CHAPTER 3 – AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Introduction

Delineating Ecosystems

Originally, in the Preliminary Analysis of the Management Situation (USFS, 1999) we identified delineating ecosystems as the first in a series of steps for implementing ecosystem management. Because the planning regulations require decisions be made at the national forest administrative boundary level, we must use the national forest boundary as one broad scale. We recognize the artificial nature of this delineation so we have chosen to reference broad, mid, and fine scales for the revision analysis.

Both biophysical (plants, animals, land, and water) and human (social, economic, and political) scales to be considered vary with activity and/or issues. For example, vegetation can be easily described at a relatively broad scale because of similar land capabilities and common associations of plant communities. Recreation uses on the other hand are more easily and appropriately described at a finer scale based on facilities and access from population centers.

Broad Scale - Ecological Sections

At the broad biophysical scale the Wasatch-Cache National Forest is a part of three large geographic areas ("Sections") – the Uinta Mountains, Overthrust Mountains, and Bonneville Basin Sections as defined by McNab and Avers (1994). Each Section has its unique geology, climate, vegetation, wildlife and associated ecologies. The Wasatch and Bear River Ranges of the Overthrust Mountains Section, the Stansbury Mountains portion of the Bonneville Basin, and the Northern portion of the Uinta Mountains Section are used for description and analysis of vegetation as well as disturbance processes such as fire, insects and disease, and noxious weed invasion.

Mid and Fine Scales - Management Areas and Watersheds

As work proceeded we discovered that our earlier delineation of fine scale areas (watersheds at the 5th hydrologic unit code) dividing the Forest into 36 areas was too fine a scale for the data we have on hand and for some of the types of decisions being made in Forest Plan revision. We have now grouped those 36 watersheds into 7 "Management Areas" for the purpose of this FEIS. These are delineated on watershed boundaries, which combine similar lands with common access to people into recognizable but larger areas for description and analysis. These are shown on the map "Management Areas for the Wasatch-Cache National Forest" in this section. In cases where there is a specific need to consider a finer scale, we have used the original watershed delineations for reference. We have used the Management Areas for description and analysis of watersheds and aquatic resources. For recreation we have used portions of Management Areas (with data compiled by Ranger District) because of specific access or issues. Much of the

economic analysis is based on County boundaries because that is how the available data is organized. There is also a full ten county scale with rural portions of those counties highlighted separately.

Management Areas

The following Setting descriptions of each Management Area are provided to "paint a picture" for the reader of the prominent features in the area and what one might expect to see if the area was traversed. The remainder of the Chapter is arranged by Topic such as "Watershed Health" with affected environment and environmental consequences described at the scale or scales most appropriate to that topic.

Bear Management Area Setting Description:

The Bear management area is located along the western front of the Bear Lake valley in Northern Utah. It forms the east slope of the Bear River Range and creates the border for three ecological subsections Bear River Highlands, Bear Lake Section, and Monte Cristo-Weber Valley Hinterlands (Bailey, 1994). This transition area has a mosaic of vegetation types, with conifer, aspen and mountain mahogany at higher elevations and sagebrush and grass on the lower slopes. Infrequent broad canyons descend from the upland to the base of the Bear Lake valley. The Ogden River scenic byway (Highway 39), and Logan Canyon scenic byways wind their way down the slope of the Bear management area. Scenic overlooks provide exceptional views of Bear Lake, contrasted with the upland desert beyond. Year-round recreationists can find trails, primitive roads, camping spots, and open snow play fields to explore. Cattle and sheep can be seen grazing on rangelands in the area. Forest openings resulting from vegetation management approximate historic patterns. Monte Cristo and Sunrise campgrounds provide a pleasing setting for recreation amidst quaking aspen, lodgepole pine and Douglas-fir.

Cache Box Elder Management Area Setting Description:

The Cache-Box Elder management area is located in the northeast mountain ranges of northern Utah. The management area covers three ecological subsections (Bailey, 1994), Bear River Highlands, Cache Front and Wellsville Mountains. The diverse character of the well-defined plateaus, wide valley floor, and sharply rising mountains is the consequence of a turbulent geologic history. The limestone walled canyons are a result of sediment left by a shallow tropical sea. Glaciated cirques and upland basins are the result of ancient glaciers. Faults and sinking valley blocks created the steep mountain slopes and the multi level lineal benches are the remnants of Lake Bonneville. The two mountain ranges included in this unit are the Bear River Mountains and the Wellsville Mountains, with elevations ranging from 5,000 to 10,000 feet.

The portion within the Bear River Highlands on the east has rolling uplands cut through by valleys. Mixed conifer stands (Engelmann spruce, subalpine fir, lodgepole pine, limber pine, and Douglas-fir) form a mosaic with aspen, maple, shrublands and grasslands. In many aspen stands the dark green conifers can be seen rising up through older, decadent aspen. Livestock can be seen grazing on gentler slopes throughout the area. Fences and water developments are constructed to better distribute livestock for appropriate use of forage. The mostly unpaved road

system forms a series of corridors along which recreation thrives, primarily on weekends. Visitors engage in activities including scenery viewing, camping, hunting and fishing, all terrain vehicle (ATV) riding, hiking and horseback riding. In the winter, deep snow packs blanket open flats and rolling hills, providing outstanding recreation opportunities, such as snowmobiling, skiing, snow shoeing and sledding. In the higher elevations, snow covered peaks and bowls with wind swept cornices provide a contrast to the gentle slopes and flat lands.

Canyons within the Cache Front are deep, with sheer limestone walls and cliffs. These canyons provide unique habitats for a number of endemic plants. Logan Canyon Scenic Byway (Highway 89) travels along the Logan River and Beaver Creek, dropping down into the Bear Lake Valley below, providing outstanding opportunities for scenery viewing. Recreation is a major feature in these canyons. Developed recreation facilities include campgrounds, summer homes, picnic areas and trails. Popular recreation activities in this unit include fishing and hunting, kayaking, picnicking, biking, rock climbing, hiking, snowmobiling, and ATV-riding, as well as scenery and wildlife viewing. North facing slopes in these canyons support mixed conifer-aspen stands at the higher elevations contrasted with maple and mountain brush at lower elevations. Oak occurs in the southern portion of the unit. Junipers dot the south and west facing, grass covered slopes. The contrast between these vegetation types is especially apparent in the fall as the aspen, maple and oak leaves change colors, creating a remarkable scenic attraction. Wilderness opportunities for solitude, challenge and primitive recreation are provided in the Mount Naomi Wilderness.

The Wellsville Mountains are at the northern end of the Wasatch Mountains, jutting out of the Cache and Great Salt Lake valley floors, creating a north-south wall between these valleys. On the east side, maple dominates the lower slopes and is interspersed with aspen at mid elevations. Conifers reach down from higher elevations along north-facing slopes of the steep, short side canyons, creating fingers of dark green. On the west facing side, steep, rocky slopes and extensive cliffs are prominent. The Wellsville Wilderness provides opportunities for solitude and challenge, with hiking and horseback riding being the dominant recreation uses.

North Wasatch Ogden Valley Management Area Setting Description:

The North Wasatch Ogden Valley Management Area is located in the Wasatch Mountains of northern Utah. The Area covers two ecological subsections, Monte Cristo Hinterlands and Northern Wasatch. Managed by three Ranger Districts, Logan, Ogden, and Salt Lake, this Management Area forms the west-facing slope of the Wasatch front and goes east to the divide between the Cache and Bear Lake Valleys. The Wasatch Front is composed of deep V-shaped canyons cut through the benches of ancient Lake Bonneville and forming pyramidal shapes that mirror into the Great Salt Lake. North facing slopes support mosaics of dark green conifer of varying densities. Scrub oak and mountain mahogany are found on the dryer slopes along with talus, rock cliffs and grassy side hills creating scattered openings. Cottonwood, dogwood, willow, birch and cherry occur along streams to their headwaters. Horizontal lines can be seen on the upper slopes left from early efforts to stabilize watersheds.

The northwestern part of the North Wasatch is characterized by jagged, craggy pinnacles and ridgelines supported by eroded rock ramparts. Ben Lomond Peak spires to an elevation of 9,712

feet, overlooking surrounding landscapes. To the east from Ben Lomond, Mount Ogden, and Francis Peak abut moderately defined drainages through subalpine stands of coniferous forest. Large basins include talus slopes, conifer patches, and aspen groves. On lower slopes oak, mountain shrub, and maple cover rolling foothills into the valleys. In Ogden Valley, Pineview Reservoir's footprint is surrounded by a rural patchwork of fence farmsteads, pastures, farmlands and small rural communities. Trappers once called the valley of the convergence of three rivers "Ogden's Hole" because of the plentiful trapping for beaver. The valley has changed over time and now includes the rural communities of Ogden Valley along with the popular water playground Pineview, attracting visitors from Ogden and surrounding communities.

Ridgelines and broad valleys covered in aspen, scrub, and sage flat mosaics create a landscape prime for both winter and summer recreation. Connecting canyons provide places for weekend campers who enjoy developed and undeveloped camping. Conifer stands of lodgepole pine, Douglas-fir and subalpine fir, mingled with aspen cover the eastern flank of this unit where cattle and sheep graze the grassland openings.

Near Causey Reservoir numerous rock outcrops can be seen jutting from the mountainsides. Mostly subalpine fir is found on north facing slopes in the Monte Cristo area, while Douglas fir is on north facing slopes along the Wasatch Front. An intermingled public/private land ownership pattern is evident across much of the area. Watershed improvements from 1930's Civilian Conservation Corps work is still evident in the Davis and Willard Peak areas. Most of the Front is acquired private land that did not become National Forest until the 1930s' after floods and degradation in the earlier part of the century. Major utility corridors are located across the forest in this area. Davis County, especially the area along the Front, is very arid even at the higher elevations. East and West Canyons are also a part of this Management Area.

Central Wasatch Management Area Setting Description:

Located east of Salt Lake City in the Wasatch Mountain Range, the Central Wasatch Management Area extends from the Davis and Salt Lake County line on the North to the Salt Lake and Utah County line on the South. It contains three designated Wilderness areas, Mt. Olympus, Twin Peaks, and Lone Peak and four major ski areas, Brighton, Solitude, Alta and Snowbird. The canyons in this area are valuable watersheds for Salt Lake and adjoining cities along the Wasatch Front.

Seven major canyons comprise the Central Wasatch Area. These range from broad, gentle sloping drainages in the north to steep narrow drainages in the south. Mountain peaks rise nearly seven thousand feet above the Salt Lake Valley. Lone Peak reaches an elevation of 11,253 feet and provides an impressive backdrop to the valley below. The U-shaped canyon of Little Cottonwood Creek rises from typical stream bottoms of cottonwood, willow and dogwood to the granite, red-quartzite and limestone walls of the upper mountainside. The circular basin at Brighton to the north drains into the V-shaped canyon of Big Cottonwood Creek. The ski areas include runs that appear similar to avalanche chutes falling from open glacial troughs through aspen and conifer stands.

Small communities such as Alta and Brighton have developed in these canyons supporting recreation, skiing, and in the past, mining activities. Each of these communities has a character of its own set within aspen and conifer stands. Developed campgrounds, picnic areas, and trailheads are located in the major drainages providing refuge from the summer heat in urban areas below. The variety of vegetation and rock types from low to high elevations provides remarkable scenery enjoyed both within the Canyons and as the backdrop to the cities along the front. Mill Creek Canyon is a highly popular area for evening and weekend picnics, hiking, biking, and running or walking with only a short drive from the city below. A wide variety of recreation opportunities are provided for a growing urban population.

Drier, more rolling mountains typify the northern end of this area in Lambs, Emigration, and Red Butte Canyons. Lower elevations, poorer soils, past fires, and historic activities have created a vegetation mosaic with patches of scrub oak, maple, grasses and forbs. Cottonwood trees and other hardwoods occur along streams in the area. Rock outcrops are common along ridges and on sideslopes creating an interesting variety of colors and textures across the landscape.

Stansbury Mountains Management Area Setting Description:

The Stansbury Mountains Management Area is located at the south end of the Great Salt Lake between Tooele Valley on the east and Skull Valley on the west. It occupies the south end of the Stansbury mountain range. North south trending, the unit rises from the valley floor and varies in elevation from 5400 feet to 11,031 feet at the top of Deseret Peak in the Deseret Peak Wilderness. This is a semi-arid range created by basin and range type faulting and defined by steep V shaped canyons, juniper forests and craggy mountain peaks. Many of the north-facing slopes are accented by dark green fingers of conifer extending down the ridgelines. Vegetation is a mosaic of juniper and Douglas-fir at lower elevations and Spruce/Fir at higher elevations. Hardwood bottoms and openings of sagebrush and grass/forb meadows also occur. Crested wheat grass was planted in the 1960's, and covers large areas at lower elevations on the east side of the Stansbury range. Native species are beginning to reestablish in these communities, but the crested wheat grass is likely to persist for decades into the future. The replacement of aspen by conifers due to fire suppression has likely resulted in lower water flows in the streams. Few perennial streams and springs are found on the Area. South Willow Canyon is the location of the only developed campground facilities. In addition, South Willow Creek is essentially completely diverted at the Forest boundary so no perennial flow occurs east of the Forest. Mining Fork has been diverted from its natural stream channel into South Willow Creek at a location near the S curves. Historically mining occurred although its remnants are no longer dominant on the landscape. Primitive roads that go up many of the canyons are braided and are creating a high impact on the landscape as people drive vehicles further up the mountain and off designated routes.

Western Uintas Management Area Setting Description:

Located in the Northeastern corner of Utah, next to the Southwestern border of Wyoming in the Uinta Mountains. The area rises in elevation from 6,800 in the foothills to 12,718 feet on Ostler Peak. This Management Area contains four ecological subsections: West Flank Uintas, High Uintas, North Slope Outwash and Monte Cristo-Weber Valley Hinterlands (Nelson, 1993) and is

managed by two Ranger Districts, Kamas and Evanston. The Western Uintas Management Area includes diverse landscapes of open sagebrush flats, aspen, and coniferous forests, high mountains, semi-circular cirque basins, deep U-shaped river valleys, grassy meadows, alpine tundra and an abundance of lakes, streams and wetlands. The high amount of wetlands in the area is a unique feature compared with other areas in the intermountain west. It offers a wealth of recreation opportunities such as backcountry hiking and horseback riding, ATV trails, fly-fishing, scenic driving, rock climbing, backpacking, mountain biking, hunting, peak bagging, large group/family camping, snowmobiling, snowshoeing and cross-country skiing. Cattle or sheep can be seen grazing in portions of the area, as well as elk, deer, and moose.

Created by glaciers, this landscape is composed of broad vistas of deep U-shaped valleys coursed by mountain streams that tumble down steps of hard quartzite stone, and meander through open grassy meadows with lush riparian borders. At the heads of these U-shaped valleys are majestic domed peaks and stacked blocked ridgelines whose concave bases are blanketed with conifer and patches of aspen. Large and small lakes that reflect the surrounding peaks are scattered across the landscape. Rolling uplands provide large open snowfields mingled with conifer and aspen stands in winter that in summer provide a vivid display of colorful wildflowers. Campgrounds, trailheads and visitor pullouts follow the gentle weaving alignment of Mirror Lake Scenic Highway as it climbs from broad valleys through the Upper Provo River Canyon to the summit. There, Bald Mountain is at the headwaters of four of the most important river systems in Utah (Duchesne, Provo, Bear, and Weber) and swirled quartzite originally arising from ancient ocean bottoms has been polished smooth by Pleistocene Glaciers. Bald, Murdock, Hayden and many other peaks stand on the horizon as sentinels with coats of talus and craggy cliff bands.

Eastern Uintas Management Area Setting Description:

Located in the Uinta Mountains, the largest east/west mountain range in the lower 48 States, and found in the northeastern corner of Utah and the southern border of Wyoming, the Eastern Uintas Management Area ranges in elevation from 8,000 feet along the northern Forest boundary to 13,442 feet at Gilbert Peak. Within this Management Area there are three ecological subsections: High Uintas, North Slope Outwash, and Phil Pico Highlands (Nelson, 1993) that are managed by two Ranger Districts- Evanston and Mt. View. The diverse landscapes of the Eastern Uintas include open sagebrush flats, aspen, mixed conifer, and pure coniferous forests, high jagged mountains, semi-circular cirque basins, deep U-shaped river valleys, grassy meadows, alpine tundra and a profusion of lakes, streams and wetlands.

The area offers a variety of recreation opportunities such as backcountry hiking, horseback riding, fishing, camping, snowmobiling, cross-country skiing, ATV riding and hunting. The area is also rich in history and community ties to national forest resource uses from extensive tie hacking for construction of railroads, to livestock grazing, oil production, timber harvest, and reservoirs for agricultural irrigation. A network of roads and trails criss-cross the lower slopes providing access for a variety of recreation opportunities and other forest uses. Traveling these routes one climbs from southern Wyoming's gray-green sage prairies and shimmering aspen groves through deep green conifer to views of jagged barren peaks. Upper portions of the area are primarily undeveloped (unroaded) where semi-circular glacial basins pour surround streams with rich riparian vegetation. These streams often flow from mountain ice and snow melting to

lake to reservoir to mountain plain through concave valleys. Giant rock ramparts can be seen at the entrance of the three main rivers: Beaver, Henrys and Blacks Fork flowing from their headwaters in the High Uintas Wilderness. Oil wells and oil production facilities are sprinkled through the lower uplands of the landscape, mostly hidden from a distance by careful design and placement in pockets of vegetation. Remnants of bygone eras can be found throughout the landscape in sagging log cabins, wooden check dams, stumps cut waist high and historic ranger stations.

Topic 1 – Watershed Health

Soils, Water, and Geologic Resources

Introduction

This section will address existing watershed conditions and analyze the effects of the different alternatives on these resources. Within the affected watershed environment subsection, information is presented on the physiographic (geology and soils), hydrologic (streams and lakes), and climatic (precipitation and temperature) components of watersheds found on the Forest. Within the environmental consequences subsection, the direct, indirect and cumulative effects on soil and water quality are disclosed in terms of the various activities proposed in the alternatives. Comparisons are then drawn between the effects on watershed health between the action alternatives and the no action alternative.

Laws, Policy, and Direction

Numerous legal directions pertains to soil and water resources on federal, state and private lands in the United States. Those most applicable to National Forest Lands include:

- **The Organic Administration Act (1897) --** Recognizes watersheds as systems that have to be managed with care to sustain their hydrologic function. It states that one purpose for establishing national forests is to secure favorable conditions of water flow.

- **The Federal Water Pollution Control Act (1972) --** Commonly known as "The Clean Water Act", an act and series of amendments passed to maintain and restore the chemical, physical, and biological integrity of the nation's waters. It requires compliance with state and federal pollution control measures; no degradation of in stream water quality needed to support designated uses; control of nonpoint sources of water pollution through conservation or "best management practices;" federal agency leadership in controlling non-point source pollution from managed lands; and rigorous criteria for controlling pollution discharges into waters of the United States.

- **The National Forest Management Act (1976) --** Directs national forests to protect watershed conditions from irreversible damage and to protect streams and wetlands from detrimental impacts. Amended RPA by adding sections that stressed the maintenance of productivity and need to protect and improve the soil and water resources, and avoidance of permanent impairment of the productive capability of the land. Fish habitat must maintain viable populations of existing and desired non-native vertebrate species.

- **The Forest and Rangeland Renewable Resources Planning Act (RPA)(1974) --** Requires an assessment of the present and potential productivity of the land. Regulations are to specify guidelines for land management plans developed to achieve the goals of the program that "…insure that timber will be harvested from NFS land only where…soil, slope, or other watershed conditions will not be irreversibly damaged."

- **The Endangered Species Act (1973) --** Requires federal agencies to conserve threatened and endangered species and the ecosystems they depend on, including riparian and aquatic ecosystems.

- **The Safe Drinking Water Act (1976) --** Requires federal agencies having jurisdiction over any federally owned or maintained public water system to comply with all authorities respecting the provision of safe drinking water. The State of Utah has primary enforcement responsibility through its drinking water regulations.

- **Executive Orders 11988 and 11990 --** Direct federal agencies to avoid to the extent possible the impacts associated with the destruction or modification of floodplains and wetlands. Agencies are directed to avoid construction and development in flood plains and wetlands whenever there are any feasible alternatives.

- **Forest Service Manual (Section 2500) --** Provides additional laws and executive orders as well as agency policy pertaining to watershed management.

- **Forest Service Manual, Soil Management Handbook (FSH R4 Supplement 2509.18-95-1) --** Provides direction for the protection and monitoring of long-term soil productivity through the establishment of soil quality standards.

- **R1/R4 Soil and Water Conservation Practices Handbook (FSH 2509.25) --** Provides standards that must be followed.

- **Federal Agency Source Water Agreement --** effort to coordinate among federal agencies the increasing numbers of individual programs to protect drinking water sources.

Affected Environment

Watersheds contain terrestrial, aquatic, riparian, and wetland resources that include both physical and biological components. They provide critical habitat for wildlife and serve as important links between upland sites and streams by providing shade, bank stability, and filtration of pollution. Watersheds are dynamic systems that respond to disturbances by both human and natural agents. Disturbances can cause direct impacts such as flow reduction, wetland loss, and bank instability, or can produce indirect impacts in the uplands of a watershed, such as soil loss or landslides that introduce sediment to the stream. These impacts are of concern to overall watershed health. They can affect water quality and quantity, fish and wildlife habitat, and soil productivity.

Soils and geology are an integral component of ecological groupings. They influence vegetation, watershed condition, mineralogy, and land uses. Soils and geology have been used to determine the suitability of forestlands for timber sales and the effects that land management projects may have on watersheds.

In stream flows in alluvial, perennial, and fish-bearing streams are an important component of aquatic and riparian resources also. When high and low flows occur without significant artificial influence, important stream processes are maintained that protect riparian habitats and recreation and aesthetic values.

Healthy watersheds are critical to protecting water quality, sustaining dependent ecosystems, providing a reliable water supply, and preventing or reducing the downstream impacts of high runoff events. In a natural state, watersheds are in a dynamic equilibrium determined by geologic and climatic variables. Significant disturbances, whether caused naturally (e.g., landslides, stand-replacement fires, or floods) and/or by human impacts (e.g., roads, large-scale timber removal, or ground disturbance), can throw a watershed out of equilibrium. Often a watershed will recover from such disturbances with a balance of vegetation cover and stream flow. However, chronic impacts that severely impair watershed recovery can affect the long-term health of watershed resources as well as their benefits to ecosystems and human settlements.

The WCNF provides water for aquatic and riparian habitat and domestic, agricultural and recreational uses. Water is the main component of productive fisheries and riparian habitat, and wetlands. Domestic uses include drinking water for campgrounds, picnic areas, rest stops, and Forest facilities. Agricultural uses include water for crops and livestock grazing. Recreational uses include aesthetics, fishing, and boating. They also support habitat for fisheries and wildlife and contribute to aesthetic values important to many Forest users.

Climate

The major forest areas in Utah occur in the high mountains where the climate is humid and the precipitation is 22 to 40 inches annually. Generally, precipitation is the result of three types of storm systems: (1) winter storm fronts which move across the state from the west or northwest primarily from October through May; (2) cold lows which form over Nevada or southern Utah principally during October or late April and May and then drift across the state accompanied by gentle rain or snow; and (3) summer thunderstorms which develop in the summer months from the Gulf of Mexico (Wilson et al. 1975).

Strong temperature inversions occur in most valleys during the winter months. The freeze-free season ranges between 160 to 180 days on elevations near the tops of the inversions. It is 80 to 90 days in the bottoms of some of the colder valleys and less than 20 days on the tops of the higher mountains. Average wind speeds generally range between 7 and 12 miles per hour in the lower valleys but increase to 15 to 20 miles per hour on the tops of the mountains (Wilson et al. 1975).

Physiography

There are three major physiographic provinces in Utah of which the Wasatch-Cache National Forest (WCNF) is in two: the Basin and Range Province and the Middle Rocky Mountain Province. On the WCNF, the Stansbury Mountains and the Wasatch Front (Central Wasatch and Stansbury Management areas), west of the crest of the Wasatch Range from Point of the

Mountain in Salt Lake Valley to the northern end of the Wellsville Range, is within the Great Basin section of the Basin and Range Province. The Great Basin section consists of a large number of separately enclosed basins scattered throughout the region. The dominant land forms are lake terraces, bars, beaches, fans and valley plains. During the Pleistocene geologic period, many of the basins were filled by Lake Bonneville (Wilson et al. 1975).

In Utah, the Middle Rocky Mountain Province occurs in two mountain ranges: the Wasatch and the Uinta. On the WCNF (Eastern and Western Uinta Mountains, Bear, North Wasatch, and Cache Box Elder Management Areas), east of the crest of the Wasatch Front; Cache Valley; Rich County; the Bear River, Blacks Fork, and Henrys Fork drainages on the north side of the High Uinta Mountains; and the Weber and Provo River drainages on the western part of the Uinta Mountains are in the Middle Rocky Mountain Province. The western slope of the mountains is very steep and remarkably straight, but on the eastern side it is generally less steep and irregular. Generally, the range grades into dissected plateaus in the east. For a distance of about 35 miles between Salt Lake City and Provo, the range was glaciated. The longest glaciers descended westward from the mountain crests at an elevation of 11,000 to 12,000 feet from a distance of about 10 miles to an elevation of about 5,000 feet (Wilson et al. 1975).

Status of land types and soil surveys

Soil resource inventories have been prepared for most of the Forest. Approximately 90,000 acres of National Forest land are not covered by a modern soil survey. Areas not covered include the Bountiful Front of the Wasatch Mountains from North Ogden to North Salt Lake, and the Curtis Ridge area of the Ogden Ranger District. The inventories map unique combinations of landforms and soils called land-types. The WCNF has about 225 land types delineated and stored on digital soil maps in the Forest GIS system. The forest maintains an active updating program for these inventories, creating a periodic need to revise the GIS land-type layer. Recent updates on the Kamas and Logan Ranger Districts have resulted in a need to re-enter soils information from about 25 quadrangles into the corporate database. In the near future, a relational database will be available for the storage, display, and manipulation of soil chemical and physical information associated with the inventories. Future inventory updates will be directed towards populating this database with more accessible information that provides better support to land management planning activities.

Management Area Descriptions

The geology, soil, and water characteristics are described for each of the management areas. The geologic units are based on information from ecological subsections of the Forest. The soils description is a compilation of many different soil types and represents the range of soil conditions on the Forest. Information for geology, and soils is mainly from LeMoyne Wilson (1975) and DeVon Nelson (1994).

Bear Management Area

Geology - Bear River Highlands – These are gently sloping, eastward tilting uplands at elevations ranging from 5,200 to 9,500 feet. The structure is a plateau-like surface of uplifted

portions of overthrust fault zone and the lithology is Wasatch limestone, dolomite and quartzite with Cambrian rocks (Tintic quartzite, Maxfield limestone) on the west side. Geomorphic processes are fluvial and glacial; peri-glacial features are widespread.
Monte Cristo-Weber Valley Hinterlands – These are a modified ridge and valley network between the Wasatch Front and the high Wyoming Basins at an elevational range of 5,400 to 9,000 feet. The structure is graben-like and the lithology is Wasatch sandstone, limestone, conglomerates with pockets of Tertiary volcanics and Precambrian crystalline rocks. Alluvium is in the valleys and drainage ways. The geomorphic processes are fluvial and colluvial.

Soils - Soils are deep to moderately deep at elevations from 6,000 to 12,000 feet. Slopes are mostly steep to very steep with some slightly steep slopes on the alluvial fans along the foothills. The soils are moderately well to somewhat excessively drained. Permeability is slow to moderately rapid. Runoff is slow to rapid and sediment production is low to moderate. The hydrologic groups are mainly B and C.

Water - This unit is in Rich County from the Idaho border to Monte Cristo. No major rivers flow through this area but the area is the headwaters for streams flowing into the Bear River and Bear Lake. There are no large bodies of water in this unit but numerous small ponds and springs are found throughout the area. Most of the drainages have intermittent stream channels.

The main human influences that affect watershed condition are timber, livestock grazing, recreation, and roads. Timber has been harvested in many of the drainages and livestock graze throughout the area. This area was overgrazed in the late 1800s and early 1900s and poor soil productivity is found in some areas. Topsoil losses through erosion have been particularly severe in the tall forb communities, where low ground cover annuals such as tarweed have supplanted the native forbs. Undeveloped recreation use occurs along many roads and trails. There are a few main dirt roads through the area and many trails. Some of the roads and trails are located along riparian areas and contribute sediment to the streams. In general, the downward trends in topsoil losses had been reversed through a combination of allotment stocking reductions, livestock exclusion from riparian area and tarweed eradication efforts. Recent expansions in off-road and all-terrain vehicle use threaten to reverse the trend once again by creating a new cycle of accelerated erosion. Overall watershed condition trend in this unit is stable to downward.

The watershed conditions are good from Laketown Canyon to the north. The Woodruff, Big Creek, and Otter Creek drainages contain some areas with poor soil productivity and ground cover. Remnants of past beaver activity indicate much more water used to be in the drainages in the past.

Wetlands are found mostly near numerous springs and seep areas. Narrow riparian corridors are found along the main streams that drain the area. Some of the drainages have beaver that impound water behind their dams and create larger riparian areas.

There are no impaired water bodies in this unit.

Cache – Box Elder Management Area

Geology - Bear River Highlands – These are gently sloping, eastward tilting uplands at an elevational range of 5,200 to 9,500 feet. The structure is a plateau-like surface of an uplifted portion of overthrust fault zone and the lithology is Wasatch limestone, dolomite and quartzite with Cambrian rocks (Tintic quartzite, Maxfield limestone) on the west side. Geomorphic processes are fluvial and glacial; peri-glacial features are widespread.

Cache Front – These are wall-like mountain slopes and ridge systems along the east edge of Cache Valley at elevations ranging from 5,000 to 10,000 feet. The structure is an up-thrown side in a block fault and the lithology is dolomite, sandstone, limestone, mudstone, and tuffaceous sediments. Geomorphic processes are fluvial, colluvial, glacial, and peri-glacial.

Wellsville Mountains – This is a narrow ridge system forming the north end of the Wasatch Front at an elevational range of 5,000 to 9,000 feet. The structure is a fault block ridge with numerous lateral faults and the lithology is quartzite, dolomite, and limestone. The geomorphic process is fluvial and nivational on the upper east slopes.

Monte Cristo-Weber Valley Hinterlands – This is a modified ridge and valley network between the Wasatch Front and the high Wyoming Basins at elevations ranging from 5,400 to 9,000 feet. The structure is graben-like and the lithology is Wasatch sandstone, limestone, conglomerates with pockets of Tertiary volcanics and Precambrian crystalline rocks. Alluvium is in the valleys and drainage ways. The geomorphic processes are fluvial and colluvial.

Soils - Soils are deep to moderately deep at elevations from 4,300 to 12,000 feet and slopes that are rolling to very steep. On some low elevation areas, slopes are nearly level to gently sloping, but have some steep terrace escarpments. The soils are moderately well to somewhat excessively drained. Permeability is slow to rapid. Runoff is slow to rapid and sediment production is moderately to low. The hydrologic groups are mainly B and C.

Water - This unit includes the area draining into the Bear River in Cache Valley and the Wellsville Mountains. The Logan River and Blacksmith Fork flow through the Forest into the Bear River. High Creek and Summit Creek are good size creeks that flow from the Forest. A very small part of the headwaters of the Little Bear River drainage is within Forest boundaries. No large bodies of water occur, but a few small lakes, such as Tony Grove and White Pine, are found in this unit. Many small springs and seeps occur throughout the area. Almost all of the Wellsville Mountains are within the Wellsville Mountain Wilderness area and most of the watershed area from High Creek to Green Canyon is within the Mt. Naomi Wilderness area.

The Logan FERC project is located on the Logan River near the mouth of Logan Canyon. The Hyrum FERC Project is located on the Blacksmith Fork River just above the Left Hand Fork.

The main human influences that affect watershed condition are timber, livestock grazing, recreation, and roads. Timber has been harvested in Logan and Blacksmith Fork Canyons and livestock graze through much of the area. Most of the developed recreation sites are located in riparian areas along the Logan River causing bank trampling and bare soils at these sites. During

high runoff years, flooding occurs at some of the developed recreation sites. Undeveloped recreation occurs throughout the area and during hunting season many of the roads and trails become rutted from OHV use. Roads have constricted the streams in most of the main canyon bottoms.

Tony Grove Lake is listed as impaired because dissolved oxygen does not meet State water quality standards.

Central Wasatch Management Area

Geology - Central Wasatch – These are rugged ridges, scenic canyons, and high basins forming a front along the east side of the Salt Lake Valley and northern Utah Valleys at elevations ranging from 5,000 to 11,300 feet. The structure is an uplifted fault block with numerous internal faults and plutonic stock; the lithology is granite, quartzite, argilite, tillite, and limestone. The geomorphic processes are glacial, stream cutting, and mass wasting.

Soils - Most of the soils are shallow to deep soils at elevations from 5,800 to 12,000 feet and slopes that are rolling to very steep. They are moderately well to somewhat excessively drained. Permeability is slow to rapid. Runoff is slow to rapid and sediment production is moderate to low. The hydrologic groups are mainly B, C, and D.

Rock land occurs in the Wasatch Mountains in the vicinity of Alta. Areas of this land type are mainly on steep to very steep rocky colluvial areas that are above timberline, usually above 11,000 feet elevation. Rock land occupies about 70 percent of the area, and the other 30 percent is shallow to very shallow, stony soils. Because of their high elevations, these areas are important watershed. They receive large amounts of precipitation much of it as snow and these snowfields are important sources of late summer stream flows.

Water - This unit is located in the Wasatch Mountains east of Salt Lake City. Large streams drain out of Big Cottonwood, Little Cottonwood, and Mill Creek Canyons and smaller streams drain from Emigration, Red Butte, and City Creek Canyons. These canyons are important public water supply watersheds. Some small lakes are found in the headwaters areas of Big and Little Cottonwood Canyons and two public water supply reservoirs are located off-Forest in Parleys Canyon. The Mt. Olympus, Twin Peaks, and Lone Peak Wilderness areas are located between Mill Creek and Lone Peak. Large slope wetlands are found in the upper parts of Little and Big Cottonwood Canyons such as Albion Basin and Brighton.

The main human influences that affect watershed condition are recreation, homes, historic mining, hydropower, and roads. Most of the developed recreation sites are located in riparian areas in Mill Creek, Big Cottonwood and Little Cottonwood Canyons causing bank trampling and bare soils at these sites. Four ski resorts are located in Big and Little Cottonwood Canyons. Watershed conditions are affected by development along the riparian areas, ski run land terrain and vegetative changes, and snowmaking water use. With the exception of City Creek and Red Butte Canyons, many homes are located on public and private land with many of them in stream riparian corridors. Historic hard rock mining took place from the late 1800s through the early 1900s in the upper part of Big and Little Cottonwood Canyons releasing metals into surface and

groundwater. Hydropower projects in Big and Little Cottonwood Canyons have reduced the amount of water flowing below the projects. Roads in the Canyons have constricted the stream channels and contributed sediment and salts into the streams.

Two FERC projects are located in this unit, Stairs Project on Big Cottonwood Creek and the Murray/Whitmore projects on Little Cottonwood Creek. A non-FERC regulated hydroelectric facility, the Granite project, is located at the mouth of Big Cottonwood Canyon. In Little Cottonwood Canyon, a small hydropower facility is located on private land at the mouth of the Wasatch Tunnel at Snowbird.

A minimum in-stream flow is required on Little Cottonwood Creek for snowmaking water diversions at Alta and Snowbird Ski Resorts and on Big Cottonwood Creek below Brighton Ski Resort. Through the regimenting process for dams regulated by FERC, an in-stream flow of 4 cubic feet per second (cfs) in Big Cottonwood Creek is required to be released past the Stairs Gulch Plant (FERC, 1999).

Salt Lake City regulates the flows from several reservoirs in Big and Little Cottonwood Canyons. Regulated flows from storage water in Cecret Lake in Little Cottonwood Canyon and Lake Mary and Twin Lakes in Big Cottonwood Canyon provide culinary water for Salt Lake City.

Two stream segments in this unit are considered impaired by the State: Mill Creek and Little Cottonwood Creek. Mill Creek is listed because of stream sedimentation and has received funding through the Clean Water Act Section 319 funds. Little Cottonwood Creek is listed because zinc concentrations exceed State water quality standards. A multi-agency study is currently underway to evaluate the sources of metals in Little Cottonwood Creek. Mill Creek has had several stream rehabilitation projects helping to stabilize stream banks impacted by recreation use.

Historic overgrazing occurred throughout this unit until the early 1900's. Loss of vegetation and topsoil became so severe that flooding and landslides were common occurrences during the 1930's. Property damage and loss of life prompted the elimination of livestock grazing from the Wasatch front at this time, followed closely by a large program of watershed study and restoration that continued until the early 1970's. By that time, watersheds had mostly been stabilized and downward condition trends reversed. Current watershed conditions are still stable, however the potential for fire caused erosion and flooding is very high due to the almost uniform overage condition of the mountain brush communities that are common to the Wasatch Front.

Eastern Uintas Management Area

Geology - High Uintas – This is the glaciated center of the Uinta Mountains with elevations ranging from 8,000 to 13,578 feet. The structure is a broad, arculate, anticlinal fold slightly overturned to the north; the lithology is quartzite and shale of the Uintah Group with Mississippian limestone, Weber sandstone, and extensive glacial and fluvial deposits. The geomorphic processes are glacial and peri-glacial with secondary fluvial action.

North Slope Outwash – These are gently sloping benches and valleys forming the lower north slopes of the Uinta Mountains at elevations ranging from 8,000 to 10,000 feet. The structure is benches on north anticline limb and the lithology is quartzite, conglomerates with thick glacial outwash overburden extending out into the Wyoming Basin. The geomorphic process is fluvial over earlier glaciation.

Phil Pico Highlands – These are a series of hogback ridges along the north flank of the Uinta anticline with an elevational range of 6,500 to 9,000 feet. The structure is a hogback ridge and the lithology is limestone, siltstone, shale and sandstone. The geomorphic processes are colluvial and fluvial being secondary.

Soils - Most of the soils are deep to moderately deep soils, 30 to 36 inches deep, at elevations ranging from 8,000 to 11,000 feet and slopes that are rolling to very steep, mainly 15 to 65 percent. They are well to excessively drained. Permeability above bedrock is very slow to very rapid. Runoff is slow to medium and sediment production is low. The hydrologic groups are mainly B and C.

A small area of the very northeast part of the WCNF contains soils that are shallow to deep and moderately deep at elevations ranging from 6,000 to 7,000 feet. The rock outcrop is exposure of bare sandstone. These soils are well drained and permeability is moderate to slow. Runoff is medium and sediment production is moderate. The hydrologic groups are mainly D for the Lithic Argiborolls and C for the Typic Argiborolls.

Rock land is located in the High Uinta Mountains. Areas of this land type are mainly on steep to very steep, rocky, colluvial areas that are above timberline, usually 11,000 to 13,500 feet elevation. Rock land occupies about 70 percent of the area, and the other 30 percent is shallow to very shallow, stony soils. Because of their high elevations, these areas are important watershed. They receive large amounts of precipitation much of it as snow and these snowfields are important sources of late summer stream flows.

Water - This unit is located on the north slope of the Uinta Mountains. The main rivers that drain this unit are the Blacks Fork, Smiths Fork, Henrys Fork, and Beaver Creek. Many small lakes and ponds and three large reservoirs, Meeks Cabin, Beaver Meadow, and Hoop Lake, are found in this unit. Many large riparian areas and wetlands are located along most of the main rivers and tributaries and around the small lakes and ponds. A few irrigation diversions are located near the Forest boundary.

The main human influences affecting watershed condition are timber, livestock grazing, irrigation, recreation, and roads. Timber harvest has occurred and livestock graze most of the area. Historic overgrazing created conditions of accelerated erosion and gully formation, most noticeable in the large wetland meadows and riparian parks that are common in both the Eastern and Western Uinta Mountains. One of the main watershed concerns is the sheep driveway that has erosion problems occurring over many years. Extensive restoration efforts have almost completely reversed the historic downward trends in watershed condition, to the point where most gully complexes are revegetated and healed over. Some segments of streams are dewatered from irrigation diversions. Some developed recreation sites are located along riparian areas of

the main rivers. Some of the roads contribute sediment to the stream because of poor road drainage features.

Altered flow regimes occur on the Smiths Fork River below State Line Dam, the Blacks Fork River below Meeks Cabin Reservoir, Beaver Creek below Hoop Lake, and Lost Creek below Beaver Meadows Reservoir.

Smiths Fork in Wyoming on the north slope of the Uinta Mountains is listed by the State of Wyoming as impaired for habitat degradation and an evaluation of stream conditions is planned.

Bridger Lake, China Reservoir, Lyman Lake, and Marsh Lake do not meet State of Utah water quality standards for dissolved oxygen.

North Wasatch – Ogden Valley Management Area

Geology - Monte Cristo-Weber Valley Hinterlands – This is a modified ridge and valley network between the Wasatch Front and the high Wyoming Basins at an elevational range of 5,400 to 9,000 feet. The structure is graben-like and the lithology is Wasatch sandstone, limestone, conglomerates with pockets of Tertiary volcanics and Precambrian crystalline rocks. Alluvium is in the valleys and drainage ways. The geomorphic processes are fluvial and colluvial.

Northern Wasatch – This is a bold, straight mountain front crossed by large east-west canyons at elevations ranging from 5,000 to 9,700 feet. The structure is an uplifted fault block; the lithology is mostly Farmington Canyon crystalline rocks, gneiss, quartzite, and dolomite. The geomorphic processes are fluvial, glacial, and colluvial.

Wellsville Mountains – This is a narrow ridge system forming the north end of the Wasatch Front at an elevational range of 5,000 to 9,000 feet. The structure is a fault block ridge with numerous lateral faults and the lithology is quartzite, dolomite, and limestone. The geomorphic process is fluvial and nivational on the upper east slopes.

Soils - These are deep to moderately deep soils at elevations ranging from 5,200 to 10,000 feet on slopes that are steep to very steep with some that are gently rolling. The soils are moderately well to somewhat excessively drained. Permeability is moderately slow to rapid. Runoff is slow to rapid and sediment production is low to moderate. The hydrologic groups are mainly B and C with some D.

Water - This unit is located from Brigham City to Bountiful to the Monte Cristo area. Two main rivers, the Weber and Ogden Rivers, drain large areas of this unit. Along the Wasatch Front, most of the drainages have small intermittent streams. However, when there is high winter precipitation, large debris flows have come out of many of the drainages during spring runoff. This part of the Wasatch Front is considered a high hazard area because of high debris flow potential. This unit has a few small lakes and ponds but for the most part is fairly dry. Pineview Reservoir is a large body of water located near Huntsville used extensively for water-based recreation. Riparian areas and wetlands occur mainly along the South Fork Ogden River. A large wetland meadow is located on Wheeler Creek near the Snowbasin Ski Resort.

The main human influences affecting watershed condition are livestock grazing, recreation, and roads. Livestock graze in the drainages above Causey Reservoir. Most of the developed recreation sites are located in riparian areas along the South Fork Ogden River causing some bank trampling and bare soils. ATV use has had a sharp increase in the last few years and many small two-track trails are found near Willard Peak, along the foothills and top of the Wasatch Front range.

FERC projects are located at Pineview Dam on the Ogden River and Causey Dam on the South Fork Ogden River. A minimum stream flow has been set for Wheeler Creek as part of the Phase I planning for the Snowbasin Ski Resort development and a flow monitoring study is currently being conducted to provide better water flow information near the resort. The Ogden River Water Users Association maintains an in-stream flow of at least 10 cfs in the Ogden River below the Pineview Dam during normal water years, but flows may be reduced if water rights in the basin are shorted (FERC, 2000).

Pineview Reservoir does not meet State water quality standards for Total Phosphorus and dissolved oxygen and is listed as high for conducting a TMDL.

Stansbury Management Area

Geology – Stansbury Range - This is a fault block mountain range in the eastern Great Basin at elevations ranging from 5,500 to 11,100 feet. The structure is a tilted block with western dip slopes and eastern scarp face and the lithology is mostly Prospect Mountain quartzite and rocks (limestone, dolomite, and shale) of the Oquirrh Group. The geomorphic processes are fluvial, glacial, and nivational.

Soils - Soils are deep to moderately deep at elevations from 6,000 to 12,000 feet. Slopes are mostly steep to very steep with some slightly steep slopes on the alluvial fans along the foothills. The soils in this association are moderately well to somewhat excessively drained. Permeability is moderately rapid to slow. Runoff is slow to rapid and sediment production is moderate. The hydrologic groups are mainly B and C.

Water - This unit is a mountain range in the Great Basin west of Tooele, Utah. There are no large rivers flowing in this area and the largest streams are about 10 to 20 feet wide. There are no large bodies of water in the area, although Grantsville Reservoir is located in the Willow Creek drainage off the Forest. The Deseret Peak Wilderness occupies a large area in the center of the unit.

Gradual shifts over the last century towards a drier and warmer climate have resulted in degraded watershed conditions. The climatic changes have enhanced the ability of poor ground cover species such as cheat grass and pinyon/juniper to invade the sagebrush grass communities common to this area. Increased runoff and soil erosion have been a product of these invasions. Past attempts at eradicating cheat grass and at slowing pinyon/juniper encroachment have been successful in restoring favorable soil hydrologic conditions in isolated areas. Overall, these efforts have had little effect on reversing downward watershed condition trends in this unit.

Along with the North and Central Wasatch Management areas, this area has experienced the most active wildfire history on the WCNF. Past wildfires have burned at high intensities, creating an acute need for post fire rehabilitation. Monitoring has shown these efforts to be generally successful in restoring proper watershed function and protecting long-term soil productivity.

The main human influences affecting the watershed are livestock grazing, recreation use, and mining. A few water diversions are located near the Forest boundary.

Wetlands are found mostly near numerous springs and seep areas. Several of the springs are fenced to protect from livestock damage. The riparian areas are found along the main streams that drain the area. Riparian areas that are located by campsites and picnic areas in North and South Willow Canyons have bare stream banks and vegetation trampling.

There are no impaired water bodies in this unit.

Western Uintas Management Area

Geology - West Flank Uintas – These are ridges, valleys, and benches forming the west end of the Uinta Mountains at elevations ranging from 7,000 to 12,000 feet. The structure is an anticline with exposed curve; the lithology is Uinta quartzite and glacial deposits in the center, and limestone and Weber sandstone mostly on the sides. The geomorphic processes are glacial, peri-glacial, stream cutting, and mass wasting.

High Uintas – This is the glaciated center of the Uinta Mountains with elevations ranging from 8,000 to 13,578 feet. The structure is a broad, arculate, anticlinal fold slightly overturned to the north and the lithology is quartzite and shale of the Uintah Group with Mississippian limestone, Weber sandstone, and extensive glacial and fluvial deposits. The geomorphic processes are glacial and peri-glacial with secondary fluvial action.

North Slope Outwash – These are gently sloping benches and valleys forming the lower north slopes of the Uinta Mountains at an elevational range of 8,000 to 10,000 feet. The structure are benches on north anticline limb and the lithology is quartzite, conglomerates with thick glacial outwash overburden extending out into the Wyoming Basin. The geomorphic process is fluvial over earlier glaciation.

Soils - Most of the soils are deep to moderately deep, 30 to 36 inches deep, at elevations of 8,000 to 11,000 feet and slopes that are rolling to very steep, mainly 15 to 65 percent. The soils are well to excessively drained. Permeability above bedrock is very slow to very rapid. Runoff is slow to medium and sediment production is low. The hydrologic groups are mainly B and C.

Soils in the lower elevations of the Weber River and Beaver Creek drainages are deep to moderately deep at elevations from 5,200 to 8,000 feet on slopes that are steep to very steep but with gently rolling included. The soils are well to somewhat excessively drained. Permeability

is slow to moderately rapid. Runoff is medium and sediment production is low. The hydrologic groups are mainly B and C.

Rock land is located in the High Uinta Mountains. Areas of this land type are mainly on steep to very steep, rocky, colluvial areas that are above timberline, usually 11,000 to 13,500 feet elevation. Rock land occupies about 70 percent of the area, and the other 30 percent is shallow to very shallow, stony soils. Because of their high elevations, these areas are important watershed. They receive large amounts of precipitation, much of it as snow; these snowfields are important sources of late summer stream flows.

Water - This unit is located in the drainages east of Kamas including the Bear River drainage. The headwaters of the Weber, Provo, Duchesne, and Bear Rivers are located in this unit. These large rivers provide drinking and irrigation water to many users. Many small lakes and reservoirs are located in this unit. Large reservoirs in the area include Washington Lake, Trial Lake, Smith and Morehouse, and Whitney Reservoirs. Large areas of wetlands and riparian area are found in the High Lakes Country and along the Weber, Provo, and Duchesne Rivers. Part of the High Uintas Wilderness is located in this unit.

The high lakes area of the Kamas Ranger District has many of the reservoirs on the Forest. Notch, Ibantec, Fish Lake, Sand, Castle Lake, Kamas Lake, and Abes Lake are active reservoirs operated by irrigation water users under special use permit. Washington Lake, Trial Lake, and Lost Lake are reservoirs operated by the Central Utah Water Conservancy District and are withdrawn under the jurisdiction of the Bureau of Reclamation. Since 1994, 12 reservoirs were stabilized as part of the Central Utah Project mitigation project to reduce the hazard of the dams to a low or no hazard. The reservoirs are Star (1994), Crystal (1995), Long (1995), Duck (1996), Lilly (1996), Fine (1997), Island (1997), Pot (1997), Marjory (1997), Weir (1997-98), Big Elk (1998), Wall Lake (1999).

The main human influences that affect watershed condition are timber, livestock grazing, recreation, irrigation, and roads. Timber harvest has occurred and livestock currently graze in all of the main drainages. This area was overgrazed in the late 1800s and early 1900s and poor soil productivity is found in some areas. Topsoil losses through erosion have been particularly severe in the tall forb and aspen communities, where low ground cover annuals such as tarweed and coneflower have supplanted the native forbs. Expansions in off-road and all-terrain vehicle (OHV/ATV) use in the 1980's contributed to the general downward trend in watershed condition. In general, the downward trends in topsoil losses had been reversed through a combination of allotment stocking reductions, livestock exclusion from riparian area and tarweed eradication efforts, and confinement of OHV/ATV use to a system of designated trails. Overall watershed condition trend in this unit is stable.

Most developed recreation sites are located along riparian areas of the Weber, Provo, and Bear Rivers. Many watershed improvement projects that protect riparian areas and stream banks have been done along the Mirror Lake corridor. Irrigation diversions withdraw water and augment water flows in several basins. Some roads and trails contribute sediment to streams particularly during the fall hunting season.

A diversion is located on the Duchesne River East Portal of the Duchesne Tunnel. Water flows from the East Portal through the Duchesne Tunnel to the upper Provo River above Soapstone Campground.

The City of Oakley has petitioned the Environmental Protection Agency for Sole Source Aquifer Designation for the aquifer located in the Weber Canyon area east of Oakley.

Mirror Lake does not meet State water quality standards for dissolved oxygen.

Geologic Hazards

The main geologic hazards that affect the WCNF are earthquakes and landsides. For the most part, the earthquake hazard is low to very low. Landslides are very common geologic hazards in Utah and many have occurred on the WCNF. Utah is among eight states with a landslide hazard of "severe," the highest hazard class. Conditions favorable to landslides exist primarily in mountain ranges and along the edges of high plateaus. However, shallow landslides on steep mountain slopes generate debris flows causing damage and loss of life in urban areas at canyon mouths far removed from the source of the slope failure. In northern Utah's Davis County residential areas on alluvial fans were especially hard hit by debris flows in the 1920s, 1930s, and 1980s (Harty 1991).

Landslides in Utah are most common in the Middle Rocky Mountain Province, and in the High Plateau Province. These regions contain a high density of steep slopes and the highest average annual precipitation in Utah (Harty 1991).

Geologic formations on the WCNF commonly involved in landslides are the Lake Bonneville Formation, the Farmington Canyon Complex, and the Ankkarah Formation. The Farmington Canyon Complex and the Ankarah Formation are two of five formations producing most of the shallow landslides within Utah. The Bonneville Formation is located along the west flank of the Wasatch Range (Salt Lake, Weber, Davis Counties) and between the Wasatch Range and the Great Salt Lake (Weber and Davis Counties). The Farmington Canyon Formation is located on the west flank of the Wasatch Range between Bountiful (Davis County) and Willard (Box Elder County). The Ankarah Formation is located in the Wasatch Range east of Salt Lake City between Mill Creek and Parleys Canyon (Salt Lake County) (Harty 1991).

Almost all of the historic landslides occurring on the WCNF are located along the west face of the Wasatch Front from Pleasant View to Draper. While most are small, shallow slides less than 2000 feet long, several large, shallow slides occurred in the canyons from Bountiful to Kaysville and from Weber Canyon to Ogden Canyon. Several large deep-seated prehistoric slides were identified in the Blacks Fork and Smiths Fork drainages on the North Slope of the Uinta Mountains and in the Wasatch Range east of Willard. Most of the small deep-seated prehistoric slides less than 2000 feet long are located along the foot of the mountains of the east side Cache Valley and the west side of the Wasatch Range (Harty 1991).

Most communities in Utah experience severe rainstorms causing flooding and landslide damage, such as in Davis County during the 1920s and 1930s. However, landslides resulting from rapid

snowmelt are more geographically widespread than rainstorm-related landslides. During the record-breaking years between 1982-1984, the resulting damage from flooding and landslides was so extensive that 22 out of 29 counties were declared eligible for national disaster assistance. In 1983, a debris flow from Rudd Canyon in Davis County deposited 80,000-90,000 cubic yards of debris throughout a 9-block square residential area in Farmington, resulting in damage to 35 houses (Harty 1991).

All mapped landslides should be considered hazard areas. The distribution of the most recent (historical) landslides can be used as a guide to landslide susceptibility in that it shows areas that may continue producing landslides under current climatic conditions. However, many of Utah's largest and most destructive landslides were reactivations of prehistoric landslides. The hazard potential of "older" landslides should not be underestimated but investigated in further detail when development is considered (Harty 1991).

Surface Water

The WCNF is within 15 fourth-order watersheds, 28 fifth-order watersheds, and 119 sixth-order watersheds. The WCNF straddles the Colorado River Basin and the Great Basin watersheds. The Henrys Fork, Smiths Fork, Blacks Fork, Muddy Creek, and upper Duchesne River watersheds drain into the Colorado River Basin. The upper Bear River, Weber River, Ogden River, Provo River, and Jordan River drain into the Great Basin watershed.

The WCNF contains more than 1178 miles of perennial streams and numerous natural springs and seeps. Many small natural lakes and reservoirs supplying water for wildlife, grazing animals, recreation sports fisheries, and irrigation are found in the Uinta Mountains. Several of the natural lakes in the system have been dammed and converted to reservoirs.

The conversion of aspen to conifer due to fire suppression during the 1900s has increased the amount of water that is transpired and has reduced the amount of water available for stream flow and other vegetation. On the WCNF, it is estimated that there is about a 60 percent reduction in the amount of aspen communities from historic levels.

Groundwater

Forest snowmelt recharges ground-water aquifers. Recharge to deep, confined aquifers occurs almost exclusively near or at mountain fronts. Streams originating on the Forest contribute to the recharge of aquifers within and outside the Forest boundary.

In general, groundwater quality on the WCNF is good to excellent. Groundwater wells are used for domestic purposes at campgrounds and administrative sites. And, groundwater from springs is used for domestic livestock and wildlife. Typical forest management activities have limited impact on groundwater. Activities that pose the greatest risk to groundwater quality are hard rock mining and oil and gas development. In the late 1800's, hard-rock mining in Big and Little Cottonwood Canyons exposed mineral bearing ore in underground shafts and adits causing increased metals concentrations in groundwater. As a result, the groundwater flows to the surface into Little Cottonwood Creek causing zinc concentrations to exceed state standards for

aquatic life. No problems are known to have occurred to the groundwater from oil and gas development occurring along the north slope of the Uinta Mountains on the Evanston/Mountain View Ranger District.

Wetlands, Riparian Areas, and Floodplains

Wetland and riparian areas occupy a small amount of the lands managed by the WCNF. Most of the wetlands occur on the north slope of the Uinta Mountains. Composed of sedges and willows, they are found in broad meadows, potholes and wide floodplain areas along the major river bottoms. Other areas having large wetlands include the Beaver River near Kamas, the Provo River, and Wheeler Creek. Large slope wetlands are located in Big and Little Cottonwood Canyons. The remainder of the Forest has small or narrow wetlands associated with streams flowing through narrow valley bottoms along the Wasatch Front and in the Logan/Ogden areas. Wetlands are key to productive fisheries and wildlife habitat, attenuated flooding, quality water for downstream users, continuous ground water recharge, diverse scenery, recreation sites, and sustaining timber and forage production.

Riparian ecosystems constitute the transitional area between the aquatic ecosystem and the adjacent terrestrial system. The aquatic ecosystem includes the streams, ponds, lakes, and the biotic communities and habitat found in these features. Wetlands are found on land that is inundated by surface or groundwater with a frequency sufficient to support vegetation or aquatic life that requires saturated or seasonally saturated soil conditions. Wetlands generally include marshes, bogs, wet meadows, river overflows, mud flats, and natural ponds.
Floodplains are relatively flat areas adjoining a river way that are prone to flooding. Statistically, these areas are subject to a 1 percent (100-year recurrence) or greater change of flooding in any given year. Floodplains occupied by healthy vegetation communities reduce the severity of floods by allowing water to spread out over the floodplain. Vegetation slows the speed of the water and allows sediment to settle out and water to infiltrate. Water is slowly released from alluvial aquifers back to the channel during drier periods of the water.

Large floodplains occur along the main rivers including Beaver Creek near Lonetree, Henrys Fork, Smiths Fork, Blacks Fork, Bear River, Provo River, Beaver Creek near Kamas, Ogden River, the Blacksmith Fork, and the Logan River. These floodplains are up to several hundred feet wide and may have several channels. Most of the streams on the Forest have small floodplains adjacent to the channel.

Water Uses

Water uses on the Forest include livestock stock water, irrigation-diversion flows, irrigation-augmentation flows, Federal Energy Regulatory Commission (FERC) hydropower projects, recreation uses, and road maintenance. Livestock water use is very small compared to the water yield of the Forest. Most water diversions are near the Forest boundary and are used to irrigate land outside the Forest boundary. Road maintenance water use is a temporary use for dust abatement. Culinary water is used in campgrounds, picnic areas, and Forest administrative sites.

Five hydropower projects regulated by FERC are located on the Forest. In 1995, relicensing was initiated on the Stairs Project in Big Cottonwood Canyon and the Pioneer Project at Pineview Reservoir. As a result, minimum instream flow requirements below the Stairs project for the protection of fisheries and aesthetics and mitigation on the tailrace section (off-Forest) of the Pioneer Project to provide water for fisheries and to enhance aquatic habitat conditions are now in place.

Many reservoirs have been constructed on the WCNF. Large reservoirs, more than 1000 acre-feet of volume, are Pineview, Causey, Meeks Cabin, Beaver Meadow, Whitney, Hoop Lake, Washington Lake, Trial Lake, and Smith and Morehouse. These reservoirs store more than 176,000 acre-feet of water and have a surface area greater than 4,500 areas. Many small reservoirs are located throughout the Forest.

Public Supply Watersheds

A public supply watershed is defined as the portion of a river basin consisting of lands that contribute surface water, groundwater, or both, to a public water system as defined in the Safe Drinking Water Act, as amended. There are several key public supply watersheds whose source partially or almost entirely drains from the WCNF.

The main watersheds supplying water for public consumption are the Provo River, Weber River, Big Cottonwood Creek, Ogden River, and the Logan River. Almost 60 percent of the watersheds draining from the Forest provide water for public drinking water needs. Many of the watersheds supply drinking water from springs and well developments. These watersheds are located in major population areas such as Salt Lake City, Ogden, and Logan that are currently experiencing a steady increase in population growth.

As an example of the importance of Forest water supplies, currently within the Jordan River Basin (primarily Salt Lake County), only 26 percent of presently developed water supply for municipal, industrial, irrigation, domestic and stock-watering purposes is from ground water sources (Utah, State of 1997b). The remaining 74 percent is from surface water sources of which most originate from the mountains draining into the Jordan River Basin. The protection of the large amount of drinking water sources that originate on the WCNF is very important to the adjacent communities.

Public supply water is used on the Forest for campgrounds, picnic areas, and administrative sites. Public supply water used at these sites are transient water sources that are used less than 6 months out of the year supplying a small amount of water, for example providing water needs for 2 to 68 units per campground.

Sewer lines are installed in Big and Little Cottonwood Canyons to protect the public health. The Little Cottonwood Canyon sewer line was installed in the early 1970's and the Big Cottonwood Canyon sewer line was installed in the early 1990's. These lines have worked well although some temporary blockages with spilled sewage have occurred.

The City of Oakley has petitioned the Environmental Protection Agency for Sole Source Aquifer Designation to acknowledge that Cottonwood Springs and the recently installed Humbug Well are the only water sources available to the community and to raise awareness about the importance of keeping the aquifer free of contamination (Jarvis, T. 1999). The aquifer is located along the south side of Weber Canyon east of Oakley and is the only Sole Source Aquifer petitioned on the WCNF.

Instream Flows and Water Rights

Irrigation diversions and hydropower storage or diversions have reduced the flow of several streams on the Forest. Most of these streams are at or near the Forest boundary. De-watered stream conditions occur mostly off the Forest.

The Forest does not have instream flow water right claims recognized by the State of Utah. However, minimum instream flow requirements are set through special use authorization for a few streams.

Water Quality

Overall, water quality is good. Active and inactive mining sites have contributed to degradation of water quality in several streams within the Forest. Other impacts to water quality are associated with natural debris flows, roads, water diversions and augmentation, livestock grazing, and recreation activities.

The State of Utah has designated the waters above the Forest boundary as Antidegradation Segments indicating that the existing water quality is better than the established standards for the designated beneficial uses. Water quality is required by state regulation to be maintained at this level. The beneficial uses of streams within the Forest, as designated by the Utah Department of Minimum instream flow requirements are set through special use authorization for a few streams. Environmental Quality, Division of Water Quality, are Class 2B – protected for recreation; Class 3A – protected for cold water species of game fish and other cold water aquatic species; and Class 4 – protected for agricultural uses. Also, the beneficial use of streams draining into the Logan River watershed include Class 3D – protected for waterfowl, shore birds and other water-related wildlife, and necessary aquatic organisms in their food chain. The numeric water quality standards are in Section R317-2, Utah Administrative Code, Standards of Quality of Waters of the State (Utah, State of 2000a).

Water bodies are assessed by the states of Utah and Wyoming to determine if the water bodies are meeting water quality standards. Most water bodies on the WCNF are fully supporting their beneficial uses. In Utah, two streams and seven lakes or reservoirs are listed as impaired on the WCNF (Utah, State of. 2002a). In the State of Wyoming, the East and West forks of the Smiths Fork to the Utah Wyoming boundary, and Willow Creek to the Utah Wyoming boundary is listed as impaired based on a 319 Watershed Improvement project on the Smiths Fork (Wyoming, State of 2002).

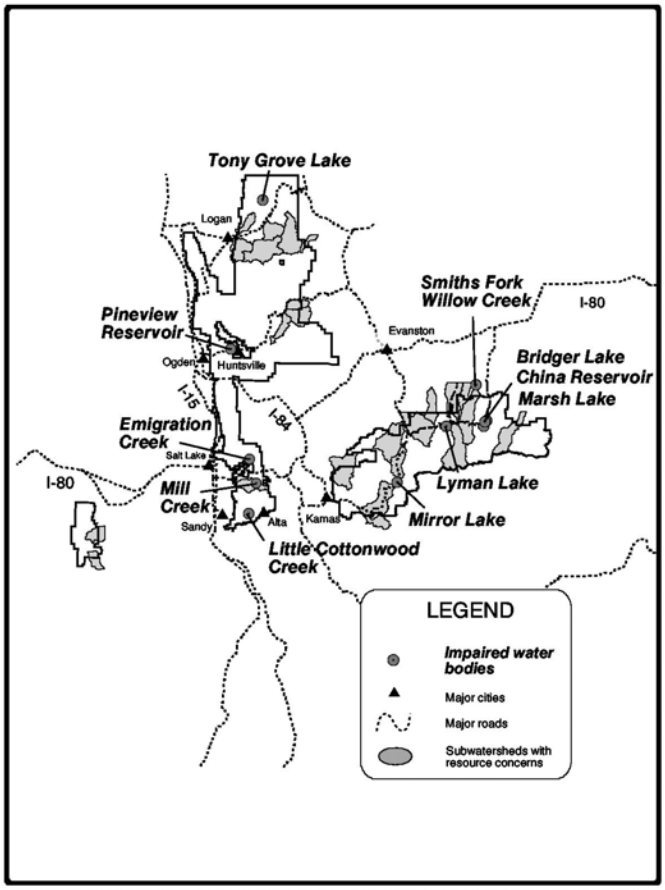
Table GEO-1. Streams, Rivers, Lakes, and Reservoirs on the Wasatch-Cache National Forest that are on Utah's and Wyoming's 2002 303(d) List.

Waterbody	HUC	Pollutant or Stressor
East Fork Smiths Fork (in Wyoming)	*14040107*	*Habitat degradation*
West Fork Smiths Fork (in Wyoming)	*14040107*	*Habitat degradation*
Willow Creek (in Wyoming)	*14040107*	*Habitat degradation*
Bridger Lake	14040107	Dissolved oxygen
China Reservoir	14040107	Dissolved oxygen
Marsh Lake	14040107	Dissolved oxygen
Lyman Lake	14040107	Dissolved oxygen
Mirror Lake	14060003	Dissolved oxygen
Tony Grove Lake	16010203	Dissolved oxygen, *total phosphorus*
Pine View Reservoir	16020102	Dissolved oxygen, *total phosphorus*
Emigration Creek	*16020204*	*Fecal coliform*
Mill Creek	16020204	Sediment, habitat alteration
Little Cottonwood Creek	16020204	Zinc

Every two years, the Utah Department of Environmental Quality submits a list of waters in a report to the US Environmental Protection Agency (USEPA) containing those water bodies in Utah that are considered impaired and not meeting its beneficial uses. In April 2002, Utah submitted its 2002 303(d) list to the USEPA for review and approval. On the WCNF, water bodies that are listed on the Utah's 2002 303(d) list are shown in Table WA-1. Several water bodies on the WCNF have been requested for removal from the 2000 303(d) list. From table WA-1, Emigration Creek for Fecal coliform, and Tony Grove for total phosphorus are new additions within the WCNF on the April 2002 list. Mill Creek is on the list of water bodies to be removed from Utah's 2000 303(d) list of impaired water bodies for fecal coliform, sediment, and habitat modification. For the last several years, stream bank improvement projects have been implemented in Mill Creek in order to reduce sedimentation of Mill Creek and to improve streamside habitat.

The State of Utah has submitted several lake and reservoir waterbodies and specific parameters for removal from Utah's 2000 303(d) list. If approved, Pineview Reservoir will be removed from the list for dissolved phosphorus and dissolved oxygen because a TMDL is submitted, and for temperature because of a beneficial use classification change. If approved, China Reservoir will be removed from Utah's 2000 303(d) list because more information is needed to determine if this reservoir should be listed.

Figure GEO-1. Locations of Impaired Water Bodies and Watersheds in need of Restoration



The WCNF is working with the State of Utah to determine the causes of *water quality* impairment. The WCNF has been working with the Little Cottonwood Group since 1998 assessing the effects of mining on Little Cottonwood Creek. Field data on water quality, stream morphology, and aquatic health has been collected and a Total Maximum Daily Load (TMDL) assessment is being reviewed by the USEPA. In the Smiths Fork drainage, water quality samples are being collected and stream condition surveys have been completed for the purpose of assessing the quality of water on Forest Service land.

As part of a cooperative monitoring program with the State of Utah, the Forest Service collects water samples in selected drainages and sends them for analysis. Other water quality monitoring activities include macro-invertebrate sampling on selected streams to determine aquatic biological health and stream stability surveys. In addition to this, several cooperative efforts concerned with water quality are ongoing between the WCNF, state and local governments, regional planning agencies, and state colleges and universities.

Since 1985, the WCNF has completed R1/R4 level II riparian surveys on 54 streams, stream stability surveys on 14 streams, chemical water quality monitoring on 34 streams, and macroinvertebrate sampling on 7 streams. This data indicates that several areas of the Forest are in need of improvement in channel stability, vegetative density and structure, and riparian conditions.

Watershed Condition Assessment

Under the Inland West Watershed Initiative, a course filter assessment at the watershed scale was conducted on the sixth-code watersheds of the WCNF to identify the probable condition of watersheds, identify locations of critical water-dependent resource values at risk needing priority protection, and to identify locations of damaged soil, riparian, and aquatic resource values needing to be restored. The assessment was qualitative and relied on the knowledge of resource specialists and on-the-ground personnel.

The assessment was used to classify the watersheds according to condition classes (FSM 2521). Briefly, Class I watersheds are described as providing a robust basis for sustained production of goods and services with no long-term changes occurring even when major storms occur. Class II watersheds are those not attaining the requirements for Class I but not requiring capital investments to restore watershed conditions. These watersheds can be restored through integrated, ecological approach to management. Class III watersheds require technological and economically feasible capital investment to restore watershed conditions to a level consistent with management goals. At the sixth code watershed scale, the assessment shows four Class I watersheds, 91 Class II watersheds, and 24 Class III watersheds.

Watersheds that are highest priority for watershed improvement are those that have water quality impairment, those that have the greatest threat to riparian health and aquatic habitat conditions, and/or those that have partnership opportunities to accomplish work. Priority watersheds needing restoration are listed in Table WA-2. These watersheds have one or more resource concerns such as poor riparian and stream conditions, potential for large wildfires, lack of woody debris, channel scour from tie hacking, lack of aspen and beaver habitat. Poor riparian and stream conditions are those that have conditions such as high streambank instability, areas with a lot of trampling within riparian areas, or low vegetative cover.

Future trends

Water supply will become a more critical issue as population increases in the communities adjacent to the Forest. Water rights held by the Forest Service will become important in meeting management goals such as maintaining adequate stream flows for healthy riparian areas and developing recreation sites. As snowmaking increases at ski resorts, water withdrawals during critical base flow periods will require alternative methods of diversion to ensure that ecosystems and fisheries are maintained downstream.

In Big and Little Cottonwood Canyons, water quality will continue to be a concern as runoff from mining sites carries toxic pollutants downstream. Sediment sources such as roads and diversion ditches will continue to require regular maintenance to ensure that water quality is not adversely affected. OHV/ATV use will increase dramatically on the forest and will result in watershed damage where it is not managed and confined to suitable areas and designated trails. Oil and gas development, with its potential for affecting surface and ground water, will require inspections to protect these resources.

Table GEO-2. Wasatch-Cache National Forest High Priority Watersheds Needing Restoration

Fifth Code Watershed	Subwatersheds with Resource Concerns	Resource Concerns
1404010606	West Fork Beaver Creek	Fire exclusion, potential for large fires, lack of woody debris
1404010706	West Smiths Fork headwaters	Channel scour form tie hacking
1404010706	Willow Creek	Lack of aspen resulting in lack of quality riparian and beaver habitat
1404010707	East Fork Blacks Fork area	Erosion on sheep driveway and channel scour from tie hacking, poor beaver habitat from fire exclusion and livestock.
1404010707	Lower Blacks Fork River area	Gully system and poor riparian conditions from grazing
1404010803	West Fork Muddy Creek	Riparian impacts from grazing
1601010101	Hayden Fork	Channel scour from tie hacking, roads near stream in Gold Hill area
1601010101	West Fork Bear River	Extensive off road vehicle trails, poor soil productivity
1601010102	Mill Creek area (Bear River drainage)	Channel scour from tie hacking, roads near stream
1601010105	Upper Woodruff Creek (Wheeler Ck)	Poor soil productivity and ground cover, poor stream stability, lack of beaver habitat
1601010105	Sugar Pine Canyon	Poor soil productivity and ground cover, poor stream stability, lack of beaver habitat
1601020101	Laketown Canyon	Poor soil productivity and ground cover, poor stream stability, lack of beaver habitat
1601020301	Right Hand Fork Logan Canyon	Poor riparian conditions from roads
1601020302	North Logan area	Poor riparian conditions from roads and water pipeline in Green Canyon bottom
1601020303	Saddle Creek	Poor riparian conditions from roads and grazing
1601020303	Left Hand Fork Blacksmith Fork	Poor riparian conditions from roads and grazing
1601020303	Providence/Millville area	Poor riparian conditions from roads, gravel quarry, and heavy ATV and 4X4 use
1601020304	South Fork Little Bear River	Poor ground cover conditions from roads, and heavy ATV and 4X4 use
1601020405	Box Elder Creek	Poor riparian and upland conditions from roads, grazing, and OHV use
1602010101	Swifts Canyon to Stillman Creek area	Poor riparian conditions from roads, grazing, and OHV use
1602010206	North drainages of Causey Reservoir (Wheatgrass Ck)	Poor riparian conditions from roads, grazing, and OHV use
1602020301	Upper Provo/Soapstone area	Poor stream stability below Duchesne Tunnel from water augmentation.
1602020401	Mill Creek (SLC front)	Poor riparian conditions from use in developed recreation sites.
1602030403	East Hickman Canyon	Poor upland conditions from OHV use
1602030404	East Stansbury Mountains area	Poor upland conditions from OHV use and poor riparian conditions near dev rec sites

Environmental Consequences

General Effects

Management activities affecting watershed processes are described in terms of their potential to increase erosion and sediment yields, their ability to alter the physical, chemical, or biological properties of both soil and water, or by their influence on the timing or magnitude of surface water runoff. Management activities may directly or indirectly impact riparian and wetland habitats, resulting in impacts to channel stability, water quality, and aquatic habitat quality. Impacts to stream channels, floodplains and wetlands may also lead to increased flooding downstream by reducing the capacity of floodplains to store floodwaters and increasing the rate of watershed runoff. Most of the management activities on the WCNF have the potential to impact water quality and quantity. Some of these activities have the potential to increase the magnitude of the relatively small but frequently occurring floods to which natural stream channels are adapted and which control the form and dimension of the channel (Wolman et al. 1960, Andrews 1980). Activities that influence the rate of watershed runoff and the resulting magnitude of individual flood peaks can have long-term impacts on channel stability leading to increased bank erosion, channel degradation, and sedimentation in alluvial channels. Individual activities generally do not, by themselves, result in this kind of change, depending on their severity, but the impacts of multiple management activities over long time periods can. This is very important in central and northern Utah where large floods occur periodically that are much greater in magnitude than the average of floods in all other years. In northern Utah, the recurrence interval of large floods has been approximately 30 years. Such floods can cause significant damage and channel change in streams previously impacted by land management activities and potentially result in changes in riparian habitat, increased erosion and loss of aquatic habitats.

Many activities on the forest result in mechanical ground disturbance that reduces vegetative ground cover and exposes soils to wind and water erosion. Where activities involve heavy equipment, compaction and rutting of soils can occur. The short-term effect of these changes is to cause increases in runoff and sediment delivery to surface waters. Where these effects are prolonged in duration, a degradation of long-term soil productivity will occur. Fine sediments are the primary agent responsible for reduced water quality in forested watersheds. Fine sediments reduce water clarity and increase turbidity. Sediments reduce the quality of aquatic habitat by filling gravel interstices, affecting fish as well as aquatic insects and other life. Increased fine sediment loads result in reduced water and oxygen flow in spawning gravels that, in turn, result in reduced spawning success in cold-water fish.

Many management strategies can, at least partially, alleviate these adverse effects. Providing adequate road maintenance, improving road drainage, and removing or re-aligning damaging road segments can greatly reduce the adverse impacts of roads. Changes in grazing management strategies, such as those developed over the last 20 to 30 years, allowing for retention of ground vegetation and protection of riparian areas can also result in improved stream channel and aquatic habitat conditions. Streamside buffer zones protect channel stability and water quality by maintaining the integrity and function of riparian and wetland areas. Minimizing ground disturbance in riparian areas and on hill slopes protects soils from erosion, avoids compaction,

preserves soil organic matter, all of which help reduce excess erosion and runoff. Dispersing activities such as timber harvest over time and space can allow natural recovery processes to take place.

Issues

There are three issues tracked through effects analysis on soil and water resources. They are, soil productivity, water quality, and water yield. There are eight principle categories of management activities generally having the potential to affect one or more of the three issues. Of the eight categories discussed below, most have no potential to affect water yield. Only one, "Timber Harvest/Vegetation Management" discusses this issue. All eight have the potential to affect soil productivity and water quality, and those issues are discussed throughout. No impacts to geologic resources have been identified from activities expected to take place on the WCNF in the next planning period.

Effects on Soil and Water Resources from Roads and Access Management

Roads represent a total commitment of the ability of the soil resource to support vegetation communities. In the absence of extensive restoration efforts, even temporary roads or timber harvest skid trails will result in a loss of long-term soil productivity. System roads create an irretrievable loss of the soil resource, while temporary and non-system roads can cause a similar loss if not closed and restored to productive condition.

Roads modify natural drainage networks and accelerate erosion processes resulting in increased stream sedimentation, degraded aquatic habitats and altered channel morphology. Road impacts increase as they become more hydrologically connected to the natural channel network (Jones et al. 1996). Roads and their drainage systems typically act to intercept surface and subsurface runoff and route excess runoff into the channel system (Hauge et al. 1979, Megahan 1972), resulting in both increased stream flows (Harr et al. 1975) and increased sediment delivery to streams (Wemple et al. 1996). Especially in steep terrain, roads increase the rate of hill slope failures and soil mass wasting (Swanston et. al. 1976, Swanston 1991). Fine sediments can be delivered to natural streams by erosion of road surfaces as well as from non-vegetated road cut and fill surfaces (Reid et al. 1984). Roads impact aquatic habitats by limiting fish passage through culverts at road-stream crossings (Furniss et al. 1991) and increasing fine sediment in spawning gravels which in turn reduces dissolved oxygen levels and sub-surface stream flow and results in reduced spawning success by salmonids (Bjornn et al. 1991, Phillips et al. 1975). Some of the effects of roads can be mitigated by design changes that disperse, rather than concentrate road runoff by gravel surfacing (Burroughs et al. 1989, Furniss et al. 1991), seasonal road closures to protect roads without gravel surfaces from use during adverse weather, or by designating undisturbed protective buffers along streams to allow filtering of fine sediments (Roby et al. 1977). The effectiveness of streamside buffers generally increases with width, but the impacts of large-scale or chronic disturbances can still impact streams, even with relatively wide and intact buffer strips.

Direct and Indirect Effects

This section describes effects on soils and water from travel management of existing roads and trails. Soil erosion and sedimentation from new road building for timber sales and oil and gas exploration and development are described in sections Effects on Soil and Water Resources from Timber Harvest/Vegetation/Fuels Treatment and Effects on Soil and Water Resources from Oil and Gas Activities

Based on past road maintenance, about 23 percent of the WCNF roads have been maintained. Some of these roads are intentionally not maintained because some users desire a rough driving experience. Many of the roads that are not maintained have a cobble or gravel surface that do not have an adverse effect on soil and water conditions. Generally, road maintenance is done on roads with the highest use and helps to minimize erosion and sedimentation into streams from these roads by providing proper drainage from the road. The remaining WCNF roads are not maintained and some of these contribute sediment to streams. New roads would be designed to minimize erosion and would be located to provide a buffer from streams.

During the last 15 years about 148 miles of road have been decommissioned, which is a rate of about 10 miles per year. Road decommissioning is anticipated to continue under all alternatives at a similar rate. The main difference between alternatives is the additional decommissioning of roads and motorized trails in recommended wilderness (Prescription Number 1.5). With respect to roads and trails, Alternative 1 would improve soil and water conditions the fastest by closing to motorized use and decommissioning 2 miles of existing roads and about 76 miles of motorized trails. In Alternative 2, about 7 miles of trails would be closed to motorized use and be decommissioned. In the long-term, these roads and trails will revegetate and soil erosion would be negligible. Alternatives 3 through 7 would have no roads or trails closing to motorized use and decommissioning in recommended wilderness (Prescription Number 1.5) and would not improve soil and water conditions from this activity. Since all alternatives would decommission some roads and rehabilitate trails that are currently in poor condition there would be an improvement in soil and water conditions with respect to roads and trails for each alternative.

Effects on Soil and Water Resources from Timber Harvest/Vegetation Treatment

Timber harvest can impact stream flows by altering the water balance within a watershed or by affecting the rate at which water moves from hillsides to stream channels. Removal of vegetation in forested watersheds alters the watershed response to precipitation by reducing interception, evaporation and transpiration and increasing water storage and runoff.

Opportunities to increase water yield are greater in forests associated with higher precipitation, and higher precipitation is associated with higher elevations in the western US. Research treatments aimed at increasing water yield have been applied to large portions of relatively small watersheds, generally less than one square mile in size. In these small watersheds, any increases in water yield generally occur during the wettest time periods. Studies by Hibbert suggest that the increase is a uniform percentage on the hydrograph over the range of flows investigated. This means that if low flows were increased in one study by 15% for significant treatments then

flood peaks also increased by 15%. In areas much greater than one square mile, realities of generating significant water yield are limited by land ownership, land allocation, vegetation types, variable elevations and aspects, and other multiple resource needs (USDA Forest Service 2002d).

The USFS publication, Water & the Forest Service (USDA Forest Service 2000j) responds to the question "Can Forests be Managed to Improve Stream Flow? It states that:

> Flooding and sedimentation from cutover lands was one of the primary reasons for establishing national forests. The timing of water yields was also an important issue, especially the desire to augment late-season flows.
>
> Vegetation cover and on-site control measures effectively reduce flood peaks. However, significant shifts in the timing of late-season runoff are not likely to be achieved through managing forest vegetation and snow across national forest lands. Treatments that restore slopes, meadows, and channels; increase the routing time between precipitation and runoff; and recharge ground waters can be expected to have a greater effect in sustaining late-season flows.
>
> Although theory suggests that vegetation management can produce more streamflow, for a variety of reasons, general water yield increases through forest management are likely to fall in an undetectable range. The data suggest that relying on augmentation from national forests will not be viable strategy for dealing with water shortages. Reducing water consumption, and improving conservation, can make greater gains and establish water markets to allocate scarce supplies more sufficiently.

Direct effects on soils include increased surface soil displacement and compaction from disturbance by road construction, log skidding, log landing construction and burning of logging slash after timber harvest (Christner et al. 1982, Harr 1983). Full tree skidding during harvest to a centralized log landing can serve to concentrate limbs and branches, and remove a source of valuable nutrients from the harvest area. The net result of detrimental soil disturbances can be an indirect loss in long –term soil productivity. The greatest ground disturbance per unit area usually is done by ground-based skidding equipment, where logs are hauled across the soil to landing areas. Yarding schemes which cause less ground disturbance than ground-based skidding have usually not been employed due to a local lack of alternative types of equipment, although availability is also affected by local economics. Slope instability and landslides may increase following timber harvest due to lost root strength within the soil mantle (Swanson et al. 1976, Furniss 1991). Consequently, timber harvest and associated roads, skid trails, and landings can adversely affect water quality by increasing sedimentation, associated nutrient loadings, and decreasing dissolved oxygen.

Direct and Indirect Effects

The largest effect from timber harvest is from road building activities associated with the removal of the timber. These new roads represent a permanent loss of productive soil acres. Thus, there is a permanent conversion to non-productive ground during the life of the road.

When the roads are not to be used for timber harvest they would be decommissioned and the soils would regain their productivity. Alternative 1 is expected to have no adverse effects to soil, water and air resources from new road construction because no new roads are allowed. In Alternatives 2, 6, and 7, some short-term erosion from roads is expected because about 6 miles (10 acres) to 7 miles (12 acres) of new road is anticipated for timber harvest activities. Alternative 3 would have a greater potential for short-term soil erosion and sedimentation because 39 miles (66 acres) of new road construction for timber sales is anticipated. Alternatives 4 and 5 have the highest potential for short- and long-term soil erosion and sedimentation because it is estimated that about 49 miles (83 acres) of new road construction would be needed over the planning period. Roads constructed under Alternatives 4 and 5 will be needed to support future harvest activities (prescription 5.2), and would likely be left open longer than in other Alternatives. In the long-term, potential soil erosion will be much less under Alternatives 2, 6, and 7 since new roads in prescriptions other than 5.2 would likely be closed soon after the vegetation treatments are completed.

Some soil erosion and compaction is likely to occur from the harvest of timber, and would increase roughly in proportion to the acres proposed for harvest under each alternative. The acres proposed for harvest include aspen/conifer vegetation treatment and aspen/conifer commercial harvest from MPC 5.2. Accordingly, with a predicted harvest on about 12,500 in Alternative 4 and 15,500 acres in Alternative 5 during the planning period, these Alternatives are expected to have the highest potential for soil erosion and compaction. Alternatives 2, 3 and 7, with a predicted harvest between 6,500 and 8,500 acres, will have less potential for soil erosion and compaction than Alternatives 4 and 5, but slightly more than Alternative 6 with harvest levels estimated at about 5,000 acres over the planning period. Effective implementation of Soil and Water Conservation Practices would help to minimize these potential effects. No direct impact from timber harvest is expected in Alternative 1 because no harvest is allowed.

A long-term indirect effect of Alternative 1 is the potential for a large fire that could consume large contiguous areas of timber since no harvest or vegetation treatment other than wildland fire use would be allowed. Large fires could result in extensive areas with low ground cover for at least the first year after a fire and would increase the potential for soil erosion and sedimentation of streams.

An indirect effect of timber harvest is an increase in water yield from reduced evapotranspiration of vegetation. On a Forest-wide basis it is not likely that the water yield from any alternative will be either measurable or quantifiable. This is because it is not known at the Forest Planning level which individual watersheds will have the treatments. Furthermore, only at a site-specific level do we know the portions of those watersheds that might be treated (elevation, aspect, time of harvest), and those are the precise factors necessary to estimate a water yield. Therefore, at a scale as course as the Forest Planning level, the best indicator of possible water yield differences between alternatives would be to compare the estimated acres of vegetation removed for the vegetation type most likely to effect water yield (aspen/conifer). For this analysis the silvicultural treatment for aspen/conifer commercial harvest is assumed to be the same as aspen/conifer vegetative treatment. Both treatment types are included for the water yield indicator.

Using acres as an indicator, alternative 5 would have the highest direct potential to increase water yield since it treats the most acres of aspen/conifer at 15,500 acres with Alternative 4 being similar at 13,500 acres. Alternatives 2, 3, 6, and 7 have similar acres treated, ranging from 5,000 acres to 8,500 acres. No direct effect to water yield from aspen/conifer treatment is expected in Alternative 1 since no treatment occurs.

Effects on Soil and Water Resources from Recreation

Recreational impacts may include rutting, erosion, and loss of ground cover from user created roads and trails; trampling of vegetation; vegetation removal; and soil compaction of streamside and upland sites. They may be similar in type, but of a different magnitude, than the impacts associated with livestock grazing (Clark et al. 1991). Rutting may increase surface erosion associated with heavily used hiking or horse trails and off-road vehicles. High use of some campsites may cause root damage in trees, resulting in reduced vigor or mortality. When snow packs do not provide adequate cover over-the-snow vehicles can damage vegetation and cause ground disturbance.

Many developed campsites occupy flood plains or are located within riparian areas resulting in direct impacts to streamside vegetation and alteration of the establishment mechanisms of riparian plants. At many sites, understory vegetation is either greatly reduced or removed completely over time, resulting in altered vegetative composition and stand structure as well as increased runoff and sediment delivery to adjacent streams and lakes. In the extreme, these changes can reduce stream shading, destabilize channels, and degrade water quality. Poor sanitary conditions at undeveloped campsites can also impact water quality with increased levels of coliform bacteria resulting from bathing, dishwashing, etc. Fishing may directly affect aquatic habitats in areas where recreation use and fishing pressure is highest, resulting in reduced fish populations.

Direct and Indirect Effects

In Alternative 1, no new recreation development will be allowed and existing developed recreation sites would be maintained. Since management of developed sites is allowed, no new motorized recreation is allowed, and no new sites are allowed, Alternative 1 would result in the fastest improvement in soil and water conditions of all the alternatives. For Alternatives 2 through 7, effects on soil and water resources would be the same from projected recreation outputs of 2 new developed sites and 10 recreation sites maintained or rehabilitated during the planning period.

In all alternatives, OHV use is expected to increase along with improper use off of designated trails that may adversely affect soil and water resources. Unauthorized OHV use commonly occurs in areas alongside designated roads and trails because of immediate access to the area. Alternative 1 reduces the potential for unauthorized OHV use the most of all the alternatives by closing 2 miles of roads and 76 miles of trails. Alternative 2 reduces the potential by closing 7 miles of trails. Alternatives 3 through 7 do not reduce the potential because no roads or trails are closed.

In Alternatives 5 only, new ski area development and ski area expansion would be allowed at several existing ski areas which has the potential for additional erosion and sedimentation from road construction, snowmaking system construction, and trail modifications. Water development may be needed for snowmaking in expanded ski area, which has the potential to reduce flows in streams.

Effects on Soil and Water Resources from Livestock Grazing

Livestock grazing directly impacts soil infiltration by trampling, soil compaction and loss of vegetative cover on both upland and riparian sites. Fecal wastes can increase bacterial concentrations in water through livestock defecation in a stream or riparian area. Soil and water quality can be indirectly affected by the resulting increased soil runoff and erosion, and sediment delivery to adjacent riparian areas and streams (Holechek et al. 2001). Impacts are often greater in riparian zones because they are preferred because of the availability of shade, water and more succulent vegetation (Platts 1991). Over longer time periods, grazing can result in increased fine sediment loads from stream bank erosion, loss of riparian habitats by stream channel widening or degradation, and lowering of water tables through channel degradation.

Changes in grazing management such as rest, implementation of rest-rotation grazing schemes, reduced livestock numbers and adherence to forage utilization standards can lead to improved range and riparian conditions (Gifford 1975). Grazing may result in low magnitude but long-term impacts to aquatic systems, especially from changes in ground cover, species composition, and sedimentation rates and are difficult to detect because the aquatic systems themselves are dynamic and naturally variable (Platts 1991). In addition, degraded stream channels may remain in relatively poor condition for long periods after the original impact due to the way that sediment is stored and routed through natural channels making it difficult to identify the principal cause of degradation.

Direct and Indirect Effects

Between alternatives, the effects on soil and water resources from range management are similar in most alternatives because the 1996 Rangeland Health Amendment will apply to all alternatives. There are a few key differences between Alternatives for watershed effects including the relative amounts and likelihood of success with implementation of removal of or differential forage use of areas in unsatisfactory condition, and the relative number and acreages of vacant allotments closed.

Alternative 7 includes a lower forage utilization guideline for key species in uplands and riparian areas that are in unsatisfactory condition making likelihood of improving these areas somewhat higher than Alternatives 1, 2, 3, and 6 which remove these areas from the suitable land classification and Alternatives 4 and 5 which depend on future site-specific analysis to identify approaches to improving these areas. Alternative 2 would have the greatest reduction in the amount of area suitable for grazing, with subtraction of unsatisfactory condition areas as well as 26,000 acres for cutthroat trout management. Since livestock grazing could be removed from these contiguous watershed areas, improvements to soil and water resources would have a high probability. Changes to soil and water conditions expected from unsatisfactory condition

capable acres removed (in Alternatives 1, 2, 3, and 6) would be variable because of site-specific factors. Areas in unsatisfactory condition that can be easily avoided through livestock herding, and/or salting would be most likely to improve in ground cover and species composition over the long-term. Areas that are fenced or can be fenced would also be likely to improve if removed from livestock grazing. Areas in unsatisfactory condition that are relatively small, scattered, or in locations where it is difficult to avoid grazing without expensive structural improvements (fence construction) would be much less likely to improve. Given that acres for this analysis were extrapolated forest-wide from areas with monitoring, the relative proportions of the above conditions are unknown. There would likely be a range of improvement probability that can only be predicted with site-specific assessment. Alternatives 1, 2, and 6 would result in this range of improvement on a total of 18,300 upland and riparian acres and Alternative 3 would result in 2,100 acres with a range of improvement on riparian acres. The Revised Forest Plan also guides future allotment management plans and annual operating instructions to consider standards for bank trampling and riparian woody utilization.

Although currently vacant allotments are available for use in several alternatives, vacant allotments are not likely to be filled any time soon because of the limited budget available to complete analyses for and administer active grazing allotments. Therefore, the short-term on-the-ground consequences of these alternatives would be similar to closure- i.e. the vacant allotments would remain in ungrazed condition. Given this, closure of vacant allotments is considered only as a long-term effect. Alternatives 1 and 2 provide the most long-term watershed benefits closing all vacant allotments. Alternative 7 provides somewhat less long-term watershed benefits than 1 and 2 because it focuses closures only on Salt Lake and Davis County watersheds and on the three allotments in the Eastern Uinta Mountains Management Area. Alternative 6 provides the long-term benefits for these three allotments but not for the other vacant allotment areas. Alternatives 3, 4, and 5 do not close vacant allotments thus not providing for long-term benefits although as explained above, short-term the allotments would likely continue to remain in ungrazed condition accruing those benefits for the short-term.

Effects on Soil and Water Resources from Hard-Rock Mineral Development

Within the administrative boundary of the WCNF, hard-rock mining has occurred primarily in Big and Little Cottonwood Canyons east of Salt Lake City and in the Stansbury Mountains. Most of the mines are historic, abandoned, and located on private land within the Forest administrative boundary. Hard-rock mining can contaminate water through acid mine drainage, toxic metals, chemical processing agents, and erosion and sedimentation (Da Rosa, et al. 1997).

Direct and Indirect Effects

Currently, no hard-rock mining sites have been identified that have shown contamination of soil or water resources where remedial action is necessary on lands under the jurisdiction of the WCNF. Based on development trends on the Wasatch-Cache National Forest during the previous 20 years, no new hard-rock operations are anticipated during the next planning period. If sites are found that contaminate soil and/or water resources, Alternative 1 would not allow for cleanup of the site. All alternatives will allow remedial action and protection of soil and water resources.

Effects on Soil and Water Resources from Oil and Gas Activities

This section provides a description of potential general effects on soils, water, riparian, and wetland, steep slopes and geologic areas from oil and gas exploration and development. This section is organized by general effects and effects by each alternative. General effects are described as potential without protective or reclamation measures employed.

General Effects

The following description of effects refers only to the area identified as the "Appeal Settlement Zone" described in Topic 9 – Oil and Gas. It is estimated to be about 68,300 acres.
Steep Slopes and Geologic Hazards – Although the direct impacts to steep slopes and geologically unstable areas as a result of oil and gas construction activities are not significant in and of themselves, conditions are created that cause significant impacts to surface resources and resource uses. Construction activities in steep slope areas result in the direct removal and loss of soil from steep sidehill cuts or the sidecasting of earth materials onto undisturbed slopes, lost vegetation, alteration of soil structures, soil compaction, and loss of topsoil resources. Surface disturbing activities in unstable areas and steep slopes increase surface water runoff, accelerate erosion, interfere with drainage systems, increase landslide and rockfall potentials. The potential for long-term mass movement, exposure of underlying materials, and erosion are increased significantly on unstable landslide and rock-fall areas.

Locating well sites, roads, pipelines, and similar type facilities on steep slopes greatly increases the height of cuts and length of fills that are needed to provide sufficient room to accommodate the facility or the use to be made of the site. The increased cuts and fill areas also increase the amount of land area subjected to surface disturbance. The steeper the slopes, the greater the area affected. Sidehill cuts and fills on slopes greater than 40 percent require extensive highwall cuts that cause instability of the upper slopes. Roads and pipelines have the greatest potential to intercept and activate or reactivate unstable areas that are susceptible to land slides, rock fall, mass slumping and erosion.

Exploratory drilling is generally only a short term activity and reclamation of disturbed areas follows immediately upon completion of activities. Because of the relative short time unstable areas are exposed to increased instability, the probability of successful reclamation and restoration of stability to the site is increased significantly. If field development and long term production of oil and gas are undertaken in areas of steep slopes and other unstable conditions, the probability of maintaining longterm stability is significantly reduced. The potential for successful reclamation, stabilization and restoration under such conditions is significantly reduced.

Soils and Unstable Soils – Impacts to soil productivity range from the direct removal of vegetation and soils, to the burial of topsoil by sidecasting of earth materials onto undisturbed surfaces, soil compaction, soil alteration, displacement and loss through erosion. These lead to accelerated runoff and erosion, increased sediment loads in streams, alteration of drainage

systems and reduced water quality. Impacts resulting from soil loss would be significant if reclamation measures are not employed.

Most soil losses associated with oil and gas developments occur during the construction of well pads, roads and pipelines. The degree to which soils are impacted from oil and gas activities depends on the type of soils and topographic conditions at the construction sites. Unstable soils are particularly sensitive to road, well pad and pipeline construction. Overall, the chance for significant soil impacts occurring is much higher in areas of inherently unstable soils.

Impacts to soils from exploratory drilling activities are generally short-term because access roads and well pads operate only long enough to determine the viability of long-term production. Should a discovery of oil and gas occur, the impacts to the soil resources will increase significantly as a result of the construction activities needed to accommodate the well sites, access roads, pipelines, gas processing plants, tank batteries, and other oil field support facilities. Disturbances and loss of soils resulting from development fields is expected to be long-term.

Surface Water – The potential for greatest impact to water resources would be from a spill of oil or release of other pollutants directly into a stream or water course. Sediment loading of surface waters as a result of surface disturbing activities is another potential impact associated with oil and gas activities. Downstream effects include lower water quality and diminished aquatic habitat effectiveness. Under extreme circumstances, there may be a direct loss of water use, fish, waterfowl and other water-dependent animals as well as adverse effects to human health.

Oil and gas construction activities that involve the removal of vegetation and earth work usually result in short-term increases in sediment production when water flows erode exposed soil materials. Some local stream reaches may be directly impacted by construction activities at road and pipeline crossings. Impacts from increased sedimentation are usually short term and insignificant if erosion and sedimentation controls, revegetation, and reclamation are timely implemented.

Ground Water – Impacts to groundwater quality from oil and gas operations may result from either unprotected wells during drilling and production or from the intentional or unintentional release of contaminates to the environment. Water bearing zones may be encountered and penetrated by well bores during drilling. Drilling fluids and saline production water could impact fresh water aquifers if properly weighted drilling muds are not used and borings are not properly cased and cemented. Oil, drilling muds, fuels, chemicals, saline production water, and human biological waste can easily enter groundwater systems during storage, handling, transportation and disposal. Leakage from unlined reserve pits, fuel and chemical storage areas, and other similar type situations are also potential contaminate sources.

Riparian and Wetland Areas – Assuming that no protection of wetlands/riparian areas was to be undertaken, the principal impacts to wetlands and associated riparian areas would occur during clearing and earth-moving operations needed to construct access roads, well pads, and ancillary facilities. Direct impacts could include the loss of riparian vegetation, increased erosion, soil loss and deterioration of water quality. Secondary or indirect impacts could include loss of plant

and animal habitats as well as habitat diversity, alteration of plant communities and biological productivity. Impacts to wetland and associated riparian areas would not only include the direct removal of riparian vegetation and loss of wetland area, but construction activities outside the wetland areas may also disrupt the water sources. Oil and chemical spills could be expected to occur at several times during the life of an oil and gas field. These could cause severe and long term damage to wetland/riparian ecosystems.

Direct and Indirect Effects

Special lease stipulations affect where exploration and development occur within a lease area. Stipulations vary between alternatives and have a direct affect on the potential for erosion and sedimentation. For watershed concerns, lease stipulations vary according to how they allow activities on unstable soils, geologic hazards, land slopes greater than 40 percent, wetlands greater than 40 acres, and riparian areas greater than 40 acres. Table OG-4 lists the lease stipulations according to each alternative.

The decision being made in the Forest Plan affects new leases not existing ones. In all alternatives (except Alt 4) an area of existing leases, 19,000 acres in the Table Top Exploratory Unit, could be explored and result in effects to soil and water resources. The degree to which exploration is predicted within the Table Top Unit is affected by whether or not new leases could be issued and under what stipulations.

Each alternative has new roads and pads that represent a loss of productive soil acres. Thus, there is a conversion to non-productive ground. The total acres for each alternative are presented in the individual discussion of each alternative below.

Though **Alternative 1** does not allow new leasing in the Appeal Settlement Zone, development of existing leases within the Table Top Exploratory Unit has an estimated 20 acres converted to non-productive ground because of oil and gas exploration activities. Impacts to steep slopes, geologic hazards, unstable soils and surface water could result from oil and gas development on private minerals. As existing leases terminate, lands would no longer be available for leasing.

Alternative 2 is very similar to Alternative 1. Again, development of existing leases within the Table Top Unit has an estimated 20 acres converted to non-productive ground because of oil and gas exploration activities. Once existing leases expire, leasing availability in areas recommended for wilderness is precluded. On remaining available acres, new leases could be issued but surface occupancy would not be allowed. It is doubtful that development of oil and gas resources would be undertaken when adjoining Federal lands are not available for surface occupancy and there is no possibility of exploiting oil and gas resources from adjoining lands.
Steep Slopes and Geologic Hazards – Except in situations where access cannot be denied to existing leases or private minerals, no impacts would result from construction on steep slopes or other unstable areas if this option were implemented.

Surface Water, Riparian and Wetland Areas - The potential adverse effects to surface waters, riparian and wetland areas would not increase if this leasing option were to be implemented.

Groundwater – The potential for impacts to occur to the groundwater resources would be decreased significantly if this option were to be implemented. Impacts would be limited to those that may occur from operations currently being conducted on existing leases or interspersed private minerals.

Alternative 3 precludes leasing availability in areas recommended for wilderness in the future and does not allow new leases with surface occupancy in areas managed for undeveloped (Prescription 2.6) and backcountry recreation (Prescription 4.1 and 4.2) values and terrestrial habitat (Prescription 3.2). Additional new leases could be issued outside the areas listed above with stipulations applied to protect sensitive resources. An estimated 10,400 acres are available under Standard Lease Terms. Oil and gas exploration and development activities have an estimated 75 acres converted to non-productive ground. Some of this development is predicted on existing leases within the Table Top Unit. The degree of effects depends on the leasing terms applied. Refer to Alternative 2 for a description of effects from No Surface Occupancy and Alternative 5 for a description of effects from Standard Lease Terms.

Geologic hazards and unstable soils are leased with a Controlled Surface Use stipulation. The stipulation would require that activities be located so as to avoid or minimize impacts to these areas, and the design and reclamation plans for the activities provide for mitigation. However, it may not be possible in all cases to totally avoid geologic hazard areas unavoidable impacts could still occur from the construction of roads, well pads, pipelines, and plant sites in these areas. Slope failures, erosion, topsoil displacement and loss and sedimentation of streams could still occur. Impacts from exploratory drilling would expected to be insignificant and short term under this leasing option, however, impacts may be significant and long term if an oil and gas field were to be developed. Because this alternative allows occupancy, the chances for significant adverse impacts have not been totally eliminated.

Soils and Unstable Soils – Because the CSU stipulation specifies avoidance and reclamation of unstable soil areas, disturbances occurring under this alternative would be low and short term for exploration activities and moderate and long term for oil and gas field development and production. Increased protection of unstable soil areas reduces the probability that significant adverse impacts would occur. Soil losses in highly erodable soil areas would be minimized and may be held within acceptable limits provided that the use is made of effective erosion control, reclamation, and revegetation practices as well as appropriate engineering design of roads and well pads. The impacts to the exploration, development, and production of oil and gas is not expected to be significant.

Alternative 4 does not make a leasing decision. Because lessees would not be able to effectively develop a field should one be discovered due to nearby unleased parcels, future activities are not likely. No effects to soil and water resources are predicted.

Alternative 5 would provide for leasing with standard lease terms and therefore provide the greatest opportunity for full field development. Oil and gas exploration and development activities have an estimated 105 acres converted to non-productive ground. Some of the effects could last 20-30 years because of field development. Other mitigation measures that could be

required as conditions of approval could include moving the site up to 200 meters (656 feet) if the site could be better located.

Steep Slopes and Geologic Hazards – If steep slopes and geological instability are found to occupy very large areas, the lessee may not be able to move a sufficient distance to avoid occupying such areas. There are also situations where unstable and steep slope areas, when taken together with other protected areas, result in combined areas to large to require avoidance. When these areas cannot be avoided, reliance would have to be placed on special construction and reclamation techniques to mitigate impacts. Under the circumstances, this alternative is the least restrictive and offers the greatest potential for significant adverse impacts to occur.

Soils and Unstable Soils – Under this option, mitigation of impacts to soils will be required as a condition of approval. It may be required that wellsites, roads, tank batteries, pipelines etc. be located at the most topographically suitable locations available consistent with the terms of the lease. In unstable soils areas, special measures such as contouring, terracing, gouging, scarifying, and installation of waterbreaks, may be needed to provide additional site stability before reclamation.

Under normal soil conditions, most impacts to soil resources and soil related impacts can be satisfactorily mitigated under the standard lease terms, however, when steep slopes or unstable soil areas cannot be avoided, the impacts may be unavoidable, longterm, irrepairable, and unacceptable. This leasing option is the least restrictive and offers the greatest potential for significant adverse impacts to unstable soils. It can be expected that this leasing option will have a low, short-term impact to soils under normal soil conditions but high, long-term impacts when unstable soil conditions cannot be avoided. Impacts to soils would be low to high and short term for exploration activities and moderate to high and long term if oil and gas field were undertaken.

Surface Water – Although this leasing option appears to have the highest potential to result in adverse impacts to surface waters, compliance with the Clean Water Act and implementing State and Federal regulations is mandatory. Under most circumstances, undesirable locations for well sites and other facilities can be avoided, and operations can be delayed to avoid undesirable weather and field conditions that would result in accelerated erosion and increased sediment production. Under this leasing option, adverse effects to surface waters including increases in runoff from drill sites and access roads. Increased stream sediment derived from construction activities cannot be totally eliminated but can be substantially mitigated.

The Environmental Protection Agency (EPA) requires that oil and gas production and storage facilities have adequate spill protection documented in the Spill Prevention Control and Countermeasure Plan. Although threat of water contamination from oil spillage cannot be totally avoided; a well-devised spill plan may prevent serious damage, should a spill occur.

It would be expected that potential impacts would be low and short-term for exploratory activities and low-to-moderate and long-term for oil and gas field development and operation. Impacts should be minor and temporary from construction activities if erosion control measures

and reclamation are undertaken immediately after construction. There would be no irretrievable commitment of water resources under this leasing option.

Ground Water – It is anticipated that the potential for impacts to groundwater to occur would be low for a single well and moderate for oil field development and operations. If substantial alteration of the groundwater quality were to occur, it would be a long-term impact and, for all practical purposes, irreversible. However, it is not anticipated that an irritrievable commitment of groundwater resources would occur under this alternative. Existing requirements in the regulations governing the drilling of wells, disposal of produced water provide sufficient opportunities to assure that impacts to groundwater would not occur.

Riparian and Wetland Areas - Wetlands are protected under Section 404 of the Clean Water Act. Under the requirements of the Act, jurisdictional wetlands and coincidental riparian areas are to be avoided whenever possible and the impacts mitigated when avoidance is not possible. A permit is required to occupy or otherwise affect a "jurisdictional" wetland/riparian area. The permit is normally conditioned on the protection or replacement of the wetland/riparian resource.

However, because occupancy of all wetland/riparian areas is not precluded by existing law or lease terms, there is no guarantee that the potential impacts described under the General Effects section would not occur. Oil and gas activities in wetland/riparian areas may still occur and result in the loss of wetlands and associated riparian areas, including special wildlife and native plant habitats. Wetlands could also be adversely affected by an increase in sedimentation, and decreased water quality, and changes to existing drainage patterns and flows.

In **Alternative 6**, leasing availability in areas recommended for wilderness is precluded in the future. New leases issued as a result of the leasing decision made in the plan revision would not allow surface occupancy. However, existing leases in the Table Top Unit that expire would be immediately renewed in areas not precluded by management plan direction. Leases would be renewed in areas managed for motorized recreation values and terrestrial habitat. Oil and gas exploration and development activities have an estimated 75 acres converted to non-productive ground. Some of this development is predicted on existing leases within the Table Top Unit. In this alternative geologic hazards and wetlands and riparian areas over 40 acres are protected in new leases with no surface occupancy so the effects to soil and water resources are similar to Alternative 2.

Alternative 7 would preclude leasing on 20,400 acres recommended for wilderness. On the remaining 47,900 acres available for leasing, surface occupancy would be allowed on 27,000 acres. Oil and gas exploration and development activities have an estimated 85 acres converted to non-productive ground. Some development (included in the 85 acre estimate) is predicted within the Table Top Unit because of existing leases and new leases being offered with surface occupancy.

Similar to Alternative 3, geologic hazards and unstable soils are leased with a Controlled Surface Use stipulation. The stipulation would require that activities be located so as to avoid or minimize impacts to these areas, and the design and reclamation plans for the activities provide for mitigation. However, it may not be possible in all cases to totally avoid geologic hazard

areas, unavoidable impacts could still occur from the construction of roads, well pads, pipelines, and plant sites in these areas. Increased protection of unstable soil areas reduces the probability that significant adverse impacts would occur. Soil losses in highly erodable soil areas would be minimized and may be held within acceptable limits provided that use is made of effective erosion control, reclamation, and revegetation practices as well as appropriate engineering design of roads and well pads. The impacts of exploration, development, and production of oil and gas is not expected to be significant.

Areas available for surface occupancy with more stable soil conditions would be leased with standard lease terms. Soil and water conservation practices would be applied to any soil disturbing activities caused by the developments. It is expected that through implementation of these practices that erosion and sedimentation would be minimized from these activities. Wetlands and riparian areas greater than 40 acres are available for leasing but with no surface occupancy. Water quality should be adequately protected because compliance with the Clean Water Act and implementing State and Federal regulations is mandatory.

Further impacts to the vegetation could occur as a result of the development of private minerals. Oil and gas activities on lands with private minerals are not required to meet Forest Plan standards.

Effects on Soil and Water Resources from Fire Management/Fuels Treatments

Fire consumes vegetation, partially or completely removes ground cover and may or may not result in the formation of water repellant soil layers, depending on soil temperatures during the burn and the characteristics of the local vegetation and soils (Debano et. al. 1966). Fires may result in increased stream flows following fires due to removal of vegetation and decreases in evapo-transpiration (Helvey 1980). The magnitude of impact on watershed processes is dependent on physical and biologic attributes of individual watersheds and on the severity of the fire. Low severity fires, by definition, have little long term effect on ecosystem functions, and in fact can be beneficial to soil and water quality by reducing fuels buildup and the potential for higher severity fires. For some vegetation types (i.e. lodgepole pine, spruce-fir forests) stand replacement fires were part of the normal *historic* range of variability. However, some vegetation types have changed due to the exclusion of fire (i.e. oak brush, sagebrush, Douglas-fir) and current fires in these types are typically severe and the effects are outside of the *historic* range of variability. Currently, high severity fires in these vegetation types alter above ground vegetation, soil organic material, and litter to such an extent that watershed properties such as runoff, erosion, and sedimentation are pushed far outside the normal range of variability (Durgin, 1985). In central and northern Utah, areas impacted by moderate to high severity fire are particularly susceptible to high-intensity summer thunderstorms which can produce extreme surface erosion, debris flows, or landslides that, in turn, have the potential to impact downstream property, especially along the Wasatch Front. Erosion rates after large high severity fires may be elevated above background levels by more than a factor of 200 immediately after the fire (Morris et. al. 1987) and, in extreme cases, may persist for decades following a fire. Under controlled circumstances, fire use and mechanical treatments can modify existing vegetation or reduce excess fuel loadings that could otherwise lead to a high severity fire. In most of the forested

areas of Utah the role of fire in maintaining forest ecosystems has been greatly altered by aggressive fire suppression efforts since around 1900. This may have provided near-term protection to local watersheds from the effects of severe fires, but it has also led to a buildup of fuels that makes the possibility of such fires more likely.

Effects of mechanical treatments on soil and water resources may vary greatly. Activities such as cutting by hand with a chain saw, crushing, or chipping have very little impact on the soils and may improve ground cover. Activities such as cutting using tracked equipment and chaining using a bulldozer and chain may cause some short-term soil erosion from soil disturbance from ruts left by the tracks and/or chains or from lack of ground cover left on site when vegetation is removed. Chemical treatments or biological treatments may cause short-term erosion from lack of ground cover until vegetation establishes itself again.

Direct and Indirect Effects

Several general effects are expected to soil and water resources from fire management and fuel treatments. For every Alternative, short-term soil erosion and sedimentation could occur from fuels treatments. In oak communities over the long-term, Alternatives 2 through 7 will reduce adverse effects to soil and water resources from wildfire by treating oak under prescribed fire conditions and mechanical treatment with the objective of reducing the potential for severe, unwanted wildland fire in this vegetation type. In conifer, wildfire potential and subsequent adverse effects to soils and water resources are expected *to increase* over the long term because the amount of vegetation treatment (*prescribed* fire and mechanical) is so little compared to the total amount of forested area.

Wildland fire use is allowed under all alternatives on most areas of the Forest and its use will not vary by alternative. There is a wide range of effects that could occur from wildland fire use. It is expected that very little adverse effects will occur to soil and water resources because wildland fire use will be managed to cause low impacts to resources. However, there is a potential that wildland fire could exceed a trigger point that would put the fire into a suppression mode and higher impacts to soil and water resources may occur.

Benefits to soil and water resources from the use of fire and fuel treatments will be seen in Alternatives 2-7 on the small watershed scale. In a few watersheds, treatments will substantially reduce the risk of high severity burns. In the short-term, some increase in soil erosion and sedimentation may occur from prescribed fire in these smaller watersheds in Alternatives 2-7.

For the comparison of alternatives, the effects of prescribed fire and mechanical treatments on soil and water resources are considered very similar because both of these activities have the potential for ground disturbance, ground cover reduction, and erosion; these treatments are expected to be done at times when impacts to soil resources are the least such as mechanical treatments when the soil is dry and prescribed fire and wildland fire use when soils and weather conditions will only cause low soil burn severity. Because site-specific actions are not described at the Forest Plan level, the combined treatment area for prescribed fire, wildland fire use, and mechanic treatments is used as an indicator of the potential for soil and water effects.

In Alternative 1, prescribed fire and mechanical fuels treatment would have the least effect to soils and water because its use is not allowed. In Alternative 2, prescribed fire and mechanical treatment have the highest potential to adversely affect soil productivity and erosion because these treatments would be used on most acres, about 18,000 acres per year. In Alternatives 3, 6 and 7, prescribed fire and mechanical treatments have less potential to adversely affect soil resources since the amount of treatment is estimated at about 8,200 acres per year. Alternative 4 has a slightly higher potential to adversely affect soil and water resources since prescribed fire and mechanical treatments are expected on about 9,000 acres per year. Of the alternatives with prescribed fire and mechanical treatments, Alternative 5 would have the least potential to adversely affect soil and water resources because less area is treated, being about 4,500 acres per year. Effective implementation of Soil and Water Conservation Practices, particularly those that minimize severe burns, avoid heavy equipment in riparian areas, and distribute fire use both temporally and spatially, would help to minimize these potential effects.

Effects on Soil and Water Resources from Water Developments

Hydrologic effects of water development include, flow depletion, flow augmentation, and flow regulation downstream of dams and reservoirs. Flow depletions can result in lost riparian habitat and reductions in fish populations and aquatic habitats. In-channel structures fragment habitats by blocking fish migration or by dewatering sections of streams. Increased stream flow can result in altered channel form, channel widening, bed aggradation, or increased channel migration rates, all of which can lead to lost riparian vegetation and increases in sediment loads (Dominick et. al. 1998). Numerous streams are diverted at or near the Forest boundary for use in irrigation, or for domestic water supplies.

Direct and Indirect Effects

The impacts to soil and water resources from existing permitted or authorized water developments will not vary by alternative. Under all alternatives, access and maintenance of these water development facilities will continue to be allowed.

The effects on soil and water resources from new water developments varies by alternative according restrictions on the ability to develop the water. The main restrictions would be from no motorized access or ability to build roads in order to construct the water development. The potential for new future development of some water sources on the WCNF would be limited by recommended wilderness and/or roadless areas because no motorized access is allowed in wilderness and no road building is allowed in Alternatives 1, 2, and 6, and in some prescription categories in Alternatives 3 and 7. Water development would be restricted the least in Alternatives 4 and 5 because they have the least area restricted to road building or access. These alternatives have the highest potential for adverse effects on soil and water resources from water development.

Cumulative Effects

The Council on Environmental Quality's regulations define cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonable foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertakes such actions (40 CFR Section 1508.7)". The range of alternatives considered must include the no-action alternative as a baseline against which to evaluate cumulative effects. Cumulative effects result from spatial (geographic) and temporal (timing) crowding of environmental perturbations. The effects of human activities will accumulate when a second perturbation occurs at a site before the ecosystem can fully rebound from the effect of the first perturbation (CEQ, 1997).

The approach for this analysis is to take a programmatic look at the Forest wide scale of past, present, and reasonably foreseeable activities on the WCNF that may positively or negatively affect soil and water. The cumulative effects analysis for soil, water, and geologic resources considers activities that affect soil and water resources. Since the Forest Plan makes no "on-the-ground" decisions, the most appropriate indicators for cumulative effects are reflected in the size and magnitude of the different resource programs most likely to affect soil and water resources, either positively or negatively.

Issues

There are three issues tracked through effects analysis on soil and water resources. They are, soil productivity, water quality, and water yield. On the WCNF, there are eight principle categories of management activities generally having the potential to affect one or more of the three issues. Of the eight categories discussed below, most have no potential to affect water yield. Water yield is only discussed in relation to Timber Harvest/Vegetation Management activities. All eight have the potential to affect soil productivity and water quality, and those issues are discussed throughout. No impacts to geologic resources have been identified from activities expected to take place on the WCNF in the next planning period. The cumulative effects analysis will have a qualitative description of effects to soil productivity, and a qualitative description of the potential effects to water quality and yield to describe the cumulative effects of the alternatives on soil and water conditions.

Cumulative Effects Area and Time Frame

Soil productivity effects are limited spatially to the site. Activities carried out on National Forest System lands do not typically affect off-site soil productivity. Therefore, the cumulative effects area for soil productivity is limited to the Forest boundary. When water quality is affected by increased sedimentation, off site effects can occur. Yet, since the Forest Plan prescribes no specific activity in any specific area, potential spatial and temporal effects to water quality cannot be attributed to any specific watershed. Cumulative effects to water quality can only be described in terms of potential to generally effect trends on a Forest-wide scale. In other words, the cumulative effects of a "program" (at the Forest Plan scale) as opposed to the effects from a "project" (at the site specific scale) can only be discussed in terms of general programmatic

tendencies either toward improved or declining water quality at no specific site. Consequently, there is no easily defined "area" that may experience cumulative effects beyond the Forest boundary. Therefore, the potential cumulative effects from Forest programs to water quality will generally be discussed at the Forest scale.

The time frame for this analysis is the next Forest planning period, about 10 to 15 years from now.

Past, Present, and Reasonably Foreseeable Actions

This section describes the past, present, and reasonably foreseeable actions that may have an affect on soil productivity, water quality, and water yield. These include WCNF management actions; land use and soil and water management in areas adjacent to the WCNF; and land use, development, population, and recreation trends; and state and local government environmental protection programs. Table GEO-3 is a summary of the past, present, and reasonably foreseeable actions that may have and affect on soil productivity, water quality, and water yield.

On the Wasatch-Cache National Forest

The management activities on the WCNF that may affect soil productivity, water quality are Roads and Access Management; Timber Harvest/Vegetation Treatment; Recreation; Livestock Grazing; Hard-Rock Mineral Development; Oil and Gas Activities; Fire Management/ Fuels Treatments; and Water Developments. A management activity that may have a substantial affect on water yield is Timber Harvest/Vegetation Management activities.

Several activities on the WCNF have improved soil and water conditions through road and travel management. The WCNF has about 1,500 miles of roads. Most of the roads that are maintained on an annual basis are main access roads and those that have the most use. Several roads have been moved out of riparian areas or decommissioned, and culverts installed in several stream channels where ford crossings were causing sedimentation. During the last five years, many roads that are graded have had new surfacing such as gravel or oil put on them to reduce the rate of road deterioration and has reduced the rate of erosion from the road surface. The maintenance and decommissioning of roads are expected to be at similar or slightly increased levels based on experienced budget levels. In the next planning period, Level 1 and 2 roads analysis should be completed. The travel plan for Evanston/Mt. View Ranger Districts should be ready for implementation toward the end 2002 and the travels plans for Ogden and Logan Ranger Districts should be completed in the next few years. With the completion of the Evanston/Mt. View Ranger Districts travel plan, it will be WCNF policy that roads will be closed unless designated open. Travel plans identify roads to remain open, roads to be closed and decommissioned.
A variety of timber harvest treatments have been used in the past and most harvest units are fully stocked. Since the 1940s, timber harvest treatments have occurred on almost 43,000 acres in 44 sixth code watersheds. Most of the harvest treatments occurred in the Eastern Uintas, Western Uintas, and Bear management areas during the 1970s and 80s on about 11-12,000 acres each decade. During the 1990s, almost 6,300 acres were harvested. A variety of treatments were used and include clearcut, partial cut, selection cut, shelterwood, and aspen chaining. Although there are some small areas, such as stream crossings, where small amounts of sedimentation occurs, at

Table GEO-3. Summary of the Past, Present, and Reasonably Foreseeable Actions that may affect Soil and Water Resources.

	Actions	Issue that could be Cumulative[1]	Primary Area Affected
On Wasatch-Cache National Forest			
	Road Construction	S, W	Eastern Uintas, Ogden Valley
	Road decommissioning	S, W	Forest wide
	OHV and ATV use	S, W	Cache-Box Elder, Bear, North Wasatch-Ogden Valley, Western Uintas
	Timber Harvest and Vegetation Treatments	S, W, WY	Eastern Uintas, Western Uintas, Bear
	Wildfire	S, W	Forest wide
	Prescribed Fire and Wildland Fire Use	S, W	Forest wide
	Developed Recreation Projects	S, W	Forest wide
	Livestock Grazing	S, W	Forest wide
	Abandoned Mine Land Cleanup Activities	W	Central Wasatch
	Oil and Gas Exploration and Development	S, W	Eastern Uintas, Western Uintas
	Impaired Waters Assessment and Remediation	W	Central Wasatch
Areas Adjacent to the WCNF			
	Urban Expansion and Land Development	S, W	Wasatch Front, Kamas area, Bear Lake, upper Bear River, Meeks Cabin Reservoir, Ogden Valley, Cache Valley
	Water Development and Planning	W	
	Population Growth	S, W	
	OHV and ATV use	S, W	
State and Local Government Environmental Protection Programs			
	State of Utah	W	Statewide
	Salt Lake County	S, W	Salt Lake County
	Salt Lake City	S, W	Salt Lake City and Drainages East of SLC

[1] S = Soil Productivity, W = Water Quality, WY = Water Yield

present, overall soil productivity and water quality have not been impacted from past harvest activities on the WCNF as indicated by the revegetation of treatment areas and streams in these drainages meeting state water quality standards.

The WCNF averages about 60 wildfires per year and 70 percent of the fires are less than 0.1 acres. The number of large fires (greater than 100 acres) appears to be increasing and the largest fire recorded since 1970 is 14,200 acres that occurred in year 2002. The use of prescribed fire has been very limited in the past. For the past three years the WCNF has prescribed burned about 1,250 acres per year, primarily in aspen stands. Dense, young vegetation has grown back quickly and very good ground cover currently occurs under most of the burned treatment areas.

These treatments have reduced the potential for wildfire and the potential for adverse effects on soil and water conditions resulting from severely burned and hydrophobic soils that occur from wildfire. Several areas along the Wasatch Front have high opportunities and needs for fuels treatments and it is anticipated that specific treatments, particularly mechanical treatments, will be used to treat fuels.

Many recreation projects have been completed that improve water quality and protect or rehabilitate soils. During the last planning period and particularly during the last five years leading up to the 2002 Olympic Games in Salt Lake City, many developed recreation sites have been improved by placing asphalt over gravel roads, putting cement pads in campsites, moving restrooms away from streams, and installing new restrooms. Hiking and biking trails have been relocated away from streams and wet areas, and bridges have been constructed across streams channels to protect water quality and aquatic resources. Soil productivity should improve in small areas within developed recreation areas due to adjusting the location of picnic sites and campsites, and roads in response to wetland concerns during reconstruction and maintenance of existing facilities. During developed recreation site reconstruction and maintenance in the last planning period, the location of campsites and restroom facilities have been adjusted for the protection of wet areas, improvement of soil productivity and water quality. These soil and water conservation measures are expected to continue in the future.

During the last planning period since 1985, off highway vehicle (OHV) and all terrain vehicles (ATV) use has increased greatly on the WCNF. OHV use is expected to increase along with improper use off of designated trails that may adversely affect soil and water resources. Unauthorized OHV use commonly occurs in areas alongside designated roads and trails because of immediate access to the area. The highest density of OHV use is in Cache/Box Elder, Bear, Western Uintas, and Stansbury management areas. The WCNF has been and will continue to close and decommission user-created ATV trails.

Ski resorts on the WCNF have modified some terrain and cleared vegetation for the purpose of improving ski trails, installing snowmaking pipelines, and installing new ski lifts, utility lines, and base facilities. The projects were done with specific soil and water conservation measures to minimize erosion and sedimentation and onsite inspections showed that these practices were effective in minimizing erosion and sedimentation. For example, projects at Snowbasin Ski Resort for the 2002 Winter Olympic Games had some of the largest land disturbing activities that the WCNF has ever had. The Best Management Practices that were used to minimize impacts on soil and water resources were very effective (USDA Forest Service 2001g). Using soil and water conservation measures will continue to minimize adverse effects from future activities on the WCNF.

Although livestock numbers on the WCNF have not changed much since the start of the last planning period in 1985, some activities have helped manage livestock and improve soil and aquatic habitat conditions at specific areas within allotments. In 1996, the Rangeland Health Forest Plan Amendment was completed that established a desired future condition for the rangeland resource and set standards and guidelines necessary to maintain healthy rangeland. Several exclosures have been constructed along riparian areas that have kept livestock from trampling stream banks and have increased the overhanging vegetation along the stream. In the

future, it is expected that additional guidelines will address effects such as stream bank trampling and will reduce adverse effects to soils along stream channels and improve water quality.

Abandoned mine clean up activities has improved soil and water conditions in specific areas on the WCNF and future activities have the potential to improve water quality. On the WCNF, most hard rock mineral development occurred at the head of Big and Little Cottonwood Canyons east of Salt Lake City during the mid to late 1800s and since then, only a small amount of mining work has been done. In Little Cottonwood Canyon since the last planning period began in 1985, old tailings at the Tanners Flat Campground area have been cleaned up and assessment work on zinc sources has been ongoing since 1997, a total maximum daily load (TMDL) has been submitted to the USEPA this year, and projects to reduce zinc loading into Little Cottonwood Creek will begin next year. No hard rock mining development is expected in the near future.

During the last planning period, several oil and gas activities have occurred on the WCNF. A pipeline was constructed across the WCNF east of Bountiful, Utah. Oil and gas exploration and development have occurred on the Evanston and Mt. View Ranger Districts and currently, 19 active wells are on the WCNF. New drilling activities on the WCNF in the past several years has been limited due to the depressed oil market and unavailability of adjacent (unleased) lands that create financial risk. The surge in oil and gas prices since 1999 and the spectre of potential hydrocarbon shortages may renew interest for exploration and development in the area. Past oil and gas exploration and development activities have had a very small impact on soil productivity and water quality. Soil and water conservation practices that were applied to these activities have been very effective in controlling erosion and sedimentation as indicated by streams meeting water quality standards of in these development areas. The largest effect to soil productivity has been the irretrievable commitment of soil resources from road construction and oil pads and, overall, has been a very small portion of the soil resource in the areas of development.

For those streams of the WCNF that are not meeting water quality standards, the WCNF is working with the State of Utah to determine the causes of water quality impairment. The WCNF has been working with the Little Cottonwood Group since 1998 assessing the effects of mining on Little Cottonwood Creek. Field data on water quality, stream morphology, and aquatic health has been collected and a Total Maximum Daily Load (TMDL) assessment is being reviewed by the USEPA. In the Smiths Fork drainage, water quality samples are being collected and stream condition surveys have been completed for the purpose of assessing the quality of water on Forest Service land.

As part of a cooperative monitoring program with the State of Utah, the Forest Service collects water samples in selected drainages and sends them for analysis. Other water quality monitoring activities include macro-invertebrate sampling on selected streams to determine aquatic biological health and stream stability surveys. In addition to this, several cooperative efforts concerned with water quality are ongoing between the WCNF, state and local governments, regional planning agencies, and state colleges and universities.

Areas Adjacent to the WCNF

Lands within the watersheds draining the WCNF have a variety of land use activities. As an example of the types of activities that represent this area, a description of land use is taken from the Utah State Water Plan for the Weber River Basin. The area is diverse in terms of naturally occurring landscapes and land use practices. The high mountain areas are used extensively for a broad variety of outdoor recreational purposes and the production of agricultural crops, livestock, and timber. The upper basin contains six ski resorts, seven major reservoirs, a matrix of cross-country hiking trails, and a number of streams utilized by sport fishermen, rafters and kayakers. Livestock production in the high mountain valleys is limited to dairy and meat producing livestock, mink, and a few fish farms. Irrigated agriculture generally includes varieties of pasture grasses, alfalfa, small grains, some orchard crops and a variety of vegetables (Utah State of 1997a).

With the exception of the Snyderville Basin and Park City Area, populated areas in Summit County generally consist of small rural towns with small commercial businesses. The Snyderville Basin and Park City Area is one of the fastest growing in the state. The area primarily includes residential developments with a high percentage of the populace working in the Salt Lake Valley. The area supports major commercial and industrial concerns including ski resorts, tourism, a major manufacturing business (Utah State of 1997a).

Davis County has highly developed residential, commercial and industrial areas. Several cities have registered significant residential population growth rates in recent years. The northern part of the county supports a number of small family farms, while the southwestern part supports large industries including oil refineries and manufacturing facilities. Northeastern Davis County also supports municipal and residential developments with related small commercial businesses (Utah State of 1997a).

Agricultural is the largest single land use. This includes irrigated and dry cropland, rangeland, and timber production (Utah State of 1997a).

Other than Emigration Creek, there are no streams in the immediate watersheds adjacent to the WCNF that are listed on Utah's 2002 303 (d) list of impaired water bodies. Emigration Creek is listed as impaired for fecal coliform. National Forest System lands are located in the headwaters of Emigration Canyon and older residences are located right next to the stream and many new homes have been built and are continuing to be built in the main part of the canyon. Analysis of fecal coliform pollution problems in Emigration Canyon is expected to begin in 2003 by Salt Lake County through a 319-funded project.

Land Use, Development, Population, and Recreation Trends

In the watersheds that drain the WCNF, land use trends over the last 20 years show that demand for residential and commercial land has consumed agricultural land at a rapid pace, particularly in Salt Lake and Davis Counties where in 1992, agricultural land occupied less than half of the acreage it occupied in 1974 (Utah, State of. 1998a).

Rapid urban expansion is expected in the next 20 years and as open space diminishes pressure to build on the foothills will increase (Utah, State of. 1998a). Private land development is occurring adjacent to the WCNF boundary with high density of housing along the foothills and in some more mountainous areas such as canyons east of Salt Lake City from Emigration Canyon to Little Cottonwood, upper Weber drainage, Woodland, north side of the South Fork Ogden River, Little Bear drainage, west of Bear Lake, near Bear River Service, Meeks Cabin Reservoir.

The population of Utah is expected to increase to 3.3 million in 2020 with 2.5 million living in Davis, Salt Lake, Utah, and Weber Counties. The youth population will continue to be the largest age group in the state (Utah, State of. 1998a).

Motorized recreation is increasing in the state. In 2000, the number of off-highway motorcycles, ATVs, snowmobiles and recreational 4X4s in Utah is estimated at almost 163,000 (Fisher et al. 2001). Technology is continually making improvements to All Terrain Vehicles (ATV), Snowmobiles and Mountain Bikes. ATV's are more powerful, have better suspensions and have better traction than they have ever had before. With lighter frames, better gearing and suspensions, mountain bikers are continually pushing the limits of what and where people can ride.

State and Local Government Water-Related Programs

Several state and local programs control or improve water conditions on lands on or adjacent to the WCNF. The Utah Department of Natural Resources and the Wyoming Water Development Commission identify water development needs, the Utah Nonpoint Source Pollution Management and Drinking Water Source Protection programs control water pollution, coordinate statewide watershed activities, develop source protection guidelines, assess water quality, enforce water quality standard compliance, provide funding for watershed improvement projects, and monitoring. Salt Lake City and Salt Lake County are involved in the management of watershed conditions, water quality, and riparian areas in the canyons east of Salt Lake City and along the Jordan River.

The Utah Department of Natural Resources and the Wyoming Water Development Commission have developed water plans for major basins in Utah and Wyoming. State water plans discuss water development that is planned in the watersheds draining the WCNF. These are construction of conveyance and treatment facilities to deliver water from Willard Bay to the Wasatch Front and construction of a dam on the Bear River west of the Wellsville Mountains (Utah, State of. 2002b). The Jordan River Water Basin Plan states the development of additional water from the Wasatch Range mountain streams but does not identify any specific project (Utah, State of. 1997b). No projects other than existing Central Utah Project will be developed. No additional projects are identified in the Utah Lake Basin Plan (Utah, State of. 1997c) and no projects are identified in the Weber and West Desert basin plans (Utah, State of. 1997a and Utah, State of. 2001c). Water conservation measures are considered in the water plans and include incentive pricing; outdoor watering guidelines and ordinances; landscape guidelines and ordinances; commercial and residential audits; installation of water meters on all water connections; retrofit, rebate, and incentive programs; and leak detection and repair programs would not directly affect

soil and water resources of the WCNF. Wyoming Water Development Commission's Green River Basin and Bear River Basin water plans do not have any on-the-ground projects that are identified for analysis or implementation within the cumulative effects study area and within planning period of the WCNF plan revision (Wyoming, State of. 2001b and Wyoming, State of. 2001c).

One of Utah's key water quality programs is concerned with non-point source pollution control. The mission of the Utah Non-point Source Pollution Management Program is "1) to conserve the waters of the State 2) to protect, maintain, and improve the quality of the waters of the state …3) provide for the prevention abatement, and control of new or existing sources of polluted runoff"(Utah, State of. 2001d). Several Clean Water Act Section 319 funded water quality projects in Utah that are located adjacent to the WCNF have been completed or in progress. These projects include on-the-ground watershed or demonstration projects; information and education projects; and surface and ground water investigations. Several on-the ground projects that are adjacent to the WCNF include Mill Canyon Watershed Project, Emigration Creek Water Quality Study, East Canyon Creek, and the Little Bear River. Several statewide education programs have been funded in part with Section 319 funds. For example, Utah State University has reached many educators and individuals within the state through the USU Statewide NPS Education program.

Another key water quality program is the Utah Drinking Water Source Protection program that protects both ground water and surface water drinking sources. The program uses a watershed approach to assessing and protecting drinking water sources by reviewing potential pollution sources at various scales throughout the watershed in which a water source is located. Because of its proximity to the large population areas near the WCNF, many water sources are located on or adjacent to the forest. Water resources on and off the WCNF are reviewed, protected, and improved by water companies, agencies, and the general public because of the importance of drinking water quality to the nearby communities.

Actions by Salt Lake City and Salt Lake County have protected and enhanced water quality in the canyons east of Salt Lake City through education, signing, enforcement, watershed improvement projects, and monitoring. According to the Salt Lake City Watershed Management Plan (Salt Lake City 1999)" the Salt Lake City Department of Utilities, and other affected jurisdictional parties are seeking to proactively manage this watershed [seven major watersheds to the east of Salt Lake City] by addressing issues that have arisen since the 1988 Watershed Management Plan. …Salt Lake County has adopted master plans for Emigration Canyon (1985), Little Cottonwood Canyon (1973), and the Salt Lake County Wasatch Canyons Master Plan (1989)".

Cumulative Effects Among Alternatives

This section describes the past, present, and future cumulative effects between alternatives on soil productivity, water quality, and water yield. The analysis takes a programmatic look at activities and management on and adjacent to the WCNF and considers general trends, levels of outputs, management controls on activities, standards and guidelines, and practices that minimize adverse affects of activities. The specific effects of activities on soil and water resources have

been described previously under the Watershed Health topic. The analysis looks at short and long-term cumulative effects and irretrievable commitments of soil and water resources.

Soil Productivity

Unwanted wildfire, growing population and residential development adjacent to the WCNF, and increasing recreation use will occur under all alternatives and has the potential to adversely affect soil productivity. All alternatives have about the same potential for unwanted wildfire because the amount of activities that would prevent or reduce wildfire is very low compared to the size of the WCNF. On the WCNF, where unwanted wildland fire results in a potential loss of soil productivity, rehabilitation work will be prescribed to mitigate these effects. Housing developments adjacent to the WCNF bring many more people closer to the Forest and have a higher potential to cause wildfire, use ATVs, and impact soil and water conditions. With a large, young growing population in Utah that is primarily located near the WCNF and technology that is continuing to allow access to land that was previously not used for recreation, recreational demands on the WCNF are expected to increase and a higher potential exists for adverse soil and water effects to occur on the forest. With the increase in OHV and ATV use, soil productivity on and off the WCNF may deteriorate particularly in specific areas where use is concentrated. In the long-term, education, enforcement, and on the ground management on and off the WCNF should help to reduce the adverse effects to soil productivity from these activities.

Short-term adverse effects to soil productivity may occur from most on the ground activities on the WCNF. The WCNF implements soil and water conservation practices that minimize these adverse effects. In reviewing all of the proposed activities and outputs in Table 2-?, Comparison of Alternatives for Projected Activities and Outputs, very little difference occurs between alternatives under Watershed Health, Range Livestock, and Recreation and the short and long-term effects to soil productivity are very little for these proposed activities. Activities and outputs vary substantially between alternatives under Roads and Trails, Oil and Gas Exploration and Development, and Vegetation Treatments. Cumulatively, alternatives 3, 4, and 5 have the greatest potential to affect soil productivity through an irretrievable commitment of soil resources for timber harvest and vegetation treatment road, and oil and gas roads and facilities. Alternative 2 has the highest potential to cause short-term adverse affects to soil productivity because of the large amount of prescribed fire use in aspen and aspen / conifer mixed. Alternative 1 has the least short and long-term cumulative effects on soil productivity because of the small amount of project activities and outputs, and it has the greatest amount of land that is allocated to recommended wilderness and roadless protection where active management is very limited.

When properly implemented, activities such as timber harvest and fire use have very little long-term commitment of soil resource. Only a fraction of those acres affected by timber harvest or fire use will actually suffer detrimental soil impacts such as displacement, compaction, or severe burning. Very few detrimental impacts to soils are expected from timber harvest (excluding roads, skid trails, and landings) and mechanical treatments for fuels reduction because these activities will leave adequate ground cover to protect soils and compaction is limited to a small amount of designated area. The actual amounts of long-term soil resource commitment, and their relation to Forest wide soil quality standards, will be determined on a site-specific basis for

each proposed harvest project. Prescribed fire and wildland fire use will be implemented with soil and water conservation practices. These measures should minimize adverse effects to soil productivity.

New roads represent an irretrievable commitment of soil resources. On the WCNF, the long-term use of roads for new timber harvest and new roads and development for oil and gas activities will occur mainly in the Eastern Uintas Management Area. On lands adjacent to the WCNF in this management area, timber harvest and oil and gas development has occurred in the past and is continuing with activities that may affect soil and water resources such as road building and facility development. The highest potential for adverse cumulative effects to soil and water resources from these activities is in Alternative 5 with Alternatives 3 and 4 somewhat less than this. The lowest amount of irretrievable commitment of soil resources is in Alternative 1.

Under all alternatives, no irreversible effects should occur from the proposed activities because no soil resources are affected where the soil resources cannot be returned to its previous condition.

Water Quality

The short-term effects to water quality are similar to those described in the cumulative effects for soil productivity. This is because ground disturbing activities that have an adverse effect on soil productivity, usually have the potential for adverse effects on water quality, particularly in disturbance area that are close to water bodies. In the short-term, some impacts to water quality may occur from on-the-ground activities on the Forest. Similar to cumulative effects for soil productivity, Alternatives 3, 4, and 5 have the greatest potential to affect water quality because of they have the greatest amount of timber and vegetation treatment roads, and oil and gas roads and facilities. Cumulatively, Alternative 2 has the highest potential to cause short-term adverse affects to water quality because of the large amount of prescribed fire use in aspen and aspen/ conifer mixed vegetation communities. Alternative 1 has the least short and long-term cumulative effects on soil productivity because of the small amount of project activities and outputs, and it has the greatest amount of land that is allocated to recommended wilderness and roadless protection.

In the long term cumulatively, management activities on and off the WCNF should improve water quality through road decommissioning that will reduce erosion and sedimentation; vegetation treatments that will improve ground cover and reduce potential for wildfire; revised grazing guidelines that include bank trampling review during allotment management plan updates and annual operating permit review; and state and local environmental programs that assess water quality and plan actions for the improvement of impaired waters. No irretrievable or commitment of water resources have been identified in any of the alternatives.

Under all alternatives, no irreversible effects should occur from the proposed activities because no water resources are affected where the water resources cannot be returned to its previous condition.

Water Yield

Of the management activities that occur on the WCNF, only Timber Harvest/ Vegetation Treatment activities have the potential to substantially effect water yield. Utah and Wyoming are experiencing an increase in timber harvest on private lands in response to declining sales on public lands. This will cause an increase in water yield from private lands that are harvested. Between alternatives, water yield increase is assumed to be greatest with alternatives 4 and 5, which have the greatest amount of suited lands and would most likely have treatments proposed on them in addition to private land holdings. In all alternatives, most of the water yield increase would occur in the eastern Uintas, north part of the western Uintas, and Bear management areas and in private lands adjacent to these areas.

Topic 1 – Watershed Health

Air Resources

Introduction

This section presents information about air quality conditions; trends; monitoring sites; resource protection measures; and direct, indirect, and cumulative effects to air resources from proposed activities on the WCNF during the planning period.

Laws, Policy, and Direction

- **The Clean Air Act (1967) and amendments to the Act (1972, 1977)** -- Protect and enhance the quality of the Nation's air resources and protect public health and welfare. Section 118 of the Clean Air Act requires that the federal government comply with all federal, state, tribal, interstate, and local air quality standards and requirements (Integration of Air Quality Management into Land Management Planning, pg 1-4). The Act established National Ambient Air Quality Standard (NAAQS) and gave the States primary responsibility for air quality management. States carry out this responsibility through development of a State Implementation Plan (SIP). Federal and State land managers must be certain that their actions comply with all procedural and substantive requirements contained in Federal, State, and local air pollution control regulations (USDA Forest Service. 2000c).

- **The 1977 Clean Air Act Amendment (42 U.S.C.& 7401 et seq) --** Areas of the country were designated as Class I, II, and III air sheds for the prevention of significant deterioration purposes. Class I areas include national parks and wilderness areas designated before 1977 and over 5000 acres in size. Class I provides protection to pristine lands by severely limiting the amount of additional human-caused air pollution that can be added to these areas. There are five Class I areas in Utah: Bryce Canyon, Zion, Arches, Capitol Reef and Canyonlands National Parks. The rest of the state, including Forest Service wilderness areas, is classified as Class II. Presently, there are no haze (visibility) criteria that are enforced in Utah (USDA Forest Service. 2000c).

- **The Wilderness Act (1964) --** Directs the Forest Service to preserve and protect the natural condition of Wilderness, including the intrinsic wilderness value of air quality.

- **The Forest and Range Renewable Resource Act (1973) --** As amended by the National Forest Management Act, directs the Forest Service to "…recognize the fundamental need to protect and, where appropriate, improve the quality of soil, water and air resources."

- **The EPA's Natural Events Policy --** Includes a provision to prevent an area from being designated as "non-attainment" for particulates when high concentrations result from wildfires.

- **The EPA's Interim Air Quality Policy on Wildland and Prescribed Fires** -- Provides guidance on mitigating air pollution impacts caused by wildland and prescribed fires while recognizing the current role of fire in wild-land management.

- **Utah State Smoke Management Plan --** The State of Utah, Division of Air Quality and an interagency workgroup are presently drafting a Utah Smoke Management Plan. Its purpose is "… to identify the responsibilities of the Utah Division of Air Quality (DAQ) and Federal, and State land managers (Land Managers) to coordinate procedures that mitigate the impacts of prescribed fire and wildland fire used for resource benefits on public health, public safety and visibility." This plan is designed to meet the requirements of Title R307, Utah's air quality rules and the policies of the EPA's Interim Air Quality Policy on Wildland and Prescribed Fires. (Utah, State of, 2000c).

Affected Environment

Monitoring Sites

An Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring site is located near Timpanogos National Monument in American Fork Canyon near Orem, Utah.

Qualitative visibility monitoring sites have been in operation on the Ashley NF and WCNF. The Ashley National Forest manages a visibility site near Mill Park in the High Uintas Wilderness area. The WCNF collected visibility data between 1995 and 1997 from two monitoring sites located near the Snowbird top tram terminal. Cameras took photographs to the west toward Salt Lake City and to the south toward Mt. Timpanogos in order to qualitatively assess the visibility across Salt Lake Valley and across the Wasatch Mountains near Salt Lake and Provo, Utah. The WCNF site has not been operating since 1997. These sites give an indication of the haziness of the atmosphere.

Air Quality Conditions

Sources of air pollution occur from activities both on and off the WCNF. Impacts to air quality on the Forest include regional haze, caused by transported pollutants from large urban areas adjacent to the Forest, including industry and manufacturing, traffic, and wood-burning stoves. Localized air pollution occurs from heavy traffic during peak hours and from skiers driving to resorts in Big and Little Cottonwood Canyons in the winter months. Air pollutants of concern include fine particulate matter, nitrogen oxides, sulfates, and carbon monoxide. These pollutants can affect human health, reduce visibility, and can lead to acidic deposition in high-elevation lakes.

Most lands managed by the Forest currently are in attainment of national ambient air quality standards (NAAQS). Part of the Salt Lake Ranger District is in non-attainment areas for PM 10 (particulate matter less than 10 microns in diameter), sulfur dioxide, and ozone. Salt Lake County is a non-attainment area for PM 10, sulfur dioxide, and ozone. Davis County is a non-attainment area for PM 10 (Utah, State of. 2000d). Land-use practices within or adjacent to this

non-attainment area are closely scrutinized by local and state regulatory agencies to ensure that further violations do not occur.

A visibility-monitoring site is located in American Fork Canyon that represents conditions near the Lone Peak Wilderness. The site has collected data (Copeland et. al. 2001) since 1993 and complete seasonal data is available for three years from 1996-98. Interpretations are made from 1996-98 since data is complete for each season during this period. Information on current and natural visibility conditions is from a newsletter about the interagency IMPROVE visibility-monitoring program (Malm, et. al. 1994).

Information from the site shows that winter season has greatest extremes in visibility where it has the cleanest of the "clean" days (average about 120 miles) and the dirtiest of the "dirty" days (average about 38 miles). The cleanest of the "clean" days is above the estimated natural mean visibility in the West, which is 110-115 miles. In comparing winter to other seasons, poor visibility for the dirtiest 20% of days is attributed in the most part to increases in nitrates and sulfates. The visibility of the mean of the median 20% of days in 1997-98 showed very little difference between each season. Average annual visibility for 1996-98 of the mean of the median 20% of days is about 75 miles and is less than the best current mean visibility in the inner mountain west and Great Basin regions which is 90 miles.

Future Trends

Sources of air pollution on the WCNF are both local and regional. As population increases in northern Utah, air quality effects are expected to increase. Locally, some air quality impacts are expected due to increased development of ski resorts and ancillary effects of increased traffic and residential development in the canyons along the Wasatch Front. Regionally and locally, smoke impacts from prescribed burns are expected to increase as attempts are made to reduce fuel loading. Specific impacts include reduced visibility as well as short-term increases in the concentration of particulate matter in communities downwind of a burn. Under wildfire conditions high fuel consumption often creates high particulate outputs.

Resource Protection Measures

The conformity regulations promulgated by the EPA in 1994 specifically require federal compliance with the Clean Air Act. Forest management activities must therefore be analyzed for their potential air quality impacts and these must be mitigated if necessary.

A cooperative effort called the Utah Smoke Management Program is established between the Utah Department of Air Quality (UDAQ) and agencies that are involved in the use of prescribed fire and wildland fire use. As part of this program, a Utah Smoke Management Plan (SMP) is developed to coordinate procedures that mitigate the impacts of prescribed fire and wildland fire use for resource benefits on public health, public safety and visibility. State and Federal agencies have signed an MOU that commits the signatories to voluntarily abide by the smoke management plan and are members of the Utah Airshed Group that provides overall management direction and guidance by functioning as an interagency steering committee to ensure appropriate implementation of the SMP (Utah, State of. 2000c).

Direction in the Utah Smoke Management Plan provides for organization and operating procedures, prescribed fire and wildland fire requirements, and program management. Under prescribed fire, several items are required including an annual burn schedule, prescribed fire burn plans, burn request form, implementation of emission reduction and dispersion techniques, a daily emission report form, surveillance and enforcement by UDAQ staff, and monitoring (Utah, State of. 2000c). Similar requirements are expected for wildland fire use.

Environmental Consequences

Effects on Air Quality from Fire Management

Direct and Indirect Effects

The main effect to air quality from activities on the WCNF is the introduction of smoke and particulates into the air from fire management activities. The WCNF uses prescribed fire and wildland fire use for fuels reduction and resource benefits by managing a fire that is within a prescription. Wildland fire use differs from prescribed fire in that wild land fire use is a result of a lightning ignition, where prescribed fires are started by fire management personnel. Unwanted wildland fire is fire that is not within prescription and is managed under a suppression strategy.

Alternative 1 would have the least effect to air quality from prescribed fire since its use is not allowed. Alternatives 3, 6, *and 7* are expected to have similar effects to air quality from prescribed fire between these alternatives since all of these alternatives would have about *12,000 to* 13,500 acres of prescribed fire per year. Alternative 2 is expected to have more effect to air quality than Alternatives 3, 6, *or 7* since prescribed fire would be used on about 23,000 acres per year, which is almost twice as much as Alternatives 3, 6, *or 7*. Alternatives 4 and 5 would have the least potential for smoke using prescribed fire since the predicted area of treatment is about 5,400 acres per year.

In all alternatives, unwanted wildland fire has the potential to cause a large amount of smoke. There is a trade-off between smoke generated by unwanted wildland fire and prescribed fire and wild land fire use, in that, when using prescribed fire *or wildland fire use* smoke would be generated under *more* controlled conditions and mitigated while smoke generated by unwanted wildfire could be much greater and unmitigated. The prescribed fire use and vegetation treatments in Alternatives 2, 3, 5, 6, *and 7* would help to reduce the potential for unwanted wildland fire, particularly in oak vegetative communities, and should reduce smoke that would develop under uncontrolled conditions. When using prescribed fire or wildland fire use, smoke dispersal is taken into consideration in the fire plan. Prescribed fire and wildland fire use activities occur during the time of the year when it is less likely to have temperature inversions. Air quality conditions that occur in the valleys during the winter season inversions will not be present when prescribed fire or wildland fire use is implemented.

Effects on Air Quality from Ski Resort Management

From years 1997 to 2001, ski area master development plan (MDP) final environmental impact statements (FEISs) were written for Alta (USFS 1997), Snowbird (USFS 1999e), Brighton (USFS 1999d), and Solitude (USFS 2001h) ski resorts. These reports analyzed the effects of ski area development on air quality and included the direct, indirect and cumulative effects of proposed activities at the ski resorts and emissions from vehicles that drive in Big and Little Cottonwood canyons and the main roads that lead to them. The results of these analyses indicate that (1) air quality impacts are minor when compared to indirect emissions under baseline conditions; (2) air quality is in compliance with the General Conformity thresholds for ozone (volatile organic carbon emissions), ozone (nitric oxides), PM_{10} (particulate matter), and sulfur dioxide; and (3) selected alternatives in the FEISs do not cause an exceedance of any National Ambient Air Quality Standard.

A main decision that the Forest Plan Revision will make is whether to allow expansion of ski resort boundaries. The effect on air quality from expansion of ski resort boundaries is complicated because of several factors. The expansion of ski area permit boundaries may decrease air quality due to increases in emissions from vehicles using the roads leading to the resorts. The increase in use of the ski areas would be a result of encouraging more visitors to the resort because of the larger facilities and terrain available. Since parking on federal land is limited to existing parking area, the potential increase may occur in more days when the number of vehicles approach the canyon travel capacity, than in the number vehicles in the canyon on the peak days.

Air quality is not expected to decrease in Alternatives 1, 2, 3, 6, and 7, since no expansion of permit boundaries is allowed. Air quality may decease in Alternatives 4 and 5 since ski area permit boundary changes are allowed in Alternative 5 and are considered and decided through master development planning and other analyses in Alternative 4. Although air quality may decrease on more days, it would not be expected to exceed the General Conformity based on the results of latest ski resort master development plan air quality analyses. The latest MDPs for the Big and Little Cottonwood ski resorts have recognized that air quality is a concern particularly at the mouths of the canyons and that traffic going to the resorts need to be managed. Management of traffic such as additional parking for mass transit may reduce vehicle use on roads leading to the canyons nullifying the concern of decreased air quality due to expansion of ski area permit boundaries.

Effects on Air Quality from Snowmobiles

An issue that has gained more attention in recent years is the effects of 2-stroke engines on air quality. As snowmobiling has gained in popularity over the last 20 years, the concerns related to effects of snowmobiles on air quality has increased. Snowmobile use on the Wasatch-Cache National Forest has increased proportionately to the increases in other locations.

There have not been any studies done specific to the Wasatch-Cache National Forest to determine the effects of snowmobiling on air quality. A number of studies of the effects of

snowmobiling on air quality were done as part of the "Winter Use Plans Final Environmental Impact Statement for the Yellowstone and Grand Teton National Parks and John D. Rockefeller, Jr. Memorial Parkway" (Winter Use Plans FEIS), (USDI National Park Service 2000) (http://www.nps.gov/planning/yell/winterfinal/frames.htm). Although many of the studies were specific to that area, they have some applicability to effects of snowmobiling on the Forest. Following is a summary of analysis of air quality presented in the Yellowstone FEIS and a comparison of snowmobile use levels between Yellowstone and the Forest.

The Federal Clean Air Act, as amended in 1990, requires the Environmental Protection Agency (EPA) to establish national ambient air quality standards (NAAQS) to protect public health and welfare. Standards have been set for six pollutants: particulate matter less than 10 microns (PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), ozone (O_3), and lead (Pb). These pollutants are called criteria pollutants because the standards satisfy criteria specified in the act. The areas covered by the three park units are in attainment of ambient air quality standards. (USDI National Park Service 2000)

A particulate sampling station operated by the Montana Department of Environmental Quality is located outside Yellowstone National Park (YNP) in the town of West Yellowstone. As reported in the aerometric information retrieval system (AIRS), the second highest CO 8-hour average in 1999 was 5.0 parts per million (ppm), and the corresponding average in 1998 was 3.6 ppm (http://www.epa.gov/air/data/index.html). These compare to the federal and Montana CO 8-hour ambient air quality standards of 9.0 ppm. At the West Yellowstone monitor, the highest 24-hour PM_{10} measurement in 1999 was 61 $\mu g/m^3$, and the corresponding measurement in 1998 was 40 $\mu g/m^3$. These compare to the 24-hour 150 $\mu g/m^3$ federal and Montana PM_{10} ambient air quality standards. (USDI National Park Service 2000)

To assess the relative impacts of the proposed winter use alternatives on ambient air quality in the Greater Yellowstone Area, short-term air quality analyses were performed by means of atmospheric dispersion modeling for carbon monoxide (CO) and particulate matter (PM_{10}). The air quality study includes the inherent uncertainties of the model and the temporal and spatial biases due to limited meteorological and emission data. The following table displays air quality data predicted at high use locations in YNP for current use in YNP:

Table AIR-1: Yellowstone Air Quality Predictions

Pollutants Modeled	West Yellowstone Entrance	West Entrance To Madison Roadway Corridor (14 Miles)	Old Faithful Staging Area	Federal Primary Ambient Air Quality Standards
Maximum 1-hr CO concentrations[1]	32.2 ppm	14.8 ppm	4.29 ppm	35 ppm
Maximum 8-hr average CO concentrations[2]	15.15 ppm	6.96 pm	1.62 ppm	9 ppm
Maximum 24-hr ave. PM_{10} concentrations[3]	68.19 $\mu g/m^3$	33.74 $\mu g/m^3$	5.64 $\mu g/m^3$	150 $\mu g/m^3$

[1] Prediction of parts per million of carbon monoxide based on EPA air quality models and including background CO levels.
[2] Estimated from the modeled maximum 1-hour average concentration of CO based on a persistence formula.
[3] Modeled micrograms of respirable particulates less than 10 microns in size per cubic meter including background levels.

The modeling done for the above table was based on a substantial amount of collected data. The research was reviewed in a report prepared for the State of Wyoming Institute for Environment and Natural Resources and titled "Review of Research Related to the Environmental Impact Statement for the Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr. Memorial Parkway" (2000) prepared by the University of Wyoming Institute for Environment and Cultural Resources. The authors of the review disputed the accuracy of the assessment of air quality based on methodological issues, but agreed that there is a genuine air quality problem. They stated that more monitoring and modeling is required.

The YNP Final Environmental Impact Statement (FEIS) concluded that based on previous studies and the results of air dispersion modeling conducted for this analysis, short-term, adverse impacts at the West Entrance would continue at times, during high winter use days.

The highest potential for air pollution from snowmobiles on the Wasatch-Cache National Forest occurs at the Bear River Snowpark on The Evanston/Mountain View District, the Soapstone Basin Parking area on the Kamas District and the Tony Grove and Franklin Basin parking areas on the Logan District. A comparison of the estimated use on the Wasatch-Cache National Forest and known use in YNP indicates the following:

- Estimated total snowmobile use on Forest is less than the total use in YNP.
- Estimated snowmobile use at any one of the most concentrated spots (Bear River Snowpark, Soapstone Basin, Tony Grove and Franklin Basin) on the Forest is significantly less that the use at the most concentrated spot (West Yellowstone Entrance) in Yellowstone (YNP).

Following are differences between snowmobile use on the Forest in comparison with YNP:

- Snowmobiles are not restricted to roads on any Districts. They are restricted to designated roads in YNP.
- Traffic from the West Yellowstone Entrance proceeds on a single 14 mile route to Madison Junction while traffic out of each of these parking lots is in at least two directions, Bear River Snowpark for example goes in 2 directions (about 1/3 heading east on the north slope road and 2/3 heading south on the Mirror Lake Highway) and then splits again within 2 or 3 miles going in either direction.
- Snowmobiles idle, stop and start numerous times waiting in line at entrance booths at West Yellowstone. Snowmobiles at the trailheads on the WCNF are generally unloaded, run up and down the parking lot several times to warm up engines and then turned off while operators get their gear together. They then leave the lot without stopping.

In YNP, air quality samples were collected in accordance with EPA protocol and did not exceed Federal ambient air quality standards. The exceedance predicted for some high use days at West Yellowstone was based on modeling. Based on the above estimates of use and differences in operations, and the intensive data collection and monitoring done at YNP, it is unlikely that snowmobiles would cause a violation of Federal Primary Ambient Air Quality Standards on the Wasatch-Cache National Forest at current use levels. The trend in use has been increasing but it

is unlikely that ambient air quality standards would be exceeded on the Wasatch-Cache National Forest under any of the Alternatives in the foreseeable future.

Cumulative Effects

Analysis Area and Area of Influence

The analysis area and area of influence is the airshed in northeast Utah and Southeast Wyoming.

Reasonably Foreseeable Actions

Effects from actions can be cumulative, both spatially and temporally. Cumulative effects to air quality can occur from Forest Service management activities and activities occurring on state, tribal, and private lands. Smoke emissions from fire use, in combination with urban sources along the Wasatch Front, other out-of-state sources and stagnant meteorological conditions, have the potential to cause relatively short durations of conditions not meeting State Air Quality standards. However, this is not anticipated with activities being coordinated through the Utah Airshed Group and requirements of the Utah Smoke Management Plan.

The Clean Air Act authorizes EPA to protect visibility through a number of programs. In 1987, the Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility-monitoring network was established as a cooperative effort between EPA, USDA Forest Service, BLM, National Park Service, US Fish and Wildlife Service, and state governments. Monitoring results from this network have shown that, in general, visibility is improving in the West and is much better than in the East. From 1992 to 1998, PM 2.5 levels in rural areas in the western U.S. decreased by 5 percent (US EPA 2000). Coordination of air quality impacts through the Utah Airshed Group is expected to improve visibility and reduce public concerns in Utah and down-wind airsheds and communities.