Mostly Low, Some Moderate	Variable: Low to High
LS - Landslide	Low	Moderate
MF - Mountain Foothill	Low to Moderate	Low to Moderate

BIOLOGIC DOMAIN

VEGETATION

PRE-EUROPEAN SETTLEMENT

Vegetation in this drainage is primarily influenced by interactions between precipitation, aspect and soil type; and, secondarily by fire and native ungulates. Much of the landscape in the Diamond Fork drainage is quite dry, especially in contrast to the Right Fork of Hobble Creek located just to the north and east. This is due in part to the northeast to southwest orientation of the main stem, which results in a predominance of dry southeast, south and west aspects, with truly north aspects only in short side drainages. In addition to this, several of the dominant soils types in the drainage (such as those derived from Green River Shale) have properties that make them "droughty" (i.e., they retain limited moisture available for plants compared to other similarly located soils); and therefore, support vegetation more typical of relatively lower (i.e., drier) elevations.

Plant communities dominated by sagebrush and mountain brush (predominately oak brush) were the most common vegetation on the uplands throughout the main stem of the drainage, and in the First Water Creek, Second Water Creek, Third Water Creek, Fourth Water Creek, Fifth Water Creek, and Sixth Water Creek drainages (i.e., the "Waters") as far up as Rays Valley. Only in the very heads of the Waters, just below Strawberry Ridge, were aspen and spruce-fir stands common. Typically, in the Wasatch Mountains, pinyon-juniper communities are found at the lowest elevations, along the foothills near the mouth of the canyons. The mountain brush zone becomes best developed above the pinyon-juniper, with oak, maple and other shrubs dominating the elevations between pinyon-juniper and the aspen above. In Diamond Fork Canyon however, this zonation is reversed with the mountain brush well developed from the mouth of the canyon all the way to Rays Valley Road. This reversal of mountain brush is caused by the geologic exposure of Green River shale in the upper portion of the canyon. Soils derived from these shales have droughty properties that override the influence of increased precipitation higher in the canyon.

The only text description of the Diamond Fork drainage area from this time period comes from the journals of the Dominguez-Escalante expedition. The Hispanic Friars traveled through the area in September 21 through 23 of 1776. The following excerpt includes specific information on the physical condition of the lands through which they passed.

"[After passing over the Strawberry divide from Bryant's Fork]....we went southwest for a quarter league [a Spanish league is roughly 2/3 of a mile] and descended it, breaking through almost impenetrable swaths of chokecherry and scrub oak and passing through another poplar forest so thick that we doubted if the packs could get through unless they were first taken off....We finally descended with great difficulty and labor into a deep and narrow valley in which, on finding enough of the pasturage which abounds throughout all this sierra, and water for ourselves and for the animal herd, we halted in it after having traveled a league west in the descent, naming the site San Mateo" [Sixth Water, about two miles west of the summit] (Chavez and Warner 1976:51).

Oak and Sagebrush-Grass Fire was the main disturbance factor that influenced vegetative patterns in the pre-European settlement era. Oak-dominated woodlands burned, on average, every 10-30 years which would have maintained oak stands with a minimum of decadence and kept litter and duff at levels that resulted in cooler fires than we observe today. Average clone size may have been much smaller, i.e., the interspaces of sagebrush-grass may have been larger and occupied more acres in the landscape. Sagebrush stands in the openings would have rarely exceeded 20-30% canopy of sagebrush with an understory comprised of a diversity of perennial grass and forb species. Oakbrush-maple mix types would have had a slightly longer average fire frequency of 20 to 40 years. At lower elevations, oak and sagebrush areas included a vigorous component of bitterbrush and mountain mahoganies.

It is likely that Native Americans burned the sagebrush, where it occurs in larger stands (in the lower portion of the canyon or across Ray's Valley) to increase grass production, as they did in the lower valleys. Because these areas are surrounded by brush communities that burned frequently, both vegetative types likely burned in these same fires. This would have maintained much of the sagebrush-grass complex in a state where the understory would have been comprised of a diverse mix of forbs[4] and grasses (early to mid seral stage[5]).

Pinyon-Juniper Pinyon-juniper stands were mostly restricted to steep, rocky, and/or otherwise shallow-soil sites due to frequent wildfires in adjacent brush communities. For short periods between fire intervals, it may have expanded somewhat into neighboring oak, mountain brush, and sage-grass types, but periodic fires would have prevented any long-term occupancy on these sites.

Aspen Aspen clones were young, vigorous and the understory diverse and productive. Tall forb species likely dominated the understory on higher, more moist sites. Fires periodically induced regeneration of aspen by killing overstory stems as well as competing vegetation, resulting in vigorous stands of mostly even-aged stems.

Riparian There was a predominance of cottonwood and willow types along the riparian corridor. Ute ladies'-tresses would likely have been found in recently disturbed habitat such as isolated meander "cutoffs" (oxbows) or flood channels.

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[4] Forbs are seed producing, broad-leaved annuals, biennials or perennials that do not develop persistent woody tissue but die down at the end of a growing season. This category does not include grasses.

[5] Seral status refers to succession, i.e., a species or community that will be replaced by another over time. For example, in the first few years following a fire the vegetative type would mostly be grasses and forbs with very little sagebrush (early seral). After 10-15 years, sagebrush cover would increase to 15 to 25 percent and the area covered by forbs would begin to decline (mid-seral).

There has been some speculation that the orchid is not native to the drainage, but was carried in with Colorado River Basin waters. This seems unlikely as all transbasin water originates from elevations of 7,400 feet (the elevation of Strawberry Reservoir) or higher, which is above the elevational range of the species. Because populations of Ute ladies'-tresses in Diamond Fork were not documented until 1992, any discussion of its previous extent in the drainage can only be based on the presumed extent of its habitat.

Conifers Coniferous forest types occupied similar areas in the landscape to where they now exist, and were generally restricted to northward-facing slopes where cooler, moister conditions were favorable to tree establishment and development. Some subalpine fir stands were likely in the upper drainage intermixed with aspen. Douglas-fir/white fir stands likely occupied the north slopes in the middle elevations where they now exist. Some scattered and individual blue spruce were likely to be found along drainage bottoms.

HISTORIC

A significant new disturbance factor was added during the historic era with the grazing of domestic livestock. When these valleys were settled by Europeans, sheep were brought in by rail in large numbers, and great numbers of bands grazed across the Wasatch Range. By the time the Uinta Forest Reserve was established in 1897, sheep grazing had already ravaged many areas resulting in soil loss and degradation of plant communities. In 1947 range inspection notes indicated cheatgrass was on the increase and desirable vegetation was "grazed to the nub." In 1948, notes indicated the range was "gutted", cows were on the range too early and drought conditions were taking their toll. "Range hasn't been so dry since 1934." (Grant Williams, Range Conservationist, August 1948).

Watershed improvement activities began in 1934 (earliest documented activity). Beginning in the 1960s, large range and watershed improvement activities were initiated. Since 1934 a total of 21,000 acres have been treated.[6] A more complete history of grazing use in the assessment area is covered under the Social Domain.

It is uncertain how much soil was lost from sites, and hence how much production potential was reduced. It is very likely that livestock (sheep and later cattle) removed enough grass and forbs each year, which provides the fine fuels that carry fire through sagebrush, that the fire frequency decreased substantially. As the Forest Service's fire prevention program grew, and nearly all fires were quickly suppressed, the fire frequency decreased even more until the role of fire has nearly been eliminated completely in the last decades. This caused sagebrush to increase in

[6] The watershed/elk winter range enhancement activities conducted in the Sheep Creek/Tie Fork areas during the 1990s are not included in these acres.

cover to the point that remaining grasses and forbs were suppressed and the amount of bare soil on sites increased, i.e., a majority of the stands reached a late and very late seral stage. [7]

In addition to grazing and fire prevention, several other factors contributed to a change in the vegetative pattern: clearing for agriculture and greater overall flows in Sixth Water and lower Diamond Fork due to the addition of irrigation water. Most affected were the riparian areas. Review of aerial photos dating back to 1939 show dramatic changes in riparian vegetation in the lower canyon, which began with irrigation flows in 1915 (see Appendix A). As much as 90 percent of the riparian forest may have been lost over the past 70 years.

PRESENT

Mountain Brush/ Maple/Oak Approximately 1,750 acres within the analysis area are mapped as mountain brush communities. These areas occur at lower elevations on several different aspects, but are limited to south and west exposures at middle and upper elevations within the drainage. The communities are dominated by shrub species but a single species is rarely predominate. Bitterbrush, birchleaf mahogany, curlleaf mahogany, oak, maple, and snowberry are common components but the mix of species present varies greatly from site to site, presumably dependent upon local soils, slope, aspect and elevation.

Oak woodlands are the predominant vegetation across much of the landscape, with oak and oak-maple communities occupying 41,000 acres, or 45 percent of the assessment area. They occur on south, east and west facing slopes, forming dense stands in some areas and isolated clonal "islands" surrounded by sagebrush-grass and/or aspen in others. Maple forms a significant component only on east and north aspects, forming a co-dominance on less than one-third of the acres of oak woodland. Because of the orientation of the drainage, Diamond Fork contains much less maple than adjacent Spanish Fork and Hobble Creek canyons. Bitterbrush, skunkbrush, true mountain mahogany, and curlleaf mahogany form a minor component at lower elevations. Chokecherry, service berry, snowberry, elderberry and currant can be found together with oak at higher elevations, especially adjacent to aspen stands. Oakbrush occurs from the mouth of the drainage to the very top, just below the summit of Strawberry Ridge at 9,200 feet in elevation. It is intermixed primarily with sagebrush-grass at lower and middle elevations, and aspen in the highest portions of the drainage. In a few places in the upper drainage, stands of considerable shrub diversity have developed. Neither oak, or any of the other shrub species show a strong dominance on these sites; they are mapped as "mountain brush" in the Forest's mid-scale vegetation set.

The natural fire return interval for oak types is generally considered to be 10 to 40 years, with oakbrush-dominated stands experiencing fire on the lower end of this range and mixed oak-maple types on the upper end. Typically fires remove most of the overstory of oak, leaving only

[7]Mountain big sagebrush can progress from very early seral, following a fire, to late seral (with a sage canopy cover of 30-40% or more) in about 40 years.

charred skeletons. However, oak sprouts readily, often during the same growing season in which it burned. Much of the oakbrush in the assessment area is thick and comprised of old stems (50-80 years old), as very little has burned in recent years. There is generally a good mix of understory grasses and shrubs in oakbrush stands, but in the older stands there may be fewer understory plants as there is more competition and shading from the oak overstory. Records indicate that less than 100 acres of oak-dominated woodland, only a fraction of 1 percent of the total acres of this type of vegetation within the assessment area, has burned in the last 10 years. Based on an average fire return interval of 25 years, more than 16,000 acres of oak should burn every 10 years. These mature stands have a heavy buildup of litter and duff on the soil surface, a large percentage of decadent stems, and are expected to burn very readily and more intensely than historically if an ignition source is provided. There is the potential for a large number of acres to be burned if a wildfire starts and is not readily suppressed.

Riparian Stream flows in lower Diamond Fork and its larger tributaries: Wanrhodes, Dry Canyon, Cottonwood Canyon, Sixth Water and Fifth Water support, or are capable of supporting, well-developed riparian zones dominated by narrowleaf cottonwood and box elder. Tree-dominated riparian vegetation extends up the main stem Diamond Fork to Springville Crossing, extends nearly the length of Wanrhodes Canyon, and occurs along Cottonwood Canyon and Fifth Water nearly to Rays Valley Road. The understory in the cottonwood communities is quite diverse, and often includes a variety of shrub species, resulting in a multi-storied structure. Willows, mainly coyote willow, occupy sandbars and lower banks along with sedges, grasses and forbs, resulting in a high vegetative diversity in lower elevation riparian areas.

In higher elevation reaches of these streams, riparian communities are dominated by willow and river birch, with sedges and forbs on the banks and scattered groups of cottonwoods. Stream bank stability tends to be highest where beaver are present. In sections of the Waters, impacts from grazing and the lack of beaver activity have resulted in bare, unstable banks which, in some cases, has contributed to channel downcutting and subsequent invasion by upland sagebrush-grass communities.

Four riparian study sites, designed to monitor trends in vegetation, were established in the Diamond Fork watershed between 1988 and 1991. All of the study sites are in the higher elevation, willow-dominated riparian communities and were re-analyzed 3 to 5 years after being established. When established all four sites exhibited low ecological status, or early seral conditions, due to a lack of hydrophilic (water loving) species on the greenline. Currently, two of the sites, on First Water and Fifth Water near Ray's Valley Road, show stable to slightly downward trends. Ecological status is stable on upper Diamond Fork, just above the confluence with Chase Creek. Near the Diamond Fork Guard Station, conditions have improved enough to raise the greenline ecological status to mid-seral.

The Forest Service established three additional riparian transects within the assessment area between 1993 and 1997. The methods and procedures for these transects can be found in the Integrated Riparian Evaluation Guide (March 1992 Intermountain Region USDA). These transects were established to monitor progress towards meeting the Standards and Guidelines established in the Uinta National Forest Rangeland Ecosystem Forest Plan Amendment. For a summary of the data and trends of these seven transects see Table 2-3.

Table 2-3 Results and Trends of Riparian Studies

LOCATION	YEAR	ECOLOGICAL SERAL STATUS	STABILITY RATING	YEAR	ECOLOGICAL SERAL STATUS	STABILITY RATING	YEAR	ECOLOGICAL SERAL STATUS	STABILITY RATING	VEGETATIVE TREND
Diamond Fork Guard Station	88	Early (39)		93	Mid (51)	Moderate (5.96)	96	Mid (52)	Good (7.28)	Stable to upward
Halls Fork	90	Early (36)	Poor (4.16)	94	Early (36)	Poor (4.8)	96	Early (39)	Moderate (5.18)	Improving
Chase Creek	93	Very Early (13)	Moderate (5.0)							Unknown
Shingle Mill	93	Very Early (3)	Poor (3.34)							Unknown
Fifth Water	92	Early (30)	Poor (3.6)	95	Very Early (13)	Poor (4.3)	96	Early (21)	Moderate (5.43)	Data indicates downward photos indicate slight upwards
First Water	91	Early (30)	Poor (4.1)	95	Early (19)	Poor (4.0)				Downward
Third Water	97	Early (19)	Poor (4.2)							

There are no long-term riparian studies in cottonwood-dominated communities in the lower portion of the drainage. However, review of a time-series of aerial photographs shows dramatic changes in both channel morphology (shape) and total forested riparian area since 1939. Additional changes are assumed to have occurred between 1915 and 1939 with the onset of irrigation releases through Sixth Water and lower Diamond Fork from Strawberry Reservoir.

Six stream reaches in Diamond Fork were analyzed on air photos dated 1939, 1956, 1971, and 1984. Reach one includes the lower 1.75 miles of Diamond Fork from the mouth upstream to Lavanger Hollow; reach two begins at Lavanger Hollow and extends upstream approximately 1.8 miles to the Redford Bridge near the mouth of Brimhall Canyon; reach three begins at Brimhall and extends upstream 3.1 miles to Little Diamond; reach four includes Little Diamond Creek to Sam's Canyon; reach five from Sam's Canyon to Monk's Hollow; and reach six from Monk's Hollow to Three Forks. Partial results of this analysis are shown below in Table 2-4.

Table 2-4 Acres Per Segment by Time Period[8]

STREAM REACH	POTENTIAL TOTAL FORESTED AREA	LENGTH (MI)	1939	1956	1971	1984
1: Mouth of canyon to Lavanger Hollow	130	1.75	40	13	7	8
2: Lavanger Hollow to Brimhall Canyon	75	1.87	26	19	7	5
3: Brimhall Canyon to Little Diamond Creek	20	1.0	13	11	6.5	7.5
4: Little Diamond Creek to Sam's Canyon	45	1.3	37	36	26	22
5: Sam's Canyon to Monk's Hollow	33	1.5	20	20	25	21
6: Monk's Hollow to Three Forks	38	2.2	28	26	28	20.4
Total acres	341		164	125	99.5	84
% of potential acres			48%	37%	29%	25%
% of 1939 acres				76%	61%	51%

The loss of riparian forest in lower Diamond Fork has been substantial. Development of the floodplain for agriculture resulted in significant loss, potentially resulting in the estimated removal of 67 percent of the original riparian forest below Brimhall Canyon by 1939. More than 80 percent of the forested area present in the same section in 1939 had been lost by 1984 due to flood damage and lateral channel migration. It appears that cottonwood regeneration in this reach has been severely limited because 1) the surfaces available for cottonwood regeneration have been eroded; and, 2) in the majority of years, summer irrigation flows are higher than the spring snow melt peaks so that new seedlings are inundated or washed away soon after they begin to grow. Cottonwood establishment may be limited to only three periods (1920-23, 1952 and 1983-4) in which natural flood peaks exceeded irrigation flows.

Measures have been taken to remove some impacts from the riparian zone. Livestock use along the lower riparian corridor has been nearly eliminated due to construction of a fence from Sam's Canyon to Brimhall Canyon. This fence was necessary to mitigate impacts from grazing on

[8] The acres identified are those of mature trees only and not the total area occupied by all ages of cottonwood/box elder trees. Additionally, the numbers should not be taken as absolutes due to errors resulting from photo distortion and small photo scale, which make resolving differences in vegetation types difficult especially on older black and white photos. Note also that "Potential Total Forest Area" is based on 70 percent of the valley area in Reaches 1 and 2 and average valley width times length of segment in Reaches 3 through 6.

newly rehabilitated slopes created by the Diamond Fork Pipeline and road project. At present, the riparian corridor is fenced to exclude cattle from the area extending from Sam's Canyon to the mouth of Diamond Fork Creek. Additionally, dispersed camping has been eliminated from this same corridor. Previously, dispersed camping was concentrated in the riparian zone between Camp Diamond and Monks Hollow.

One riparian species of particular interest in this assessment is the ***Ute ladies'-tresses*** (*Spiranthes diluvialis*), a Federally listed "threatened" orchid that occurs in lower Diamond Fork.[9] The species is endemic to moist sites and primarily occurs near springs, lakes, and perennial streams (USFWS 1995). The plant occurs in several states in the Intermountain West at elevations between 4,000 and 7,000 feet. The most significant known populations occur along the east slope of the Front Range in Colorado and the south slope of the Uinta Mountains of Utah. The Diamond Fork-Spanish Fork population is the largest along the Wasatch Front and is possibly the largest occurrence west of the Uinta Basin.

This population consists of 60 colonies, extending from near the old Three Forks Campground on Diamond Fork downstream to near Cold Springs on the Spanish Fork River. The number of individuals occurring within these colonies varies greatly from year to year from a high of over 13,475 individuals observed in 1998 (Rick Black of Michael Baker Jr., Inc., Midvale, Utah, pers. comm.) to a low of 325 in 1992. This population consists of more than 95 percent of all individuals known to occur along the Wasatch Front (Western Wetland Systems 1996).

The orchid colonies occur along the river, primarily within the two and ten-year floodplains (Western Wetland Systems 1996). The plant seems to be well adapted to disturbances caused by channel migration through time. It is believed to also be tolerant of some level of disturbance from other sources, such as grazing, which may mimic natural disturbance processes affecting floodplains (USFWS 1995).

Because the orchid was not discovered in Diamond Fork until 1991, it is difficult to establish any trends in population size or quantity/quality of habitat. It is possible that under pre-settlement conditions less habitat was available for the orchid. A predominance of cottonwood and willow types would have provided less suitable habitat for the species, which is sensitive to shading and relies on recently disturbed habitat. Much of the currently occupied habitat seems to have developed over the last few decades as the result of lateral movement of the stream, a process accelerated by the increased flows and loss of stable riparian vegetation. Under pre-settlement conditions it is likely that suitable habitat was limited to a few isolated meander "cutoffs" (oxbows) or flood channels.

Sagebrush-Grass Sagebrush-grass complex is found throughout the landscape, but mostly as small, scattered patches surrounded by oakbrush. These small pieces are not portrayed on the Forest's mid-scale vegetation maps, as most are less than 5 acres in size and are "lost" in the

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[9] No Forest Service Region Four sensitive plant species occur within the assessment area.

more extensive oak and pinyon-juniper communities surrounding them. Extensive stands of sagebrush are found in two portions of the assessment area, creating a distinct landscape pattern. In the lower canyon, along the main stem and on Billies Mountain, large expanses of sagebrush-grass are surrounded by oak and oak-maple communities. Higher in the drainage, along gentle terrain known as Ray's Valley, sagebrush-grass forms a discontinuous band at approximately 7,200 feet.

Sagebrush is of the mountain big sage variety, with the grass component dominated by bluebunch wheatgrass or Basin wildrye at lower elevations and mountain brome and needle grasses at higher elevations, where native grasses still dominate the understory. Some sagebrush areas have been converted to other types, either cultivated for agricultural use and/or seeded to introduced grasses to provide additional livestock forage or to stabilize soils. On some sites sagebrush has been successfully kept out of the community by repeated treatment (chaining or herbicides) and planting with smooth brome which forms nearly continuous cover. In Ray's Valley, where treated sites were planted with crested wheatgrass, sagebrush has been maintained in the community. These sites usually lack native forbs, because either treatment (especially with herbicides) or sheep grazing greatly impacted their production. Annual forbs have increased substantially in number but provide little cover because they are so small and short lived; they do not serve the same function as native, perennial forbs. For a summary of the condition and trends for upland sites, see Table 2-5.

Table 2-5 Condition and Trend of Upland Sites

LOCATION	STUDY TYPE[10]	CONDITION	TREND
Wanrhodes	P3S, NF	Satisfactory (converted)	Stable
Farmers Slope	P3S, NF	Mid-seral	Down
First Water	P3S, NF	Satisfactory	Stable
Second Water	NF	Satisfactory*	Down
Sterling Ranch	PP	Satisfactory	Stable
Rays Valley Excl.	NF, PP	Satisfactory	Stable
Rays Valley Sage Sp.	PP	Satisfactory	Stable

* These sites have been converted by past range treatments. They are now dominated by non-native grasses and are not compared to Potential Natural Community.

Pinyon-Juniper These communities, with a fairly small component of pinyon pine, are common at the lower and mid-elevations from Little Diamond up to Three Forks in the main stem, and up the secondary drainages as well. They occur on lower slopes having south and southwest

[10] NF - Nested Frequency Study; P3S - Parker 3-Step Study; PP - Photo Point

exposures, occupying just under 10 percent of the assessment area. Rocky Mountain juniper is common in the deeper soils nearer the canyon bottom, adjacent to riparian areas; Utah juniper is the common species on all other sites. Pinyon-juniper communities occur again, higher in the main stem of Diamond Fork Creek above Springville Crossing, mixed with oak and maple. These higher elevation stands are likely associated with outcrops of Green River Shale.

Pinyon-juniper likely occupies more acres within this landscape than during pre-settlement times and some stands are more dense. Comparison of recent and old photos demonstrate that pinyon-juniper has expanded in some areas. Pinyon-juniper has invaded sagebrush-grass, mountain brush and oak communities with the near-elimination of fire disturbance. In the past, frequent fire disturbance killed juniper seedlings that would have established in these types.
This reduction in fire frequency can be attributed to heavy livestock grazing in the early part of the century (which reduced the availability of fine fuels (e.g., grass) and hence the stands ability to carry fire) and an aggressive fire suppression program. The increase in density of these tree species has caused a reduction in the density of understory plants and an increase in bare soil. This is, in part, due to competition for scarce soil moisture and possibly due to allelopathic[11] effects. Reduced soil cover has resulted in deteriorating watershed conditions as soil erosion has increased.

Aspen Aspen form large, pure stands only in the heads of the Waters drainages along the west side of Strawberry Ridge and above Ray's Valley. On drier sites at this same elevation, aspen occurs in small clones intermixed with small clones of oak-maple, stands of mountain brush, perennial grass communities and subalpine fir. Aspen and aspen-oak is also found on the east flanks of Spanish Fork Peak, which drain toward Little Diamond, and on Timber Mountain. Aspen and aspen-oak communities occupy 20 percent of the landscape.

Although limited within the assessment area, aspen makes up an important vegetation type serving as valuable wildlife habitat, adding to the area's visual diversity, and providing valuable watershed protection. Much of the aspen in this area is not in critical danger of succeeding to conifer encroachment because conifers, which normally would succeed aspen, are not well suited to the soil in the area so that aspen becomes a stable vegetative type. About one-quarter of aspen acres exhibit a mix with conifers, with the canopy cover of conifers ranging from 10 to 35 percent, and amount of conifers increasing.

Most aspen clones are advanced in age, beginning to deteriorate, and becoming more susceptible to disease with many individuals stems 80 to 120 years of age. Some regeneration is occurring, but at low levels. Fire, which would stimulate aspen regeneration, has been suppressed, and grazing by domestic livestock and big game has impacted aspen regeneration that does occur. Due to grazing and fire suppression, species composition under the aspen has probably shifted,

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[11] Allelopathic effects refer to the suppression of growth of one plant species by another due to the release of toxic substances. For example, juniper trees needles contain chemical substances which can inhibit other vegetative growth.

with a reduction in forbs and subsequent increase in grasses and shrubs. Some unpalatable forb species, such as western coneflower, have increased dramatically.

Coniferous Forests Conifer stands occupy less than five percent of the landscape within the assessment area. The only conifers below Three Forks are found in small patches on the south and east flanks of Spanish Fork Peak (subalpine fir) and just underneath and to the north of Teat Mountain (Douglas-fir). Just above Three Forks, Douglas-fir occurs in small patches and is often mixed with white fir on north-facing slopes along Cottonwood, Fifth Water and Sixth Water. At higher elevations, in the heads of the Waters, larger stands of subalpine fir occupy north aspects; blue spruce occupies the lower portions of slopes and extends into riparian areas. Some scattered ponderosa pine trees are also found in the assessment area.

White Fir and Douglas-fir White fir and Douglas-fir are the predominant conifer species within the area, although they make up only a minor portion of the landscape. Most of these stands are mature with few young and few very old trees. White fir readily regenerates in the understory of Douglas-fir stands, and can remain in the understory for a number of years until a break in the overstory canopy releases it. Since 1993 the fir engraver beetle (associated with white fir) and the Douglas-fir beetle have killed substantial numbers of trees within many of the stands. The fir engraver has been at epidemic levels in many portions of the Forest surrounding Diamond Fork. The level of mortality caused by the fir engraver beetle throughout Utah has been without precedent. It is thought to be due to several factors, one of which is the increase in abundance of white fir over the past century (coincident with the reduction in low-intensity wildfires). The Douglas-fir beetle has been killing pockets of Douglas-fir in the area periodically for the last decade, or likely longer. What this effectively has done is reduce the percentage of Douglas-fir and increased the percentage of white fir. Pre-settlement low-intensity wildfires likely occurred on a 30 to 50 year cycle in many of these stands. These fires would have kept white fir regeneration in check while doing little damage to the more fire-resistant Douglas-fir. Without the periodic fires, white fir has increased, the number of stems per acre has increased (thus making competition for resources more severe), and ladder fuels[12] have increased. These stands are under increased risk of stand replacing, high intensity fires.

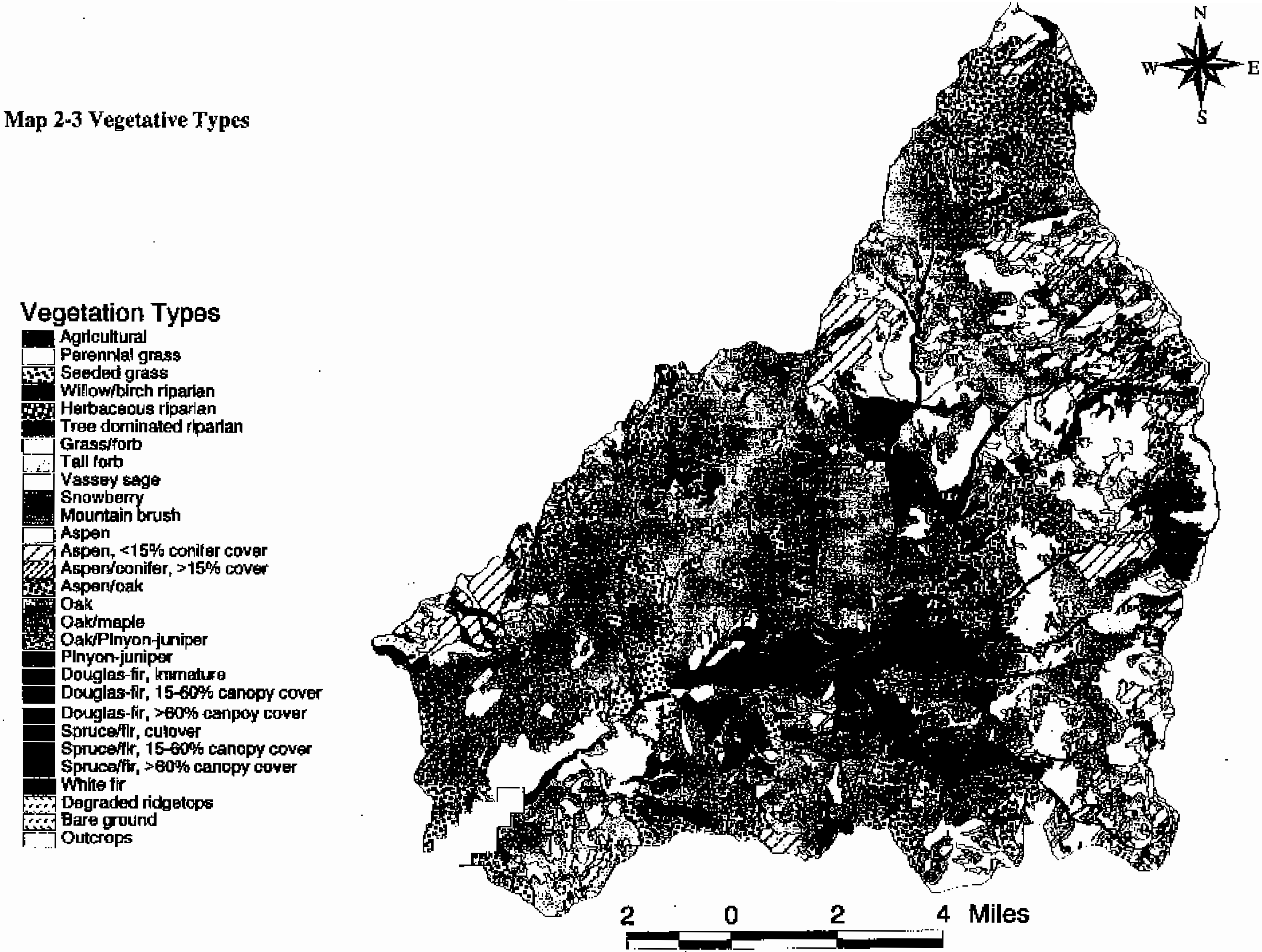
Subalpine fir A few stands in the area consist primarily of subalpine fir with some blue spruce. The balsam bark beetle, among several other species, has increased in recent years causing significant mortality in the subalpine fir component. These stands are generally mature and beginning to deteriorate. Both insect and fire susceptibility is high. Neither subalpine fir nor spruce can withstand even low intensity fires. As the overstory canopy breaks apart, subalpine fir seedlings in the understory are released and a fuel ladder is formed. Should a fire occur in the stands, it will likely be somewhat more intense than one occurring in pre-settlement conditions given the increased ladder fuels as well as the older, more fire susceptible vegetation that tend to surround these somewhat isolated stands.

[12] Ladder fuels are small trees that reach to the larger trees. Fire travels from the ground into the crowns of the larger trees easily with fuel ladders.

Ponderosa pine Ponderosa pine is not a cover type within the assessment area; however, it is notable that some scattered groups occur in Diamond Fork. Very few native ponderosa pine exist in the areas, and none in stands of more than 5 acres. Some scattered individuals can be found in Sawmill Hollow. Whether these are relics from pre-settlement times, or are the beginning of an expanded population, or are just an anomaly is not known. Ponderosa pine can be established in the oakbrush cover type on the Uinta National Forest, as proven by various pockets of pine planted early in the century. However, oakbrush stands on the Uinta tend to be relatively dense and fires in these stands tend to burn rapidly and intensely. It may be that this combination has kept ponderosa pine from expanding its range here.

Map 2-3 displays the areas covered in the assessment by each vegetative type.

Map 2-3 Vegetative Types



WILDLIFE

PRE-SETTLEMENT

Fish Prior to European settlement, the streams in the Diamond Fork drainage would have contained only native fish. Species present were Bonneville cutthroat trout, mottled sculpin, mountain sucker, dace, leatherside chub, and redside shiner. June suckers likely spawned in the Spanish Fork River but it is unlikely they would have migrated as far upstream as Diamond Fork. Utah chub and Utah sucker inhabited the Spanish Fork River drainage and prior to European settlement may have inhabited portions of the Diamond Fork drainage (Charlie Thompson, UDWR, personal communication, 2000).

Riparian and fish habitat would have been near the maximum potential for the streams. Willows and cottonwoods were the dominant woody vegetation in the wide valleys with water birch and dogwood being more abundant in the narrow reaches. As trees aged, wood was added to the stream. This wood came into the stream either through capture by natural bank erosion or as the trees aged and fell into the stream. This added wood created a complex channel by forming debris jams which 1) created scour and plunge pools; 2) stored sediment; 3) provided growing surfaces for cottonwoods, willows and other riparian plants; and, 4) maintained stream gradient.

These debris jams at times would have caused the water to leave the existing channel and create a new channel (evulse). Single or multiple logs would have also been important for bank protection. Most pools were either associated with large wood, bedrock, large boulders or stable meanders. Deep pools were often found on the outside of meander bends as the stream tried to dissipate energy. This energy was either dissipated by the widening of the channel through bank erosion (meander migration) or by scouring of a pool, which caused the water to slow and dissipate the energy and provide slow moving water to hold fish. Trees growing along the stream bank provided shade to the stream creating suitable water temperatures for coldwater fish. The input of leaves every fall provided a valuable source of energy into the stream providing food for many aquatic insects and eventually fish. Trees and shrubs along with grasses also stabilized the banks. These stable banks provided excellent habitat as the roots held tightly to the soils allowing undercut banks to form providing hiding and escape cover for the fish. Banks were 80 to 95 percent stable with frequent overhanging banks.

Amphibians Amphibians in the Diamond Fork drainage generally inhabited wetland habitats such as wet meadows, ponds, streams, springs and marshes. Utah tiger salamanders (*Ambystoma tigrinum utahensis*), chorus frogs (*Pseudacris tiseriata*), leopard frogs (*Rana pipiens*), Woodhouse's toad (*Bufo woodhousei*), western boreal toads (*Bufo boreas boreas*) and spotted frogs (**Rana pretiosa**) likely inhabited the Diamond Fork drainage prior to European settlement.

Reptiles Reptiles in the Diamond Fork drainage are described in the *1999 Diamond Fork System, Bonneville Unit, Central Utah Project, Final Supplement to the Final Environmental Impact Statement*, as follows: "Foothill shrub and grassland habitats ... provide good habitat for reptiles. Lizards common to these habitats include northern sagebrush lizard (*Sceloporus graciosus*), northern side-blotched lizard (*Uta stansburiana*), Great Basin (western) whiptail (*Cnemidophorus tigris*), and Salt Lake horned lizard (*Phrynosoma douglassi ornatum*). Snakes occur most commonly near water in canyons and near valley wetlands. Species likely to occur ... include wandering garter snake (*Thamnophis elagans vagrans*), Great Basin gopher snake (*Pituophis melanoleucus deserticola*), and western yellow-bellied racer (*Coluber constrictor mormon*)."

Beaver Beaver were an important species of wildlife that helped create the riparian conditions by storing and expanding the influence of water. When a beaver dam is first constructed it creates a large pool. The beaver use the pools as protective cover and as a place to cache winter food supplies. Pools are also used by fish and contain aquatic insects different than those in the faster-flowing portions of the stream. Over time, as the pools fill with sediment, they become less suitable for fish. In situations where topography of the stream valley allows, alternative stream courses may develop around the beaver pond. As the edges of the pool become filled with sediment, and the sediment is exposed, this soil becomes vegetated and stabilized. As the pool continues to fill it becomes
useless to the beaver and maintenance of the dam is abandoned. Without maintenance the dam eventually fails during spring runoff. At this time the sediment that has not been stabilized by vegetation is released downstream.

It is likely that beaver occupied the same areas that they do today; however, beaver populations were likely higher in pre-settlement times than they are currently. Early records describe Spanish Fork Canyon as "a morass of timber stands and beaver dams" (Merrill and Nielson 1981). This description indicates a far greater structural and biological diversity than exists today and it is assumed that the same probably applies to the Diamond Fork drainage.

In many areas there were wide willow complexes. These willow complexes commonly spanned from one valley wall to the other in small drainages as they stair stepped down the drainage. The whole valley bottom was wet and conducive to willows. The dams were wide, and even at high flows were not prone to being blown out since the force of the water was dissipated over a wide area. These complexes reduced the gradient by giving the stream a wider area over which to flow. They also captured most of the sediment maintaining a more flat bottom valley versus a V-shaped bottom. Through the construction of their dams, beaver contributed to the storage of sediment, widening of the valley bottom, moderation of flood flows and storage of water for later season use.

Upland Species Blue grouse and ruffed grouse could be found in Diamond Fork during the pre-settlement era. Blue grouse used conifers for winter habitat; summer habitat was in openings at lower elevation vegetated with grasses, forbs, shrubs and aspen patches where they raised their chicks. Ruffed grouse are considered the bird of the aspen. Aspen was heavily utilized as cover forage year long; with grouse feeding on insects, fruits and leaves in the aspen. Males selected drumming logs under dense overstory, but with good horizontal visibility. Hens chose similar cover for nesting. During the summer the broods were found along stream bottoms. Cottontail, blacktail and whitetail jack rabbits were the most common upland species. These species served as prey for raptors and other predator species. Additionally these species served to disperse seeds from grasses, sagebrush, juniper berries and other vegetation.

Large Ungulates According to *Early Records of Wildlife in Utah*, (Rawley 1985) Fremont Indian (500-1300 A.D.) rock art in northern and central Utah included illustrations of bighorn sheep, elk, and deer. These species utilized the aspen, mountain brush (chokecherry), oak, grassy open ridges and riparian areas of Diamond Fork. Bighorn sheep were the dominant ungulate, even though deer and elk were prevalent.

Neotropical Migratory Birds The riparian corridor was dominated by cottonwoods and willows. These mature forests with multiple vegetation layers and dense shrub understory were the most productive habitats for neotropical migratory birds (birds which breed in North America and winter south of the U.S. border.) Neotropical migratory birds also occupied upland habitats (oak-sagebrush-grass and pinyon-juniper) for summer breeding and nesting. Species and their habitats would have fluctuated with natural succession. The aspen and conifer stands would have supported neotropical migratory birds as well. The understory in these stands was diverse with native forb species. Fire as well as other natural processes would have influenced species richness.

Threatened, Endangered and Sensitive Species The gray wolf, northern goshawk, three-toed woodpecker, flammulated owl, boreal owl, great gray owl, spotted bat, Townsend bat, North American lynx, wolverine, and fisher, may have occurred in the assessment area. Fluctuations in the populations of these species would have coincided with natural processes.

Predators Predators existing in Diamond Fork during the pre-settlement era included wolves, coyotes, black bears, cougars, grizzly bears, bobcats, raptors and possibly lynx. These species' ranges would have been widespread with only natural barriers preventing migration.

HISTORIC

Documentation of wildlife in Utah began with the first European expedition into Utah by Fathers Dominguez and Escalante in 1776. Subsequent expeditions also noted wildlife existence. Species composition began changing from all native species to a combination of native and introduced species in the mid-1800's with the settlement of Utah Valley. Conflicts between the settlers and native wildlife were noted in several historic accounts. Hubert Howe Bancroft noted in 1890 that two hunting companies in December 1847 were formed for the extermination of wild beasts; there were eighty-four men in all and their efforts were successful.

Fish Changes to the Sixth Water and Diamond Fork Creeks from high irrigation flows, loss of riparian communities, and grazing[13] led to reduced fish habitat and decreased survival of fish in these streams especially fry (young of year). The high flows led to a more homogenous system as large woody debris was washed through the system. The elevated summer flows made it difficult to establish vegetated banks. Without stable banks, pool habitat was lost as the stream energy was used in lateral migration at the meanders rather than vertical bed migration and formation of pools. Undercut banks were eliminated as erosion rates and flow regime were not conducive to plant establishment. Suitable spawning gravels were removed from the upper reaches and deposited in the braided sections. Backwater and side channel habitats were also lost due to vertical bed migration.

Fish habitat in tributaries to Sixth Water and Diamond Fork were heavily impacted. During this period beaver were removed and the riparian area was severely over-grazed. This resulted in a loss of bank stability, vegetative cover, pool habitat, vertical channel stability, thermal cover and a severe decline in fish numbers.

Species composition changed from all native species to a combination of native and introduced trout species. In the late 19th century fry of many trout species were indiscriminately stocked in many streams across the United States. Many of the streams in Diamond Fork were probably stocked at this time. There are records from 1931 to 1932 that document presence of rainbows, natives (the term natives is used to refer to cutthroat with no differentiation between Yellowstone or Bonneville cutthroat) and brook trout in Diamond Fork, and stocking of rainbow in Fifth Water. Radant (1976) reports a stocking of 5,000 cutthroat fry in Fifth Water in 1968. These were most likely a Yellowstone cutthroat. The main impact of introduced cutthroat and rainbow trout was to degrade the purity of the Bonneville cutthroat trout by hybridization. Brown trout were also introduced to the streams. The abundance and distribution of leatherside chub and redside shiners were likely changed by the introduction of the more aggressive and piscivorous (fish-eating) brown trout. The bottom dwelling sculpin, mountain sucker and dace were likely less affected by introduced species.

Amphibians Wetland and aquatic habitats for amphibians were impacted as described for fish. These impacts were particularly severe in the lower reaches of Diamond Fork drainage where many riparian forests were cleared or lost. Impacts to amphibian habitat around springs and wetlands also occurred in the upland areas. Historic grazing in these areas reduced ground cover, impacted water quality, and affected the plant composition in these habitats.

[13] A study done by Jim Kimball and Frank Savage (1964-1977) showed dramatic improvement within an exclosure on upper Diamond Fork Creek. Bank stability increased from 55 percent to 95 percent, riffles decreased from 95 percent to 82 percent, pools increased from 5 to 18 percent. Total numbers of fish increased 425 percent (from 35 to 149). There were dramatic changes in and outside the exclosure as AUM's were reduced from 23,315 to approximately 8,800. It is expected that there were similar changes in habitat on other streams due to reductions in cattle numbers.

Reptiles Reptiles were also impacted by historic land uses. Wetlands and aquatic habitats important to many reptiles were impacted as described previously for fish. Upland grassland, shrub and spring habitats were also impacted by clearing for agriculture and heavy grazing. Heavy utilization, changes in species composition, and reduced ground cover occurred in many areas. This would have adversely affected reptile habitat quality.

Beaver Overgrazing, shooting, road building and trapping led to decreasing beaver numbers. The historic overgrazing depleted the willows and led to direct competition among the remaining beaver. Roads were commonly built in the bottoms of the drainages as these were the flattest and easiest places to build. In areas where there were conflicts between the roads and the beaver - the beaver were removed. Beaver populations probably reached their lowest levels during this period as they were viewed as decreasing water flows and making areas ungrazable. Beaver were also viewed as impeding fish migration and spawning as well as creating sediment sinks that become useless as fish habitat. In a 1942 report (West and Rasmussen, 1942) beaver were listed as present in the headwaters of Diamond Fork and Fifth Water. The report identified a need for beaver in First Water, Wanrhodes, and Little Diamond Creeks. These waters were stocked respectively with two, four, and four beaver in 1940 (West and Rasmussen, 1942). The UDWR has a record of beaver occurring in Fourth Water in 1955. Without the beaver ponds to slow the runoff, catch sediment, and spread out the flows, some stream channels became incised.

Upland Game Populations of upland game increased and decreased depending on habitat changes, precipitation, and insect production. Livestock grazing, and agricultural and water development in Diamond Fork resulted in a shift from native upland forb species to non-native grass species in many areas. This negatively affected upland game chicks as the forb seeds, and insect-attracting potential of the native forbs, were lost or reduced. Seeds and insects are an important part of an upland game chick's diet. Additionally, as the Forest Service continued to suppress fire, stands of aspen and conifer and uplands reached late and very late seral stages which also suppressed grasses and forbs important for upland game diets.

Large Ungulates By the time the Uinta National Forest Reserve was established in 1897, livestock grazing resulted in loss and degradation of plant communities which directly affected all native species. Bighorn sheep are believed to have been eliminated in Diamond Fork by 1890. Pioneers eliminated most of the elk from its natural range due to unrestricted shooting and livestock grazing. By 1907 the State began protecting the small deer herds and eventually reintroduced elk. The first recorded sighting of a moose in Utah was around 1906 at the head of Spanish Fork Canyon.

Neotropical Migratory Birds The lower portion of the riparian area in Diamond Fork lost as much as 90 percent of the riparian forest from the 1920s to the present. This would have decreased neotropical migratory bird populations (dependent on riparian habitat) dramatically and may also have impacted species diversity in the canyon. European settlement, agriculture, grazing and water development probably contributed to the observed decline in neotropical bird populations.

Threatened, Endangered and Sensitive Species With increased human impacts and resulting alterations of natural habitats, many species declined with some (grizzly bear, gray wolf, peregrine falcon, North American lynx, wolverine, fisher) becoming extirpated in the Diamond Fork drainage.

Predators Grizzly bears were extirpated not only from Diamond Fork and Spanish Fork Canyons but from the State of Utah. Their demise is attributed mostly to over hunting and loss of habitat due to human encroachment. Black bears were still present and most likely utilized mixed stands of conifer, feeding on roots and berries, insects, and small to medium sized mammals. They also used the conifer stands for day beds and travel corridors. The gray wolf was also eliminated from Diamond Fork due to hunting and declines in the wild ungulate population, which served as a food source for the wolf. North American lynx, wolverine, and fisher are also believed to have disappeared during this period.

PRESENT

Fish Habitat surveys have been completed on Chase Creek, Lower Diamond Fork, and Sixth Water. The results of the survey in Chase Creek show an over-widened channel with an extreme sediment load in the lower reach below the confluence with Shingle Mill. The indicators of this high sediment load are the percent of fines found in the riffles as well as pool tailouts (the transition area between a pool and a riffle). A low residual pool depth also indicates sediment problems. High sediment levels reduce success of egg hatching as well as food availability. Of the 2.5 miles of stream surveyed, 2 miles had 30 percent unstable streambanks. The pool/riffle ratio ranges from .06 to .11 is much lower than desired and indicates disturbed banks and riparian vegetation. Pools per mile in the three reaches ranged from 11 to 15. This channel would be characterized as an over widened Rosgen B channel (see Appendix D for an example of this type channel). In a pristine B channel with similar substrate one would expect to have 80 to 96 pools per mile (based on a rhythmic spacing of pools every 4-5 channel widths). No other headwater streams in this drainage have been surveyed. The other headwater streams may be in similar condition as they are managed similarly. No fish occur in Second, Third or Fourth Water.

Sixth Water was surveyed by Trihey and Associates in 1996 (for details see Trihey and Associates, 1997). In general, they found between 12 and 32 percent of stream banks to be unstable. Over 75 percent of the habitat was classified as turbulent, fastwater habitat. At stream flows of 12-15 cfs they reported only 19 pools in over 5 miles of stream. At stream flows of 30 cfs, half of these pools would become fast water habitats. Trout spawning and rearing habitats were also noted to be limited in Sixth Water.

In 1990 during the rotenone treatment of Strawberry Reservoir and its tributaries, an accidental release occurred to Sixth Water and Diamond Fork. This greatly altered fish populations in Sixth Water. The Utah Division of Wildlife Resources restocked Sixth Water with brown trout during 1991-1995. Wiley and Thompson (2000) report the stream has since been resurveyed, and 1999 data indicates this stream supports an excellent and productive brown trout fishery containing about 900 trout/mile (estimated 213 to 251 pounds per acre).

Diamond Fork was also surveyed by Trihey and Associates (1997). In 7.3 miles of stream surveyed between Monk's Hollow downstream to the Spanish Fork River, they found fast water habitat types over 72 to 92 percent of the channel length. Eighty-six pools were reported, most of which were associated with side channels and backwaters or eddies. The river was characterized as having long stretches of homogenous riffles or other fast water habitats with infrequent pools. Information on current fish distributions in Diamond Fork and its tributaries is displayed in Table 2-6.

As previously noted, an accidental release of water containing rotenone occurred in 1990. This release impacted fish populations in lower Diamond Fork (below Fifth Water confluence). UDWR restocked this stream with brown trout and leatherside chub. A 1997 survey of this stream reach found the trout population to be 87% brown trout, 12% cutthroat trout, and 1% rainbow trout. The rainbow trout present were primarily hatchery-reared "catchables" (8 to 11 inches in length). The wild trout biomass was estimated to be 70 to 127 pounds per acre (Wiley and Thompson 1997). Leatherside chub, mountain sucker, and mottled sculpin were also observed during the survey.

Wiley (1997) reports that 1996 data indicates upper Diamond Fork (above the Guard Station) contains an estimated 739 Bonneville cutthroat trout, 158 brown trout, and 159 rainbow trout/mile. Compared to 1991 data, populations of brown trout have increased about 20% while populations of cutthroat trout have more than doubled. Three size classes of cutthrout trout, two of brown trout, and one of rainbow trout were observed in 1996.

Macroinvertebrate Sampling has been used on the Uinta National Forest as a method of monitoring water quality since the 1970's. In the Diamond Fork watershed, sampling has mainly occurred at four sites: Hall's Fork (sampled in 1993); Fifth Water above Sixth Water (1993), Diamond Fork above Three Forks (1977, '78, '79, 80, and '93) and Diamond Fork below Brimhall Canyon (1977, '78, '79, '90, '94). Only two of the sites have been sampled frequently enough, or over a long enough period, to establish a baseline condition.

Sample results from the Diamond Fork, Hall's Fork, and Fifth Water sites typically have shown a pattern of higher numbers of sediment and organic tolerant species early in the year during spring runoff, and higher numbers of clean water species in the fall. This pattern was observed in Hall's Fork in 1993, but the opposite pattern was observed in Fifth Water, perhaps due to a disturbance in the watershed. The season-long dominance of sediment-tolerant species in Fifth Water is indicative of a stream with a constant, high sediment load.

Macroinvertebrate data from Diamond Fork above Three Forks typically shows a recovering trend with an increase in the abundance of cleaner-water species. This may in part be due to changes in grazing management in the last two decades as well as stream stabilization work in the late 1980's and early 1990's.

Sampling results from Diamond Fork below Brimhall station clearly show the impacts of flow augmentation by trans-basin diversions from the Strawberry and Syar tunnels. The number and biomass of organisms observed varies measurably between June and October, and during this period populations of some species dip to low numbers. This is indicative of the instability of the channel system. There are both clean water and sediment/organic-tolerant taxa present, with an abundance of sediment and organic-tolerant taxa. In most years, an increase in overall species abundance can be observed after the trans-basin diversions have ceased. This suggests a good potential for improved water quality in the absence of augmented flows.

Table 2-6 Current Fish Distribution in Diamond Fork

STREAM	BROWN TROUT	CUT-THROAT TROUT	STOCKED RAINBOW TROUT	LEATHER-SIDE CHUB	SCULPIN	DACE	MOUNTAIN SUCKER	REDSIDE SHINER
Cottonwood	X							
First	?	?						
Upper Fifth		X*						
Lower Fifth	X	X*		X		X	X	
Upper Sixth	X							
Lower Sixth	X	X		X	X	X	X	X
Halls		X*						
Chase	X	X*			X			
Shingle Mill		X*			X	X	X	
Upper Diamond Fork	X	X*	X		X	X	X	
Lower Diamond Fork	X	X	X	X	X	X	X	X
Wanrhodes	X	X			X			
Little Diamond	X	X			X			

* Probable occurrence of native Bonneville cutthroat trout.

It is likely that non-game fish occur in more streams than indicated. Sixth Water has a high number of resident brown trout that are likely to persist in the stream and perhaps dominate without angler management.[14]

In a 1996 study of leatherside chub in the 14 kilometer reach of Diamond Fork between Monks Hollow and Spanish Fork River, Walser et. al. (1997) reported that leatherside were present, but occurred almost entirely in back water and cutoff habitats. This lack of use of main channel habitats by leatherside chub is not consistent with other studies done where brown trout were absent. This suggests that the difference in habitat use may be due to the presence of brown trout and the associated predation. They estimated the leatherside population to be between 2050 and 4250.

Bonneville cutthroat trout historically inhabited streams in the Diamond Fork drainage. Stocking of rainbow trout in the main stem of Diamond Fork, and the passage of rainbow and stocked cutthroat through the Strawberry Tunnel, has diluted gene pools in Sixth Water and lower Diamond Fork. Bonneville cutthroat are known to occur in upper Diamond Fork (above Springville Crossing) and UDWR has implemented special fishing regulations to protect this population. Forest Service fisheries biologists believe there may be Bonnevilles in Chase Creek, Halls Fork, Fifth Water, Shingle Mill, Cottonwood Creek and Little Diamond.[15] Samples for genetic testing (to verify purity) have been collected in Cottonwood Creek and Little Diamond, but have not yet been analyzed. There is some suspicion that Bonnevilles may also occur in First Water, and that some natives may still be found in Sixth Water.

Amphibians Changes in grazing management, partial implementation of the CUP, and other changes in management have stabilized or improved amphibian habitat conditions. The completion of CUP and associated restoration, and implementation of other management practices in the drainage is expected to improve amphibian habitat conditions. Portions of Diamond Fork drainage were surveyed for amphibians in 1992 and 2000. These surveys found chorus frogs, but no boreal toads or spotted frogs. Boreal toads are generally found above 7,500 feet in elevation and the Diamond Fork drainage is generally below this; however, this species has sometimes been found at lower elevations in the general vicinity.

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[14] Data from Radant (1976) indicates that Fifth Water from the hot springs to the confluence with Sixth water may act as a refugium for leatherside chubs. He reported temperatures of 21 degrees celsius, which restricted trout numbers although the habitat was excellent. They electrofished one brown, four cutthroat, 67 mountain sucker, 22 dace, and 71 leathersides in a .25 mile station. There were no leatherside reported in the section sampled above the hotsprings and waterfalls.

[15] Martin and Shiozawa (1985) used electrophoretic techniques to distinguish between Yellowstone and Bonneville cutthroats. They tested fish from Shingle Mill, Chase, Fifth Water, Little Diamond, and Wanrhodes creeks. Of these streams only one stream contained a pure strain of cutthroats the others were hybrids or cutthroat crosses. Only the Chase Creek population tested as being pure. These fish are either Bear Lake Bonnevilles or Yellowstone cutthroat. These fish are most likely Yellowstone cutthroat (Shiozawa Pers. Comm.). Northern Bonnevilles are the strain of Bonneville cutthroat that would naturally occur.

Reptiles Reptile habitat conditions are stable or improving from historical conditions due to changes in resource management and land use. This trend is expected to continue with full implementation of CUP and further implementation of other management practices.

Beaver Beaver currently occur in First Water, Fifth Water, Sixth Water, Halls Fork, Chase, Shingle Mill, Diamond Fork, and Little Diamond. Terrain and flows are limiting in Little Diamond. A healthy beaver complex exists between Springville Crossing and Sawmill Hollow. In other areas where one would expect to find vigorous beaver complexes such as First Water, beaver do not appear to be thriving. These beaver complexes are not vigorous as willows are still in short supply due to overuse by cattle, encroachment of roads and related beaver control.

The downcutting that occurred with the removal of beaver earlier this century and overgrazing has decreased the riparian zone and the ability of beaver to flood a valley bottom. Beaver are now building dams in more confined channels that are more prone to be washed out in the spring as the force of the water is concentrated in the entrenched channel. Sediments are no longer being stored to foster expansion of the willow and riparian community. Less water is being stored in these dams for late season release leading to a likely reduction in the capability of these small headwater streams to support fish.

The introduction of beaver into Wanrhodes in the1940's did not succeed. Habitat in Wanrhodes may not be suitable due to the narrow canyon. The populations in Fifth Water, Shingle Mill, and one mile below and above Springville Crossing are vigorous with numerous dams and abundant willows. The beaver present in Sixth Water and lower Diamond Fork are bank dwelling non-dam builders. The numbers in Sixth Water appear to be low but are expected to increase with reduced flows possible due to completion of the Diamond Fork System. Beaver in Sixth Water are starting to build dams. These dams will benefit riparian vegetation by raising the water table.

Upland Game Upland game species such as the blue grouse and ruffed grouse are present in Diamond Fork. Ruffed grouse have declined in numbers nationally due to declines in aspen stands. Aspen is an important habitat element for grouse and is used for foraging and cover year long. Riparian/seep areas are also important for grouse as brooding and nesting habitat.

Twenty-five Rio Grande turkey were introduced into the assessment area in 1990. Augmentation to this population was completed in 1991 with 15 more turkey. There are over 300-500 turkey currently utilizing the assessment area. The UDWR now traps turkey in Diamond Fork for transplant to other suitable sites. Cottonwood forests along Little Diamond, Diamond Fork, and Wanrhodes Creeks serve as winter roost sites for this population. The turkey utilize riparian cottonwood trees to roost at night and juniper and oak trees to feed and rest during the day. Riparian areas are also important to the turkeys for nesting and brooding habitat.

Large Ungulates Currently the dominant big game species in Diamond Fork are elk and deer. The land between 4,500 and 7,500 feet elevation is currently winter and spring/fall transitional range for deer and elk. Elk calving areas occur in the Waters, Two Tom Hill, Billies Mountain, Shingle Mill, Timber Mountain and south side of Maple Mountain areas. Deer use the riparian corridors for fawning areas. There is also transitory use by elk from surrounding areas. Elk and deer winter range consists mostly of sagebrush/grass and mountain brush communities. Deer and elk are normally present within the assessment area during every month of the year.

The moose population in Diamond Fork has been growing since their reintroduction into the area over 20 years ago. Currently numbers range from 20 to 25. Moose are solitary in the summer utilizing riparian (willow) and aspen vegetation types. In winter, moose migrate up and down mountain slopes, packing down snow, which facilitates movement, then browse on woody plants such as mahogany, birch, aspen, maple and dogwood.

Neotropical Migratory Birds (NMB) A breeding bird survey in Diamond Fork was completed in 1996 (Ammon 1997) (See Appendix E for a list of species). Results from the study illustrated that riparian forest birds require a great diversity of micro habitats. The survey showed that NMB populations have a higher occurrence and greater species diversity in large stands of multi-layered forests with dense shrub understory and snags than in stands with low structural diversity. Because of the correlation between vegetative diversity and bird species richness, total bird abundance was highest in the upper half of the study area (Monk's Hollow through the Diamond-Palmyra campground and the campground through the Brimhall confluence) and lowest in the agricultural fields of lower Diamond Fork.

In addition to changes to NMB habitat due to loss of riparian forest, additional human activities in Diamond Fork have also been identified as affecting NMB habitat. Many bird species depend on riparian shrub thickets. Recreational and grazing activities can cause removal of the vegetation layers through trampling. Research has shown that with removal of each vegetation layer of a naturally multi-layered riparian forest, as many as 10 species of breeding birds are lost (Ohmart and Anderson, 1982).

Additionally, mature trees in riparian forests are affected if firewood gathering occurs. There is also an impact on the soil by compaction and erosion. Tree reproduction has been found to be significantly lower in areas used for camping than in control sites not used for camping (Marion and Cole 1996). Finally, the presence of humans near active bird nests has been shown to be detrimental to the birds' reproductive success. Most common reasons for nest failure after human disturbance were nest abandonment, parasitism and nest predation by brown-headed cowbirds.

Threatened, Endangered and Sensitive Species Presently, the following species are all listed as sensitive by Region 4 of the Forest Service. The ***northern goshawk*** is listed as a sensitive species due to loss of habitat through conversion of mature and late successional habitats to younger, even-aged stands. Goshawk population densities in the assessment area are unknown. There have been surveys conducted in the canyon and one territory has been identified. It is likely that if additional surveys were conducted additional territories would be identified. The ***three-toed woodpecker*** is listed as a sensitive species due to loss of habitat. Surveys have been conducted in the assessment area but did not identify any three-toed woodpeckers.

The ***flammulated owl*** is a sensitive species due to habitat loss through conversion of mature trees and late successional habitats to younger, even-aged stands. Recent surveys in southern Utah National Forests have indicated that flammulated owls are more abundant and widely distributed than previously thought. Surveys conducted in the assessment area did not identify the presence of flammulated owls. Since the surveys cover a limited area, it is likely that if additional surveys were conducted potential habitat could be found. The ***boreal owl*** is closely tied with mixed coniferous, aspen, Douglas-fir and spruce-fir habitat types. While some potential habitat does exist in the drainage, and boreal owls have been identified on the Heber Ranger District, surveys have not been conducted in the Diamond Fork drainage. ***Great gray owls*** use mixed conifer habitat types which include primarily the lodgepole pine/Douglas-fir/aspen zone and ponderosa pine, usually bordering small openings or meadows. There has been one reported sighting on the Wasatch-Cache and three on the Ashley National Forests. In Utah great gray owls are generally believed to be winter vagrants.

The ***spotted bat*** utilizes a variety of habitats including pinyon-juniper, open pasture and hay fields. They roost alone in rock crevices high up on steep cliff faces. Although there is habitat present in Diamond Fork, no spotted bats have been found. The ***Townsend big-eared bat***, utilizes caves, buildings, mine and bridge undersides for nursery and hibernation purposes. The Forest Service has not conducted extensive surveys in the assessment area. However, a recent survey at two adits (the horizontal passage from the surface in a mine) showed Townsends using one of the adits. There is no other data available to determine if they occur elsewhere in the drainage.

Potential habitat for ***North American lynx*** is found in the Uinta Mountains to the north and on the Wasatch Plateau to the south. Dense conifer stands above 7,000 feet provide habitat for snowshoe hare, the primary prey for lynx. This type of habitat is very limited within the assessment area. While there are no historic sightings of lynx in the Diamond Fork drainage, there is may be potential habitat based on connectivity of habitat between the Uinta Mountains and the Wasatch Plateau. ***Wolverines*** generally occupy the coniferous forest zones, but low elevation riparian corridors may be important winter habitat for the species. While potential wolverine habitat exists on the Forest, no wolverines were sighted in Utah between 1961 and 1983 (Ruggiero, et al, 1994). There have been unconfirmed sightings on the Ashley, Wasatch-Cache and Uinta National Forests. No sightings have been reported in the Diamond Fork watershed. ***Fishers*** prefer extensive, continuous canopies such as dense lowland forest or mature to old-growth spruce-fir forests with high canopy closure. The species is currently experiencing habitat loss due to forest fragmentation which reduces the size of available habitat and/or isolates patches of suitable habitat. Although there have been unconfirmed sightings of fishers on the Uinta National Forest, recent research does not indicate any confirmed sightings of fishers in Utah.

Predators All predators existing in Diamond Fork during the pre-settlement era exist today with the exception of the grizzly bear, wolverine, lynx, and wolves. This includes coyotes, black bears, bobcats, cougars, avian predators, nest predators, skunks, snakes, weasels, and mink. Cougars can be found in Diamond Fork and 4 to 12 individuals may exist in the drainage. Because deer are the main diet for the cougar, cougar populations increase and decrease with fluctuations in the deer population. Raccoon, a non-native predator, is common in the drainage. Red fox, another non-native predator, has also been observed there. These species may have detrimental effects on some native wildlife species.

A study conducted from 1986-1989 by S. B. Bates and UDWR showed that Timber Mountain is a critical breeding area of black bears. Black bears use a large portion of the Timber Mountain area as a breeding ground. According to UDWR the Timber Mountain area is unique in the State. They documented that both male and female bears congregate in this area in June and July to breed. Bears were trapped in Timber Mountain and then radio locations showed they dispersed to south fork of the Provo River, Strawberry Ridge, Fourth Water, Tie Fork, Maple Mountain and "Y" Mountain. Bears in this area show a definite preference for mixed dense stands of conifer. They use these stands for security areas, day beds and travel corridors. Nine collared bears were recorded within a one square mile radius on Timber Mountain.

The status of golden eagles in the Diamond Fork drainage is described in the *1999 Diamond Fork System, Bonneville Unit, Central Utah Project, Final Supplement to the Final Environmental Impact Statement*, as follows: "Surveys for nesting raptors in the Diamond Fork drainage area have been conducted annually since 1990 (Keller 1990) ... Six pairs of golden eagles are known to nest within Diamond Fork Canyon."

SOCIAL DOMAIN

PRE-EUROPEAN SETTLEMENT

The Dominguez-Escalante journal (Chavez and Warner 1976) gives us some insights into Native Peoples' use of the Diamond Fork area. First, the area seems to have been well known to the Ute guides who accompanied the expedition, and appears to have been a common travel route for Utes moving through their territory. However, Escalante notes no actual Ute peoples or camps along Diamond Fork or its tributaries. This may have been a function of the season of travel (late September), but archaeological surveys of the canyon bottom itself have not found very many Native American sites, and all of those have been temporary hunting and plant gathering sites.

The area that the 1776 observers found to be heavily populated with Utes was Utah Valley. This pattern had been in place for thousands of years, since Utah Valley offered so many advantages to Native Peoples. Utah Valley is the most archaeologically rich area in this part of Utah. Therefore, places like Diamond Fork probably functioned as occasional hunting and gathering locations -- and as important travel routes. As a result, the degree to which Native Peoples may have manipulated the environment there was probably limited to occasional burning off of vegetation to encourage more favorable wildlife forage.

HISTORIC

Native People The relative isolation of Diamond Fork from Utah Valley offered Utes refuge during periods of conflict with Mormon settlers. For example, Ute raiders during the Black Hawk War used the canyon as an escape route for themselves and stolen cattle in 1866. Spanish Fork settlers caught up with the raiders near the mouth of Little Diamond Creek, where a skirmish occurred. More importantly, however, the canyon was used by extended Ute families who were trying to avoid conflict with Anglo settlers. One of these band leaders, Wanrhodes, had a tributary canyon named after him. Area settlers remember Utes returning to the area from the Uintah Reservation on summer trips up until after the end of the 19th century (Connie Childes, personal communication, 1997).

European Settlers Although European settlement of nearby Utah Valley began in 1848, significant activity in the Diamond Fork area did not begin until the 1860's. This was because only a narrow Ute trail existed up Spanish Fork Canyon, which was described as a "morass of timber stands and beaver dams" (Merrill and Nielson 1981). Federal troops from Camp Floyd changed this in 1861 by constructing a rough wagon road up the canyon. In 1864 settlers from Spanish Fork combined their labor and built a 13 mile wagon road up Diamond Fork Creek. These roads were intended mainly to relieve timber shortages in southern Utah Valley settlements, where families still lived in dugouts for lack of logs or saw timber. Several small sawmill operations began cutting conifers in the canyon, and both sawtimber and firewood was gathered by residents from Utah Valley.

The opening of better roads also meant a steady increase in ranches to the southeast of Spanish Fork. The first road was at the confluence of Pole and Spanish Fork Canyons, built by a man named Sterling in 1865. The Spanish Fork Canyon road was further improved in 1875, largely in support of a narrow-gauge railroad that was completed up the canyon to the Pleasant Valley (Scofield) coal mines in 1877. These road improvements allowed easier access to even more distant grazing areas such as Diamond Fork.

Actual settlement of the Diamond Fork area did not begin in earnest until around the turn of the century. By then most Utes had ceased using the area, and population growth in Utah Valley was forcing families to look elsewhere for property. In addition, the Rio Grande railroad completed a much improved wagon road up Spanish Fork Canyon in 1883. The first known private land in Diamond Fork was about 1.5 miles up from Spanish Fork Canyon. It was patented in 1886 by Joshua Gay, who sold the land to his brother Moses in 1889. The family had a large complex of corrals and apparently kept cattle and sheep there during the summers (Merrill and Nielson 1981). By 1900 Moses was living in Thistle, and this pattern of using the canyon only seasonally was common amongst all the landowners to come.[16]

Grazing Use By the turn of the century overgrazing was a significant issue in Utah, and the then-young Forest Service commissioned Albert F. Potter to evaluate range conditions across the state in 1902. He recorded the following entry in his journal (Potter 1902:17-18).

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[16] In 1887 Robert McKell had acquired property at the mouth of Diamond Fork and was living there in a log cabin during the summer, raising cereal grains and running cattle in the hills nearby. He lived in Spanish Fork, and had other small farms in that area. The property was acquired in 1916 by John I. Hayes, who built a craftsman bungalow, named the place the "Mountain Rose Ranch", and lived there until his death in 1942. He raised oats, barley, alfalfa, wheat, sheep, cattle, horses, and turkeys. Myron Childs bought the ranch in 1953 and his family lived there until the early 1980's when the ranch was condemned by the State after reconstruction of Highway 6/50. The ranch was unusual as it was the only one lived in year-round, probably because of its close proximity to the highway.

Other Diamond Creek properties included a small summer ranch at the south end of Diamond Campground, patented in 1904 by William Pace (who also had a larger ranch at the mouth of Pole Canyon). Another large canyon operation was located at the mouth of Monk's Hollow. Here Andrew Pierce patented lands in 1920 that included a log cabin and corral complex. He raised wheat on property to the west of his cabin, and ran cattle during the summer. During the winter he and his family moved back to Springville where he was a carpenter. The property was sold in 1935 to R.W. Bradford, who lost it three years later in a tax sale, when it came under government ownership. An unusual piece of privately owned land was patented at the mouth of Brimhall Canyon in 1898 by Ruth Brimhall, a schoolteacher from Spanish Fork. She used the property for recreation, and likely had a small cabin there (Merrill and Nielson 1981).

Lands in Wanrhodes Canyon were under cultivation by the turn of the century as well, and several small ranching operations followed the typical canyon pattern of summer use. Several of these are still in operation, and serve as recreation cabins for the owners as well. Ranching also developed in Red Hollow, where the Diamond family began limited farming and ranching in about 1910. By the 1960's this operation had expanded considerably, and the family began raising even more hay at the site. This particular ranch was bought by the Bureau of Reclamation in 1986 as part of mitigation for the CUP.

"August 16, 1902 -- ....Crossed the divide to the head of Wanrhodes basin and went down the valley. Springville parties have about 1,000 acres fenced and have plowed perhaps 100 acres to plant in grain. The entire basin is an oakbrush country and has been very heavily grazed. . . Below this ranch the country looks pretty hard; the cattle are living entirely upon oak leaves. Went around to the head of Little Diamond Creek and went up that stream. There are a large number of cattle and very little feed, browsing mostly on the brush. From the top of the divide a good view of the entire country is had. There is a very small proportion of the country seen which has any pine and fir timber. It is all brushy and used primarily for grazing. . . Country is stocked with cattle subsisting principally on oakbrush. Sheep drive over the range every spring and fall and have helped to do up the feed. The soil is clayey and does not look like it ever did produce much grass, claims of stockmen to the contrary notwithstanding."

Clearly the Diamond Fork area was suffering from dismal range conditions, and this led to the inclusion of all non-privately owned lands into the Uinta National Forest in several different stages. The first acquisition included all lands roughly east of Palmyra Campground and the top of the divide with Hobble Creek in 1906. The second included Sections 28 and 33 at the head of Pace Hollow up Little Diamond in 1910. The third involved all of the remaining (non-private) lands in the lower part of the Diamond Fork Creek drainage itself. Many of these lands had previously been in private hands, and were bought back by the government after the devastating economic and climatic conditions of the 1930's. The last major transfer of lands into Federal management came in the 1980's and 1990's during expansion of the Central Utah Project, and included some bottomlands along Diamond Creek and Red Hollow.

After establishment of the Forest, many sheep were removed from the more critically damaged areas that drain into Utah Valley (primarily the Wasatch Front Range and lower to mid-elevational ranges). In 1918, about 1,500 head of cattle were moved to common use pastures in Strawberry Valley and Willow Creek as part of an attempt to reduce grazing pressure and impacts on the Diamond Fork Allotment. In 1953, the stockmen agreed to segregate cattle and sheep use, and cattle were placed in the Indian Creek drainage, while sheep were kept in Strawberry Valley and Willow Creek.

As of 1961, the allotment was still being grazed all season, although there were three units to be grazed. Common use still existed with two sheep allotments in a portion of the Soldier Fork area (Upper Tie Fork). One major stock driveway still crossed the allotment providing access to Strawberry Valley. Table 2-7 identifies livestock use from 1918 to present.[17]

[17] Information regarding sheep use on the Diamond Fork area is not available at this time.

Table 2-7. Livestock Use from 1918 to Present on the Diamond Fork Allotment (excluding the Strawberry Pastures)

YEAR	NUMBER	KINDS/ CLASS	SEASON OF USE	ANIMAL UNIT MONTHS (AUM'S)
1918 - 1945	est. 6,830 unknown	cow/calf ewe/lamb	4/15 - 10/31 same	est. 58,600 unknown
1946 -1950	4,293 - 5,028 unknown	cow/calf ewe/lamb	4/15 - 10/31 same	25,489 - 31,625 unknown
1951 - 1953	4,400 - 4,937 2,050 - 2,185	cow/calf ewe/lamb	4/15 - 10/31 same	27,675 - 30,697 416 - 888
1954 - 1961	4,581-4,968 unknown	cow/calf ewe/lamb	5/13 - 6/1 through 8/15-9/14 same	27,432 - 30,779 unknown
1962	4,606 3,054	cow/calf ewe/lamb	6/3 through 10/8 same	25,335 6,550
1963	3,786 3,907	cow/calf ewe/lamb	6/1 through 9/30 same	19,624 5,157
1964	2,914	cow/calf	6/1 through 9/30	15,348
1965 - 1974	1,923-2,082	cow/calf	6/1-6/16 through 9/30	9,619 - 10,573
1975 -present	1,906 - 2,437	cow/calf	6/11 through 9/30-10/30	9,392 - 13,251

Between 1962-65 stocking rates were reduced 20 percent per year to affect an overall reduction of 60 percent. The reduction was initiated as part of the range improvement management plan. Season of use was reduced, too, delaying the on-date until June 15.[18]

Timber Use There is limited merchantable timber in the area, and so the area has only had a small timber harvest program with infrequent sales. Some timber cutting was done historically in Sawmill Hollow and other areas, and timber sales were held in both Halls Fork and Timber Mountain in the 1970's and again in the Timber Mountain in the 1990's.

[18] This season of use was consistent until 1982, at which time the Grazing Association was granted an extension of use from 10/01-10/15. This extension had been granted every year through 1986, and then from 1989 through 1993. No extension was granted in 1987 due to drought conditions. The extensions were granted for two reasons. First, trying to move cattle in late September during hot weather is nearly impossible. Second, by the time the Association had moved all their cattle from the first unit to the second unit, cattle only had about 2 weeks in which to utilize the second unit before they needed to be removed from the allotment all together. This left unused forage in the second unit, which allowed for granting the extensions.

Water Use In addition to grazing, another resource that had been stretched to its limits was water. As a result, residents in south Utah County heavily promoted a major reclamation project to bring water over the Strawberry divide. When the Bureau of Reclamation was created in 1902, the water users lobbied for the Strawberry Valley Project, which was begun in 1905. The Strawberry Water Users even supported the project by building a road up to the head of Fifth Water themselves. The road and telephone line to the construction camp near the head of the drainage were largely completed in 1906. The camp was also begun that summer; buildings included a store, hospital, cabins, project office, and powder house.

Work on the tunnel through the mountain itself was going so slowly in 1907 that labor was shifted to the diversion structure, powerhouse, and canal. When hydroelectric power became available in December of 1908, new electric drilling equipment went to work on the tunnel. Despite huge cost over-runs, construction of the entire system, including the Strawberry Dam, began in earnest in 1910. Work on the east portal of the tunnel began in 1911, and the two ends of the tunnel met on June 20, 1912. The system was ready for use in 1912 but the first irrigation water was not let through the tunnel until 1915. The construction camp at the West Portal was dismantled that same year (Merrill, Snyder and Anderson 1982).

Recreation Use Primary use of the canyon had been for livestock grazing with some occasional mining taking place over the years. However, by 1933 recreational use of the canyon had become increasingly important. At the site of the old Pace homestead at the mouth of Little Diamond Creek and Wanrhodes canyons, potatoes, hay and grain were raised by Dell and Mose Beckstead from 1907 to 1933. At that time the Palmyra Stake of the Church of Jesus Christ of Latter-Day Saints purchased their farm. The stake turned the area into a recreational site for Church activities such as summer father-son outings. The church built a popular baseball diamond east of the campgrounds where teams from Salem, Lakeshore, Palmyra, and Spanish Fork Wards competed in a championship baseball series each summer. Many church picnics and parties were held in the "Beckstead," now known as the Palmyra camping area, with baseball being a priority activity. It was estimated that 2,520 campers and 17,500 picnickers had used that area in the year of 1940 (Isbell, 1972). Unable to finance their improvements during the depression, the Palmyra Stake gave up plans for continued development of the recreation area and in 1938 sold their property to the Forest Service at a reduced price (Jackson et al).

Hawthorne, one of four campgrounds constructed in Diamond Fork, was built in the early 1930's by men employed in government work programs. The other campgrounds, Coal Mine and Three Forks, were constructed in the 1930's and upgraded twenty years later in the 50's. They all were maintained and operated until the 1970's when low budgets justified their obliteration. In 1963 Camp Diamond was constructed adjacent to the Palmyra campground.

PRESENT

Grazing Use In 1994 the allotment management plan (there is one allotment management plan for the entire assessment area) was revised, and the season of use and stocking rates were modified to affect a 20 percent reduction in overall use. Today the Spanish Fork Livestock

Association is permitted to run a total of 2127 cow/calf pairs from June 11 through Oct 15 (11,700 AUMs total). Through implementation of the allotment management plan, grazing use is more intensely managed through established standards and guidelines as per the current Forest Plan.

Timber Use Today, reasons for cutting timber have changed to primarily vegetation management rather than simply providing lumber. It is possible that future sales might occur which meet wildlife habitat and vegetative management objectives. There is no commercial firewood program in the area, and like the timber program, firewood cutting would probably only be done to meet other management objectives.

Mining Use No active mining is currently being done in the area, although there are a few old phosphate mine claims on the Forest. These lands are currently under lease, but given the current market, it is not likely that these will be developed. There is a clay pit on private property in the area that is currently open, but it is only under lease for another year.

Oil and Gas Use This is a low potential area for the development of oil and gas resources. Several drainages were tested with drill holes in the 1960's including Red Hollow, Ray's Valley, and Hall's Fork. Although some natural gas, in particular, was found in several of these wells, none of the showings were particularly significant. Since these wells were located in the most promising target areas, there is little indication that the industry will want to return to the area for more exploration or development (Ashley and Uinta National Forest 1996:3-8). The primary legacy from these projects was increased or greatly improved road access into these areas.

Private Land Development There are currently cabins and year-round homes on private lands in Diamond Fork proper, Wanrhodes, Patrick Ranch, and Little Diamond. These are an out-growth of the ranch and farm operations that have existed in the canyon since the turn of the century. Many of these cabins are used as recreational retreats, although some families live in them most of the year. County zoning currently requires a 40 acre plot for each cabin site.

Water Use In 1956 the Central Utah Project (CUP) was authorized by Congress as a way to develop a portion of Utah's allocation of Colorado River water. The CUP plan was to divert water from the south slope of the High Uintas and bring it to areas in the Uintah Basin and to the Wasatch Front. The part of the project that would transport south slope water stored in Strawberry Reservoir through Diamond Fork was called the Diamond Fork System. It updates the water delivery scheme developed in the early 1900's as the Strawberry Valley Project.

Under the original Strawberry Valley Project, water from Strawberry Reservoir was conveyed through Strawberry tunnel to the head of Sixth Water Creek. Under the CUP, the Syar tunnel and Sixth Water Aqueduct were completed in 1996. Water from Strawberry Reservoir including Strawberry Valley Project water now travels through the Syar Tunnel and exits the Sixth Water Aqueduct 6 miles downstream from the old Strawberry Tunnel outlet. The Syar Tunnel and Sixth Water Aqueduct has resulted in the removal of high flows from the upper 6 miles of Sixth Water Creek and provides for the possibility of rehabilitating upper Sixth Water.

The old Strawberry Tunnel is used to convey minimum instream flows to the head of Sixth Water Creek and may be used during times of emergency to convey up to 200 cfs of Strawberry Valley Project and CUP water. If the maximum flow of 200 cfs is delivered through upper Sixth Water on a frequent basis or of significant duration, and at the wrong time of year, it will lessen or negate the success of any restoration activities in Sixth Water and Diamond Fork.

The completion of the Diamond Fork System will bring on average up to 86,100 acre feet of CUP water and 61,500 acre feet of Strawberry Valley Project water per year through the Diamond Fork drainage through 2010. In order to deliver this amount of water and also to restore habitats from impacts of the past on local streams, a series of pipelines, tunnels and aqueducts have either been built or are in the planning stages to be built to remove the majority of the water from the stream channels. In the fall of 1997, a 510 cfs pipeline was completed from the mouth of Diamond Fork to Monks Hollow. At this time planning and design are underway to connect this pipeline to the Sixth Water aqueduct via a tunnel and/or additional pipelines. One of the main objectives of the operation of the Diamond Fork System is to provide flows that will allow mitigation or restoration of past impacts from the Strawberry Valley Project. The selected flow regime, its magnitude, timing and duration, is among the most important factors in allowing restoration of the Diamond Fork channel and riparian resources.

Recreation Use Today, there are a number of recreation activities and developments that occur in Diamond Fork, and this accounts for the majority of the area's human activity. Overall recreation use has been increasing in Diamond Fork at a rate greater than 15 percent per year. Diamond Fork had an estimated 600,000 recreation visitor days (RVD)[19] in 1995.

Recreation use is a dynamic, and sometimes unpredictable, influence on the landscape. New developments like mountain bikes and ATV's can change use patterns in short periods of time. The local economy, the amount of available free time, and public demands and expectations change over time. As rural areas become urbanized and populations increase the types of recreation uses and the overall amount of use also change. The influence and effects of recreation on the landscape is further complicated by the fact that what is perceived as an "acceptable level of impact" varies with peoples's attitudes and perceptions. It is difficult to determine these boundaries and to develop criteria for what types and levels of uses should be allowed. Concepts like recreation opportunity spectrum (ROS), which is a way for resource managers to define a variety of settings managed to produce different recreation experience opportunities, can be established. The Diamond Fork analysis area does not have current ROS determinations, and even with direction provided in the Forest Plan, specific levels of acceptable use have not been clearly defined. Year-round recreation, in a broad spectrum of use patterns, occurs across the landscape.

[19] A recreation visitor day (RVD) is defined as one person spending one 12-hour period of recreation activity on the Forest. RVDs for recreation facilities are estimated by determining days of use for the facility and the average daily use of the facility for that time period.

Up until the fall of 1999, the Uinta National Forest operated two developed ***campgrounds***, Camp Diamond and Palmyra, in Diamond Fork. The Camp Diamond and Palmyra campgrounds were closed in the fall of 1999 for reconstruction. The two campgrounds will be consolidated into a single campground connected by a bridge spanning Diamond Fork Creek. Individual campsites (single-and double-family units) will be reconstructed with new facilities and infrastructure primarily on the existing campground layout. Campsites and loop roads within the 100-year floodplain will be removed and reclaimed. Group campsites will also be removed. The total capacity of the campground will be reduced by approximately 30 percent. Reconstruction of the Diamond Campground is scheduled to be completed in the fall of 2000. A new group site campground will be reconstructed at another location within Diamond Fork in a more favorable location out of the riparian corridor.

Dispersed camping is a very popular use of the area with most sites in the drainages adjacent to the stream. There are some attendant resource issues such as sanitation, trampling of vegetation, and compaction of the soil. Many of these resource impacts are due largely to people being concentrated in small areas, rather than simply being a function of the large numbers of users. Additionally, many sites are used all summer with no opportunity for rest or recovery. Riparian areas are the most popular areas to camp because of the shade, cool water, and easy access off the roads that they provide. Other areas used for dispersed camping are the Ray's Valley road corridor and some large group areas in Wanrhodes, where group use is fairly constant all summer and through the hunting season. Loss of the group sites in the developed campgrounds has displaced some large group use to this area. All of the dispersed camping areas are used most intensively during the hunting season. Horses and ATVs in these hunting camps increase the level of resource impacts. Also, soils are often wet at this time of year which adds to the level of resource damage.

There have not been large numbers of ***ATV/OHV*** users in the past. However, over the last five years this use has increased dramatically and there are now more than can be accommodated under current management. For example, the designated Monk's Hollow ATV area contains no formal parking or toilet facilities, or ways to control inappropriate use (there are only a few barrier fences). Also, there is only one trail in that area. The Forest has a travel plan which directs ATV and motorcycle use. Under this plan, ATV riders can use the roads in Diamond Fork above Springville Crossing, the Monk's to Long Hollow trail, a connector trail off Teat Mountain to Tank Hollow, and the Hall's Fork Road. ATVs cannot travel cross-country off designated roads. Cross-country travel has not been observed to be extensive. However, use on non-designated roads and trails is beginning to increase. ATV users are riding into Green Swales and up onto Timber Mountain. Previously used two-track trails in Red Hollow have been closed for CUP wildlife mitigation, but some illegal use is still occurring..

Four wheel driving is another activity pursued on the area's less developed roads, such as Hall's Fork, West Portal (Dip Vat), and Strawberry Ridge. Four wheel driving clubs have used these loops for outings, and have requested that the roads be kept at current levels of maintenance. Some illegal use (i.e., driving off-road) is occurring along the main Diamond Fork road corridor, causing damage to recently revegetated areas, and in more remote areas, such as upper Wanrhode's and Red Hollow.

Mountain biking has become a relatively common recreational pursuit in the Diamond Fork area. The most popular trails at present are the Waters Trails (especially the Fifth Water trail), the upper end of Hall's Fork, and on the high road to Hobble Creek (bikers often come down the Wadsworth Trail and then back over Springville Crossing to Diamond Fork). This trail complex is one of the most popular mountain biking areas on the Forest. Like other trails in the area, it is not specifically designed or managed for mountain biking use. The trail complex also does not include parking or sanitation facilities designed to accommodate these levels of use.

Extensive ***hiking*** occurs only in some areas of the Diamond Fork watershed. These trails include the Waters (particularly Fifth Water), a portion of the Great Western Trail, the West Portal trail, and the Three Forks. The trail head at Three Forks is heavily used, and has associated sanitation problems and resource damage from people parking outside designated areas and driving across the river. The Fifth Water trail head in Ray's Valley is receiving more and more hiker use. These popular trails and trailheads involve some conflicts between bikers, horseback riders and hikers. During the spring and summer the Fifth Water trail also serves as a livestock trail and conflicts with other users is pronounced when cattle are moving up or down the trail.

There are no facilities in the area specifically for ***horse users*** to park, unload, or corral their stock, and no areas in developed campgrounds designated for horse use. Despite this, there is quite a bit of horse use in the area. There are presently some user conflicts between hikers mountain bikers on popular trails.

Fifth Water ***Hot Springs,*** which is an undeveloped site, has become a very popular recreation area in the last two decades. Use is heavy at some times. There are sanitation problems around the springs and also sometimes conflicts between users who want different kinds of experiences at the springs (clothing vs. nudity, developed hotpot vs. natural stream structure, etc.).

A large part of the use associated with Three Forks trailhead is tied to hot spring users. The ranger district has plans to improve trailhead facilities and trail systems. Work on these projects is projected to be completed in 2001.

Rock climbing and rappelling is another category of activity that is confined to a specific area, which is the Red Rocks. Use has not been extensive, although there have been some resource impacts, including graffiti, vegetation trampling around the rocks and the general effects of partiers in the flat below. The Red Rocks area is not only used for rock climbing, it is also a popular day-use site. Its unique scenic qualities draw many people to the area. A series of user-created trails runs through the area. This is also an undeveloped site with only a rail fence in place to mitigate parking issues.

Other activities are also pursued in the Diamond Fork area that are restricted to road or stream corridors. Scenery and wildlife viewing and general driving for pleasure are relatively common uses of the canyon. Current use of the area by ***anglers*** is low to moderate. The Utah Division of Wildlife Resources currently considers Diamond Fork to be a Class 3 fishery. However, watershed conditions and habitat in the stream are improving and the fishery is beginning to respond. The fishery is expected to continue to improve with full implementation of the Diamond Fork System, and the stream will eventually likely be considered a Class 2, or even a Class 1 fishery (Charlie Thompson, UDWR, personal communication, 2000).

Environmental Education Use The close proximity of Diamond Fork to many schools makes this area ideal for environmental education and outdoor classroom activities. The area is currently visited by about 500-1000 children per year. A more formalized "Youth Forest" is now being organized, which would create an area on the Forest where youth would be invited into the day-to-day management of the National Forest. Operating within the parameters of the Forest Plan, the Youth Forest would provide self-discovery opportunities for students to deal with issues facing public land managers.

CHAPTER 3

ASSESSMENT OF RESOURCE AREAS RELATIVE TO THE PROPERLY FUNCTIONING CONDITION

This chapter identifies for the physical, biological and social domains the status of resources relative to their properly functioning condition (PFC). "Properly functioning condition" refers to a range of conditions where an ecosystem, at any temporal or spatial scale, is dynamic and resilient to disturbance in structure, composition and processes of its biological and physical components. Included in this concept is a threshold point, below which the system is at risk of losing the integrity of its physical and/or biological components, and above which it falls into a range of sustainability.

The properly functioning condition information is presented in a series of tables. Note that for purposes of analysis the streams are divided into Lower Diamond Fork (includes the main stem of Diamond Fork downstream of Three Forks), Upper Diamond Fork (includes main Diamond Fork upstream of Three Forks), Lower Tributaries of Diamond Fork (includes Little Diamond, Wanrhodes Creek, Red Hollow, Dry Canyon, Monk's Hollow and Brimhall Canyon), and Upper Diamond Fork Tributaries (includes Cottonwood, the Waters, Dip Vat, Yellow Jacket, Sawmill Hollow, Shingle Mill, Chase Creek and Halls Fork).

This chapter includes detailed descriptions of properly functioning condition indicators for each component of the landscape.[1] Following the PFC information is a discussion which describes how the resources have been influenced by past activities (the ***assessment***). An estimate of resource ***trends*** was made assuming the continuation of existing management. Based on anticipated trend, potential ***risk*** was identified for each resource area. Risk is relative to how existing conditions compare to properly functioning condition.

A status report of wildlife species, relative to a PFC, is not included in Chapter 3. Interdisciplinary team members agreed that it was not feasible to describe PFC indicators for each wildlife species that occurs within the landscape, which includes several hundred birds, mammals, reptiles, amphibians, fish, and aquatic and terrestrial and invertebrates. If the properly functioning condition is met for the various vegetative communities that wildlife depends upon, it is assumed that wildlife will have their needs met. However, this does not mean that if the

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[1] Note that "pre-settlement conditions" have been used to develop the PFC indicators. The reader should not infer that these indicators are the only indicators of PFC, nor that they necessarily indicate a target, or that one has been identified.

that determine the existence and population levels of wildlife in the drainage. For example, if the properly functioning condition could be met for riparian habitat, it is assumed that neotropical migratory birds would benefit and perhaps increase. However, because of negative influences that might occur outside of the assessment area, neotropical migratory birds could still decline in Diamond Fork. Wildlife species impacted if PFC isn't met are identified in the assessment following the tables under ***risk***.

PHYSICAL DOMAIN

Table 3-1 Riparian, Hydrologic and Channel Morphologic Conditions

LOWER DIAMOND FORK (BELOW THREE FORKS)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Composition** Primarily cottonwood dominated communities; multi-layered canopy with understory of younger age classes of cottonwood, willow, other shrubs and herbaceous species.	**Composition** Lack of cottonwood regeneration and younger age classes. Dominance of coyote willow in lower three miles. Cottonwood regeneration occurs only in largest flood years (roughly 30 year interval). Changes in floodplain morphology and flow regime favor coyote willow & exclude cottonwoods in some sites.	**Timing of Peak** Usually near mid-May (mean date: May 13 ± 17 days) **Bankful Flow** [2]Average of 145-155 cfs near Red Hollow, 180-185 cfs near Brimhall, 190 200 cfs at mouth of canyon	**Timing of Peak** Highly variable; annual peaks larger than natural runoff; can occur between late-April and end August. **Bankful Flow** 440 - 460 cfs throughout (from Syar Tunnel outlet to canyon mouth)	**Channel Width** 25-35 feet at bank full **Floodplain Width** 100-300 feet increasing in width as it progresses downstream.	**Channel Width** 100-200 feet below Brimhall **Floodplain Width** Most historic floodplain features destroyed downstream of Brimhall Canyon. In lower 3 miles "braid-plain" 300-500 ft wide has developed.

[2] Bankful is considered the point at which the stream reaches the level of its floodplain. Tribey (1997) cites bankfull flows of 215 cfs and 268 cfs, which were developed based on regional regression equations (Berwick 1962). Based on further evaluations by the Uinta N. F., these numbers approximate the magnitude of the mean annual flood at each site, which typically is 30 to 60 percent larger than the bankfull flood for streams in central and northern Utah. The table values above are partially based on reconstruction of the record of natural annual flood peaks for the period 1904-1998 and the Forest Service believes these are a more accurate representation of the natural bankfull flows in Diamond Fork.

LOWER DIAMOND FORK (BELOW THREE FORKS)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE					**Stream Gradient** Approximately .5%-1.0% above Brimhall; near 0.5% below Brimhall	**Stream Gradient** 25-50% higher than PFC
					Shaded Channel Riparian canopy obscures channel in some locations.	**Shaded Channel** Shading reduced upstream of Brimhall; reduced or eliminated below Brimhall.
					Bank Stability Banks with erosion occurring mainly at outsides of meander bends.	**Bank Stability** Banks unstable, rapid channel migration, high induced sediment load, lower 3 miles is braided (D channel type).
					Pools and Riffle Rhythmically spaced; pools roughly every 7 channel widths.	**Pools and Riffle** Spacing completely altered; pools filled or eliminated.
					Width /Depth Ratio 10-40	**Width/Depth Ratio** 50-190
					Sinuosity 1.5-2.0 below Brimhall	**Sinuosity** 1.1 to 1.3
					Pools 25-50/mile	**Pools** 12/mile, 3/mile in main channel

LOWER DIAMOND FORK (BELOW THREE FORKS)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
COMPOSITION	Plant communities represented are dominated by native hydric species (all layers). Stream edge typically dominated by sedges with willows behind, then cottonwoods.	Coyote willow has increased in dominance on some sites and is excluding cottonwoods. Sedges absent along greenline (stream edge) in many areas. The invasive exotic shrub, tamarisk, is found in scattered patches throughout lower Diamond Fork.	Water quality, nutrient, temperature and sediment levels are within normal ranges for local geology and contribute to high quality fish habitat.	Water quality is degraded by increased sediment load Phosphorus (P) and sediment levels exceed water quality standards.	Woody debris contributes to pools, and protects banks. Streamside vegetation filters sediment and stabilizes banks during floods. Shade maintains suitable temperatures.	Woody debris occurs infrequently; high flows remove most material; input of new material is limited by availability of large mature trees. Bank stabilizing vegetation is reduced. Overhanging vegetation is greatly reduced below Brimhall. Temperatures in Diamond Fork are elevated over natural levels.

LOWER DIAMOND FORK (BELOW THREE FORKS)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
DISTURB-ANCE	Minimal carryover of disturbance features into following years. Although dynamic, plant communities and hydrologic functions persist or recover rapidly. Fire occurring in adjacent vegetation types would also burn into riparian/wetland.	Cottonwood forest is on long-term downward trend. Riparian forest loss is greater than the rate of regeneration. Change in floodplain height and flow variability during growing season excludes cottonwoods from some sites; willow species tolerant of water table fluctuation (e.g. coyote willow) appear to be favored; active channel margin depresses sedge communities (e.g. Nebraska sedge) capable of providing root support. No fire impacts in riparian in recent decades.	**Annual Runoff** Dominated by spring snowmelt; snowmelt runoff begins in early April, peaks in mid May and continues to the end of June. Peak flows on tributaries vary with aspect and elevation. **Spring Flood Events** Large spring flood events occur approximately every thirty years. Floods create new habitat but do not cause widespread alteration of riparian vegetation composition or floodplain morphology. **Thunderstorms** Annual peak is from a late season thunderstorm every 1 in 10 years.	**Annual Runoff** Irrigation flows larger than natural flows in all but largest flood years. **Spring Flood Events** still occur but are often masked by irrigation flows. Largest floods cause extensive damage to channel and floodplain. **Thunderstorms** Peaks occur with moderate frequency, but are not large relative to irrigation flows.	**Bank Full Flows** Bank full flows occur on average 10-20 days per year. **Sediment** Pulses of sediment from 1st & 2nd order drainages impact stream channels locally, for short duration. **Two-Ten Year Flood Events** determine channel size, transport sediment, maintain pool habitat, and build banks. **Fifteen-Thirty Year and Greater Events** impact channel form, scour and transport sediment. Large flood events do not cause widespread change in channel form or type.	**Bank Full Flows** Normal bankfull flow exceeded 100-140 days/year. **Sediment** High sediment load produced by lateral channel migration and bank erosion. **Two-Ten Year Flood Events** masked by irrigation flows, have little effect on channel form. **Fifteen-Thirty Year and Greater Events** cause major changes in channel form and position, mobilize very large amounts of sediment.
PATTERNS	Riparian vegetation forms a continuous corridor across the entire width of the floodplain.	Riparian vegetation is limited to a narrow fringe along the channel. Below Brimhall Canyon, areas of former riparian forest on margins of valley have been converted to upland.	60% to 80% of annual runoff occurs between early May and late July in response to spring snowmelt; periodic small flood peaks in response to summer thunderstorms.	80% or more of annual runoff occurs between late May and end of August; flow varies constantly in response to irrigation demand.	Channel is dominantly single-thread, meandering (Rosgen AC@). Width/ Depth may be less than 10 in some reaches; channel migration rate is 1-3 ft/year on average.	Channel is strongly braided (Rosgen AD@) and unstable. Width/Depth > 130 in some reaches. Main channel moves 40 ft/year in some sites.

RIPARIAN ASSESSMENT

Much of the riparian forest along the margin of the Diamond Fork floodplain was cleared for agricultural use prior to 1939. Since 1939, the area of mature cottonwood forest along Diamond Fork Creek downstream of Brimhall Canyon has declined by approximately 85%. This change is primarily the result of prolonged high flows resulting from the transbasin diversion of irrigation water from Strawberry Reservoir to the Bonneville Basin. High irrigation flows, combined with high sediment loads, resulted in high rates of bank erosion and lateral channel migration. The reduction of channel and bank stability allowed the large magnitude floods in 1952, 1983 and 1984 to cause major changes in channel and floodplain morphology. Also, changes that previously occurred only during relatively large floods, now occurred throughout the duration of the irrigation season, resulting in nearly continuous, rapid channel movement.

Cottonwoods and willows release their seed in late spring to coincide with the normal decline of stream flows during the spring snowmelt. Seedling establishment normally occurs on bare moist sites with newly deposited fine sediment. Young seedlings are highly sensitive to changes in water elevations and flooding and can be killed by scour and/or inundation. The transbasin diversions have resulted in a stream flow regime that prevents the recruitment of willows and cottonwoods because, on average, irrigation flows are higher, and occur later, than the natural spring flood peaks. In lower Diamond Fork, the peak period of cottonwood seed dispersal occurs approximately from mid- to late-June. Peak water demand typically occurs during the last week of June to the first week of July so that most or all of the surfaces on which cottonwood seedlings might establish are under water. The result has been that cottonwood establishment is limited to infrequent large flood events (as few as 3 occurrences during the period 1915-1997), when it would be expected to occur in the majority of years under normal conditions.

At the same time, the susceptibility of the channel to major changes during large flood events, combined with the nearly continuous channel movement under the irrigation flow regime has resulted in a long-term downward trend in forested riparian habitat. The main exceptions to this trend are the *apparent* short-term recovery of channel and riparian areas following the large flood events of 1952 and 1983-84 and those areas where coyote willow (*Salix exigua*) has become dominant. Coyote willow appears to be more tolerant of fluctuating water tables during the growing season than cottonwood and is dominant in areas where summer water tables are higher--for example, in the reach immediately above Lavanger Hollow. This reach remains highly susceptible to change during high flood events due to the high in-channel sediment load and the extensive occurrence of high exposed banks.

The remaining cottonwood forest in Diamond Fork supports a diverse, multi-layered understory of grass, forb and shrubs. The loss of cottonwoods in the canyon necessarily included the loss of associated understory species as well. Coyote willow stands are considerably different from cottonwood in composition, structure and ecological function. Coyote willow forms dense stands that are homogeneous in structure with little understory. It is restricted to streamside areas and is not likely to expand across the width of the valley bottom. Because of its small stem size, it does not contribute large woody debris to the channel and therefore does not influence the development of channel structure (e.g development of pools) in the same way as cottonwood.

The area of cottonwood forest above Brimhall Canyon has declined by 25-50% since 1939. Irrigation flows have had a large impact on riparian habitats in this reach but this area has had additional impacts due to road, campground construction and grazing and has, in general, had more impacts from recreational and other uses. Most recently, construction of the Diamond Fork road and pipeline resulted in the loss of more than 10-14 acres of forested riparian habitat.

RIPARIAN TREND

The present trend for riparian habitat in lower Diamond Fork is downward, especially for areas of mature cottonwood forest. There has been a noticeable upward trend in recent years, but this is only relative to the extensive damage that was caused by the 1983 and 1984 floods as existing sites with young and early-mature trees are at risk due to channel migration. A similar cycle of damage-recovery occurred following the 1952 flood and the expectation is that the same cycle will occur with the next large flood. Even though the 1952, 1983 and 1984 floods were the primary events in which cottonwood establishment occurred along lower Diamond Fork during the period 1915-1997, the decrease in mature cottonwood forest between Monk's Hollow and the mouth of the canyon is 36 percent since 1956 and fifty-three percent since 1939. Downstream of Little Diamond Creek the decrease is more dramatic: fifty-two percent since 1956 and seventy-four percent since 1939 (see Table 2-4). A continuation of this trend is expected under the current flow regime, which will continue through about 2003, at which time the Diamond Fork System of the CUP will be completed and operational.

Change in the present trend is largely dependent on future operation and management of the Diamond Fork System of the CUP. As currently proposed instream flows would be maintained downstream of Red Hollow (legislatively mandated at 60 cfs in winter and 80 cfs in summer). Substantial flexibility exists to operate the Diamond Fork System to maintain flows in lower Diamond Fork within the range of minimum to historic levels. The main ecological objective identified for operating the Diamond Fork System has been to remove the season-long high flows from the stream channels. Removal of high magnitude flows from lower Diamond Fork removes the main mechanism that is currently responsible for the lack of cottonwood regeneration but may not by itself undo the damage caused by 85 years of trans-basin diversions. Depending on location, most surfaces suitable for cottonwood recruitment have either been removed by erosion and lateral migration of the channel or isolated from potential floods by channel incision. Very few locations exist that have retained the pre-irrigation floodplain topography.

In braided sections, exposed gravels within the present bankfull stage will be sites of vegetative establishment. The majority of these sites will be within 1 foot or less of the bankfull stage and may be more suitable for species adapted to wetter conditions such as coyote willow or yellow willow which are currently dominant in much of lower Diamond Fork. For example, successful cottonwood establishment occurred following the 1983-84 floods on surfaces within 2-4 feet of the bankfull stage while willow remained dominant on surfaces upstream of Lavanger Hollow on sites that are generally within 0-2 feet of the bankfull stage. Also downstream of Lavanager Hollow, mature cottonwoods established following the 1952 flood are dead or dying in response to elevated water tables cause by river aggradation.

For much of its length, lower Diamond Fork has incised its channel by anywhere from 2 to 6 feet. Floodplain surfaces that may have been reached by common floods prior to channel incision and which would be potential sites for cottonwood establishment will either be flooded much less frequently or not at all. Increased drought stress following change in the flow regime and completion of the Diamond Fork System could adversely impact some existing trees.

Successful cottonwood regeneration on lower Diamond Fork will require:

- availability of bare, moist sites during cottonwood seed dispersal that are free from competition by more aggressive species (e.g., coyote willow),
- gradual water table decline following seedling establishment; and,
- reconstruction of floodplains by sediment deposition and vertical accretion.

In currently braided reaches, channel narrowing by sediment deposition will create extensive areas for revegetation by riparian species. On sites already dominated by coyote willow, competing vegetation may become the main factor limiting successful cottonwood regeneration.

The Forest is planning to replant the lower portions of some of the former agricultural lands to cottonwoods. This effort is intended to increase the overall number of acres of riparian forest in the lowermost reaches of Diamond Fork. If initial efforts are successful, and funding is available, the project could be expanded. Only a few acres of replanting will be implemented in this first stage. Further riparian restoration efforts will be considered once the Diamond Fork pipeline is complete and new flow regimes are established and their effects understood.

RIPARIAN RISK

High channel migration rates and alteration of the natural hydrology will continue to suppress development of riparian forest and favor species which are more tolerant to disturbance and excessive fluctuations in streamflow during the growing season. Following completion of the Diamond Fork System in approximately 2003, operation of water delivery facilities in the watershed will provide opportunities to achieve alternate hydrologic regimes to help recover riparian conditions too more properly function conditions.

HYDROLOGIC ASSESSMENT

The natural peak (average bank full) flows for lower Diamond Fork are in the range of 150 cfs (at Red Hollow) to 200 cfs (at the mouth of the canyon). On average, Spring runoff would begin in mid to late-April, peak in mid-May and recede to base levels by late July. Flows in excess of 200 cfs would occur an average of 10 to 20 days each year, but might not occur at all in some years. Under current conditions, due to irrigation releases, average annual peaks are about 450 cfs, usually beginning after the natural spring runoff has already occurred. Annual peak flows can occur any time between May and the end of August. Flows fluctuate throughout the growing season, but may exceed 200 to 250 cfs for periods up to 140 days each year.

HYDROLOGIC TREND

Although altered stream systems normally reach equilibrium with their altered environment, this has not occurred in Diamond Fork even though many of the impacts on the watershed began many years ago (i.e., heavy historic grazing occurred in the late 1800's and early 1900's, agricultural clearing occurred in the early 1900's, and stream flow augmentation began in 1915). The timing, magnitude, and duration of flows compared to the natural flow regime has led to continually affected sediment transport characteristics, channel and bank stability, and channel geometry. Consequently, the channel has been and continues to be inherently unstable and therefore, the hydrologic trend is considered to be downward. Completion of the Diamond Fork System, under currently proposed flow regimes, will remove the main mechanism responsible for this trend. However, this alone may not undo the damage caused by 85 years of augmented flows. Consequently, hydrologic conditions are expected to improve but the rate and extent is uncertain.

HYDROLOGIC RISK

Under the present flow regime, sediment delivery to the channel will continue to primarily result from bank erosion resulting from lateral channel migration and from degradation of the channel bed. High sediment loads will adversely impact fish habitat and water quality. Continued stream flow fluctuations with high velocities during summer months and low flows with limited pools and holding cover in winter restricts fish populations. Recruitment of riparian vegetation (i.e., willow and cottonwood), stream channel stability and resiliency are all at risk. Fluctuation of summer time flows may also impact fish reproduction. Monitoring will be needed to determine if future flow regimes relating to the Diamond Fork System will lead to either a resurgence of the cottonwood/willow community or a continued decline. This risk is expected to decline with completion of the Diamond Fork System; however, the extent of this is not yet clear. Without improved riparian conditions, water quality and aquatic, fish and wildlife habitat will continue to be limited.

CHANNEL MORPHOLOGY ASSESSMENT

As a result of the transbasin diversion and subsequent loss of riparian vegetation, the average bankfull channel width has increased from 20-40 feet to more than 160 feet at some locations. Channel sinuosity has decreased, gradient has increased, and rapid lateral channel migration is resulting in the delivery of large amounts of sediment to the channel because of extensive bank erosion. In most of the section the channel has downcut by 3 to 6 feet since 1939.

CHANNEL MORPHOLOGY TREND

The long-term trend has been towards a decreasingly stable channel, although there are signs of lessening of this trend in the last two decades. Channel migration remains rapid in response to irrigation flows and this is the dominant process controlling channel morphology, streambank erosion and riparian establishment. Just upstream of Lavanger Hollow, channel migration in 9 cross-sections within a 1/2-mile reach averaged more than 40 feet in one irrigation season. At another site downstream of Lavanger Hollow, channel migration has averaged 50 feet per year since 1984, with little indication of a change in the rate. The channel has shown significant change in response to past flood events in 1952, 1983 and 1984 and this is likely to occur again in future floods. Rapid channel migration limits the ability of riparian vegetation to reach later sucessional stages and this, in turn, limits streambank stability by limiting the development of dense root networks. Rapid channel migration also results in high rates of bank erosion in this reach and this may be the major contributor of in-channel sediment at the present time.

CHANNEL MORPHOLOGY RISK

The channel of lower Diamond Fork remains at risk to damage from large flood events and from the rapid channel migration during the irrigation season. Continuous changes in channel and floodplain morphology will occur under the present flow regime. This risk is expected to diminish with completion of the Diamond Fork System. The magnitude of this decrease is uncertain. Without improved riparian conditions, channel stability would continue to be limited.

UPPER DIAMOND FORK (ABOVE THREE FORKS)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Composition** Composition primarily of cottonwood dominated communities. Narrow riparian corridor from Three Forks to Sawmill Hollow is cottonwood and box elder dominated with considerable river birch. Higher elevations are willow dominated. **Seral Stage** 10-15% of bank vegetation in early seral condition **Stage** **% of Bank** Disturbed/pioneer 10-15% Mixed 25-35% Stable 35-55% 80-100% of valley bottom width is occupied by riparian species.	**Composition** There has been a loss and narrowing of the riparian area due to channel incision. Vertical structure and species diversity is reduced. **Seral Stage** There is more early than late seral vegetation. **Stage** **% of Bank** Disturbed/pioneer 20-30% Mixed 25-35% Stable 30-35% Slight decrease from historic conditions with areas of locally higher impact. Most noticeable changes may be decrease	**Timing of Peak Flows** Average peaks occur in early to late May, depending on slope, elevation and aspect of drainage. Summer thunderstorms may produce large, localized runoff events at any time between June and late September. **Average Peak Flow** Mean annual peaks vary from 2.0 cfs/sq mi to 7.0 cfs/sq mi, increasing with elevation. Summer thunderstorms peak as high as 30 to 50 cfs/sq mi in smaller basins (<10 sq mi.). **Duration of Flows** Snowmelt begins in mid-April and peaks in mid-May	**Timing of Peak Flows** Largely unchanged except as affected by roads and other disturbances which intercept surface runoff or lead to increased rates of overland flow. **Average Peak Flows** Unchanged to moderate increase due to effects of upslope disturbance; channel incision may lead to Aflashierâ stream response due to loss of bank and floodplain storage. **Duration of Flows** Unchanged	**Channel Width** Highly variable and dependent on watershed size; width/depth ratios near 10; lower gradient reaches will have narrow but well-developed floodplains. **Woody Debris** Large woody debris is available. Debris jams create pools and store sediment.	**Channel Width** Recent channel incision (2-4 ft) has occurred through most of the reach;width/depth ratios slightly increased. **Woody Debris** Locally available in sections dominated by cottonwood and box elder. Availability is limited in reaches dominated by willow. Stable debris jams are rare or absent.

UPPER DIAMOND FORK (ABOVE THREE FORKS)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE			**Source and Transport Reaches** First order tributaries are source reaches for sediment. Third and fourth order reaches are transport reaches for sediment. Some source reaches are intermittent.	**Source and Transport Reaches** Unchanged except some source reaches may have higher sediment output due to slow recovery from past disturbance.	**Floodplain Width, Channel Types and Gradient** 1st & 2nd order streams have a 4-20% channel gradient (A1,A2,A3,A4 channel types) and no floodplain. Third & 4th order streams have a 2-4% channel gradient (B,C channel types). Channel types correspond to valley width, slope, and parent material. Floodplain presence determined by local geology and valley gradient. **Shaded Channel** Yes **Bank Stability** Banks are stable with instability on outside meander bends.	**Floodplain Width, Channel Types and Gradient** Floodplain width is locally narrowed in incised sections. **Shaded Channel** Riparian vegetation still provides shade to the channel. **Bank Stability** is lowered in sections where channel is incised due to limited rooting depth of bank vegetation.

UPPER DIAMOND FORK (ABOVE THREE FORKS)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE					**Width/Depth Ratio** <15 **Sinuosity** 1.1-1.4 **Pools** Large wood provides structural control for 20-50% of pools; beaver likely abundant and dams contribute to pool formation.	**Width/Depth Ratio** Greater than historic **Sinuosity** Same as historic **Pools** Less woody debris available for structural control = beaver less abundant
COMPOSITION	Plant communities represented are dominated by native hydric species (all layers).	Regeneration of cottonwood and box elder occurs but is locally limited (by grazing, trampling/compaction at dispersed rec sites, and lack of suitable surfaces for colonization, etc). Desirable riparian species are present, but some species locally depressed.	Annual runoff is dominated by spring snowmelt but large runoff events may also be produced by summer thunderstorms in tributary channels. Nutrient, temperature, sediment levels are within normal ranges for local geology and contribute to high quality fish habitat. Some tributary channels still contribute high sediment loads during high runoff.	Annual runoff is largely unchanged but runoff rates increased locally by roads and other disturbances. Water quality is being impacted, especially by continued sediment from tributary streams.	Woody debris creates pools, protects banks, creates refuge areas, stores sediment, and provides gradient control. Beaver maintain C type channels. Disturbance or failure of beaver dams in higher order stream channels results in gullying streams (F,G channel types). Streamside vegetation filters sediment and stabilizes banks during floods. Shade maintains suitable temperatures	Woody debris is reduced; channel incision and reduction in some riparian species has increased risk of bank erosion during moderate to large floods.

UPPER DIAMOND FORK (ABOVE THREE FORKS)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
DISTURBANCE	Minimal carryover of disturbance features into following years. Although dynamic, plant communities and hydrologic functions persist or recover rapidly. Late seral fire occurring in adjacent vegetation types would also burn into riparian/wetland. Beaver dams store sediment, widen valley bottom, maintain water levels, and provide willow habitat.	Slight to moderate reduction in riparian species diversity, vertical structure and composition. Vegetation is not being regenerated by fire, due to lack of fire in adjacent types. Beaver absent or only present locally.	**Annual Runoff** Spring rain-on-snow floods and summer thunderstorms are largest disturbances and provide sediment pulses to main channel. **Spring Flood Events** Large flood events are rare. **Thunderstorms** Localized thunderstorms periodically affect smaller (1st and 2nd order) drainages by flash flood debris flows.	**Annual Runoff** Unchanged except where noted for roads and other developments **Spring Flood Events** Occurrence unchanged but impacts may be increased. **Thunderstorms** Unchanged but impacts may be increased.	**Sediment** Pulses of sediment from 1st & 2nd order drainages impact stream channels locally. **Two-Ten Year Events** determine channel size, transport sediment, maintain pool habitat, and builds banks. **Fifteen-Thirty Year and Greater Events** impact channel form, scour and transport sediment.	**Sediment** Loads from tributary channels locally increased due to channel incision and other impacts. **Two-Ten Year Events** cause little channel change. **Fifteen-Thirty Year and Greater Events** locally cause channel damage and bank erosion.

UPPER DIAMOND FORK (ABOVE THREE FORKS)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
PATTERNS	Riparian vegetation forms a continuous corridor across the entire width of the flood plain.	In valleys with an incised stream channel the riparian corridor has narrowed.	60% to 80% of annual runoff occurs between early May and late July during spring snowmelt	Mostly unchanged; roads, trails and areas of compacted soils locally contribute to increased runoff rates.	In lower gradient reaches (<2%) riparian vegetation provides bank stability. Beaver dams form pools which maintain water tables and store sediment.	In areas where beaver are in decline or are absent, channels have degraded, water levels have dropped and riparian vegetation is locally reduced to narrow fringe. Upland (drier site) species now occupy some former riparian areas.

RIPARIAN ASSESSMENT

There has been some loss and narrowing of the riparian area and a change in vertical structure and composition due to impacts from road construction, dispersed recreation, livestock grazing and trailing, compaction and browsing by wildlife. However, these impacts are not as evident in upper Diamond Fork as they are elsewhere in the watershed. The riparian area is dominated by mixed stands of cottonwood, box elder, clump willows (as opposed to coyote willow) and water birch, although some areas show signs of reduced vigor, especially near some heavily used dispersed recreational sites. Recent closures of some of these sites is likely to displace use to sites that have not been heavily used in the past as demand for this type of use is expected to be maintained or even increase.

RIPARIAN TREND

Current trends vary depending on location. Some areas will have a continued downward trend because of the existence of heavily used dispersed campsites within the riparian zone. In these areas compaction and damage/removal of vegetation are impacting both understory and overstory species. Reaches which are less heavily used appear to be in good condition with a stable trend.

RIPARIAN RISK

Impacts and downward trends in some sections of riparian habitat result in localized reduction of wildlife habitats. Channel stability and water quality are also impacted in these sections.

HYDROLOGIC ASSESSMENT

Regional climatic conditions in the early 1900's, combined with grazing, resulted in downcutting and lowering of water tables. Channel erosion in upper Diamond Fork was probably increased by erosion of lower Diamond Fork in response to augmented flows. Channel incision results in more water being focused into a smaller channel which increases runoff and lateral erosion rates. This process is still continuing in parts of Diamond Fork.

HYDROLOGIC TREND

Headward erosion will continue in tributary streams, runoff and erosion rates will remain elevated.

HYDROLOGIC RISK

At risk is continued improvement of riparian vegetation and streambank stability. Impacts from other disturbances, such as grazing, may have more noticeable effects on riparian vegetation.

CHANNEL MORPHOLOGY ASSESSMENT

The channel has been narrowed and straightened by road construction near Three Forks. Channel degradation has resulted in narrowing of the riparian zone. The amount of large woody debris in the stream and number of active beaver dams has been reduced, resulting in simplified aquatic habitat. Much of the length of Diamond Fork below Three Forks shows signs of degradation: by up to 6 feet immediately below Lavanger Hollow and 2-5 feet between Lavanger and Monk's Hollow. There are also signs of degradation on most of the tributary streams - Little Diamond, Wanrhodes Creek, Monk's Hollow, Sam's Canyon, Cottonwood Creek - as well as on upper Diamond Fork. This appears consistent with down cutting of the tributary streams following incision of the master stream (Diamond Fork - Sixth Water.)

CHANNEL MORPHOLOGY TREND

Channel restoration work has occurred over much of the length of the reach, resulting in stabilization of portions of the channel. The trend in the seral stage of riparian vegetation has been moderately to strongly upward at some sites. However, the effects of past channel degradation have not been completely reversed, and even the best sites remain "functional-at risk"[1] and would be susceptible to impacts from large flood events.

CHANNEL MORPHOLOGY RISK

The stream remains at risk to erosion and degradation during large floods. Human impacts will continue to affect the rate of recovery of riparian vegetation. Water quality, aquatic habitat and channel stability remain at risk.

LOWER DIAMOND FORK TRIBUTARIES (LITTLE DIAMOND, WANRHODES, RED HOLLOW, DRY CANYON, MONK S HOLLOW, BRIMHALL CANYON)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Composition** Upper sections (above 6,000-6,600 feet) composed predominantly of willow-dominated communities, mixed with other riparian communities (especially sedge-dominated). Lower sections (below 6,000 feet) composed predominantly of cottonwood or box elder dominated communities. **Seral Stage** Woody species are reproducing with a mix of age classes represented. Riparian communities represented in the following mix: **Stage** **% of Bank** Disturbed/Pioneer 10-20% Mixed 20-30% Stable 40-60%	**Composition** Decreased cottonwood regeneration and understory vegetation. **Seral Stage** Increase in early seral species; decline in mid to late seral species. **Stage** **% of Bank** Disturbed/ Pioneer 30-50% Mixed 20-30% Stable 20-50%	**Average Peak Flow** Mean annual peaks vary from 2.0 cfs/sq mi to 7.0 cfs/sq mi, increasing with elevation. Summer thunderstorms peak as high as 30 to 50 cfs/sq mi in smaller basins (<10 sq mi.). **Duration of Flows** Average spring runoff period is mid-April to mid-July, but varies between watersheds; high flows occur 10-20 days per year or less. **Timing of Peaks** Snowmelt begins in mid-April, peaks in mid-May; but varies with elevation and aspect of drainage.	**Average Peak Flows** Unchanged to moderate increase; loss of bottomland vegetation, roads, compaction, all contribute to increased runoff rates. **Duration of Flow** In incised channels, runoff response is more rapid due to loss of floodplain and bank storage and reduction in riparian vegetation. **Timing of Peaks** Mostly unchanged	**Channel Width** Varies with drainage area; width/depth ratios in low gradient reaches will be near 10 or less. **Woody Debris** Large woody debris is available. **Floodplain Width** Varies with geology and local valley gradient. **Channel Type and Gradient** First & 2nd order drainages have 4-20% channel gradient (A1,A2,A3,A4 channel type) and no floodplain. Third & 4th order drainages have a 2-4% channel gradient (B,C channel type). Floodplain presence is determined by local geology. Channel types	**Channel Width** Highly variable, in disturbed reaches width/depth ratios may exceed 40. Incised channels may still have low width/depth but lack floodplains. **Woody Debris** is reduced in most streams. **Floodplain Width** Variable; may be locally absent in some incised reaches **Channel Type and Gradient** Most tributary channels have downcut in response to downcutting by lower Diamond Fork. Incised channels have formed new floodplains to varying extent.

LOWER DIAMOND FORK TRIBUTARIES (LITTLE DIAMOND, WANRHODES, RED HOLLOW, DRY CANYON, MONK S HOLLOW, BRIMHALL CANYON)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE			**Source and Transport Reaches** Increased erosion and sediment from some source reaches due to slow recovery from past disturbance.	**Source and Transport Reaches** Increased erosion and sediment from some source reaches due to slow recovery from past disturbance.	**Shaded Channel** Riparian vegetation provides shade to most of the channel **Bank Stability** Variable with local sites of long-term instability such as Sawmill Hollow **Pools and Riffle** Pools roughly every 7-10 channel widths with high percentage of pools supported by large woody debris **Width/Depth Ratio** varies from less than 10 to 15 **Sinuosity** Variable from 1.1-greater than 2	**Shaded Channel** Shade provided by riparian vegetation is reduced or absent. **Bank Stability** is decreased in incised reaches; little change in higher gradient, boulder-dominated reaches. **Pools and Riffle** occurrence locally decreased **Width/Depth Ratio** locally higher than PFC **Sinuosity** Decreased locally by various impacts (roads, gully formation, bank stabilization)

LOWER DIAMOND FORK TRIBUTARIES (LITTLE DIAMOND, WANRHODES, RED HOLLOW, DRY CANYON, MONK S HOLLOW, BRIMHALL CANYON)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
COMPOSITION	Plant communities represented are dominated by native hydric species (all layers).	Cottonwood regeneration reduced; other riparian species reduced. Upland vegetation occupies floodplain sites in some incised channels.	Nutrient, temperature, sediment within normal ranges for local geology and contribute to high quality fish habitat.	Water quality is locally degraded by increased sediment and degraded riparian habitat.	Woody debris creates pools, protects banks, creates refuge areas, stores sediment, and provides gradient control. Beaver have been present historically in the lower portions of these drainages near the confluence with Diamond Fork. Stream side vegetation filters sediment and stabilizes banks during floods. Shade maintains suitable temperatures.	Woody debris and beaver dams have been reduced. Channel incision has reduced pool availability.

LOWER DIAMOND FORK TRIBUTARIES (LITTLE DIAMOND, WANRHODES, RED HOLLOW, DRY CANYON, MONK S HOLLOW, BRIMHALL CANYON)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
DISTURB-ANCE	Minimal carryover of disturbance features into following years. Although dynamic, plant communities and hydrological functions persist and recover rapidly.	Generally moderate to high decrease in species diversity, vertical structure, composition	**Annual Runoff** Dominated by spring snowmelt. Snowmelt begins in mid April, peaks in mid May. Peak flows on tributaries vary with aspect and elevation. **Spring Flood Events** occur approximately every thirty years that reset seral conditions in large portions of the system. **Thunderstorms** Localized thunderstorms periodically affect smaller 1st and 2nd order drainages by flash flood debris flows.	**Annual Runoff** Unchanged **Spring Flood Events** Unchanged **Thunderstorms** Unchanged	**Sediment** Pulses of sediment from 1st & 2nd order drainages impact stream channels locally. **Two-Ten Year Events** determine channel size, transport sediment, maintain pool habitat, build banks. **Fifteen-Thirty Year and Greater Events** impact channel form, scour and transport sediment.	**Sediment** Transport rates have increased in incised channels and where woody debris has decreased. **Two-Ten Year Events** have increased impact on channel form. **Fifteen-Thirty Year and Greater Events** cause significant channel changes.
PATTERN	Riparian vegetation forms a continuous corridor across the entire width of the flood plain. The corridor narrows toward the headwaters as flow decreases.	Channel incision has locally reduced floodplain and riparian width.	60 to 80% of annual runoff occurs between early May and mid July. Summer thunderstorms occasionally produce large runoff events.	Runoff rates are locally increased in incised reaches due to reduced flood storage and where roads and other disturbances intercept surface runoff.	In lower gradient reaches (<2%) riparian vegetation provides bank stability. Beaver dams in Little Diamond, Wanrhodes, Monks Hollow and some areas of Red Hollow form pools which maintain water tables and store sediment	

RIPARIAN ASSESSMENT

Impacts to these riparian areas have been primarily due to livestock grazing and various human impacts, including dispersed camping, especially along Little Diamond and Wanrhodes Creeks. Impacts from camping may increase with displacement of these users from the main portion of lower Diamond Fork and the anticipated increased demand for such opportunities. Off-road vehicle use is currently a problem in portions of Wanrhodes, Little Diamond and Red Hollow. Wanrhodes has a lack of cottonwood regeneration and associated understory, which is believed to be primarily due to grazing and dispersed recreation use.

RIPARIAN TREND

In privately owned parts of Wanrhodes and Little Diamond Creeks, the overall trend is unknown. On public lands, the long-term trend appears to be stable or slightly upward. Improvement is expected to continue to be slow as human use of the area increases. Current conditions show poor stability on many streams which are expected to demonstrate poor resilience to flood events or other disturbance.

RIPARIAN RISK

Water quality, channel stability, and riparian health are all at risk.

HYDROLOGIC ASSESSMENT

Climatic conditions in the early 1900's, combined with grazing, resulted in downcutting and lowering of watertables. As with other areas of the Diamond Fork watershed this channel incision has probably led to increased runoff rates and reduced floodplain storage.

HYDROLOGIC TREND

The expected trend is downward as human impacts are expected to increase. Limiting or changing the use of some areas could contribute to a reversal of this trend.

HYDROLOGIC RISK

At risk is lack of continued improvement of riparian vegetation and streambank stability due to dispersed camping and livestock use. Continued suppression of riparian vegetation by grazing and human impacts will result in continued inputs of fine sediment from tributary channels that will degrade downstream water quality in Diamond Fork and the Spanish Fork River.

CHANNEL MORPHOLOGY ASSESSMENT

Most streams have experienced some level of past degradation by grazing of livestock, homesteading and agriculture, including dryland farming. Historic use was particularly heavy along Wanrhodes and Little Diamond Creeks but also occurred in Red Hollow and Brimhall Canyons. Most may also have experienced channel degradation in response to erosion of the Diamond Fork channel. All streams may be considered as recovering from (in some cases, severe) past impacts and continue to be sensitive to new disturbances.

CHANNEL MORPHOLOGY TREND

Long term trends are stable to downward and are comparable to other parts of the watershed. Degraded reaches will continue to produce excess sediment until new floodplains are created and riparian vegetation has colonized the new floodplain surface.

CHANNEL MORPHOLOGY RISK

At risk is the ability of the stream to maintain proper structure, function, and morphology to provide for healthy riparian, fish and wildlife habitat.

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Composition** Upper sections (above 6,000-6,600 feet) composed predominantly of willow-dominated and sedge-dominated communities. Lower sections (below 6,000 feet) composed predominantly of cottonwood dominated communities. **Seral Stage** Woody species are reproducing with a mix of age classes represented. Riparian communities represented in the following mix: **Stage** **% of Bank** Disturbed/Pioneer 10-20% Mixed 20-30% Stable 40-60%	**Composition** Sixth Water is dominated by plant species, like coyote willow, that are adapted to the variable flow conditions. Sections of some channels have become incised and obligate wetland species have been replaced with more upland types. **Seral Stage** Most streams are dominated by pioneer species instead of stable late seral plant com-munities. **Stage** **% of Bank** Disturbed/Pioneer >50% Mixed 10-30% Stable 20-40%	**Timing of Peak Floods** Peak floods occur between late April and late May, depending on elevation and aspect of headwaters. Runoff from low elevation and south facing tributaries occurs earlier, north facing and higher elevation reaches later. **Peak Magnitude** Average peaks vary between 2.0 to 7.0 cfs/sq mi and increase in magnitude with elevation. Higher peak floods (to 30-50 cfs/sq mi) may be produced by summer thunderstorms. **Flow Duration** High flows (bankfull or higher) occur for periods of 2-8 weeks, usually between late April and late July.	**Timing of Peak Floods** Historical releases of transbasin diversions in Sixth Water (1915-1995) resulted in extreme change and timing of flows. **Peak Magnitude** Unaltered, except in Sixth Water **Flow Duration** Flow regime in Sixth Water is altered by transbasin diversions as described for lower Diamond Fork. Hydrology of all other streams is largely unaltered.	**Channel Types** Wide variation with position in watershed and watershed size. All Rosgen channel types are represented. Headwater (source reaches) have gradients of 4-20% (A1- A4 types); transport reaches, 2-4% gradient, B channel type; response reaches, <2% gradient, C and E channel types. See Appendix D for illustrations of channel types. **Woody Debris** Large woody debris is abundant, beaver dams are common in C and E channel types and where willow and/or aspen are available. **Shaded Channel** Provides adequate channel shade **Bank Stability** Banks pre-dominantly stable	**Channel Types** Sixth Water channel y incised in response to changed hydrology; other waters, channel incision and down cutting. Conversion from B, C, and E channels to D, F and G channels in response to various land use impacts. **Woody Debris** Avail-ability limited in some areas. Beaver absent in some streams. **Shaded Channel** Shade is variable; full shade to unshaded **Bank Stability** Moderately stable to very unstable

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
STRUCTURE					**Width/Depth Ratio, Floodplain Width, Sinuosity** Vary by Channel Type, see Appendix D	**Width/Depth Ratio, Floodplain Width, Sinuosity** Altered where conversion to F and G channels has occurred (e.g., Waters through Rays Valley), see Appendix A.

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
COMPOSITION	Multiple layer canopy with native hydric species dominating all layers.	Multiple layer canopy is being lost in some areas due to channel incision and specific land use impacts, past and present such as grazing, road construction, recreational use.	Nutrient, temperature and sediment levels are within normal ranges for local geology and watershed size. Larger perennial streams provide high quality fish habitat.	Water quality is locally degraded at and downstream of sites where riparian function or channel stability is impaired or has been lost. Natural hydrology is locally impaired where roads intercept and concentrate runoff.	Woody debris creates pools, protects banks, creates refuge areas, stores sediment, and maintains gradient control. Beaver dams maintain channel form and water surface elevations in C&B type channels. Disturbance or failure of beaver dams in higher order stream channels results in gullying streams (F,G). Streamside vegetation filters sediment and stabilizes banks during floods. Shade maintains suitable water temperature.	Woody debris availability is reduced to varying degrees. Removal/absence of beaver in some streams has contributed to channel degradation, local water table decline and contributes to downstream sedimentation. Some tributary channels may be downcutting in response to channel incision in lower Diamond Fork, but upstream migration of headcuts is limited by bedrock outcrops. Water temperatures are elevated in Sixth Water.

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)

CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
DISTURB-ANCE	Minimal carryover of disturbance features into following years. Although dynamic, plant communities and hydrologic functions persist and recover rapidly.	Riparian areas are impacted by grazing 2 of 3 years. In some areas the level and frequency of both past and present disturbance does not allow for rapid recovery. Other land uses are also sources of impact locally.	**Annual Runoff** Runoff is dominated by spring snowmelt. Snowmelt begins in mid April, peaks in mid May. Peak flows on tributaries vary with aspect and elevation. Large floods occur approximately every thirty years. Intense summer thunderstorms periodically produce large flood events in small headwater watersheds.	**Annual Runoff** Unaltered on most streams except Sixth Water where trans-basin diversions dominate flow regime.	**Source Reaches** (A-type channels) periodically produce debris flows in response to large runoff events (normal frequency range is 200-400 years). **Transport and Response Reaches** may temporarily change form in response to change in sediment supply, formation/loss of beaver dams. C channels are somewhat resilient and B channels highly resilient to normal flood events. **Two-Ten Year Events** determine channel size, transport sediment, maintain pool habitat, and build banks. **Fifteen-Thirty Year and Greater Events** have moderate impact on channel form, scour and transport sediment. A-type (source) channels	**Source Reaches** Debris flow frequency and channel erosion rates are mostly unchanged. **Transport and Response Reaches** at least locally have decreased resilience to disturbance. Channel incision has occurred on at least part of most streams. Bank erosion contributes a higher percentage of total sediment load. **Two-Ten Year Events** Transport increased sediment load in degraded reaches. **Fifteen-Thirty Year and Greater Events** capable of causing significant channel changes

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)						
CRITERIA	RIPARIAN VEGETATION		HYDROLOGY		CHANNEL MORPHOLOGY	
	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS	PFC INDICATORS	CURRENT STATUS
PATTERNS	Riparian vegetation forms a continuous corridor across the entire width of the flood plain. The corridor narrows toward the headwaters as flow decreases.	In valleys with an incised stream channel the riparian corridor has narrowed.	60% to 80% of annual runoff occurs between early May and late July during spring snowmelt.	Mostly unchanged; roads, trails and areas of compacted soils locally contribute to increased runoff rates.	In lower gradient reaches (<2%) riparian vegetation provides bank stability. Beaver dams form pools which maintain water tables and store sediment.	In areas where beaver are in decline or are absent, channels have degraded, water levels have dropped and riparian vegetation is locally reduced to narrow fringe. Upland (drier site) species now occupy some former riparian areas.

RIPARIAN ASSESSMENT

These streams have been impacted to varying degrees by grazing, sediment, roads, and dispersed recreation. The drainages are generally narrow. In Halls Fork the road and associated sidecast material has limited the movement of the stream in some places and increased its gradient. Dispersed camping has compacted soils, reduced woody species regeneration, and removed mature trees along Halls Fork. The south facing slopes are relatively barren except for junipers. During thunderstorms these slopes produce an abundance of gravel-sized material that is deposited into the stream. Relatively high sediment loads are natural to this system, although exacerbated by heavy grazing in the early 1900's. Vegetative conditions, in both riparian and upland areas, have recovered considerably but not fully since the turn of the century. Channel erosion and increased sediment loads were a response to early grazing impacts, but channel erosion has also occurred in response to downcutting by the main channel of lower Diamond Fork. In most areas the willow community is vigorous.

RIPARIAN TREND

Most streams have riparian zones that are currently functional-at risk or have reaches that are non-functional; trends will be stable to upward, but current conditions are poor in many reaches. Upper portions of Waters are non-functioning. There is concern that at-risk sections will begin to affect functioning sections. Rate of change in improving sections is slow. Forest Plan goals/objectives for improvement of riparian conditions within specified time frames (5, 10 or 20 years, depending on the Value class) will likely not be met on some streams based on riparian trend studies.

RIPARIAN RISK

Localized pockets of riparian vegetation are at risk or non-functional due to heavy dispersed recreation activities (camping), and impacts from livestock use. Wildlife and fish habitat provided by riparian areas is also at risk, as is bank stability and water quality. Beaver habitat and the associated highly diverse willow complexes are at risk.

HYDROLOGIC ASSESSMENT

Climatic conditions in the early 1900's, combined with heavy grazing, resulted in downcutting and lowering of water tables. At present, streams are impacted from a combination of recreation use (trails and camping) and livestock use (trails and general use). Runoff rates have likely been increased due to the effect of roads and other disturbances which intercept and concentrate sub-surface and surface runoff. Incised and degraded reaches are also contributing to increased runoff rates because of the diminished floodplain capacity.

HYDROLOGIC TREND

The current trend is stable to downward for vegetation.

HYDROLOGIC RISK

All of Sixth Water could be impacted by development of the Diamond Fork System of the CUP. The primary mechanism of recovery of the Sixth Water channel from the impacts of the historic flow regime will be by deposition of new sediment on the channel margins and encroachment and recolonization by riparian vegetation. Both the continued introduction of augmented flows and the potential for periodic emergency releases from Strawberry Tunnel pose a risk to the natural recovery of the stream channel. The benefits of maintaining minimum instream flows to aquatic habitats are recognized; however, proposed flow regimes have yet to integrate aquatic habitat, riparian, and channel stability concerns or reconcile the impacts of proposed flows in Sixth Water on lower Diamond Fork. Thus, the ultimate recovery needs of Sixth Water and Diamond Fork should be considered together as they are, to some extent, mutually dependent. As mandated by CUPCA, proposed flows in Sixth Water have emphasized fishery benefits, but any such benefit will likely be incompletely realized unless riparian and channel stability and recovery needs are also taken into account. The pre-irrigation floodplain and channel morphology in Sixth Water may not be recoverable, but this potential has not been completely evaluated and should not be discounted without further study.

CHANNEL MORPHOLOGY ASSESSMENT

In Sixth Water, channel and floodplain morphology has been completely altered by the release of irrigation flows through Strawberry Tunnel. Channel erosion in lower Diamond Fork and Sixth Water has likely forced tributary streams to downcut in response. Upstream migration of active headcuts has been locally limited by bedrock outcrops as at the falls on Fifth Water. In the Waters area, channel incision must be attributed to other causes, such as loss of riparian vegetation due to past over grazing and the loss of beaver.

CHANNEL MORPHOLOGY TREND

Present trends are variable and depend on vegetation establishment, local channel stability and whether or not channel degradation has ceased or not. Parts of some channels may still be actively eroding. Upward trends will be slow as improvement in incised channels requires either reintroduction of beaver or creation of new floodplain by channel migration.

CHANNEL MORPHOLOGY RISK

The primary risks are to downstream water quality and aquatic habitats with the main cause being elevated sediment levels caused by continued bank erosion in incised reaches. This affects the ability of the stream to maintain proper structure, function, and morphology to provide for healthy riparian, fish and wildlife habitat.

Table 3-2 Soil and Hillslope Processes

LOWER DIAMOND FORK (BELOW THREE FORKS)		
CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS AND HILLSLOPE PROCESSES
STRUCTURE	**Geology** Consists primarily of layered and predominantly non-marine sedimentary rocks. Major geologic formations include (from youngest to oldest): ***Wanrhodes Volcanics*** Interbedded volcanic pyroclastic flows and tuffs, mostly andesitic ***Uinta Formation*** Variegated shale interbedded with gray and buff sandstone ***Green River Formation*** Freshwater/saline shale, limestone, thin sandstone and conglomerate interbeds ***Flagstaff Limestone*** Gray to bluish-gray fossiliferous freshwater limestone ***North Horn*** Varied, conglomerate, sandstone, shale, and freshwater limestone, all non-marine ***Price River Formation*** (Mesa Verde Group) inter-bedded sandstone, shale, siltstone, conglomerate and coal beds ***Navajo/Nugget Sandstone*** Cross-bedded, wind-deposited sandstone ***Ankareh Shale*** Red, non-marine, shale, siltstone, sandstone Navajo Sandstone and Ankareh Shale outcrop near mouth of canyon; Uinta Formation occurs on Billies Mountain and in Wanrhodes Canyon; Wanrhodes volcanics occur in broad belt extending north and east from Little Diamond Creek into Wanrhodes Canyon; other formations outcrop discontinuously throughout the area.	**Geology** Unchanged

LOWER DIAMOND FORK (BELOW THREE FORKS)

CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS AND HILLSLOPE PROCESSES
COMPOSITION	**Texture** Soil textures vary from fine grained (clay and silt) to very rocky depending on parent materials. Soils in Green River and Uinta Formations tend to be fine grained, clayey. Soils in North Horn Formation are rocky to very rocky. **Depth** varies from zero at bedrock outcrops to over 54 inches on lower slopes of stream valleys and on north-facing, timbered slopes. **Infiltration** On roughly 58% of the area, soils have restrictive layers at shallow depths that impede infiltration.	**Texture** mostly unchanged. Topsoil may have been lost locally due to intensive early grazing. **Depth** Mostly unchanged, some sites likely lost considerable topsoil during heavy grazing early in the century. **Infiltration** Mostly unchanged, in some areas locally reduced by trampling, grazing, recreation use, roads, and expansion of pinyon-juniper.
DISTURBANCE	Nearly all soils (97%) have moderately low to moderately high inherent (undisturbed) erodibilities. Three percent of soils have high inherent erodibility. 61% of soils have high to extreme erosion rates when disturbed. Erosion rates average 3 tons/acre/year when undisturbed and 33 tons/acre/year when disturbed. Active and inactive landslides comprise roughly 5% of the area.	Most of floodplain of lower Diamond Fork was in agriculture in the early 1900's. Intensive grazing use occurred outside the floodplain. Erosion rates are likely elevated over Aundisturbed@ conditions in much of the area, but few sites have erosion rates in the upper end of their potential range. Road access was developed after about 1903. Landslides are occurring within the range of natural variability.
PATTERNS	Ground cover tends to be lower on south aspects, erosion rates higher. Deeper soils occur on north aspects, on lower slopes and in valley bottoms.	Mostly unchanged.

SOILS AND HILLSLOPE PROCESSES ASSESSMENT

Soils are derived from numerous geologic formations consisting of marine and non-marine sedimentary rocks. Natural erosion rates are highest on lower slopes of stream canyons and on slopes greater than about 30%. In lower Diamond Fork, the primary past impacts have been from agricultural development of the floodplain, grazing, and road construction. Grazing use has been modified significantly in the past 30 to 50 years resulting in reduced erosion rates and noticeable improvements in cover on most, but not all, sites. Recreational use of the area has increased steadily in the last 30 years and may become the major land-impacting use of this area.

SOILS AND HILLSLOPE PROCESSES TREND

Trend is generally towards improved conditions for surface erosion, ground cover, and soil stability. Some sites with naturally high sensitivity to disturbance and impacted by historic and recent disturbances have not fully recovered.

SOILS AND HILLSLOPE PROCESSES RISK

Sites with high erosion rates remain at risk to surface disturbance. This includes sites impacted by past activities and which have not fully recovered. New or recurrent disturbances could reverse upward trends on recovering sites. Ground disturbing activities (recreation use, grazing, roads, etc.) could increase erosion and decrease downstream water quality in Diamond Fork and the Spanish Fork River.

UPPER DIAMOND FORK (ABOVE THREE FORKS)

CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS AND HILLSLOPE PROCESSES
STRUCTURE	**Geology** Major geologic formations include (from youngest to oldest): ***Uinta Formation*** Variegated shale interbedded with gray and buff sandstone ***Green River Formation*** Freshwater/saline shale, limestone, thin sandstone and conglomerate interbeds ***Flagstaff Limestone*** Gray to bluish-gray fossiliferous freshwater limestone ***North Horn*** Varied, conglomerate, sandstone, shale, and freshwater limestone, all non-marine ***Price River Formation*** (Mesa Verde Group) inter-bedded sandstone, shale, siltstone, conglomerate and coal beds	**Geology** Unchanged
COMPOSITION	**Texture** Soil textures vary from fine grained (clay and silt) to very rocky depending on numerous factors including parent materials, slope, aspect, elevation and vegetation type. Soils in Green River and Uinta Formations tend to be fine grained, clayey. Soils in North Horn Formation are rocky to very rocky. **Depth** varies from zero at bedrock outcrops to over 54 inches on lower slopes of stream valleys and on north-facing, timbered slopes. **Infiltration** On roughly 47% of the area, soils have restrictive layers at shallow depths that impede infiltration.	**Texture** mostly unchanged. Topsoil may have been lost locally due to intensive early grazing. **Depth** mostly unchanged, some sites likely lost considerable topsoil during heavy grazing early in the century. **Infiltration** mostly unchanged; in some areas infiltration is locally reduced by trampling, grazing, recreation use, roads, and expansion of pinyon-juniper.

UPPER DIAMOND FORK (ABOVE THREE FORKS)		
CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS AND HILLSLOPE PROCESSES
DISTURBANCE	Nearly all soils (96%) have moderately low to moderately high inherent (undisturbed) erodibilities. 2.4% of soils have high inherent erodibility. Eighty-one percent of soils have high to extreme erosion rates when disturbed. Erosion rates average 3.0 tons/acre/year when undisturbed and 46 tons/acre/year when disturbed. Active and inactive landslides comprise roughly 3.1% of the landscape.	Intensive grazing reduced ground cover and increased erosion in most of area prior to about 1930. Grazing impacts have been reduced significantly, but some areas may not be fully recovered. Erosion rates are likely elevated over Aundisturbed@ conditions in much of the area, but few sites have erosion rates in the upper end of their potential range. Landslides in Sixth Water Creek have been activated by augmented flows from trans-basin diversion. Roads, grazing, recreation are primary impacts. Landslides are occurring within the range of natural variability.
PATTERNS	North Horn conglomerate outcrops on Tanner Ridge and on east slope of Red Mountain. Debris and mud flows are common in drainages on westside of Tanner Ridge. Active landslides in Sawmill Hollow are also in North Horn Formation and may be centuries old.	Mostly unchanged, elevated erosion rates currently occur on disturbed sites, south-facing slopes and in drainages with recent debris flows.

SOILS AND HILLSLOPE PROCESSES ASSESSMENT

Geology is similar to Upper Diamond Fork Tributaries with shales of the Uinta and Green River Formation dominating. Conglomerates of the North Horn Formation outcrop on Tanner Ridge and the east-facing slopes of Red Mountain. The large landslides in Sawmill Hollow are located in the North Horn Formation and were noted during the Dominguez and Escalante expedition in 1776 (Chavez 1976). Upper west-facing slopes above Hall=s Fork, Shingle Mill Gulch and Chase Creek in the Uinta Formation have naturally high erosion rates, are actively eroding, and are among the dominant sediment producing areas in those watersheds. The landslides in Sawmill Hollow are also currently active and are a major source of sediment in Diamond Fork. West-facing slopes along Tanner Ridge locally have poorly developed soils with limited ground cover and are often sources of coarse debris, especially in large runoff years and in response to intense summer thunderstorms.

SOILS AND HILLSLOPE PROCESSES TREND

Most soils in this area are highly erosive and highly sensitive to disturbance. Debris flows and slumps are natural events that occur here, especially in wet years. These events set back soil stability and result in accelerated erosion. Historical grazing undoubtedly exacerbated this natural process; however, livestock management was significantly changed 30-50 years ago in response to concerns about erosion. Available data indicates soil stability in the area is slowly improving. There are some localized areas at risk where trends are stable or downward. This includes upper Halls Fork and to a lesser extent, upper Chase and Shingle Mill Creeks.

SOILS AND HILLSLOPE PROCESSES RISK

Risks are for continued elevated levels of surface erosion that impacts downstream water quality and may locally affect soil productivity. High levels of fine sediment may impact the reproductive success or otherwise impact habitat quality for fishes, including native Bonneville cutthroat trout in Upper Diamond Fork, Hall's Fork, Shingle Mill Gulch and Chase Creek.

LOWER DIAMOND FORK TRIBUTARIES (LITTLE DIAMOND, WANRHODES, RED HOLLOW, DRY CANYON, MONK S HOLLOW, BRIMHALL CANYON)

CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS AND HILLSLOPE PROCESSES
STRUCTURE	**Geology** includes marine and non-marine sedimentary rocks consisting mainly of shale, sandstone, conglomerate, limestone. Major formations, from youngest to oldest: ***Wanrhodes Volcanics*** Interbedded volcanic pyroclastic flows and tuffs, mostly andesitic ***Uinta Formation*** Variegated shale interbedded with gray and buff sandstone. ***Green River Formation*** Freshwater/saline shale, limestone, thin sandstone and conglomerate interbeds ***Flagstaff Limestone*** gray to bluish-gray fossiliferous freshwater limestone. ***North Horn*** Varied, conglomerate, sandstone, shale, and freshwater limestone, all non-marine ***Price River Formation*** (Mesa Verde Group) inter-bedded sandstone, shale, siltstone, conglomerate and coal beds ***Navajo/Nugget Sandstone*** cross-bedded, wind-deposited sandstone ***Ankareh Shale*** red, non-marine, shale, siltstone, sandstone ***Park City Formation*** cherty limestone, siliceous shale, phosphorite beds ***Oquirrh Formation*** quartzite, with beds of limestone or dolomite, sandstone and shale	**Geology** Unchanged
COMPOSITION	**Texture** Soil textures vary from fine grained (clay and silt) to very rocky depending on parent material. Soils in Green River and Uinta Formations tend to be fine grained, clayey. Soils in North Horn and Oquirrh Formations are rocky to very rocky. Glacial debris occurs on upper slopes of Spanish Fork Peak near head of Little Diamond Creek. **Depth** varies from zero at bedrock outcrops to over 54 inches on lower slopes of stream valleys and on north-facing, timbered slopes. **Infiltration** On roughly 52% of the area, soils have restrictive layers at shallow depths that impede infiltration.	**Texture** mostly unchanged. Topsoil may have been lost locally due to intensive early grazing. **Depth** mostly unchanged, some sites likely lost considerable topsoil during heavy grazing early in the century.. **Infiltration** mostly unchanged; in some areas infiltration is locally reduced by trampling, grazing, recreation use, roads, and expansion of pinyon-juniper.

LOWER DIAMOND FORK TRIBUTARIES (LITTLE DIAMOND, WANRHODES, RED HOLLOW, DRY CANYON, MONK S HOLLOW, BRIMHALL CANYON)		
CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS AND HILLSLOPE PROCESSES
DISTURBANCE	Nearly all soils (88%) have moderately low to moderately high inherent (undisturbed) erodibilities. Nine percent of soils have high inherent erodibility. Fifty-nine percent of soils have high to extreme erosion rates when disturbed. Erosion rates average 1.6 tons/acre/year when undisturbed and 34 tons/acre/year when disturbed. Active and inactive landslides comprise roughly 12.9% of the landscape.	Some dry-land farming occurred historically near Brimhall Canyon, resulting in conversion from natural vegetation and change in ground cover. Intensive grazing occurred early in 1900's but has been reduced significantly since 1950's. Erosion rates are likely elevated over Aundisturbed@ conditions in much of the area, but few sites have erosion rates in the upper end of their potential range. Landslides are occurring within the range of natural variability.
PATTERNS	Ground cover tends to be lower on south aspects, erosion rates higher. Deeper soils occur on north aspects, on lower slopes and in valley bottoms.	Mostly unchanged. Elevated erosion rates likely occur on south-facing slopes, and in drainages with recent debris flows.

SOILS AND HILLSLOPE PROCESSES ASSESSMENT

Soils are derived from numerous geologic formations consisting of marine and non-marine sedimentary rocks. Shale of the Uinta Formation and sandstone of the Price River Formation and Navajo Sandstone are the dominant rock types east of lower Diamond Fork and on Billies Mountain. Limestone is abundant west of lower Diamond Fork on the east slopes of Spanish Fork Peak and the ridge separating the Diamond Fork and Hobble Creek watersheds. The Ankareh Shale and Park City Formations also occur in this area. Small landslides and rotational slumps are relatively common in both the Uinta and Ankareh Formations. Natural erosion rates are highest on south-facing slopes, on the lowermost slopes of stream valleys and on slopes greater than about 30%. The major recent disturbances resulted from grazing of cattle and sheep on both private and Forest Service lands, road construction, and recreation use.

SOILS AND HILLSLOPE PROCESSES TREND

Current trends are stable to upward on most hillslope sites except for localized areas of Little Diamond, Wanrhodes and Brimhall Canyons. Some sites with naturally high sensitivity to disturbance and impacted by historic and recent disturbances have not fully recovered.

SOILS AND HILLSLOPE PROCESSES RISK

Sites with high erosions rates remain at risk to surface disturbance. This includes sites impacted by past activities and which have not fully recovered. Soil productivity may be at risk on severely disturbed sites. New or recurrent disturbances could reverse upward trends on recovering sites. Ground disturbing activities (e.g., recreation use, grazing, roads, etc.) could increase erosion and decrease downstream water quality in Diamond Fork and the Spanish Fork River.

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)		
CRITERIA	**PFC INDICATORS SOILS AND HILLSLOPE PROCESSES**	**STATUS OF PFC SOILS HILLSLOPE PROCESSES**
STRUCTURE	**Geology** Includes mainly younger, non-marine sedimentary formations. Major geologic formations include (from youngest to oldest): ***Uinta Formation*** Variegated shale interbedded with gray and buff sandstone ***Green River Formation*** Freshwater/saline shale, limestone, thin sandstone and conglomerate interbeds ***Flagstaff Limestone*** Gray to bluish-gray fossiliferous freshwater limestone ***North Horn*** Varied, conglomerate, sandstone, shale, and freshwater limestone, all non-marine ***Price River Formation*** (Mesa Verde Group) Inter-bedded sandstone, shale, siltstone, conglomerate and coal beds	**Geology** Unchanged
COMPOSITION	**Texture** Soil textures vary from fine grained (clay and silt) to very rocky depending on numerous factors including parent materials, slope, aspect, elevation and vegetation type. Soils in Green River and Uinta Formations tend to be fine grained, clayey. Soils in North Horn Formation are rocky to very rocky. **Depth** varies from zero at bedrock outcrops to over 54 inches on lower slopes of stream valleys and on north-facing, timbered slopes. **Infiltration** On roughly 63% of the area, soils have restrictive layers at shallow depths that impede infiltration.	**Texture** mostly unchanged. Topsoil may have been lost locally due to intensive early grazing. **Depth** mostly unchanged, some sites may have lost topsoil during the heavy grazing that occurred early in the century. **Infiltration** mostly unchanged; in some areas infiltration is locally reduced by trampling, grazing, recreation use and roads. Expansion of pinyon-juniper in the lower part of this area likely reduced infiltration rates.

UPPER DIAMOND FORK TRIBUTARIES (COTTONWOOD CANYON, THE WATERS, DIP VAT, YELLOW JACKET, SAWMILL HOLLOW, SHINGLE MILL, CHASE CREEK AND HALLS FORK)		
CRITERIA	PFC INDICATORS SOILS AND HILLSLOPE PROCESSES	STATUS OF PFC SOILS HILLSLOPE PROCESSES
DISTURBANCE	Nearly all soils (97%) have moderately low to moderately high inherent (undisturbed) erodibilities; 2.4% of soils have high inherent erodibility. Seventy-eight percent of soils have high to extreme erosion rates when disturbed. Erosion rates average 2.0 tons/acre/year when undisturbed and 35.6 tons/acre/year when disturbed. Active and inactive landslides comprise roughly 1% of the landscape.	Intensive grazing reduced ground cover in most of landscape. Though reduced from historic levels, some impacts from grazing still apparent on Farmer=s Slope and the Waters. Overall erosion rates are likely elevated over Aundisturbed@ conditions, but few sites have erosion rates in the upper end of their potential range. Landslides in Sixth Water Creek have been activated by augmented flows from trans-basin diversion. Primary impacts are roads, grazing, recreation use. Landslides are occurring within the range of natural variability. However, Sixth Water has undercut (presumably due to increased flows) and reactivated a landslide.
PATTERNS	Ground cover tends to be lower on south aspects, erosion rates higher. Deeper soils occur on north aspects, on lower slopes and in valley bottoms.	Mostly unchanged. Elevated erosion rates likely occur on disturbed sites, south-facing slopes, and in drainages with recent debris flows.

SOILS AND HILLSLOPE PROCESSES ASSESSMENT

Soils are predominantly derived from sandstones and shales of the Uinta and Green River Formations east of Three Forks and Tanner Ridge and conglomerates of the North Horn Formation on Tanner Ridge. Slopes are locally slumpy, as in upper Sixth Water. Erosion rates are naturally high throughout the area and response to disturbance is high to extreme on nearly all sites. Headwater areas on west facing slopes of Strawberry Ridge are high sediment producers in most, if not all, drainages in the Waters.

SOILS AND HILLSLOPE PROCESSES TREND

Current trends from vegetation plots are stable in First Water, Sterling Hollow and Rays Valley and downward in parts of Second Water. Landslides in Sixth Water are a continuing source of fine sediment in Sixth Water and Diamond Fork.

SOILS AND HILLSLOPE PROCESSES RISK

As with other parts of the watershed, grazing, roads and recreational use are the principal sources of impact in the area. Hillslope conditions on grazed sites are much improved over historic (early 1900's) conditions. Roads, recreational use and local areas of hillslope instability are sources of risk to surface soil erosion and downstream water quality.

Table 3-2 Vegetative Conditions

BLUE SPRUCE - SUBALPINE FIR (*PICEA PUNGENS - ABIES LASIOCARPA*)		
CRITERIA	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Structural Stages** Seedling/Sapling ≈20% Young/Mid Age Forest ≈40% Mature/Old Forest ≈40% Forty percent of stands have multiple canopies. Stand densities are such that insect ratings are moderate to low. (Stand Density Index (SDI) does not exceed 60% of maximum for the vegetative type and Basal Area is less than 150.[2]) Grass/forb openings are interspersed with this type and occupy 5-10% of the acreage.	**Structural Stages** Stands are primarily mid-aged and older. Estimate that greater than 40% have multiple canopies Stand densities and basal areas high. Insect ratings are moderate to high in some stands. Less than 10% of stands have grass/forb openings within them.
COMPOSITION	Subalpine fir generally dominates these stands. Species composition may grade into Douglas-fir/white fir in the upper reaches of the stand as the site dries near the ridge line, and on the lower end blue spruce becomes a common component where the site becomes more mesic.	Subalpine fir is more common throughout the stands, currently dominating most sites. Blue spruce is common in riparian zones.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Endemic insect and disease populations. No defoliation of >50% of crown is observed. Mortality in groups of <5 trees per acre. Avalanche, windthrow or landslides do not affect more than 2% of the spruce trees 10 inches or greater d.b.h. (diameter at breast height). Less than 5% of acres in root disease centers. Mixed severity and lethal fire regimes are within historical ranges. Mixed severity regime on a 40 to 60 year cycle and lethal regime on a 100 to 300 year cycle.	Epidemic levels of balsam bark beetle complex. This is actually working to offset composition problem noted above. Avalanche, windthrow and landslide impacts are within the range of natural variability. Fire cycle lengthened for mixed severity incidents.

PATTERNS (e.g. connectivity, shapes, size, distribution)	Patterns are within historical ranges, based on habitat type and site potential. (Pattern sizes, shapes and corridors are maintaining processes. Juxtaposition with surrounding types within historical ranges.) Fire is maintaining a heterogenous pattern of species and structure classes. A mixed severity fire regime produces vegetation mosaics due to the patchy nature of fire, preventing development of large continuous blocks of homogenous ages and species.	Patterns remain mostly within historical ranges, with small stands occurring on north-facing slopes at higher elevation. Sub-alpine fir is encroaching into riparian areas and aspen and thus the area occupied by this type has expanded. Some scattered, individual blue spruce seedlings are becoming established in aspen stands.

BLUE SPRUCE - SUBALPINE FIR ASSESSMENT

The subalpine fir type is very limited within this landscape, occupying approximately 1,700 acres. Where stands occur they tend to be dominated by mature and older age classes. These stands currently occur in approximately the same locations as they did historically, but stands may be somewhat larger in acreage and denser. Subalpine fir stands are generally small and occur on north-facing, cool, moist sites. Blue spruce is most common within the riparian zone; subalpine fir dominates mid-slopes, and may grade into Douglas-fir/white fir where the site becomes drier near the ridgeline or where aspect changes from a predominately north-facing slope.

The historic role of fire in these communities was to initiate regeneration. Virtually any fire in this type is lethal due to the shallow-rooted and thin-barked nature of these species. The mixed severity fire regime in this type is influenced by the surrounding vegetation types. These surrounding types have all missed several fire return intervals, and this has likely allowed the subalpine fir type to expand somewhat, particularly into the aspen type. The lethal fire regime for the subalpine fir type (100-300 year intervals) has not been exceeded.

BLUE SPRUCE - SUBALPINE FIR TREND

The current trend for this vegetative type in the absence of disturbance is to slowly continue its development toward a late seral stage. Stands would likely become more dominated by the late-seral species (primarily subalpine fir) with a reduction in the blue spruce component. Reductions could also be expected in the small amount of aspen that is associated with these stands. Some stands mapped as spruce/fir are dominated by subalpine fir with a mix of aspen. These stands are uneven-aged and both species appear to be maintaining themselves. As large, old subalpine fir trees in these stands die, aspen suckers are released to grow into overstory position. Subalpine fir seedlings also become established in these small openings but take somewhat longer than aspen suckers to develop, thus allowing the aspen to have micro-site dominance for a period of time sufficient to maintain a viable root system.

Individual tree age is being reduced as subalpine fir (a relatively short-lived species) replaces blue spruce. Associated with this is an increase in overall stand densities, a reduction in understory species (due to overstory shading), an increase in density-dependent mortality, and a build-up of fuels.

BLUE SPRUCE - SUBALPINE FIR RISK

Risks to this type include continued insect mortality and increased potential of catastrophic stand-replacing wildfire. This could pose a threat of reducing the incidence of spruce/fir within the landscape by reducing the seed source and creating unfavorable micro-sites for tree regeneration to establish. High fire intensity could also potentially impact soils and watershed by setting up conditions conducive to increased erosion and sediment rates, or on the opposite end limit water permeability by baking soil surfaces.

Spruce/fir types may pose some risk to adjacent vegetation types, primarily aspen, through encroachment and replacement of seral stands, primarily with subalpine fir (see aspen narrative). In some areas this type may also be expanding into riparian corridors, causing a reduction in lower-growing, shade intolerant riparian species such as willows, alders and birches which help maintain stable stream banks.

Loss of healthy conifer stands can, in general, adversely impact wildlife habitat for a variety of wildlife species. With ever increasing age of these stands, and replacement of spruce by fir, and replacement of aspen by conifer, risk of losing effective habitat to wildfire increases. Loss of older stands to fire could severely limit habitat for cavity nesters and other species dependent on stands with multi-storied canopies and older aged trees. These stands are particularly valuable because of their limited occurrence within the landscape.

ASPEN (SERAL) (*POPULUS TREMULOIDES*)		
CRITERIA	**PFC INDICATORS**	**CURRENT STATUS**
STRUCTURE	**Structural Stages** Regeneration stage 15-30% Young/Mid-Aged Ranges 40-60% Mature/Old Ranges 10-30% and less than 120 years old Stand densities are such that risk from insect and disease remain moderate to low. (Stand Density Index (SDI) does not exceed 60% of maximum for the vegetative type. Basal Area is less than 140.)	**Structural Stages** More mature & old stands, little regeneration SDI ranges between 60 and 75% of maximum.
COMPOSITION	Conifer composition not more than 15% cover in stands. Shrub and herbaceous layers well developed. Ground cover nearly 100%.	Conifer >15% in some stands. Shrub & herbaceous layer in some stands is dominated by undesirable species (e.g., western coneflower). Reduced ground cover in limited areas.

ASPEN (SERAL) (*POPULUS TREMULOIDES*)

CRITERIA	PFC INDICATORS	CURRENT STATUS
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Endemic populations of insects and disease. More than 30% topkill and branch mortality in mature and old age classes. In seral stands, low to moderately intense fires return on an interval of 20 to 50 years. This is dependent on surrounding vegetation types and generally slows conifer encroachment. Even low to moderately intensive fires are lethal and stimulate regeneration. Intervals that approach 100 years are typical of stable aspen stands that don=t require frequent disturbance to perpetuate the clone. Browsing does not prevent successful regeneration of clones. Beaver are present and rejuvenate aspen within 150 feet of streams.	Insects and diseases are common in the aspen type. Many stands show repeated years of defoliation by leaf blights. Stem cankers and rots are very common. It appears that many of the stable aspen stands are regenerating themselves as the overstory is damaged or killed by insect and disease. Because fire interval has increased, continued succession toward conifer in the seral stands has accelerated. In some localized areas browsing does prevent successul regeneration in clones.
PATTERNS (e.g. connectivity, shapes, size, distribution)	Patterns are within historical ranges. (Pattern sizes, shapes and corridors are maintaining processes.) The role of fire is to influence distribution of structural classes and patterns across landscapes.	Pattern size, shapes and corridors are mostly within historical ranges. Some conifer encroachment into stands.

ASPEN ASSESSMENT

Aspen types currently occur within this landscape in the same basic areas where historic stands occurred; however, some may now be mixed aspen/conifer sites due to encroachment by the more shade tolerant conifers (primarily subalpine fir or white fir). Most stands are mature and old (exceeding 80 years). There is a general lack of healthy seedling/sapling sized aspen. This is due largely to the lack of regenerating fires across this landscape during the period since European settlement. Aspen reproduces by suckering and requires a healthy root system for successful establishment of regeneration. Fires serves to rejuvenate seral aspen stands and remove invading conifer trees.

Fire suppression has had some influence on size of fires, but the larger influence on fire size and frequency has come from historic grazing practices that removed fine fuels, effectively preventing fires from spreading. Grazing/browsing by domestic livestock and wildlife has also significantly affected the establishment of aspen regeneration in localized areas, effectively preventing successful aspen regeneration in some stands. Historic heavy grazing also caused a shift in understory species, reducing the shrub and forb component and impacting preferred browse species such as elderberry. Livestock trail and water locations have impacted some aspen stands by concentrating use there. Where aspen intergrades with oak (on drier sites) there is a dynamic interaction that is not fully understood and needs additional study. Approximately 2,000 acres of this mix occurs as large stands in the upper parts of the basin, especially in the northwest corner of the watershed. It has been suggested by some that oak and aspen are relatively equal competitors, that their root systems have similar characteristics and appear to occupy separate zones. Both species are vigorous sprouters after fire, and both species are shade intolerant. However, it may be that the absence of fire in these systems favors oak dominance through the build-up of tannins from oak litter that can alter soil chemical properties. Differential animal browsing (i.e., preference for aspen) may serve to favor oak over aspen. It is possible that the risks posed to soils and watershed where this intergrade occurs, would be similar to that described in the oak narrative. It may be that the loss, where these two types come together, has been to the small interspersed openings of sage-grass that typically occur with these types.

ASPEN TREND

In the continued absence of widespread disturbance, aspen stands would continue their slow development toward later seral stages. Stable aspen stands will begin deteriorating due to age-sinescence between 80 and 110 years of age. These stands may replace themselves as older, overstory stems die, releasing root suckers. If this "turn-over" occurs on a widespread basis, it may be sufficient to disperse wildlife and livestock use and result in the successful establishment of younger age classes. However, if this "turn-over" occurs on a sporadic basis on small areas, concentrated wildlife and livestock use could prevent the successful establishment of young aspen.

Seral aspen stands (perhaps 1/3 of the acres in this landscape), would continue to have greater encroachment from conifers and may eventually become dominated by the more shade tolerant conifers.

ASPEN RISK

There is the potential for relatively large acreages of "stable" aspen to "turn over", or shift from being old aspen to being predominantly young aspen, at approximately the same time (older aspen stands become decadent and overstories degenerate, stimulating sprouting and establishment of a younger age class of stems). Heavy browsing/grazing could impact regeneration and prevent successful establishment of new stands or reduce the incidence of aspen stems within a given clone, and can also affect the form and vigor of aspen stands.

Continued encroachment of shade tolerant conifer species can, in time, replace seral aspen (subalpine fir poses the greatest threat to aspen). As aspen stands are replaced by conifer species, understory plant species are affected. Fir stands support a less diverse and much less abundant understory than aspen stands. Forage production of vegetative species used by wildlife and livestock can decline. Populations of wildlife which utilize aspen can be impacted (less effective habitat) or actually have an adverse impact on the type itself by overuse of what effective habitat is available.

Although some aspen stands are being replaced by conifer, aspen can persist within those stands as long as healthy, viable root systems remain in place. Local observations indicate it may take several generations of conifer dominance to eliminate aspen from a site. Actually, "losing" aspen is a relative term. However, additional research is needed to determine more narrowly what is a reasonable threshold beyond which aspen will be lost from a site.

DOUGLAS-FIR/WHITE FIR (*PSEUDOTSUGA MENZIESII/ABIES CONCOLOR)*

CRITERIA	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Structural Stage** Grass/Forb/Seedling/Sapling =15-30% Young/Mid Age Forest =30-50% Mature/Old Forest =30-50% Not more than 50% of the stands have multiple canopies. Stand Density Index (SDI) does not exceed 60% of maximum for the vegetation type and Basal Area is less than 160.	**Structural Stage** Stands are generally mid-aged and older with a general lack of Douglas-fir seedlings/saplings and young forest. Stand densities and basal areas high.
COMPOSITION	White fir and/or sub-alpine fir composition is less than 25%-35%. Understory vegetation is influenced by periodic low intensity fire.	Shade tolerant species, white fir and subalpine fir, >35% of stands and increasing. Understories are primarily shade tolerant species, especially white fir regeneration.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Endemic insect and disease populations exist. Mortality less than 5 trees per acre in groups of less than 10 trees. Less than 15% of acres with root disease centers. The fire interval is tied to the fire interval of the surrounding vegetation. The nonlethal fires occur at 15 - 40 year intervals, and limit the percent of true fir. Stand replacing fires occur at 100-200+ year intervals. Fires of low to moderate severity open dense stands of pole-sized or larger trees. Subsequent	Epidemic engraver beetle in true fir. Douglas-fir beetle at high levels, serving to kill overstory trees and release advance regeneration of true firs. High occurance of dwarf mistletoe in Douglas-fir. Fire cycle longer for nonlethal incidents.
PATTERNS (e.g. connectivity, shapes, size, distribution)	Patterns are within historical ranges. (Pattern sizes, shapes and corridors are maintaining processes. Juxtaposition with surrounding vegetation is within historical range.) Fire's role on dry and mesic sites is to prevent a shade tolerant understory from developing. Subsequent light burns maintain these stands in a park-like condition.	Douglas-fir/white fir is encroaching into riparian areas and aspen but to a lesser degree than spruce/fir types. More Douglas-fir/white fir within the landscape, denser stands, increase of true fir understory. Fuel densities higher; ladder fuels present. Some scattered encroachment into oak, oak-maple, and mountain brush types.

DOUGLAS-FIR/WHITE FIR ASSESSMENT

The Douglas-fir/white fir type occurs in roughly the same locations as did historic stands. The current stands are likely somewhat larger in acreage, with scattered individuals and small groups spreading into adjacent aspen, sagebrush-grass and mountain brush types. Stands are typically denser, with a larger component of white fir and/or subalpine fir, than historic stands. Most stands are mid-aged and older. Understory regeneration is heavy toward white fir and/or subalpine fir (on moister sites). Douglas-fir beetle and the fir engraver beetle are both very active within this landscape, serving to kill overstory trees, release advance regeneration (mostly true firs), and increase fuel loadings. The incidence of dwarf mistletoe appears to be higher than historic.

Periodic, low-intensity ground fire historically served to limit stand expansion, limit understory regeneration, and to keep the stands more open than current. Fire also has an influence on the incidence and severity of dwarf mistletoe, helping to keep it somewhat in check.

DOUGLAS-FIR/WHITE FIR TREND

The current trend for this vegetative type in the absence of disturbance is to slowly continue its development toward a late seral stage. Stands would likely become more dominated by the late-seral species (primarily white fir and some subalpine fir) with a reduction in the Douglas-fir component. Reductions could also be expected in the aspen that is associated with these stands. Associated with this undisturbed development would be an increase in overall stand densities, a reduction in understory species (due to overstory shading), an increase in density-dependant mortality, and a build-up of fuels.

DOUGLAS-FIR/WHITE FIR RISK

The largest risk to this type is more intense wildfire which may occur due to higher fuel loading and development of multi-layered stand characteristics which would allow fire to access tree canopies from the forest floor and lower vegetation. Lethal fires could result. Such fires could reduce the incidence of this type in the landscape and could result in increased impacts to soils and watershed and thus to long-term stand productivity. A second risk to this type is an overall increase of shade-tolerant species (white fir and subalpine fir) being established in the understories of Douglas-fir. This is a shift from long-lived fire tolerant species to shorter lived fire intolerant species. Wildlife habitat is also at risk of being made less favorable for those species that utilize conifer stands. Concurrent with this increase in true fir species is an increase in stand densities resulting in greater competition and stress on individual trees, and reduction in resistance to insect and disease.

The Douglas-fir/white fir type can pose some risk to adjacent vegetation types should it expand its range. Very likely there has been some expansion of average stand size on some sites where favorable habitat is adjacent to historic stands (aspect has a strong influence on site moisture and the potential for this type's expansion). Expansion has occurred primarily into the aspen type. Because white fir is more shade-tolerant and produces denser stands than Douglas-fir, it poses a greater threat to aspen. Scattered individual trees have expanded into some adjacent oak and mountain brush sites. In some areas, the type may also be expanding into riparian corridors, causing a reduction in lower-growing riparian vegetative species such as willows, alders and birches.

GAMBLE OAK (*QUERCUS GAMBELII*)

CRITERIA	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Structural Stages** Young (<15 yrs. old) =10-35% Mature (>15 yrs. old) = 30-60% Over-mature (decadent) =5-10% Sage/Grass/Forb openings are interspersed and occupy 10-20% of the acreage.	**Structural Stages** Structural stages are dominated by mature classes. Over-mature stands exist in landscape. Sage/Grass/Forb openings occupy fewer acres, with clones encroaching.
COMPOSITION	Understory herbaceous layers are sparse and dominated by perennial species. Bare ground is less than 20% in openings between clones, and ground cover is 100% within clones. Maple comprises 35% or less of tree strata. Less than 10% of tree strata is made up of Douglas-fir or white fir.	More oak throughout the landscape - encroaching into adjacent vegetation types. Increased litter layers and reduced herbaceous layers with more dominance of annuals and less desirable species.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Weather, endemic insects and disease affect less than 20% of the host type. Less than 20% branch and clump mortality caused by insects, disease or winter mortality. Fires have a 10 to 30 year interval in this mixed severity fire regime.	Increase in insect defoliator activities as clones age. Branch mortality is greater than 20% in some stands. Fire interval generally longer: 50-80+ years (as indicated by stem age data and fire records).
PATTERNS (e.g. connectivity, shapes, size, distribution)	Pattern is a mosaic of structural classes intermixed with sage-grass openings and scattered white fir and/or Douglas-fir, and sometimes with aspen. Aspen and oak are interspersed within this area.	Increase of scattered white fir and Douglas-fir and pinyon-juniper into oak. Expansion of clones resulting in loss of openings. Mosaic of structural classes has shifted to a predominance of older age classes.

GAMBLE OAK ASSESSMENT

Stand conditions are overmature due to a general lack of fire. Clone sizes are believed to be larger and stands are denser and contain a larger proportion of decadent stems than prior to European settlement. Grazing by both domestic livestock and wildlife has limited availability of fine fuels in the understory which might otherwise have carried fire through these stands. Recent fuel studies show a preponderance of stands with stems exceeding 100 years of age. Fuel loads range from 15 to 30 tons/acre with litter depths of 4.7 to 6.7 inches.

GAMBLE OAK TREND

The current trend for this vegetative type in the absence of disturbance is to continue its development at a moderate rate toward an overmature state, where individual stems and clones are older and larger than those that were historically on the landscape. It is likely that increased insect and disease mortality may be associated with this less vigorous stage of development. Associated with this undisturbed development would be a reduction in understory species (due to overstory shading) and a build-up of both standing and ground fuels. There is a trend for increased clone size and reduced opening size.

GAMBLE OAK RISK

There is the threat of short-term risk to watershed, soil conditions, and water quality due to potential for large, high intensity wildfires in the Gambel oak. Such fire would result in temporary loss of perennial cover and remove litter layers which provide soil surface protection from wind and water erosion. Without manipulation, these stands will continue to expand, resulting in loss of interspersed openings, and also result in increased horizontal obscurity which would reduce overall usability of the stands by wildlife. Especially at lower elevations, risk of expansion of cheatgrass, other annuals and invasive exotic weeds following wildfire would alter the fire return interval, increasing fire frequency. This also increases the risk of dramatic change in the understory/interclonal vegetation, changing from native perennials to exotic annuals. Higher occurrence of fire could reverse the trend described for this type at lower elevations.

GAMBLE OAK/BIGTOOTH MAPLE (*QUERCUS GAMBELII/ACER GRANDIDENTATUM*)

CRITERIA	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Structural Stages** Young <15 =10-25% Mature >15 = 30-60% Over-Mature = 5-15% Sage/Grass/Forb openings are interspersed and occupy 5-15% of the acreage.	**Structural Stages** More mid to late seral stages prevalent; dominated by older age classes. Occupy less acres
COMPOSITION	Understory herbaceous layer better developed and distributed with larger forb component than in oak type. Bare ground is less than 20% (except in late seral stands which occupy a limited portion of the landscape , see above.). Maple comprise >35% of tree strata. Less than 10% of tree strata is made up of Douglas-fir and white fir.	Overall, reduction in species diversity and cover of understory (especially grasses and shrubs) and increased litter layers.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Weather, endemic insects and disease affect less than 20% of the host type. More than 20% branch and clump mortality caused by insects, disease or winter mortality. Fires have a 20 to 40 year interval in this mixed severity fire regime.	Greater than 20% branch/clump mortality Fire return interval lengthened, with 2 to 3 missed incidents.
PATTERNS (e.g. connectivity, shapes, size, distribution)	Pattern is a mosaic of structural classes intermixed with sage-grass openings and scattered white fir and/or Douglas-fir, and sometimes with aspen.	Increase of scattered white fir and Douglas-fir; continuous stands - loss of openings. More oak-maple complex, with loss to oak type, across landscape (i.e., maple component has increased on some sites to the degree that oak stands now classify as oak-maple).

GAMBLE OAK/BIGTOOTH MAPLE ASSESSMENT

The amount of oak-maple has increased in the landscape, as maple has increased substantially in stands which were once almost pure oak. Stand conditions are mostly overmature due to a general lack of fire. Grazing by both domestic livestock and wildlife has limited availability of fine fuels in the understory which might otherwise have carried fire through these stands. These impacts were widespread earlier in the century, but are much more localized now. Reduction of the role of fire has also resulted in an increase of scattered white fir and Douglas-fir. Stands are generally more dense and continuous, with a loss of openings (usually occupied by sagebrush-grass).

GAMBLE OAK/BIGTOOTH MAPLE TREND

The current trend for this vegetative type in the absence of disturbance is to continue its development at a moderate rate toward an overmature state, where individual stems and clones are older and larger than those that were historically on the landscape. It is likely that increased insect and disease mortality may be associated with this less vigorous stage of development. Associated with this undisturbed development would be a reduction in understory species (due to overstory shading), a build-up of fuels, and an increase in the maple component (maple is a very shade tolerant species, whereas oak is a shade intolerant species). There is a trend for increased clone size and reduced opening size.

GAMBLE OAK/BIGTOOTH MAPLE RISK

Risks for this type are similar as for the Gamble oak type, but with somewhat less risk due to fire characteristics; fires in this type tend to burn with less intensity because of the maple component. As overstory density of maple decreases, understory vegetation is decreased, affecting wildlife habitat and limiting stand resiliency following fire (oak clone vigor is reduced and seed sources for understory species are reduced). Maple doesn't sprout as aggressively as oak following fire.

MOUNTAIN BRUSH COMPLEX		
CRITERIA	**PFC INDICATORS**	**CURRENT STATUS**
STRUCTURE	**Structural Stages** Mosaic of various shrub species interspersed with an understory of forbs and grasses. Representation of all age classes of shrubs on the landscape. Minimum of decadence in each species.	**Structural Stages** Dominance of older individuals for most shrub species on a majority of sites.
COMPOSITION	Representation of all native shrub species, with dominance and presence on a particular site dependant on site conditions and species requirements. A healthy understory comprised of perennial grasses and forbs is interspersed with the shrubs.	Composition shift to less palatable species. Some juniper encroachment into type. Some scattered Douglas-fir and white fir encroachment. At lower elevations understory includes cheatgrass with less overall ground cover than desired.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Insect, disease and fire intervals within 20-40 year cycles. Fire regime is mixed severity and influenced by adjacent vegetation types (sagebrush/grass and aspen). Herbivory from wild ungulates occurs, but does not impact plant vigor/species shift.	Fire intervals have lengthened with few fires since turn of century. Increased disturbance from heavy grazing/browsing is impacting plant vigor and species compostion at lower elevations (on big game winter range) with reduced occurrence of palatable species (e.g., bitterbrush)
PATTERNS (e.g. connectivity, shapes, size, distribution)	Acreages and dispersion within historical ranges. Acres may change depending on fire occurrence.	Fewer acres across landscape with shift to pinyon-juniper; acres lost to agricultural and rangeland manipulation.

MOUNTAIN BRUSH ASSESSMENT

Lack of fire has allowed shrub stands to develop to overmaturity, with a dominance of older individuals (older stems in the case of clonal species) and an increase in overall shrub density on many sites. Browsing by wild ungulates, and to a lesser extent, domestic livestock has resulted in excessive hedging of annual growth on shrubs, limiting expansion and vigor of plants. Increases in elk densities, and increase in deer/elk winter use - as the result of loss of habitat along Wasatch Front - has further reduced shrub health and vigor. This has also resulted in a shift to predominance by less palatable species (with a noteable reduction in bitterbrush).

MOUNTAIN BRUSH TREND

The current trend for this vegetative type in the absence of disturbance, where clonal/sprouting species (such as chokecherry and oak) dominate, is to continue its development at a moderate to fast rate toward an overmature state, where individual stems are older and larger than those that were historically on the landscape. It is likely that increased age-induced mortality and reduced reproductive capacity may be associated with this less vigorous stage of development. Associated with this undisturbed development would be a reduction in understory species (due to overstory shading) and a build-up of fuels. There has also been a shift in species composition to less palatable species that will likely continue due to grazing/browsing pressures. At lower elevation, the native understory has been influenced by the invasion of cheatgrass and other exotic annuals. Where non-clonal species (such as bitterbrush and the mountain mahoganies) dominate; vigor of individual plants is reduced and little regeneration is evident. Remaining plants are often strongly hedged. Planting of bare root stock has been attempted to reverse this trend but success has been limited.

MOUNTAIN BRUSH RISK

As shrub stands become more dense, understory vegetation will be reduced, and the risk of loss of palatable species increases. Overmature and decadent stands are less productive for grass/forb components, thereby limiting effectiveness of winter range for deer and elk, and limiting forage availability for livestock. Upland game habitat would also be impacted because of loss of age class diversity among stands. As ground cover decreases, watershed and soil conditions would be impacted (increased effect of erosion on sites with limited or no ground cover). Invasion by exotic annual grasses may eventually reduce the mean fire return interval in this type. These annuals generally cure earlier than natives and form continuous fuels to carry fire, resulting in fires recurring every 1-5 years. This more frequent fire interval would impact non-sprouting shrub species and result in a loss of diversity in understory species. This trend has been observed in many areas throughout the West.

BIG SAGEBRUSH/GRASSLAND (*ARTEMISIA TRIDENTATA - VASEYANA*/GRASS COMPLEX)

CRITERIA	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Structural Stages** 5-10% of area with 0-5% sagebrush crown cover (Very Early) 20-30% of area with 5-15% sagebrush crown cover (Early) 20-30% of area with 15-30% sagebrush crown cover (Mid) 5-10% of the area with >30% sagebrush crown cover (Mid/Late) Bare ground less than 20-30%, except 30-50% on high risk soils	**Structural Stages** Too many mid to late seral (heavy canopy cover) stands; more bare ground than desired except where smooth brome dominates. Where reseeding was done with smooth brome, there has been limited reinvasion of sagebrush and native understory species.
COMPOSITION	Big sagebrush is dominant on 95-100% of the historical habitat. Understory dominated by perennial, native forb and grasses. Rabbit brush dominates for short periods following disturbance.	Many introduced grass species dominate on treated areas. The forb component is reduced. Cheatgrass threatens to dominate lower elevation sites after disturbance.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Fire has a lethal fire regime on an approximately 20-30 year return cycle.	Fire cycle out of sync; the period between fire events has lengthened, with many stands missing 1-2 fire cycles.
PATTERNS (e.g. connectivity, shapes, size, distribution)	Patterns are within the historical range.	Conversion of acres due to agriculture, and watershed and range improvement activities. Conversion to pinyon-juniper and other types (15-20%) due to encroachment and manipulation.

BIG SAGEBRUSH/GRASSLAND ASSESSMENT

Mountain big sagebrush-grass communities have progressed to overmaturity due to lack of fire. Grazing has reduced fine fuels which would otherwise carry fire. Dense sagebrush stands tend to limit understory vegetation (sagebrush roots fill the interspaces between plants and outcompete understory species for moisture), impacting soil stability and overall watershed conditions. Past range/watershed improvement activities set back several hundred acres of sage/grass communities to earlier seral stages by removing sagebrush cover. These treatments effectively limited forb presence in these sites where herbicides were used. Reseeding smooth brome for watershed restoration resulted in loss of native grass and forb species on these acres. On some sites, sagebrush has yet to re-establish on treated sites. Where crested wheatgrass was used for reseeding, sagebrush has been able to reoccupy the sites within the same amount of time as would occur following natural disturbance (i.e., wildfire). At lower elevations, introduced annual species (especially cheatgrass) are prevalent and threaten to dominate following disturbances. Basin big sagebrush is present only as scattered, isolated patches along the drainage bottoms. Patches rarely exceed an acre in size.

BIG SAGEBRUSH/GRASSLAND TREND

The current trend for mountain big sagebrush in the absence of disturbance is to continue its development at a fairly rapid rate toward mid and late seral stages (with the exception of recovering former agricultural lands and the monocultures of smooth brome). Associated with this undisturbed development would be a reduction in understory species and an increase in bare ground. Introduced species (especially cheatgrass) can be expected to continue to increase. Sagebrush is slowly seeding itself into the former agricultural lands that were seeded to non-native grasses (smooth brome and crested wheat grass) and in areas where sagebrush was removed and reseeded with smooth brome. There has been little reinvasion by native understory species. Presently, ground cover remains high on these sites. Trends for Basin big sagebrush are not well understood. Observation of these small isolated patches suggest a decline in understory species. Some active planting of Basin sage is planned in the old agricultural fields in lower Diamond Fork

BIG SAGEBRUSH/GRASSLAND RISK

Overmature sagebrush stands limit use by a variety of wildlife species which might otherwise utilize this type (small game and non-game wildlife species). Overmature and decadent stands have less grass/forb production, thereby limiting effectiveness of winter range for deer and elk, and summer range for livestock. Where vegetative production is impacted, erosion may occur where soil stability is impacted. Erosion potential increases, especially in areas where pinyon-juniper has encroached, and in late seral sagebrush stands. Where these situations are adjacent to water courses, water quality is threatened. At lower elevations, cheatgrass may come to dominate some sites following disturbance. This can greatly increase fire frequency which can maintain sites in early seral condition, keeping sagebrush from returning to dominance and eliminating many native species which are intolerant to frequent fire.

Areas reseeded to smooth brome are experiencing a buildup of thatch, and hence ground fuels, which may increase the chance of fire in these areas. However, these stands tend to be difficult to burn as leaves remain green through much of the year. If fire were to occur it is not expected to damage the smooth brome plants and may even serve to rejuvenate them. Any monoculture is at inherent risk of failure due to the lack of resilience resulting from predominance by a single species (e.g., if a pest or disease successfully weakens the species, the entire stand is at risk of demise). Smooth brome communities on the Uinta National Forest and in other parts of Utah, however, remain stable and show no signs of weakening.

Exotic, invasive grasses, such as cheatgrass, Japanese brome, and jointed goatgrass pose a particular risk to this type. Cheatgrass and Japanese brome have already invaded large areas at lower elevations, causing reduced understory diversity, reduced vegetative cover and increased runoff. The possibility of greatly shortened fire cycles also puts sagebrush at risk. If wildfires burn frequently, as is common in cheatgrass-dominated sites, sagebrush density can be greatly reduced. In addition, cheatgrass is believed to outcompete young sagebrush and to suppress new recruitment, especially in decadent stands of sagebrush. Other weeds, such as the knapweeds, dyer's woad, and Scotch thistle, may move into this type from the Spanish Fork Canyon corridor. These species would also threaten species diversity and overall productivity of these sites. Musk thistle is already creating localized problems, but species like the knapweeds and dyer=s woad pose an even greater threat. In other areas of Utah, and the West, these species have been observed to spread more rapidly and to a much larger number of acres than musk thistle.

It is important to note that weeds can pose a threat to all vegetation types, but in Diamond Fork sagebrush-grass, oak/oak-maple, pinyon-juniper and mountain brush communities are likely at greatest risk. These communities occur at lower elevations, often on drier exposures with shallow soils and lower inherent ground cover, increasing the chance of invasion. These same communities are represented in the lower portions of the drainage, adjacent to Spanish Fork Canyon which provides a corridor for weed introduction.

PINYON - JUNIPER (*PINUS EDULIS* WITH *JUNIPERUS OSTEOSPERMA*)

CRITERIA	PFC INDICATORS	CURRENT STATUS
STRUCTURE	**Structural Stage** Grass/forb/seedling ≈10-20% Young/Mid Forest ≈30-50% Mature/Old Forest ≈30-50%	**Structural Stages** Preponderance of mature and over-mature stands
COMPOSITION	Shrub, forb and grass composition make up 20% or more of total vegetation. Together, litter and vegetation rarely provide more than 30% ground cover, with a large proportion of ground cover contributed by rock. Vegetative cover varies depending on soils (parent material), aspect and seral stage of stand.	Greatly reduced grass/forb and shrub understory.
DISTURBANCE REGIME (e.g. fire, insects, pathogens, flood, wind)	Endemic insect and disease populations. Fires burning every 20 to 40 years prevent pinyon-juniper stands from spreading into neighboring grasslands/shrublands.	The period between fire events has lengthened where pinyon-juniper has encroached onto adjacent types. On historic pinyon-juniper sites (i.e., fire-safe sites) fire frequency may be within mean fire return interval.
PATTERNS (e.g. connectivity, shapes, size, distribution)	Patterns are within historical ranges. (Pattern sizes, shapes and corridors are maintaining processes.) Pinyon-Juniper is primarily limited to habitats which offer protection from fire such as bare ridgetops, rock outcrops, and steep south facing slopes on Green River shale.	Encroachment into adjacent types: sage-grass, mountain brush, oak (typically deeper-soiled sites)

PINYON - JUNIPER ASSESSMENT

Pinyon-juniper stands have expanded their range over historic conditions. This has occurred primarily into the sage-grass type. There has also been some expansion, primarily as scattered individuals, into mountain brush and oak types. Historical sites where pinyon-juniper was persistent were those that were somewhat protected from fire due to a lack of ground vegetation. These were primarily rocky ridgelines and shale-based soil sites. In the absence of fire, pinyon-juniper (primarily juniper) quickly colonizes adjacent deeper-soiled sites and can replace other vegetation. Historic overgrazing accelerated this process by reducing vegetative competition. Once pinyon-juniper dominates a new site, the frequency of fires tends to get longer, and when fires do occur, they tend to be more intense.

PINYON - JUNIPER TREND

The current trend for this vegetative type in the absence of disturbance is to continue its expansion at a slow to moderate rate into adjacent vegetation types (primarily sage-grass). Historic areas of pinyon-juniper are generally denser than they once were with mid-aged and old stems dominating the sites. Density-related and insect and disease related mortality is on the rise. The amount of bare soil is increasing in both the historic and invaded areas.

PINYON - JUNIPER RISK

Risks associated with this type are primarily at adjacent vegetation types, not the pinyon-juniper. As pinyon-juniper stands expand, there is a reduction of other plants species, causing a reduction in species diversity. Wildlife habitat is impacted due to this limited diversity of vegetation. Reduced understory vegetation also effects forage production for livestock. As pinyon-juniper dominates and other vegetation is lost, soil stability and overall watershed conditions decline. The absence of fire occurrence in adjacent types is what has allowed pinyon-juniper to encroach and dominate.

SOCIAL DOMAIN

Table 3-3 Social Conditions

CRITERIA	SOCIAL PFC INDICATORS	CURRENT STATUS
STRUCTURE (the different types of use)	**Appropriate Types of Use** To determine Aappropriate use,@ both social values (what people want) and ecological values (what the environment can sustain) must be taken into consideration. It can be identified using Forest Plan Standards and Guidelines, existing laws and regulations, Recreation Opportunity Spectrum, travel planning, and public input during NEPA project analysis.	**Appropriate Types of Use** The present uses identified in Chapter 2 are generally considered Aappropriate.@ However, this could change as new activities emerge, as the amount of use changes, or as the way in which other activities are carried out change.
COMPOSITION (the interrelationship of people, their activities, and the natural environment)	**Appropriate Levels of Use are Distributed Across the Landscape** Again, Aappropriateness@ is defined through social values, and includes both the levels of impact to other users, and levels of impact to the natural environment.	**Appropriate Levels of Use are Distributed Across the Landscape** Currently, conflicts between users and with natural resources are restricted to a few areas. These include the Three Forks Trailhead, Red Rocks, dispersed camping areas above Springville Crossing, Fifth Water trail and hot springs, and developed and dispersed campground impacts to the riparian area.
FACTORS CREATING CHANGE (Factors that might affect the structure or composition of the social domain, including both influences that might increase or decrease user conflicts or resource damage)	**Changes in the Levels and Types of Use do not Adversely Dominate or Eliminate Other Uses** Potential sources of change include changes in county zoning laws allowing more private cabins per 40 acre plot, changes in social values or the popularity of some activities, increases in local populations seeking recreation, changes in Forest Plan Standards and Guidelines, etc.	**Changes in the Levels and Types of Use do not Adversely Dominate or Eliminate Other Uses** One factor bringing rapid change is the new water conveyance pipeline and road. The road is bringing in more users during both the summer and winter months creating additional parking and waste problems. Increases in the numbers of private cabins is decreasing the chance for fire to play a role in maintaining healthy plant communities. Recent increases in OHV/ATV use are another factor creating change in the area. Parking/trailhead facilities are strained. Trails traditionally used by horseback riders are now used by motorized vehicles as well. Rapidly increasing population along the Wasatch Front is resulting in ever-increasing numbers of visitors to Diamond Fork.

CRITERIA	SOCIAL PFC INDICATORS	CURRENT STATUS
PATTERNS (Many activities tend to cluster in particular areas, such as around stream channels, trails and roads)	**Patterns of Use do not Cause Social Disharmony or Unacceptable Levels of Resource Damage** Disharmony is defined by society as a whole, and may change as social values relating to solitude and social space change. Unacceptable levels of resource damage are defined through social values, including those expressed as Forest Plan Standards and Guidelines, etc.	**Patterns of Use do not Cause Social Disharmony or Unacceptable Levels of Resource Damage** Most activities in the analysis area are connected to riparian zones, which provide fishing, shade, flat corridors for roads and trails, and other attractions such as hot springs. As a result, resource impacts are the most widespread in riparian corridors, including Diamond Fork, Sixth and Fifth Water. Most of the area=s trails and roads that are frequently used for multiple activities are also being unacceptably impacted, including Fifth Water. Resource impacts include erosion and sediment runoff into creeks. Social impacts include perceived conflicts (e.g., hikers disappointed at encountering motorized vehicles on trails) and even potential safety hazards on busier routes.

SOCIAL ASSESSMENT

Human activities in the Diamond Fork cover a broad range of types, most of which are considered appropriate if done within appropriate levels and in areas where they do not adversely impact the area=s natural resources or interfere with other users. Society as a whole will continue to define these criteria, and Forest Service management will attempt to ensure that balance is maintained. Both the values relating to land management and the types of users in the area will continue to shift through time.

SOCIAL TREND

In the past, most people using Diamond Fork were either a few farming and ranching families or recreationists who came from southern Utah Valley. Recreation use of Diamond Fork has increased dramatically in the last few decades, as have other uses such as summer home sites. Today the area has become a regional recreation magnet, and many users are from areas beyond Utah Valley. The users are also more urban-oriented than in the past. This trend is expected to continue.

Demand for both individual and group developed recreation sites is expected to continue to grow. It is expected that both kinds of developed campsites will continue to exist in the canyon, but that demand will soon exceed supply, particularly on weekends. Demand for other kinds of developed recreation facilities is also expected to increase, and these include developed parking areas, toilet facilities, etc. These correspond to increasing demand for close areas in which to experience nature, drive for pleasure, hike, mountain bike, ride horses, and four wheel drive. The use of the Diamond Fork drainage for education opportunities will continue to expand, especially with the establishment and development of the Youth Forest Program.

Other uses of the area will continue to influence the ecology and social climate of Diamond Fork. Grazing, for example, will be present in the canyon and managed through Forest Plan Standards and Guidelines, which capture public concerns about both maintaining this cultural tradition and doing so in ecologically acceptable ways. The trend is for recreation to continue to be the dominant use of the area and demand for specific kinds of recreational experiences (such as mountain biking, hiking, ATV-riding, fishing, and dispersed camping) to increase. Attitudes surrounding acceptable ecological conditions are expected to change as society increasingly values solitude and high quality natural experience.

Continued development of private land for cabins and permanent residences is expected to change some use patterns. Recreational use on these lands may become more restricted. Some private lands currently remain unfenced and unposted; but, as these larger tracts are subdivided and built on, this is expected to change. Uses on adjacent federal lands may also be impacted. For example, county ordinance prohibits firing of a weapon within 600 feet of a residence and Forest Service regulation (36 CFR 261.10) prohibits discharge of a weapon within 150 yards of a residence, building, campsite or other developed area, or across a road. Based on these laws, increases in the number of buildings and the associated access roads would somewhat reduce hunting opportunities.

Dividing of large parcels currently under single ownership, and used primarily for agriculture (i.e., livestock grazing), into many smaller parcels each with different ownership, will create many other urban-interface challenges. Construction of residences in fire-adapted vegetation types, such as Gambel oak, which are overmature and have high fuel-loads creates problems for fire suppression which can pose a public safety risk. Development also limits opportunities to use prescribed fire and wildland fire-use (i.e., management ignited fires or natural ignitions which are allowed to burn to meet management objectives) as tools to reduce fire risk.

Most of the private lands with potential for development currently provide valuable winter range for big game animals which have been displaced from traditional winter ranges along the Wasatch Front, above Springville and Mapleton. Development would reduce the value of this habitat. Similar ranges higher in Diamond Fork and Spanish Fork canyons are limited in extent, and may be unuseable by mule deer in most years due to the higher elevation and greater snow depth. Development can open additional corridors for the invasion of noxious weeds and create opportunities for escape of invasive plants used as landscape ornamentals.

SOCIAL RISK

Steady shifts in human activity in the Diamond Fork area has created a situation in which some ecological and social conditions have improved through time, while others have degraded. For example, land clearing of the riparian zone in lower Diamond Fork has ended, but heavy dispersed recreation continues to adversely impact riparian areas and creates user conflict throughout much of the canyon.

Some social activities in the area are probably at risk. Traditional farming may eventually disappear as private lands become more valuable as cabin sites. In addition, easier winter access may lead more homeowners to live nearly year-round in Diamond Fork, creating less of a backcountry feel for the area. The area is presently valued by many Utah Valley residents as a place to retreat from city life, to be involved in various forms of outdoor recreation, and for some to experience solitude. Increases in the numbers and types of users may eventually compromise the opportunities for certain kinds of recreation experience. Those experiences associated with fewer conflicts and with solitude will be the most likely to be impacted.

Risks to ecological resources will continue to grow if not reduced through management of the impacting activities. Riparian areas contain the resources currently at most risk, and that trend is expected to continue. This has important social implications, since riparian areas are the ecological areas that people currently value most. User conflicts in riparian areas are also expected to increase, particularly if restoration projects succeed in increasing the quality of fishing in Diamond Fork. User conflicts along road and trail corridors will also increase, as most use will continue in these areas. This has strong social implication, since debate over appropriate activities and activity levels in these intensively used areas may affect resource management and human activity generally throughout the Diamond Fork watershed.

CHAPTER 4

ISSUES AND MANAGEMENT OPPORTUNITIES

Chapter 4 synthesizes the information from Chapter 3 into issue statements for each resource area. Following the issues, management opportunities are listed as the means to help resolve the issue.

THE PHYSICAL DOMAIN - ISSUE STATEMENTS

Lower Diamond Fork

Due largely to transbasin irrigation diversions, the timing and magnitude of water flowing down lower Diamond Fork has been significantly altered and the physical domain is outside of a properly functioning condition. These altered flows have negatively affected the shape of the channel causing it to become wider, steeper, straighter and less stable. These flows and channel changes have resulted in a decline of mature cottonwood forest, in some places, up to 85%. This area has also had additional impacts due to agricultural clearing, road and campground construction and historic grazing.

As explained in Chapter 3, the lower Diamond Fork channel is inherently unstable, and therefore, the hydrologic trend is considered downward. Until the Diamond Fork System is fully completed and the existing high magnitude augmented stream flows are eliminated, this trend is expected to continue. At risk are the riparian forest and aquatic habitat of the wildlife that utilize these habitats and downstream water quality.

Upper Diamond Fork

Road construction has encroached on the Diamond Fork stream channel and reduced the width of the riparian area. The close proximity of the road to the stream has facilitated human access to the stream and riparian area. Dispersed recreation in this area has resulted in soil compaction, vegetative trampling and removal, contributed to bank erosion, and reduced water quality. Livestock grazing and trailing have also impacted riparian areas. Woody debris recruitment and the number of active beaver dams have been reduced. These changes have contributed to long-term changes in channel morphology and stability. The result of these changes is a more

simplified channel with reduced riparian complexity. However, this remains as one of the better sections of riparian habitat in the watershed.
Portions of the channel have been stabilized and the trend of riparian vegetation at some sites has been upward; however, the stream remains at risk to erosion during large floods. Riparian areas most at risk are those with nearby roads which provide access for dispersed recreation use. In these sections, wildlife and aquatic habitat are negatively affected as well as water quality.

Lower Diamond Fork Tributaries

Continued downcutting and erosion of incised reaches is being exacerbated by the loss of bottomland vegetation and by roads and vehicle use, both of which increase compaction and lead to increased runoff rates. Grazing, dispersed camping and OHV use have contributed to the loss of riparian vegetation along Little Diamond Creek, Wanrhodes Creek, Monk's Hollow and Red Hollow. Channel incision in these streams may, at least in part, be a response to downcutting of the main channel of lower Diamond Fork.

The long-term trend for riparian areas appears to be stable or slightly upward. An expected increase in recreational use will likely result in a continued slow rate of recovery. Continued suppression of riparian vegetation by grazing and recreation uses will result in continued inputs of fine sediment from tributary channels and contribute to lowered downstream water quality in Diamond Fork and the Spanish Fork River. However, bank erosion in lower Diamond Fork, caused by irrigation flows under operation of the Strawberry Valley Project, will still be a major contributor of fine sediment to lower Diamond Fork until completion of the Diamond Fork System of the Central Utah Project allows a change in the flow regime.

Upper Diamond Fork Tributaries

High flows from a transbasin diversion severely reduced the riparian, hydrologic and morphologic functioning of Sixth Water. The construction of the Syar tunnel and Sixth Water aqueduct has resulted in the removal of high flows from the upper 6 miles of Sixth Water Creek and provides for the possibility of rehabilitating upper Sixth Water. The formation of a narrow stream in Sixth Water would be at risk from potential, but unlikely, emergency releases from the old Strawberry Tunnel.

Other upper Diamond Fork tributaries have been impacted by roads, dispersed recreation, grazing, and the loss of beaver. These activities and losses have resulted in reduced riparian functioning and incised channels, particularly in the upper Waters. The trend is mostly stable to slightly upward or slightly downward for vegetation based on greenline transects. Some channels may still be actively eroding. Wildlife and fish habitat, bank stability and water quality are at risk.

Gamble Oak/ Big Tooth Maple

Because of the lack of periodic fire, maple (shade tolerant) and scattered white fir and Douglas-fir are increasing and understory species are being reduced. Again, largely because of lack of fire, stand conditions are overmature, dense and continuous which results in a loss of openings and increased fuel build-up. There is the threat of large, intense wildfires with the concomitant risks to soil conditions, watershed productivity and water quality.

Mountain Brush Complex

In some areas, lack of fire has resulted in a lack of age class diversity with an over abundance of mature plants. This has resulted in a reduction of understory species (due to overstory shading) important for grazing/browsing by deer, elk and livestock as well as a reduction in soil stabilization. This lack of diversity has also impacted upland game habitat. Additionally, grazing/browsing has limited the expansion and vigor of shrubs on low-mid elevation sites (i.e., winter ranges) and caused a shift to more unpalatable species.

Big Sagebrush/ Grassland

Lack of fire, caused by the widespread reduction of fine fuels due to grazing in the first half of the century and by fire suppression in recent decades, has resulted in an abundance of overmature stands of sagebrush and a build-up of fuels. These dense, overmature stands limit understory vegetation which limits deer, elk and livestock forage. The lack of understory vegetation can also result in unstable soils, soil erosion and impacts to water quality. Native grasses have been negatively affected by reseeding projects and introduced annual species, particularly cheatgrass. Cheatgrass can limit the expansion of sagebrush and other species intolerant of frequent fire. Sagebrush is slowly beginning to reestablish on the former agricultural lands that were seeded to non-native grasses.

Pinyon-Juniper

Lack of fire and grazing has lead to expansion of the pinyon-juniper type, primarily into the sage-grass type. This results in less understory vegetation, more bare ground and less habitat diversity which negatively effects forage production for livestock, soil stability, overall watershed conditions and habitat for wildlife. The trend is for this expansion to continue which will also lead to denser stands of pinyon-juniper and increased insect and disease related mortality.

THE BIOLOGICAL DOMAIN - ISSUE STATEMENTS

Subalpine Fir

Lack of fire in the blue spruce-subalpine fir (caused by the lack of fire in adjacent vegetative types) is allowing for the encroachment of the type into aspen, and some riparian corridors, causing a reduction of shade intolerant species (such as willows) and associated wildlife habitat. Lack of intermittent fire also increases the potential for catastrophic stand-replacing wildfire. Such a fire could reduce the incidence of spruce/fir within the landscape, negatively impact soils and the watershed, and severely limit habitat for cavity nesters and other species dependent on stands with multistoried canopies and older aged trees.

Aspen (Seral)

Aspen stands are reaching an age of decline (80+ years). The fire that aspen needs to regenerate is lacking due to historic grazing practices that removed fine fuels, effectively preventing fires from spreading and to fire suppression efforts in recent decades. Additionally, without fire to limit their boundaries, conifers are encroaching into the aspen stands. Many aspen stands have the ability to shift from being primarily old stems to young stems when the overstory stems die and release root suckers. Success of this regeneration will depend on the level of grazing/browsing by domestic livestock and wildlife on the young aspen shoots. At risk is wildlife habitat in the aspen stands.

Douglas-Fir/White Fir

With the lack of periodic fire, this type is encroaching into adjacent vegetative types. White fir is being favored over Douglas-fir as they are more shade tolerant and fire intolerant. Stands are becoming denser which causes a reduction in resistance to insect and disease. Douglas-fir beetle and the fir engraver beetle are both active, serving to kill overstory trees and increase the fuel loading. The risk is of lethal fires which could reduce the incidence of this type on the landscape and reduce associated wildlife habitat values. A fire of this magnitude would also put at risk soils and watershed productivity.

Gamble Oak

With the lack of periodic fire this type may: expand into interspersed openings which reduce the overall useability for wildlife, reduce understory species and increase fuel build-up, and be more vulnerable to insect and disease . There is the threat of high intensity wildfire with the associated risks to soil conditions, watershed productivity and water quality.

SOCIAL DOMAIN - ISSUE STATEMENT

The increasing level of recreation use in Diamond Fork is having an negative impact on riparian resources and associated wildlife habitat in select areas, particularly Fifth Water and lower Diamond Fork. This use is also resulting in some user conflicts between mountain bikers, anglers, hikers, ATV riders, horseback riders and livestock, which may escalate if not addressed. The increasing number of year-round residents is also changing the nature of the canyon. What was once viewed as a remote and quiet place is increasingly perceived as a backyard playground.

MANAGEMENT OPPORTUNITIES

The following is a list of management opportunities, developed by the Interdisciplinary team, that evolved as a result of this assessment. This list should not be viewed as all-encompassing or fully developed. Reviewing and expanding this list will be a logical next step for the Spanish Fork Ranger District, Uinta National Forest. Implementation of site-specific actions is subject to analysis under the National Environmental Policy Act (NEPA).

ADDRESS RESTORATION NEEDS IN DIAMOND FORK[1] AND SIXTH WATER

- Address changes in streamflow regime in lower Diamond Fork resulting from proposed CUP operations relative to
    - Existing versus potential channel stability
    - Existing versus potential riparian condition and extent
    - Existing versus potential aquatic habitat and fisheries conditions.

Focus should be on an holistic approach which recognizes all main components of the system and their interactions, mechanisms of change that have led to current conditions and identification of likely response mechanisms due to changes in the flow regime so that a sound basis can be made for determining channel and riparian restoration needs. This requires an interdiscipinary approach and should involve all Federal and state agencies and other interested parties who have had past involvement in the Diamond Fork watershed.

[1] Lower Diamond Fork restoration efforts should also include the former Child's property near the mouth of Diamond Fork that was acquired by the United States from the Child's Family.

- Provide additional analysis on the physical and riparian system of Sixth Water and how these affect aquatic life. In particular, work needs to be done to assess the potential to reconnect Sixth Water to its floodplain in the reach upstream of Ray's Valley.

Restoration needs of Diamond Fork and Sixth Water should be considered together. For example, recommended flows for Sixth Water, based on its current morphology, may not be appropriate for lower Diamond Fork.

- Investigate reestablishing native riparian vegetation along unstable sections of stream where recovery is slow, e.g. portions of Sixth Water between Strawberry Tunnel west portal and the Syar Tunnel/Pipeline outlet.

- Address potential emergency releases from Strawberry Tunnel and their potential impacts to long-term channel rehabilitation on Sixth Water and Diamond Fork Creeks.

- Address channel incision in ALL of mainstem Diamond Fork, including relation to downcutting in tributary channels.

ADDRESS IMPACT FROM ROADS

- Address impacts from all roads, including contribution to mass wasting, excess erosion and sediment delivery to streams, road maintenance needs, and identify roads in need of closure and/or relocation. Incorporate information into future travel management plans..

ADDRESS IMPACTS FROM DISPERSED RECREATION

- Address dispersed recreation impacts on upper Diamond Fork and Upper and Lower Tributaries' riparian values by

    - Reviewing conditions at dispersed campsites within the drainage and identify needs for limiting access or closing sites. Consider implementation of a rest-rotation system for these sites.

    - Where such reviews have been completed, develop a management plan to implement changes if needed.

- Evaluate OHV use in all of the Diamond Fork watershed, particularly in Little Diamond, Wanrhodes, Monk's Hollow, Brimhall Canyon and Red Hollow.

- Develop a master plan for a trail system in the assessment area.

- Provide improved signing and information on OHV use, the forest travel plan, and OHV opportunities.

ADDRESS IMPACTS FROM GRAZING

- Address grazing impacts on Lower Diamond Fork Tributaries, Upper Diamond Fork and Upper Diamond Fork Tributaries by

  - Conducting riparian surveys to identify stream reaches where stability is low and rates of improvement are slower than desired.

  - Reviewing existing data, continuing to monitor riparian conditions, and evaluating rates of change. Combine this with monitoring of utilization rates in riparian zones and continued implementation of Forest Service grazing standards and guidelines. If rate is slower than desired AND standards and guidelines are being met, assess need to implement stricter guidelines. If rate is slower than desired AND utilization standards and guidelines are NOT being met, take appropriate action to bring grazing into compliance.

- Address domestic livestock and wildlife negative grazing impacts on the regeneration of aspen shoots and the expansion and vigor of mountain brush complex shrubs.

ADDRESS IMPACTS FROM WEEDS

- Continue to address existing infestations

  - Continue to implement integrated pest management principles, using a variety of treatment methods, selecting the method best suited to the particular weed species and the specific on-the-ground situation.

  - Encourage private landowners to treat weeds on their property.

  - Look for ways to accelerate treatment efforts through increased funding from various sources.

- Prioritize treatments when funding is limited, focusing on species and situations posing the greatest risk to natural resource values.

- Work with Utah County to find ways to minimize infestation risks on newly developed land through planning and permitting processes.

ADDRESS NEW INFESTATIONS

- Train Forest Service employees and local landowners to recognize existing and potential new weed species (particularly those already in Spanish Fork Canyon).

- Treat new infestations as "wildfires" - take immediate, effective action to eradicate all new infestations.

ADDRESS IMPACTS FROM LACK OF DISTURBANCE - PARTICULARLY FIRE

- Reestablish the role of fire as a disturbance in fire-dependent vegetation types.

- Monitor the success of any prescribed burning to determine under what situations management ignited fire is the best tool in reestablishing a disturbance regime. [2]

- Monitor the statewide effort to allow for expanded wildland fire use (what the Forest Service formerly referred to as "prescribed natural fire", i.e., allowing fires resulting from natural ignitions, such as lightning strikes, to burn under certain conditions) in some areas. Current purposes are limited to fuel management and wildlife habitat enhancement. If the fire amendment is completed and accepted, the Uinta National Forest will prepare a fire management plan which will include a determination if wildland fire use would be used in portions of Diamond Fork. Based on the criteria in the current draft of the amendment, much of Diamond Fork could be considered for wildland fire use.

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[2] Note that the Spanish Fork Ranger District, Uinta National Forest, is in the process of analyzing a series of proposed prescribed burns within the Diamond Fork drainage. The proposed action includes burning of 2,700-4,400 acres annually for 3-5 years beginning in 2000. Oak and oak-maple are the primary types of vegetation targeted in this proposal.

- Monitor past treatment areas of the sagebrush-grass types. Use this information to develop a fire management plan for that type.[3]

ADDRESS DECLINE OF BEAVER POPULATIONS

- Address impacts of declining beaver populations in upper Diamond Fork and Eastside tributaries, including impacts on stream stability and sedimentation due to loss of beaver.

ADDRESS RECREATION CONFLICTS

- Address users conflicts between mountain bikers, hikers, horseback riders and livestock.

ADDRESS IMPACTS OF PRIVATE LAND USE

- Address potential impacts to National Forest systems lands due to an increase in the number of year-round residents on private lands in the watershed.

[3] It is important to note that extensive areas of sagebrush-grass types, particularly mountain sagebrush, have been altered by past range treatments. While sagebrush is typically considered to be dependent on fire for rejuvenation, these treatments have resulted in greatly altered communities which may not benefit from fire in their current state.

CHAPTER 5

COMMENTS AND RESPONSES TO THE DRAFT DIAMOND FORK AREA ASSESSMENT

Three comment letters were received on the Draft Diamond Fork Area Assessment. The commentors were:

LETTER NUMBER	INDIVIDUAL AND ORGANIZATION
1	Lee Wimmer, Central Utah Water Conservancy District
2	Reed E. Harris, United States Fish and Wildlife Service
3	John Kimball, Utah Division of Wildlife Resources

Comments from each letter and responses to those comments follow.

RESPONSE TO LETTER 1

Comment: Page 2-11, first sentence: Change "is" to "was."

Response: We do not agree that the word "was" should be used instead of "is" in the first sentence. The paragraph describes influences on vegetation and is correct as worded. It is true that these factors did influence vegetation; however, they still do, and rewording the sentence would be inappropriate given the context of this paragraph.

Comment: Page 2-24, first paragraph: Utah Chubs and Utah Sucker were likely present in Diamond Fork. Why are there no sections for Amphibians and Reptiles?

Response: These species, and groups of species should be addressed. The following sentence was added to the end of the first paragraph:

Utah chub and Utah sucker inhabited the Spanish Fork River drainage and prior to European settlement may have inhabited portions of the Diamond Fork drainage (Charlie Thompson, UDWR, personal communication 2000).

Additionally, the following sections were added:

1) Below the third paragraph on page 2-24:

Amphibians Amphibians in the Diamond Fork drainage generally inhabited wetland habitats such as wet meadows, ponds, streams, springs and marshes. Utah tiger salamanders (*Ambystoma tigrinum utahensis*), chorus frogs (*Pseudacris tiseriata*), leopard frogs (*Rana pipiens*), Woodhouse's toad (*Bufo woodhousei*), western boreal toads (*Bufo boreas boreas*) and spotted frogs (*Rana pretiosa*) likely inhabited the Diamond Fork drainage prior to European settlement.

Reptiles Reptiles in the Diamond Fork drainage are described in the 1999 Diamond Fork System, Bonneville Unit, Central Utah Project, Final Supplement to the Final Environmental Impact Statement, as follows: "Foothill shrub and grassland habitats ... provide good habitat for reptiles. Lizards common to these habitats include northern sagebrush lizard (*Sceloporus graciosus*), northern side-blotched lizard (*Uta stansburiana*), Great Basin (western) whiptail (*Cnemidophorus tigris*), and Salt Lake horned lizard (*Phrynosoma douglassi ornatum*). Snakes occur most commonly near water in canyons and near valley wetlands. Species likely to occur ... include wandering garter snake (*Thamnophis elagans vagrans*), Great Basin gopher snake (*Pituophis melanoleucus deserticola*), and western yellow-bellied racer (*Coluber constrictor mormon*)."

2) Following the first paragraph on page 2-27:

Amphibians Wetland and aquatic habitats for amphibians were impacted as described for fish. These impacts were particularly severe in the lower reaches of Diamond Fork drainage where many riparian forests were cleared or lost. Impacts to amphibian habitat around springs and wetlands also occurred in the upland areas. Historical grazing in these areas reduced ground cover, impacted water quality, and affected the plant composition in these habitats.

Reptiles Reptiles were also impacted by historical land uses. Wetlands and aquatic habitats important to many reptiles were impacted as described previously for fish. Upland grassland, shrub and spring habitats were also impacted by clearing for agriculture and heavy grazing. Heavy utilization, changes in species composition, and reduced ground cover occurred in many areas. This would have adversely affected reptile habitat quality.

3) At the top of page 2-32:

Amphibians Changes in grazing management, partial implementation of the CUP, and other changes in management have stabilized or improved amphibian habitat conditions. The completion of CUP and associated restoration, and implementation of other management practices in the drainage is expected to improve amphibian habitat conditions. Portions of Diamond Fork drainage were surveyed for amphibians in 1992 and 2000. These surveys found chorus frogs, but no boreal toads or spotted frogs. Boreal toads are generally found above 7,500 feet in elevation and the Diamond Fork drainage is generally below this; however, this species has sometimes been found at lower elevations in the general vicinity.

Reptiles Reptile habitat conditions are stable or improving from historical conditions due to changes in resource management and land use. This trend is expected to continue with full implementation of CUP and further implementation of other management practices.

Comment: Page 2-25, first full sentence: Should probably reword the sentence since it is awkward as written.

Response: The sentence was clarified as follows:

It is likely that beaver occupied the same areas that they do today; however, beaver populations were likely higher in pre-settlement times than they are currently.

Comment: Page 2-32, third paragraph, fourth sentence: "construction of Syar Tunnel" should be changed to "completion of the Diamond Fork System" to be accurate.

Response: The sentence has been changed as requested.

Comment: Page 2-34: It is interesting to note that spotted bat, Townsends Big Eared Bat, Lynx, Wolverines and Fishers are covered under the heading "Neotropical Migratory Birds."

Response: We agree that the species listed are not neotropical migratory birds. The heading "Threatened, Endangered and Sensitive Species" has been inserted at the start of the fifth paragraph on page 2-33 (paragraph starts with "Presently, the following species are all listed as sensitive...")

Comment: Page 2-34, last paragraph: Red fox have been observed in the Diamond Fork drainage by CUWCD employees and their consultants in 1999.

Response: The second to last sentence has been revised as follows to reflect this information: "Red fox, another non-native predator, has also been observed there."

Comment: Page 2-35, last sentence: There are at least 5 known nesting territories for golden eagles and maybe a lot more. Mr. Ken Keller has been studying these birds for up to twenty years and should be contacted to obtain the current nesting territory count. His work phone # is 801-253-5020.

Response: Thank you for this information. The second paragraph was replaced with the following:

The status of golden eagles in the Diamond Fork drainage is described in the *1999 Diamond Fork System, Bonneville Unit, Central Utah Project, Final Supplement to the Final*

Environmental Impact Statement, as follows: "Surveys for nesting raptors in the Diamond Fork drainage area have been conducted annually since 1990 (Keller 1990) ... Six pairs of golden eagles are known to nest within Diamond Fork Canyon."

Comment: Page 2-36, Native People, last sentence: "Turn of the century" may no longer be an appropriate phrase.

Response: We agree, the sentence was reworded as follows:

Area settlers remember Utes returning to the area from the Uintah Reservation on summer trips up until after the end of the 19th century (Connie Childes, personal communication, 1997).

Comment: Page 2-45, first paragraph, last sentence: Just keep that myth alive for as long as you can.

Response: We discussed this comment with Charlie Thompson of the Utah Division of Wildlife Resources. Based on his comments, the last sentence of the first paragraph was replaced with the following:

The Utah Division of Wildlife Resources currently considers Diamond Fork to be a Class 3 fishery. However, watershed conditions and habitat in the stream are improving and the fishery is beginning to respond. The fishery is expected to continue to improve with full implementation of the Diamond Fork System, and the stream will eventually likely be considered a Class 2, or even a Class 1 fishery (Charlie Thompson, UDWR, personal communication, 2000).

Comment: Page 3-1: Just what does the footnote mean? Is PFC a "target" to the extent that it is used to determine "Risk"?

Response: Properly functioning condition (PFC) indicators were identified based on the historic information available, assuming that Diamond Fork was in a properly functioning condition during the pre-settlement period. We know that our understanding of a PFC for Diamond Fork is incomplete. We use the concept here as an educated reference point to answer the question "why do we care?" What resources have we lost? What resources are at risk if the current trend continues? The PFC indicators are not targets, rather information to be used in combination with other factors to determine a desired future condition.

Comment: Page 3-9, second full paragraph: "2002" should be changed to 2003.

Response: The text has been changed as requested.

Comment: Page 3-11, Hydrologic Trend: Why is the hydrologic trend "downward?" Hydrologic conditions have been rather stable for the last 80 years.

Response: Flows in Diamond Fork have been augmented for the last 80 years, and streams often evolve to altered flow regimes. Our data however, indicates the channel is still inherently unstable. This situation is not clearly described in the Draft Assessment. The first sentence in the second paragraph was replaced with the following:

Although altered stream systems normally reach equilibrium with their altered environment, this has not occurred in Diamond Fork even though many of the impacts on the watershed began many years ago (i.e., heavy historic grazing occurred in the late 1800's and early 1900's, agricultural clearing occurred in the early 1900's, and stream flow augmentation began in 1915). The timing, magnitude, and duration of flows compared to the natural flow regime has led to continually affected sediment transport characteristics, channel and bank stability, and channel geometry. Consequently, the channel has been and continues to be inherently unstable and therefore, the hydrologic trend is considered to be downward.

Comment: Page 3-68, Social Trend: Recreation use of the fishery will undoubtably increase with current CUPCA changes.

Response: We agree, the third sentence of the fourth paragraph was revised as follows:

The trend is for recreation to continue to be the dominant use of the area and demand for specific kinds of recreational experiences (such as mountain biking, hiking, ATV-riding, fishing, and dispersed camping) to increase.

Comment: Page 4-1, third full paragraph, Define "altered." Post CUPCA?

Response: The third full paragraph was revised as follows in response to this comment:

As explained in Chapter 3, the lower Diamond Fork channel is inherently unstable, and therefore, the hydrologic trend is considered downward. Until the Diamond Fork System is fully completed and the existing high magnitude augmented stream flows are eliminated, this trend is expected to continue.

Comment: Page 4-5, Social Domain: You can add anglers to the list of increasing conflicts with the projected increase in the fishery on Diamond Fork with the implementation of the Diamond Fork Project.

Response: We agree, the second sentence of the first paragraph was revised as follows:

This use is also resulting in some user conflicts between mountain bikers, anglers, hikers, ATV riders, horseback riders, and livestock, which may escalate if not addressed.

RESPONSE TO LETTER 2

Comment: We have no comments on the project as proposed.

Response: We appreciate the Fish and Wildlife Service's review of the draft assessment.

RESPONSE TO LETTER 3

Comment: Page 2-2, last sentence of the last paragraph: Irrigation flows have occurred in the Diamond Fork system since the Strawberry Tunnel became operational in approximately 1916. Why was channel degradation, attributed to those flows, only seen after 1939 as stated on 2-2? On 2-6, paragraph 3, there is a reference to livestock grazing and the effect on erosion rates during the early 1900's. The last sentence on 2-6 also states that erosion rates were extremely high prior to the early 1940's. Based on these conditions, one would expect that induced changes in channel morphology would have been well advanced by 1939. What happened in that year?

Response: Based on this comment, the last paragraph was revised as follows:

Historic land uses, which began in the late 1800's and continued through the mid 1900's, have affected Diamond Fork. Heavy livestock grazing and subsequent erosion occurred in the watershed during the late 1800's and early-to-mid 1900's. Farming of the Diamond Fork valley bottom below Monk's Hollow and along Wanrhodes began around 1900 and increased steadily for several decades. Irrigation releases from Strawberry Reservoir through the Strawberry Tunnel began in 1915. These land uses undoubtedly affected the channel and floodplain structure and hydrologic regime in Diamond Fork. By 1939, the earliest date aerial photography of Diamond Fork is available and therefore the earliest date a baseline can effectively be established, the river was still bordered by a nearly continuous riparian fringe averaging up to 250 feet in total width. At this time agriculture was the dominant use of lower Diamond Fork and occupied 70 to 80 percent of the valley floor. Clearing of ground for farming probably affected the extent of total riparian area in the valley, as it is apparent from photographs that the river formerly meandered over most (roughly 80%) of the valley floor. The channel of lower Diamond Fork has widened and/or entrenched (eroded downward) significantly, depending upon the location along the valley. This widening and entrenchment occurred primarily in response to irrigation releases from Strawberry Reservoir through the Strawberry Tunnel into Diamond Fork.

Comment: Page 2-7: These paragraphs discuss the erosion that is occurring in the Diamond Fork drainage, but do not mention the aggradations of sediments that is occurring in the lowest reach of the watershed, and the resultant channel braiding and erosion conditions that are developing because of deposition of coarse sediments (abandoned channels and meanders, new channels that are undercutting or eroding established cottonwood galleries, etc.).

Response: We agree that the effects of the erosion on the streams are not discussed in this section. The impacts of transported sediment (all sources) on stream channels in the drainage are discussed in the previous section, "Stream Channel Structure, Riparian Structure and Hydrologic Regime." Discussion of these effects in this section ("Soils and Hillslope Processes") would be redundant and is not appropriate in this section.

Comment: Page 2-9: The paragraph mentions that numeric descriptors are based on shape, aspect or other topographical factors. Table 2-2 (Narrative Soil Erosion Hazard Ratings by Landtype) shows the numerical descriptors and ratings, but is rather confusing. The numerical descriptors are meaningless without some information to describe the descriptor. For instance, land types "mountain foothill" 1 and 3 (MF1 and MF3) both have low hazard ratings in either undisturbed or disturbed soil conditions, but MF4 has moderate hazard ratings. Is there an MF2? What factors do the numbers correspond to that might help the reader understand the differences between the different mountain foothill land types? Is the detail that Table 2-2 provides even needed at this point in the document? The table will become very cumbersome, but as presented in this draft, the reader does not know the location, size, shape, or aspect of the landtypes which have identical or different hazard ratings.

Response: The last paragraph on this page was replaced with the following text and Table 2-2 was revised.

Erosion hazard for a particular landtype can vary based on differences in shape, aspect, and other topographic factors. Erosion hazard ratings for landtypes found within the Diamond Fork drainage are summarized in Table 2-2.

Comment: Page 2-11: What does it mean when soils are "droughty"?

Response: The last sentence of the first paragraph was revised as follows to clarify the term.

In addition to this, several of the dominant soils types in the drainage (such as those derived from Green River Shale) have properties that make them "droughty" (i.e., they retain limited moisture available for plants compared to other similarly located soils); and therefore, support vegetation more typical of relatively lower (i.e., drier) elevations.

Comment: Page 2-11: Does "the Waters" refer to a general area within the total project area? If so, that area should be described when initially used.

Response: The "Waters" does refer to an area. The first sentence in the second paragraph was rewritten as follows to eliminate any confusion:

Plant communities dominated by sagebrush and mountain brush (predominately oak brush) were the most common vegetation on the uplands throughout the main stem of the drainage, and in the First Water Creek, Second Water Creek, Third Water Creek, Fourth Water Creek, Fifth Water Creek, and Sixth Water Creek drainages (i.e., the "Waters") as far up as Rays Valley.

Comment: Page 2-12, second paragraph: Did Native Americans actually try to increase grass production by burning sagebrush?

Response: Yes. Early trapper accounts for Utah describe Indian peoples burning sagebrush to reestablish or maintain grass stands. Native grass communities contain several species that are edible, so maintaining them was of great importance to Native Americans. We do not have any definitive data to document Native American burning in the Diamond Fork drainage; but it does seem likely this happened at least occasionally.

Comment: Page 2-20, fifth paragraph: Aspen regeneration is also being retarded by reduced fire frequency and grazing (both cattle and big game [including deer], not just elk).

Response: We agree, the fifth paragraph was revised as follows:

Most aspen clones are advanced in age, beginning to deteriorate, and becoming more susceptible to disease with many individuals stems 80 to 120 years of age. Some regeneration is occurring, but at low levels. Fire, which would stimulate aspen regeneration, has been suppressed, and grazing by domestic livestock and big game has impacted aspen regeneration that does occur. Due to grazing and fire suppression, species composition under the aspen has probably shifted, with a reduction in forbs and subsequent increase in grasses and shrubs. Some unpalatable forb species, such as western coneflower, have increased dramatically.

Comment: Page 2-24, last paragraph: As beaver ponds filled, stream channels also developed around the pond, causing the stream to develop new channels and expand riparian areas.

Response: We agree that stream channels can and do develop around beaver ponds, where valley width is sufficient to accommodate this. However, these normally develop within the confines of the existing floodplain. The following sentence was added to the paragraph.

In situations where topography of the stream valley allows, alternative stream courses may develop around the beaver pond.

Comment: Page 2-26, first paragraph: Please clarify why gray wolf would have been "abundant". With low numbers of deer, elk, bighorn sheep, and mountain goat as a prey base, it is doubtful that wolves would have been "abundant." It is probably better to include their description in the second sentence.

Response: The first paragraph has been revised as recommended:

Threatened, Endangered and Sensitive Species The gray wolf, northern goshawk, three-toed woodpecker, flammulated owl, boreal owl, great gray owl, spotted bat, Townsend bat, North American lynx, wolverine, and fisher, may have occurred in the assessment area. Fluctuations in the populations of these species would have coincided with natural processes.

Comment: Page 2-26, second paragraph: Bobcat, lynx and raptors should be included in the list of predators.

Response: The paragraph was changed to include bobcat, lynx and raptors as follows:

Predators Predators existing in Diamond Fork during the pre-settlement era included wolves, coyotes, black bears, grizzly bears, cougars, bobcats, raptors, and possibly lynx. These species' range would have been widespread with only natural barriers preventing migration.

Comment: Page 2-26, fourth paragraph: Backwater and side channel habitats were also lost due to vertical bed migration.

Response: We agree, the following sentence was added to the end of the paragraph:

Backwater and side channel habitats were also lost due to vertical bed migration.

Comment: Page 2-27, first paragraph: "Brown trout were also ~~present in most of~~ **introduced to** the streams."

Response: The eighth sentence in the first paragraph was replaced as suggested.

Comment: Page 2-27, second paragraph, last sentence: The last sentence over-simplifies the reasons for stream channels becoming incised. The same might be said of the last sentence of paragraph 3 on 2-15.

Response: We agree that the effects of beavers on stream channels is complex, this sentence is a simple summarization of these effects. However, this sentence is redundant with previous, more detailed discussion in the document and is therefore unnecessary here. The last sentence in the second paragraph was eliminated. The last sentence in paragraph three on page 2-15 was revised as follows:

In sections of the Waters, impacts from grazing and the lack of beaver activity have resulted in bare, unstable banks which, in some cases, has ~~allowed~~ **contributed to** channel down-cutting and subsequent invasion by upland sagebrush-grass communities.

Comment: Page 2-27, third paragraph: Hunting pressure has little effect on populations of upland game species. Precipitation and insect production (as forage for upland game) should be included as factors which affect upland game populations.

Response: We agree that precipitation and insect production are factors affecting upland game populations. The first sentence in the third paragraph was revised as follows:

Populations of upland game in Diamond Fork drainage increased and decreased depending on habitat changes, precipitation, and insect production.

Comment: Page 2-27, last paragraph: Bighorn sheep were **almost** eliminated...elk were impacted by unrestricted ~~hunting~~ **shooting**, as well as by unrestricted numbers of competing domestic livestock.

Response: We agree that the original wording was an overstatement and also that livestock grazing contributed to the elimination of elk in the area. The last paragraph was reworded as follows:

Large Ungulates By the time the Uinta National Forest Reserve was established in 1897, livestock grazing resulted in loss and degradation of plant communities which directly affected all native species. Bighorn sheep are believed to have been eliminated in Diamond Fork by 1890. Pioneers eliminated most of the elk from its natural range due to unrestricted shooting and livestock grazing. By 1907 the State began protecting the small deer herds and eventually reintroduced elk. The first recorded sighting of a moose in Utah was around 1906 at the head of Spanish Fork Canyon.

Comment: Page 2-28, last paragraph: You may want to mention that after the 1990 rotenone treatment of Strawberry Reservoir, Sixth Water Creek (water from Strawberry Reservoir is released down Sixth Water Creek) was restocked with brown trout. Subsequent surveys by UDWR show that brown trout are doing well in the stream.

Response: Refer to the response to your comments for page 2-31.

Comment: Page 2-29, third paragraph: Can the change in species composition in one year be described as a "trend"?

Response: We concur the use of the word "trend" here is inappropriate. The third paragraph has been reworded as follows:

Sample results from the Diamond Fork, Hall's Fork, and Fifth Water sites typically have shown a pattern of higher numbers of sediment and organic tolerant species early in the year during spring runoff, and higher numbers of clean water species in the fall. This pattern was observed in Hall's Fork in 1993, but the opposite pattern was observed in Fifth Water, perhaps due to a disturbance in the watershed. The season-long dominance of sediment-tolerant species in Fifth Water is indicative of a stream with a constant, high sediment load.

Comment: Page 2-29, fifth paragraph: Please clarify: "Few invertebrate species have resident population numbers, which is indicative of the instability of the channel system." Do you mean there was low species diversity?

Response: No, this means that few species found in the stream had high populations present through the course of the year. To clarify this, the paragraph was reworded as follows:

Sampling results from Diamond Fork below Brimhall station clearly show the impacts of flow augmentation by trans-basin diversions from the Strawberry and Syar tunnels. The number and biomass of organisms observed varies measurably between June and October, and during this period populations of some species dip to low numbers. This is indicative of the instability of the channel system. There are both clean water and sediment/organic-tolerant taxa present, with an abundance of sediment and organic-tolerant taxa. In most years, an increase in overall species abundance can be observed after the trans-basin diversions have ceased. This suggests a good potential for improved water quality in the absence of augmented flows.

Comment: Page 2-31, first paragraph: Please contact Don Wiley or Doug Sakaguchi (801-489-5678) if you would like more recent (than Radant 1976) fish survey information for some of these streams. Also, with or without "angler management", brown trout tend to outcompete rainbow and cutthroat trout.

Response: We agree that brown trout are very strong competitors with cutthroat trout. We have contacted Doug Sakaguchi for more current fish survey information. The more current information was incorporated as follows:

1) The following paragraph was added to the end of the Sixth Water discussion on page 2-28:

In 1990, during the rotenone treatment of Strawberry Reservoir and its tributaries, an accidental release occurred to Sixth Water and Diamond Fork. This greatly altered fish populations in Sixth Water. The Utah Division of Wildlife Resources restocked Sixth Water with brown trout during 1991-1995. Wiley and Thompson (2000) report the stream has since been resurveyed, and 1999 data indicates this stream supports an excellent and productive brown trout fishery containing about 900 trout/mile (estimated 213 to 251 pounds per acre).

2) The second and last paragraphs in footnote 14 on page 2-31 were deleted.

3) The following paragraph was added to the end of the Diamond Fork discussion on page 2-29:

As previously noted, an accidental release of water containing rotenone occurred in 1990. This release impacted fish populations in lower Diamond Fork (below Fifth Water confluence). UDWR restocked this stream with brown trout and leatherside chub. A 1997 survey of this stream reach found the trout population to be 87% brown trout, 12% cutthroat trout, and 1% rainbow trout. The rainbow trout present were primarily hatchery-reared "catchables" (8 to 11 inches in length). The wild trout biomass was estimated to be 70 to 127 pounds per acre (Wiley and Thompson 1997). Leatherside chub, mountain sucker, and mottled sculpin were also observed during the survey.

Wiley (1997) reports that 1996 data indicates upper Diamond Fork (above the Guard Station) contains an estimated 739 Bonneville cutthroat trout, 158 brown trout, and 159 rainbow trout/mile. Compared to 1991 data, populations of brown trout have increased about 20% while populations of cutthroat trout have more than doubled. Three size classes of cutthrout trout, two of brown trout, and one of rainbow trout were observed in 1996.

Comment: Page 2-31, second paragraph: Please clarify whether Walser et al. (1997) was a study in Diamond Fork Creek or Sixth Water. Also, clarify the length of stream where the population estimate occurred.

Response: The study was in a 14 kilometer reach of Diamond Fork between Monks Hollow and Diamond Fork's confluence with the Spanish Fork River. The first sentence in paragraph two was rewritten as follows to include this information:

In a 1996 study of leatherside chub in the 14 kilometer reach of Diamond Fork between Monks Hollow and Spanish Fork River, Walser et. al. (1997) reported that leatherside were present, but occurred almost entirely in back water and cutoff habitats.

Comment: Page 2-31, footnotes: Are all four paragraphs part of footnote 14? Please insert appropriate footnote numbers in the text as well as in the footnotes section of the page.

Response: The second and fourth paragraphs under this footnote were eliminated. The third paragraph is now footnote 15.

Comment: Page 2-32, third paragraph: Wasn't the "Syar Tunnel" completed in 1990 (page 1-4)? Would a better term be the completion of the Phase 2 of the Diamond Fork System?

Response: Yes. The text now refers to completion of the Diamond Fork System.

Comment: Page 2-32, fifth paragraph: Add Little Diamond, which also serves a winter roost site for turkey. Also, add "oak" as important for feeding (...juniper trees and oak to feed and ....).

Response: The fifth paragraph was revised as following:

Cottonwood forests along Little Diamond, Diamond Fork, and Wanrhodes Creeks serve as winter roost sites for this population. The turkey utilize riparian cottonwood trees to roost at night and juniper and oak trees to feed and rest during the day.

Comment: Page 2-32, sixth paragraph: Omit the information about Willow Creek drainage for elk calving areas and add Billies Mountain, Shingle Mill, south side of Maple Mountain and Timber Mountain to the list. Elk are NOT year round residents of the assessment area.

Response: Willow Creek is not within the assessment area and reference to it can be eliminated. We concur with the additions to the elk calving areas. However, several Forest Service employees have observed elk and deer within the Diamond Fork drainage during every month of the year. The paragraph was revised as follows:

Elk calving areas occur in the Waters, Two Tom Hill, Billies Mountain, Shingle Mill, Timber Mountain and south side of Maple Mountain areas. Deer use the riparian corridors for fawning areas. There is also transitory use by elk from surrounding areas. Elk and deer winter range consists mostly of sagebrush/grass and mountain brush communities. Deer and elk are normally present within the assessment area during every month of the year.

Comment: Page 2-34, fourth paragraph: Add lynx to the exception list (include with grizzly bear, wolverine, and wolf). Add bobcat with coyotes, black bear, etc.

Response: The first two sentences in the sixth paragraph were revised as follows:

All predators existing in Diamond Fork during the pre-settlement era exist today with the exception of the grizzly bear, wolverine, lynx, and wolves. This includes coyotes, black bears, bobcats, cougars, avian predators, nest predators, skunks, snakes, weasels, and mink.

Comment: Page 2-35, second paragraph: There are at least three known...

Response: Refer to the response to Letter #1's comment for this page.

Comment: Page 3-2, end of paragraph: There appears to be an inadvertent change in font size.

Response: The text font has been corrected.

Comment: Page 3-63, second paragraph: Cheatgrass also outcompetes young sagebrush and eliminates new recruitment, especially in decadent stands of sagebrush.

Response: We agree that cheatgrass is believed to be a strong competitor to establishing sagebrush. The following sentence was added to the second paragraph:

In addition, cheatgrass is believed to outcompete young sagebrush and to suppress new recruitment, especially in decadent stands of sagebrush.

APPENDICES

APPENDIX A
ANNOTATED AERIAL PHOTOS

Figure 1. Diamond Fork, 1939. Segment 1, mouth of canyon to Lavanger Hollow.

Reach 4

Reach 3

Reach 2

Reach 1

1) landslide and alluvial fan opposite mouth of Lavanger Hollow confine channel to center of valley.

2) alluvial fan

3) cottonwood/box elder along irrigation ditch.

4) floodplain width 220 ft, bordered by mature cottonwood. tight meander pattern and narrow channel (avg. 25-30 ft; 15 ft at narrowest point.)

5) fenceline. dark area adjacent to fence is possibly an old meander loop (presently 10-12 ft above channel).

6) channel widening & sediment deposition. width +/- 110 ft

7) alluvial fan

8) entrenched river meander

9) old meander pattern visible in tilled fields

10) channel obscured by vegetation; floodplain width 250 ft.

11) lighter colored trees probably box elder; extend to road. meander pattern visible in field left of river. Box Elder occurs at this site in 1998.

12) cottonwood forest, maximum width 600 ft, including channel.

13) young cottonwood and willow; width 280 ft. edge of fields is floodplain edge. straight fenceline on right of river borders riparian. veg line marks edge of active floodplain in 1939.

14) this section of floodplain underwater at flow of +/- 290 cfs (tunnel release 277 cfs on this date - July 21).

15) Child's Homestead

16) mature cottonwood-box elder along road

17) levee? right bank of river is hardened upstream of highway signs of channel widening and sediment deposition.

18) US. Highway 6.

19) Spanish Fork River

Figure 2. Diamond Fork, 1956. Segment 1, mouth of canyon to Lavanger Hollow.

Figure 3. Diamond Fork 1971. Segment 1, mouth of canyon to Lavanger Hollow

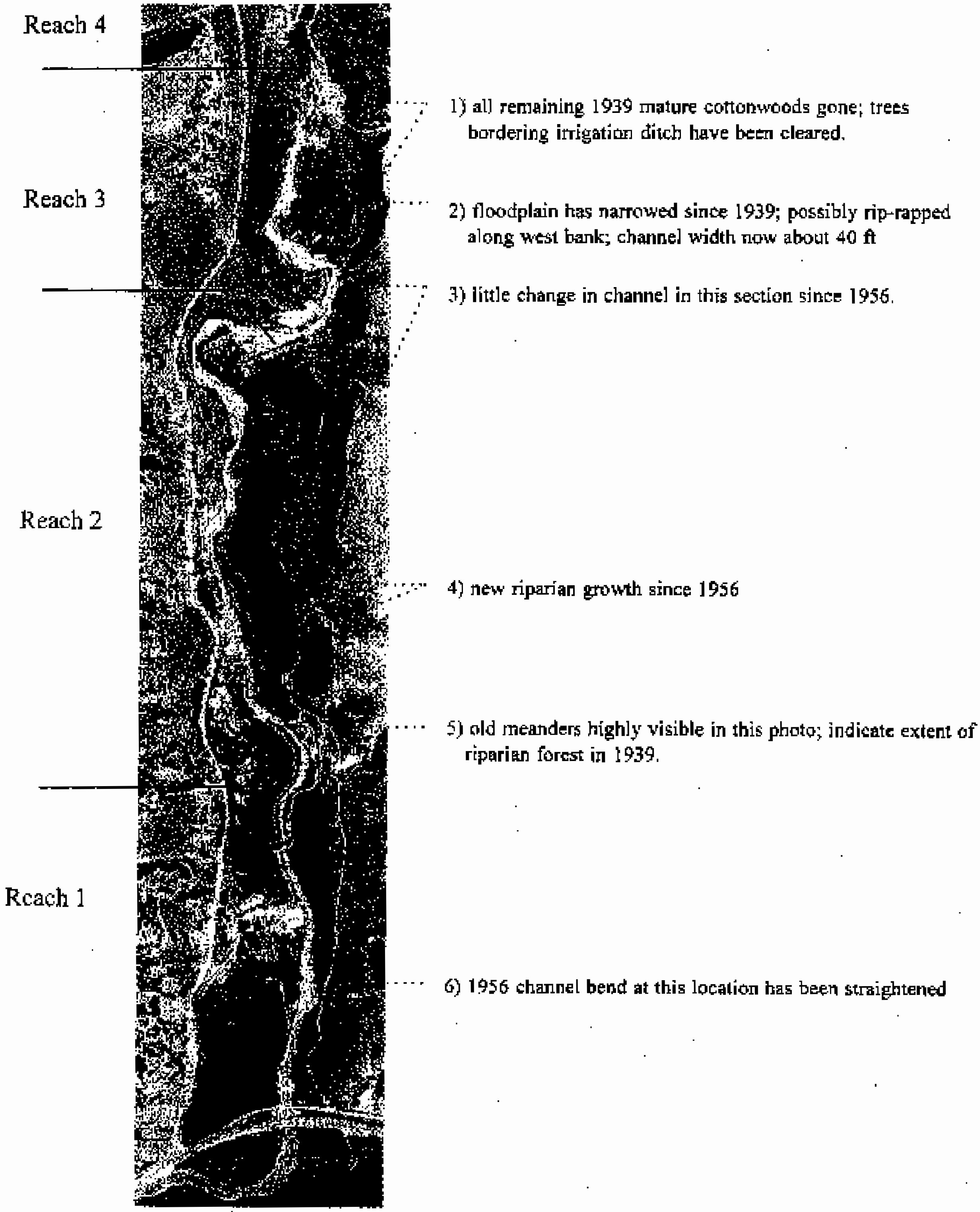
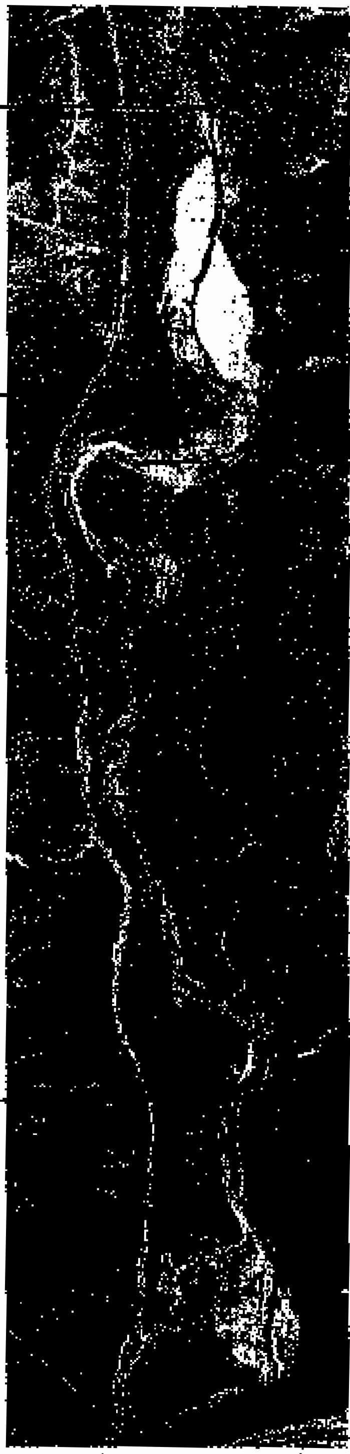


Figure 4. Diamond Fork, 1984. Segment 1, mouth of canyon to Lavanger Hollow



Reach 4

Reach 3

Reach 2

Reach 1

1) new floodplain surfaces created by 1983-84 floods; maximum width 550 ft.

2) mature cottonwood visible in 1971, but not 1956 photos. probably established following 1952 flood.

3) channel moved east roughly 160 ft; close to position of 1939 channel meander.

4) channel has migrated against upstream end of cottonwood grove; obstruction has created new meander

5) continued growth of cottonwood on surfaces scoured by 1952 flood.

6) site of willow and young cottonwood on 1939 floodplain converted to emergent marsh

7) base of new highway fill; re-constructed highway is 550 ft closer to Child's homestead

Figure 5. Diamond Fork, November 1995. Segment 1, composite photograph.

1) Reach 4 is one of two sites in segment where channel has not moved since 1939; also cottonwood present in 1939 is still intact.

2) surfaces created in 1983-84 now colonized by sapling cottonwood +/- 3.5 ft above irrigation high water. 2 areas combined total roughly 6 acres.

3) channel migrated west 360 ft since 1984. average rate 33 ft/year since 1984, indicates section remains unstable.

4) entrenched meander is 2nd site in segment where channel has remained in place since 1939, though reaches upstream and downstream have been highly unstable.

5) 1984 channel is now an oxbow dammed by beaver at downstream end. channel has moved 210 ft back to the west (19 ft / year).

6) section continues to re-develop meanders; this reach mostly straight in 1971 and 1984 photos.

7) lower reach remains channelized; 280 ft riparian width in 1939 reduced to narrow fringe, 15-20 ft wide on both sides of stream; floodplain width in this reach has also been reduced.

8) groundwater ponds upstream of highway fill; high water now inundates buildings at former Child's property during growing season; area is colonized by Ute ladies'-tresses.

Figure 6. Diamond Fork Segment 2, July 21, 1939.

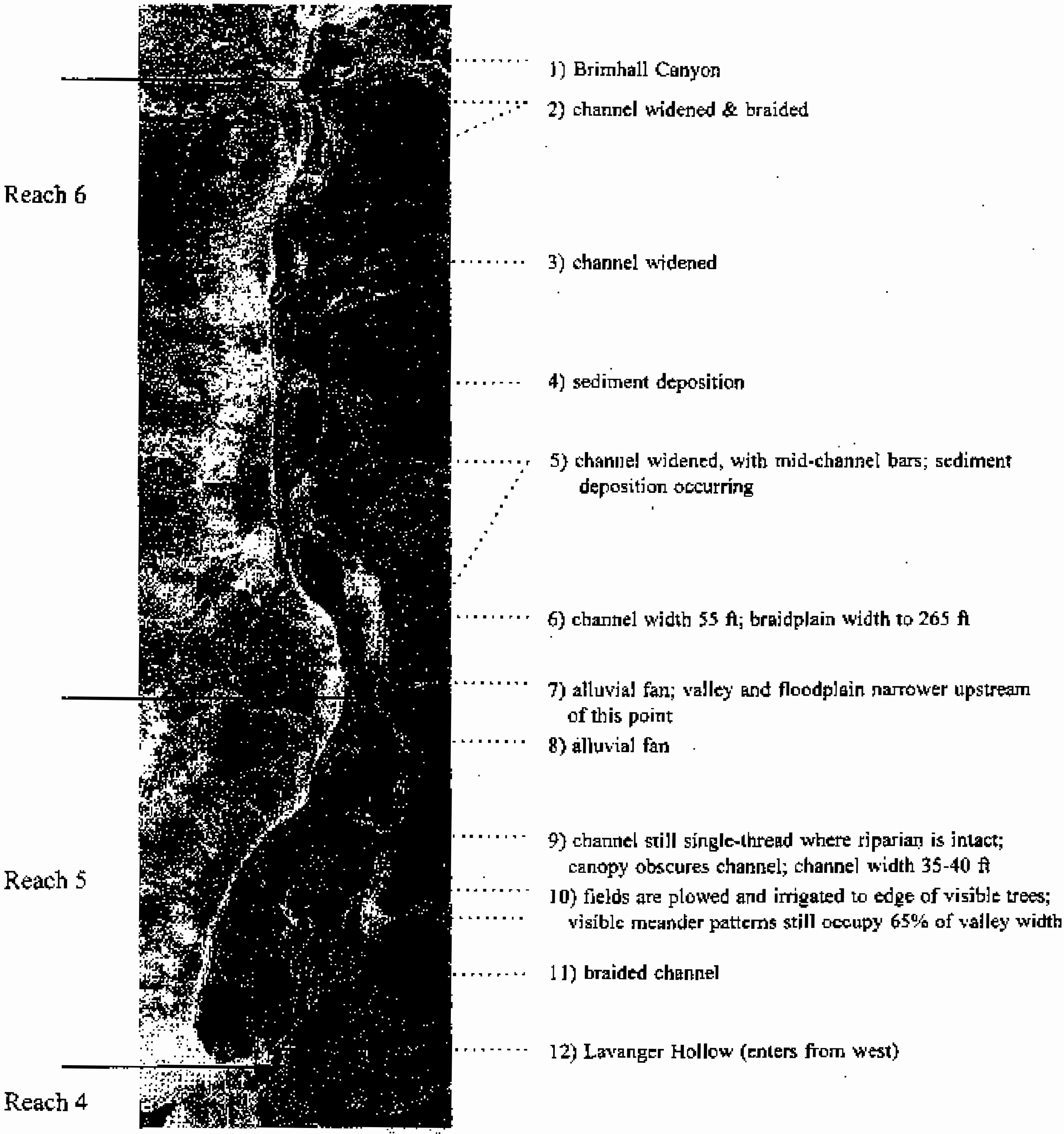


Figure 7. Diamond Fork Segment 2, 1956

Diamond Fork Segment 2, 1971

Reach 6

Reach 5

Reach 4

1) bridge

2) channel straightened and nearly all mature trees present in 1956 now gone. scour lines possibly left by thunderstorm peak in August 1969.

3) channel now completely braided; width roughly double 1956 width

Diamond Fork Segment 2, 1984

Reach 6

1) channel has straightened since 1971

2) light areas are sediment from 1983 and 1984 floods.

Reach 5

3) channel eroding into alluvial fan; banks at this site approach 20 feet in height.

Diamond Fork Segment 2, 1995

Reach 6

1) new bridge, compare reach downstream to previous photos.

2) new meanders have developed in this section since 1984.

3) created wetlands

4) vegetated floodplain surfaces less than 1 foot above irrigation bankfull stage and stay saturated to surface through growing season. dominant vegetation is now coyote willow; Ute ladies'-tresses also present. compare to 1939 photo.

Reach 5

APPENDIX B
GEOLOGIC HISTORY

The Wasatch Mountains were created by displacement on the Wasatch Fault which has averaged 0.4 mm/year over approximately the last 10 million years for a total displacement of over 4,000 meters, or approximately 13,000 feet (Stokes 1986). The Diamond Fork watershed is underlain by rocks exposed by uplift along the Wasatch Fault and primarily includes sedimentary rocks of Permian (280 to 225 million years before present) to Tertiary (65 to 2 million years before present) age which were deposited in an ancient sea which covered much of present day northeastern Utah, southwestern Wyoming and northwestern Colorado (Stokes 1986). This includes, from oldest to youngest, the Oquirrh Formation, Park City Formation, Thaynes Formation, Ankareh Shale, Nugget/Navajo Sandstone and Twin Creek Limestone. Rocks of Tertiary age include the Price River, Flagstaff Limestone, Green River Shale and Uinta Formations.

The sedimentary formations are gently folded in a broad anticline-syncline pair (Young 1975). The axis of the anticline traverses the watershed along a north-south axis beginning near Billies Mountain in the south and extending northward along Red Mountain to Pumphouse Hill at the watershed divide. West of this axis the geology is more complex due to the occurrence of several north-northeast trending normal (high-angle) faults. East of this axis, geologic formations dip gently eastward in a progressively younger sequence of Tertiary strata which includes the North Horn (Red Narrows Conglomerate), Price River, Green River, Flagstaff Limestone and Uinta Formations (Young 1975; Pashley 1975). The syncline underlies the west half the watershed and has its structural axis roughly along the trend of Wanrhodes Canyon. Together the faults and anticline-syncline pair exert strong control on the surface morphology of the watershed. Wanrhodes Canyon, Red Hollow, upper Diamond Fork above Three Forks, and lower Sixth Water can be described as "strike" valleys which largely follow the north-south trend of the underlying bedrock. From Red Hollow eastward the major ridges are capped by the Navajo Sandstone or by sandstone layers which occur within the Price River and Uinta Formations. Located between these two formations, Ray's Valley is an area of low topographic relief that traverses the Waters area from north to south and is underlain by the softer and more erodible Green River Shale.

APPENDIX C
REVEGETATION PROJECTS

The following provides a record of completed revegetation projects within the Diamond Fork Area Assessment boundaries. During the revegetation projects conducted during the 1960s-1970s, the typical seed mix included: Smooth brome, intermediate wheatgrass, pubescent wheatgrass, orchardgrass, western wheatgrass, alfalfa, yellow sweetclover, small burnett, antelope bitterbrush.

YEAR	LOCATION	ACRES	TREATMENT
1934	Sam's Canyon Monks Hollow	327	Broadcast seeding: smooth brome, slender wheatgrass, crested wheatgrass, Kentucky bluegrass, white sweet-cover
1941	Sterling Ranch	10	Broadcast seeding: crested wheatgrass
1942	Sterling Ranch Diamond Fork Allotment (?) Wanrhodes	90 175 81	Broadcast and harrowed: crested wheatgrass, smooth brome Broadcast and harrowed: common rye Broadcast and harrowed: common rye
1943	Wanrhodes	8	Drill: crested wheatgrass, smooth brome

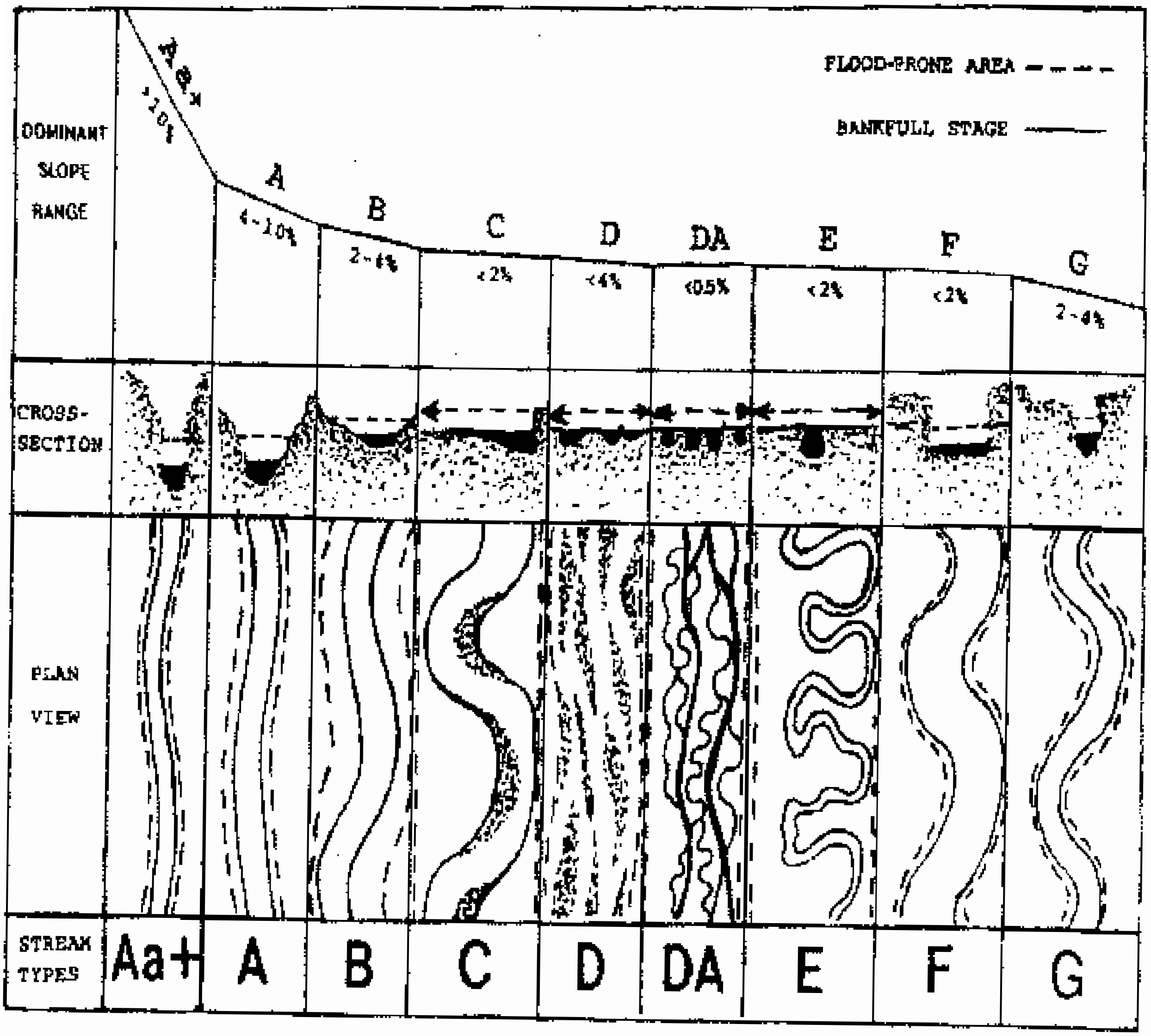
YEAR	LOCATION	ACRES	TREATMENT
1944	Blackett lands (??) Wignall Ranch	35 90	Drill: crested wheatgrass, smooth brome
1947	Maple Canyon First Water	75 60 200	Broadcast: smooth brome Burn and drill: crested wheatgrass, slender wheatgrass Broadcast: crested wheatgrass, slender wheatgrass
1948	First Water	1300	Plow and drill: crested wheatgrass, slender wheatgrass, mountain brome
1949	First Water Rays Valley	758 500 400	Drag and broadcast: crested wheatgrass, smooth brome, slender wheatgrass; Plow and drill: crested wheatgrass, smooth brome Plow and drill: crested wheatgrass, smooth brome
1954	Sterling Ranch	40	Drill and plow: crested wheatgrass
1956	Sterling Ranch	20	Disc/drill: crested wheatgrass
1962	Wanrhodes	126	Plow/drill/furrow: Ladak alfalfa, smooth brome, intermediate wheatgrass, orchardgrass, tall oatgrass

YEAR	LOCATION	ACRES	TREATMENT
1963	Wanrhodes First Water/Rays Valley	100 212 900	Ground spray 2,4-D Ground spray 2,4-D Aerial spray
1964	First Water (Mill Hollow) (Monks Hollow) (Red Mountain) (Lightening Springs) (Chicken Hollow) Three Forks (Farmers Slope)	82 119 398 194 312 491 735 136	Plow Mixed seed mix Drill Mixed seed mix Furrow/seed Mixed seed mix Furrow/seed Mixed seed mix Plow Drill Furrow/seed Hand seed in aspen
1965	Three Forks	494 900 1285 136 935	Plow Spray 2,4-D Drill: intermediate wheatgrass, smooth brome, tall oatgrass, orchard grass, clover, alfalfa Hand seed Furrow/seed

YEAR	LOCATION	ACRES	TREATMENT
1966	Monks Hollow	90	Hanson seeder: bitterbrush
		35	Hand seed in scalps: Putr
	Monks/Chicken	442	Plow/drill
		700	Aerial spray 2,4-D
		186	Plow
		428	Furrow/seed
		(458)	Drill sprayed area
		90	Furrow/seed
	Little Diamond	40	Plow/drill
1967	Monks/Chicken Hollow	100	Redrill
	Maple Canyon Unit	24	Aerial seed
	Halls Fork	42	Plow/drill
		235	Plow/drill
		307	Chained 2 ways
		128	Chained 1 way
		138	Aerial seed
1969	Halls Fork (includes 157 acres of Sixth Water unit)	1811	Aerial spray 2,4-D
	Lower Diamond Fork	1500	Anchor chain and aerial seed
1970	Sixth Water	600	Anchor chain and aerial seed smooth brome, intermediate wheatgrass, slender wheatgrass, orchard grass, alfalfa, yellow sweet-clover, Burnett

Several acres were repeatedly treated for watershed and range resource improvement. The forb component has yet to recover from earlier spray projects. Note that the negative effects of spraying may have been compounded by the grazing activities of both wildlife and domestic livestock.

APPENDIX D
ROSGEN CHANNEL TYPES[1]



This Figure includes longitudinal, cross-sectional and plan views of major stream types.

[1] Source for the Figure is D.L. Rosgen. 1994. Catena 22. Elsevier Science Inc. New York, New York,

APPENDIX E
BIRD SPECIES FOUND IN DIAMOND FORK CANYON

This Appendix lists species richness and relative abundances of birds of Diamond Fork Canyon. Species richness includes all species recorded during 1996 surveys and previous records (January 1, 1980 to July 17, 1995). Relative abundances are based on the 1996 surveys unless otherwise noted. Neotropical migratory landbirds are in **bold.** Species known to have undergone declines in western populations within recent decades are in CAPITALS (from DeSante and George 1994). The appendix was prepared by Dr. Elizabeth Ammon (Ammon, E.M. 1997).

Species name	**Habitat use**	**Relative abundance**			
		Total no. of sightings[d]	Number of plots occupied[e]	Percent plots occupied[f]	Number of birds per plot per count[f]
Pied-billed Grebe *Podilymbus podiceps*	R	(3)	--	--	--
Double-crested Cormorant *Phalacrocorax penicillatus*	R	(1)	--	--	--
Snowy Egret *Egretta thula*	--	--	--	--	--
Sandhill Crane *Grus canadensis*	R	1	1	1%	0.006
Green-winged Teal[a] *Anas crecca*	--	--	--	--	--
Mallard *Anas platyrhynchos*	R	2	2	3%	0.013
Sora *Porzana carolina*	R	1	1	1%	0.006
Virginia Rail *Rallus limicola*	R	(1)	--	--	--
American Coot *Fulica americana*	R	(3)	--	--	--
Killdeer *Charadrius vociferous*	R	13	12	16%	0.085
Spotted Sandpiper *Actitis macularia*	R	65	41	54%	0.428
Wilson's Phalarope *Phalaropus tricolor*	—	--	--	--	--
Turkey Vulture *Cathartes aura*	N	(3)	--	--	--
Golden Eagle *Aquila chrysaetos*	N	1	1	1%	0.006
Northern Harrier *Circus cyaneus*	I	1 (4)	1	1%	0.006
Cooper's Hawk *Accipiter cooperii*	I	1 (3)	1	1%	0.006
Red-tailed Hawk *Buteo jamaicensis*	N	1 (4)	1	1%	0.006
American Kestrel *Falco sparverius*	I	5	4	5%	0.033
RUFFED GROUSE *Bonasa umbellus*	I	(1)	--	--	--

MOURNING DOVE *Zenaida macroura*	I	11	10	13%	0.072
LONG-EARED OWL *Asio otus*	I	(1)	--	--	--
COMMON NIGHTHAWK *Chordiles minor*	N	1	1	1%	0.006
WHITE-THROATED SWIFT *Aeronautes saxatalis*	N	4	3	4%	0.026
BLACK-CHINNED HUMMINGBIRD *Archilochus alexandri*	R	3	3	4%	0.020
Broad-tailed Hummingbird *Selasphorus platycercus*	R	14	12	16%	0.092
BELTED KINGFISHER *Ceryle alcyon*	R	9	9	12%	0.059
Downy Woodpecker *Picoides pubescens*	I	5	5	7%	0.033
NORTHERN FLICKER (Red-shafted) *Colaptes auratus*	I	11	10	13%	0.072
Red-naped Sapsucker *Sphyrapicus nuchalis*	I	(1)	--	--	--
Western Wood-pewee *Contopus sordidulus*	R	40	26	34%	0.263
*** WILLOW FLYCATCHER** *Empidonax traillii*	R	6	3	4%	0.039
Dusky Flycatcher *Empidonax oberholseri*	I	20	17	22%	0.131
Western Kingbird *Tyrannus verticalis*	I	6	6	8%	0.039
Tree Swallow *Tachycineta bicolor*	R	15	12	16%	0.099
Violet-green Swallow *Tachycineta thalassina*	R	23	11	14%	0.151
ROUGH-WINGED SWALLOW *Stelgidopteryx serripennis*	R	22	14	18%	0.145
BANK SWALLOW *Riparia riparia*	R	116	19	25%	0.763
Cliff Swallow *Hirundo pyrrhonota*	I	87	9	12%	0.572
Barn Swallow *Hirundo rustica*	I	26	11	14%	0.171
Scrub Jay *Aphelocoma coerulescens*	N	(4)	--	--	--
Black-billed Magpie *Pica pica*	N	3	3	4%	0.020
COMMON RAVEN *Corvus corax*	I	3 (5)	3	4%	0.020
Black-capped Chickadee *Parus atricapillus*	R	5	5	7%	0.033
House Wren *Troglodytes aedon*	R	6	5	7%	0.039
Canyon Wren *Catherpes mexicanus*	N	5	3	4%	0.033
Ruby-crowned Kinglet[b] *Regulus calendula*	I	(1)	--	--	--
Blue-gray Gnatcatcher[a] *Polioptila caerulea*	--	--	--	--	--
MOUNTAIN BLUEBIRD *Sialia currucoides*	R	(3)	--	--	--
American Robin *Turdus migratorius*	I	103	61	80%	0.678
Hermit Thrush *Catharus guttatus*	N	(5)	--	--	--
Gray Catbird *Dumetella carolinensis*	R	21	18	24%	0.138
Cedar Waxwing *Bombycilla garrulus*	R	7	6	8%	0.046
European Starling *Sturnus vulgaris*	I	(25-30)	--	--	--
Solitary Vireo *Vireo solitarius*	I	9	8	10%	0.059
Warbling Vireo *Vireo gilvus*	R	30	24	32%	0.197

Virginia's Warbler *Vermivora virginiae*	I	2	2	3%	0.013
YELLOW WARBLER *Dendroica petechia*	R	284	76	100%	1.868
YELLOW-RUMPED WARBLER[b] *Dendroica coronata*	R	(2)	--	--	--
MACGILLIVRAY'S WARBLER[a] *Oporornis tolmiei*	--	--	--	--	--
* **COMMON YELLOWTHROAT**[a] *Geothlypis trichas*	--	--	--	--	--
YELLOW-BREASTED CHAT *Icteria virens*	R	58	45	59%	0.381
Black-headed Grosbeak *Pheucticus melanocephalus*	I	11	9	12%	0.072
LAZULI BUNTING *Passerina amoena*	I	83	53	70%	0.546
Green-tailed Towhee[a] *Pipilo chlorurus*	--	--	--	--	--
Rufous-sided Towhee *Pipilo erythrophthalmus*	N	17	12	16%	0.112
CHIPPING SPARROW *Spizella passerina*	N	3	3	4%	0.020
Lark Sparrow *Chondestes grammacus*	N	(3)	--	--	--
FOX SPARROW *Passerella iliaca*	R	38	26	34%	0.25
SONG SPARROW *Melospiza melodia*	R	193	75	99%	1.270
WESTERN MEADOWLARK *Sturnella neglecta*	N	6	5	7%	0.039
Red-winged Blackbird *Agelaius phoeniceus*	R	3	1	1%	0.020
YELLOW-HEADED BLACKBIRD *Xanthocephalus xanthocephalus*	R	2	2	3%	0.013
BREWER'S BLACKBIRD *Euphagus cyanocephalus*	--	--	--	--	--
Brown-headed Cowbird *Molothrus ater*	I	46	30	39%	0.303
Northern Oriole (Bullock's race) *Icterus galbula*	R	15	13	17%	0.099
Western Tanager *Piranga ludoviciana*	I	1	1	1%	0.006
Cassin's Finch *Carpodacus cassinii*	I	3	3	4%	0.020
House Finch *Carpodacus mexicanus*	I	14	12	16%	0.092
PINE SISKIN *Carduelis pinus*	I	5	5	7%	0.033
LESSER GOLDFINCH *Carduelis psaltria*	I	18 (45)	10	13%	0.118
American Goldfinch *Carduelis tristis*	I	92	51	67%	0.605

TOTAL = 81 species (73 observed in 1996)

No. of neotropical migrants = 61 species (75% of total)

R = 32 species (40% of total)

No. of species with reported declines = 27 species (33% of total)

R + I = 61 species (75% of total)

* listed as a sensitive species by the Utah Division of Wildlife Resources (May 1992).

[a] not seen during the 1996 surveys, but reported previously in Diamond Fork.

[b] not likely to be nesting within the lower Diamond Fork riparian systems (but may nest above Monks Hollow).

[c] all habitat use classifications are based on observations in Diamond Fork, supplemented with information from the literature for uncommon species. R = primarily riparian, incl. all types of wetlands; I = intermediate, i.e., needs riparian habitats some of the time or for part of its life history; N = primarily non-riparian or upland.

[d] number of sightings in 1996 totaled for all counts and all points; in parentheses: total number of sightings during 1996 including observations between censuses.

[e] number of census plots in which species was observed.

[f] percent census plot in which species was observed.

[g] average number of birds per plot per count [(# birds)/(# counts of each plot)(# plots)].

APPENDIX F
BIBLIOGRAPHY

Ammon, E.M. 1997. Final Report of the Lower Diamond Fork Breeding Bird Surveys. 1996. Appendix *In:* Trihey and Associates, Inc., Conceptual Restoration Plan and Baseline Assessment for Lower Diamond Fork. Unpubl. Report. USFWS, Uintah National Forest, Spanish Fork Ranger District, Utah.

Ashley and Uinta National Forests. 1996. Western Uinta Basin Oil and Gas Leasing Environmental Impact Statement.

Bartos, L. R. 1974. Diamond Fork Channel Analysis from Proposed Lower Power Plant to Spanish Fork Confluence. Unpublished report, Uinta National Forest, Supervisor's Office, Provo, Utah.

Bissell, H. J. 1963. Lake Bonneville: Geology of the Southern Utah Valley, Utah. U.S. Geological Survey Professional Paper 257-B, 30 pp.

Central Utah Water Conservancy District. 1998. Draft Aquatic Resources Technical Report, Spanish Fork Canyon-Nephi Irrigation System, Draft Environmental Impact Statement. Central Utah Water Conservancy District.

Central Utah Water Conservancy District. 1999. Diamond Fork System, Bonneville Unit, Central Utah Project, Final Supplement to the Final Environmental Impact Statement.

Chavez, F.A., and T.J. Warner. 1976. The Dominguez-Escalante Journal. Brigham Young University Press, Provo, Utah.

DeSante, D.F., and T.L. George. 1994. Population Trends in the Landbirds of Western North America. Pp. 173-190 in J.R. Jehl, Jr., and N.K. Johnson (eds.), A Century of Avifaunal Change in Western North America. Studies in Avian Biology No. 15.

Holmes, E. W. 1990. The Uinta National Forest: An Environmental History. Unpublished M.A. Thesis, Brigham Young University, Provo, Utah, 247 pp.

Jeppson, R. W., G. L. Ashcroft, A. L. Huber, G. V. Skogerboe, J. M. Bagley. 1968. Hydrologic Atlas of Utah. Utah Agricultural Experiment Station, Utah State University, Logan, Utah.

Kimbal, J, and F. Savage. 1977. Diamond Fork Aquatic and Range Habitat Improvement, Uinta National Forest. Presented at the 30th annual meeting of the Society of Range Management, Portland, Oregon, February 15, 1977, 19 pp.

Knapp, K. L. 1973.

Marion, J.L., and D.N. Cole, 1996. Spatial and Temporal Variation in Soil and Vegetation Impacts on Campsites. Ecological Applications. 6:520-530.

Martin, M.A., D.K. Shiozawa, E.J. Loudenslager, and J.N. Jensen. (1985) Electrophoretic study of cutthroat trout populations in Utah. Great Basin Naturalist 45:677-687.

Merrill, David B. and Asa S. Nielson. 1981. Cultural Resources Survey of the Fifth Water Alternative, Diamond Fork Power System, Utah. Prepared by Mesa Corporation for the Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Merrill, David B., Donald L. Snyder, and Jay Anderson. 1982. A Historical Mitigation Study of the Strawberry Valley Project, Utah. Prepared by Mesa Corporation for the Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Ohmart, R.D., and B.W. Anderson. 1982. North American Desert Riparian Ecosystems. Pp.433-479 *in* G.L Bender (ed.), Reference Handbook on the Deserts of North America. Greenwood Press, Westport, CT.

Pashley, B.F. 1975. Geology of the Spanish Fork Planning Unit, Uinta National Forest. U.S. D.A. Forest Service, Intermountain Region, Ogden, Utah.

Radant, R.D. (1976). Fisheries Inventory of the Diamond Fork System. Prepared by the Utah Division of Wildlife Resources for the United States Bureau of Reclamation, contract number 6-07-01-00008.

Rawley, Edwin V. 1985. Early Records of Wildlife in Utah. Division of Wildlife Resources, Utah Department of Natural Resources, Salt Lake City, Utah.

Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, J.L.Lyon, W.J. Zielinski, eds (1994). The Scientific Basis for Conserving Forest Carnivores:American Marten, Fisher, Lynx, and Wolverine in the Western United States. General Technical Report RM-254, Ft. Collins, Co. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, 184 p.

Skabelund, P.H. 1977. Watershed and Hydrologic Report, Hobble-Diamond Planning Unit, Uinta National Forest, Provo, Utah, Unpublished report.

Stokes, W.L. 1986. Geology of Utah. Utah Museum of Natural History, University of Utah, Occasional Paper Number 6, 280 pp.

Trihey and Associates. 1997. Conceptual Restoration Plan and Baseline Assessment, Lower Diamond Fork. Report prepared for the Uinta National Forest Spanish Fork Ranger District.

Trihey and Associates. 1997. Preliminary Restoration Plan, Sixth Water Creek. Report prepared for the Uinta National Forest Spanish Fork Ranger District.

Uinta National Forest. 1976. Soil Survey of the Hobble Creek, Diamond Fork and White River areas. Unpublished Report, Supervisor's Office, Provo, Utah.

U.S. Fish and Wildlife Service, Utah Field Office. 1995. Ute Ladies' Tresses Orchid Biology, Life History, and Ecology.

Walser, C.A., M.C. Belk, and D.K. Shiozawa. 1997. Abundance, Distribution, and Habitat Use of Leatherside Chub (Gila copei) in Diamond Fork Creek, Utah Co., Utah. Report prepared for the Uinta National Forest Spanish Fork Ranger District.

Walser, C.A., M.C. Belk, and D.K. Shiozawa. 1999. Habitat Use of Leatherside Chub (Gila copei) in the Presence of Predatory Brown Trout (Salmo trutta). Great Basin Naturalist. 59(3):272-277.

Wiley, D. 1997. Memorandum to Charlie Thompson regarding "Fish population estimates completed in 1996". Unpublished memorandum dated February 11, 1997. Utah Division of Wildlife Resources, Central Region. Springville, UT.

Wiley, D.E. and C.W. Thompson. 2000. The Sixth Water Fishery, 1999. Unpublished Report. Utah Division of Wildlife Resources, Central Region. Springville, UT.

West, Nolan., D.I. Rasmussen. 1942. Utah Beaver Study. Utah Fish and Game Commission

Western Wetland Systems. 1996. Diamond Fork Riparian Baseline Summary Report. Prepared for the Spanish Fork Ranger District, Uinta National Forest.

Young, G. E. 1975. Geology and Sections of Billies Mountain Quadrangle. Brigham Young University Geology Studies, vol. 23, part 1.

APPENDIX G
TEAM MEMBERS AND EXPERTISE

Joan Degiorgio	Planner and Editor - Utah Reclamation Mitigation and Conservation Commission
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Bob Gecy	Hydrologist - Uinta National Forest
Lee Mabey	Fishery Biologist - Spanish Fork Ranger District
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Carol Nunn	Wildlife Biologist - Spanish Fork Ranger District
Doug Page	Forester - Uinta National Forest
Bret Ruby	Fire Management Officer - Uinta National Forest
Tom Tidwell	District Ranger - Spanish Fork Ranger District
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ADDITIONAL ASSESSMENT DEVELOPMENT AND REVIEW EXPERTISE

The following individuals either assisted in the development or review of the Assessment: Lucy Jordan (Plant Ecologist, U.S. Fish and Wildlife Service), Chad Gourley (Hydrologist, Mitigation Commission), Richard Mingo (Recreation Planner, Mitigation Commission), Dave Christensen (Landscape Architect, Uinta National Forest), Dave Goodin (Assistant Fire Management Officer, Uinta National Forest), Diane Simmons (Editorial Review, Mitigation Commission), Mark Holden (Project Manager, Mitigation Commission), Karen Hartman (Wildlife Biologist, Spanish Fork Ranger District, Uinta National Forest), Bill Ott (District Ranger, Spanish Fork Ranger District, Uinta National Forest), Reese Pope (Ecosystem Group Leader, Uinta National Forest).