# STEP 3: CURRENT CONDITIONS

The current range, distribution, condition, and trends of the relevant ecosystem elements identified under Step 2 are described in this section for the relevant core topics at the watershed scale. Existing surveys, inventories, maps, reports and records were used to describe the current conditions, supplemented by erosion modeling and a field trip to confirm conditions on the ground.

Conditions in 2002 and 2003 have been greatly affected by a drought. Annual precipitation through September 2002 was just over 9.5 inches, or approximately half of the average rainfall at Dulce, New Mexico (WRCC 2003), resulting in poor vegetative cover and unsuccessful reseedings of disturbed areas.

## Core Topics

The purpose of this chapter is to characterize the current range, distribution, and condition of the core topics and ecosystem elements that are most relevant to the management of resources in each watershed. Of the seven core topics listed in the federal watershed analysis guidelines (USFS 1995) to be addressed in order to evaluate the basic ecological conditions, processes, and interactions at work in the watersheds, the following core topics are of primary interest within the District.

1. Erosion Processes
2. Water Quality
3. Vegetation
4. Species and Habitats
5. Human Uses

Where possible with the available data and where practical for the topic, the information is presented for each watershed listed in Table 1. Some information has been included to provide the context for the conditions presented.

## Erosion Processes

Geology and soils are the resources most affected by erosion processes. Basic descriptions of the geology in the District and the soils in each watershed are presented as background information. The type and rates of erosion in the District are sensitive to the type, distribution, quantity, and quality of vegetation and earth cover, road conditions and density, and the distribution and amount of bare ground. The intent is to answer the following question to the extent possible: *What are the current conditions and trends of the dominant erosion processes prevalent in the watersheds?*

### Geology and Geomorphology

The District is located on the northeastern part of the San Juan Basin, an asymmetrical syncline (concave geologic strata) that extends from northwestern New Mexico into southwestern Colorado. Roughly oval in shape, the basin is approximately 200 miles long (north to south) and 130 miles wide, including the portion in Colorado, covering approximately 25,000 square miles.

The lithology of the San Juan Basin includes mainly shales and sandstones of varying grain size but also includes coals, some carbonates, and igneous rocks. Sedimentary rocks display an aggregate thickness of over 14,000 feet near the Colorado-New Mexico state line. The elevation of the top of the Precambrian basement rocks is more than 7,500 feet below sea level at the deepest part of the Basin. Formations representing the Permian period through the Pennsylvanian period consist mainly of shales and sandstones. The Cretaceous-age rocks represent 6,000 feet of sandstones, siltstones, shales, and coals (Landes 1970).

The surficial geology in the District, from which the soils are formed, consists primarily of Tertiary alluvium (unconsolidated silts, sands, clays, and gravels) underlain by the pink-tinted San Jose Formation (layers of arkosic sandstone, siltstone, shale, and conglomerate). During the formation of the Basin, canyons were created in the area as the southern tip of the Rocky Mountains and the San Juan Mountains to the north rose. Tertiary sediments are exposed in the canyons that trend northwest toward the San Juan River. In areas where it is exposed, the San Jose formation erodes as irregular ledges and slopes (Chronic 1987).

Slow decomposition of plant and animal material within some of the rock formations of the San Juan Basin resulted in the development of numerous hydrocarbon deposits throughout the region. The predominant hydrocarbon-producing reservoirs are the Cretaceous Pictured Cliffs, Mesaverde Group, and Dakota Formations. They contain both source rocks and natural reservoirs for oil and gas.

The Pictured Cliffs Sandstone is a gas reservoir consisting of a shoreline sandstone composed of an upper medium to thick-bedded ledge-forming sandstone and a lower thick, very fine-grained sandstone with interbedded shales and siltstone. The Pictured Cliffs Formation produces natural gas from wells spaced at 160 acres per well, under current State of New Mexico policy.

The Mesaverde Group is a series of gas reservoirs that represents a single regression and transgression cycle of the epicontinental Cretaceous sea, composed of discontinuous shoreline deposits. The main gas-producing sandstones are the Cliff House at the top of the group and the Point Lookout at the bottom. The Mesaverde Group produces natural gas from wells spaced at 320 acres per well, with optional infill development allowed by the state on an 80-acre per well basis.

The Dakota Sandstone is a gas reservoir consisting of a transgressive sequence composed of sandstone, shale, minor conglomerates, and coal. The upper sandstones in the Dakota Formation are shoreline and offshore marine sand deposits. The Dakota produces natural gas from wells spaced at 160 acres per well. Recent studies indicate that some areas of the Basin, including the southern part of the District, could be approved for 80-acre infill development in the future.

## Soils

Most soils in the District are deep, well-drained, and formed from alluvial or residual materials derived from sandstone, siltstone, and shale. There are thirteen soil map units in the District. Soil characteristics such as susceptibility to different types of erosion and the potential for revegetation are important to consider when planning for stabilization of disturbed areas. These are a function of many physical and chemical characteristics of each soil. In general, 30 to 50 percent of each watershed in the District contains soils with low potential for revegetation, based on the Terrestrial Ecosystem Survey (TES) soils database (USFS 1993). The watersheds listed from worst to best for revegetation potential are Bancos, Compañero, Carracas, and La Jara.

Based on characteristics in the TES (USFS 1993), most of the soils in the District are considered highly erodible. Highly erodible soils are those that are likely to erode if left without vegetative cover or other protective management practices. The percentage of each watershed susceptible to sheet and rill water erosion and the average annual soil loss is shown in **Table 2**. The average annual erosion rates for each watershed were calculated from the TES database using the current soil loss rate in tons per acre per year for each map unit and the acreage of that map unit in each watershed. The current soil loss rate in the TES database for each map unit takes into account the erodibility of the soil, in addition to the amount and type of cover, and the length and slope of the land.

**Table 2. Erodible Soils and Soil Loss by Watershed**

| Watershed | Erodible Soils (%) | Gullied Soils (%) | Soil Loss from Sheet/Rill Erosion (tons/year) |
|---|---|---|---|
| Bancos | 44% | 14% | 90,685 |
| Carracas | 61% | 4% | 18,109 |
| Compañero | 83% | 7% | 42,593 |
| La Jara | 50% | 9% | 71,348 |

Source: USFS 1993.

In the Wild Horse Territory, mainly in the Bancos and Carracas watersheds, there was little or no grass cover in 2002, so the predicted sheet and rill erosion rates in Table 9 would be increased by 10 to 15 percent in watersheds that already have high rates.

The overall ability of the soil to function properly and retain its productivity is categorized as satisfactory, gullied, or unsuited in the TES soil condition. The soil condition rating system uses indicators for soil function such as infiltration, erosion, litter, and vegetative community composition (Towns 2000).

By identifying the acreage in each watershed with at least one component that is rated as gullied or unsuited in the TES, the amount of each watershed that may be considered unsatisfactory is shown in **Table 3**. This is most likely an overestimate of the amount of soils in unsatisfactory condition because it counts a map unit with one or two components with this rating as representing the entire map unit.

**Table 3. Unsatisfactory Soil Condition by Watershed**

| Watershed | Unsatisfactory Condition (%) |
|---|---|
| Bancos | 63% |
| Carracas | 27% |
| Compañero | 35% |
| La Jara | 39% |

Source: USFS 1993.

Any surface disturbance, whether for construction or from cross-country travel by vehicles, degrades soil quality and productivity because it damages the biological soil crust. A healthy soil biological crust reduces soil erosion, increases surface water infiltration into the soil, thereby decreasing surface water runoff, and helps to maintain good soil health. The amount of cross-country vehicular travel by recreationists and gas exploration equipment cannot be quantified in the District. However, as surface disturbance, soil compaction, and vehicular traffic increase, it can be assumed that these actions negatively affect the overall soil condition in a watershed.

# Water Quality

Surface water is the primary water resource of concern that would be affected by National Forest land management in the District as related to watersheds. This section describes the surface water and groundwater systems and water quality conditions of both. It is intended to answer the following question to the extent possible with available data: *What are the current conditions and trends, primarily of surface water designated uses and what management conditions may affect water quality?*

## Surface Water

As previously noted, no perennial surface water drainages exist within the District. Streamflow in ephemeral channels occurs only after storm events. Since there is no base flow, differences in rainfall patterns can cause streamflow to be extremely variable on the district.

All of the watersheds in the District drain into the San Juan River, which is part of the larger Colorado River watershed. The San Juan River originates from the western slope of the Continental Divide in southwestern Colorado and enters northwestern New Mexico to flow into the Navajo Reservoir west of the District. From the reservoir, the San Juan River flows westward for approximately 140 miles through New Mexico before re-entering the state of Colorado. It then crosses into Utah to finally enter the Colorado River.

Human activities can alter the deposition of alluvium in canyons. When watersheds lack vegetation, especially grasses and forbs, the amount and frequency of runoff that reaches streams and arroyos become greater, flood flows increase, and the stream cuts into the alluvial deposits in the canyon bottom. The resulting canyon bottom after high flows displays steep banks of soft sediments with former streamside trees stranded high and dry (Barnes 1978). As the amount of surface disturbance and unvegetated ground increases in a watershed, due to increases in roads and well pads for example, more surface water runoff reaches streams and arroyos in a shorter time, so flooding or erosive velocities in channels occur more frequently.

Peak discharges for each watershed were calculated using the methodology and equations presented in "*Analysis of the Magnitude and Frequency of Peak Discharge and Maximum Observed Peak Discharge in New Mexico*" (USGS 1996). **Table 4** lists the calculated peak flows for various storm events in each watershed.

**Table 4. Peak Discharges for 2- through 50-Year Recurrence Intervals for Each Watershed**

| HUC | 2-Year Storm Event[1] | 5-Year Storm Event[1] | 10-Year Storm Event[1] | 25-Year Storm Event[1] | 100-Year Storm Event[1] |
|---|---|---|---|---|---|
| Carracas | 530 | 1,185 | 1,840 | 2,811 | 3,782 |
| Bancos | 937 | 2,071 | 3,217 | 4,855 | 6,533 |
| La Jara | 1,217 | 2,674 | 4,153 | 6,232 | 8,387 |
| Tapacito | 1,377 | 3,019 | 4,689 | 7,018 | 9,445 |
| Compañero | 1,286 | 2,823 | 4,385 | 6,572 | 8,844 |

Source: USGS 1996.
Note: (1) Units are in cubic feet per second.

### *Surface Water Quality*

There are no data available to characterize surface water quality in the ephemeral streams and arroyos in the District. As a whole, the Upper San Juan hydrologic basin has shown evidence of contamination by sediments, mercury, benthic pathogens, turbidity, and stream bottom deposits. The likely sources of impairment (**Table 5**) include atmospheric deposition, resource extraction, petroleum activities, urban runoff, hydromodification, riparian vegetation removal, stream destabilization, agricultural activities, and rangeland activities (NMED 2000). As documented under Soils, road erosion at or near streams can cause sedimentation problems. Ephemeral flows generally consist of poor quality water resulting from the highly erosive and saline nature of the soils, sparse vegetative cover, and rapid runoff conditions that characterize the area. Surface runoff usually contains greater than 10,000 milligrams per liter (mg/L) of suspended sediment and greater than 1,000 mg/L of dissolved solids (NMED 2002).

**Table 5. Water Quality Impaired Uses in Receiving Waters**

| River and Watershed Name | HUC | Parameters Of Concern | Likely Sources of Impairment |
|---|---|---|---|
| Upper San Juan | 14080101 | Sediment<br>Mercury<br>Benthic pathogens<br>Turbidity<br>Stream bottom deposits | Atmospheric deposition; resource extraction; petroleum activities; urban runoff; storm sewers; hydromodification; riparian vegetation removal; streambank destabilization; agricultural activities; rangeland activities. |
| Blanco Canyon | 14080103 | Sediment<br>Mercury<br>Benthic pathogens<br>Turbidity<br>Stream bottom deposits | Atmospheric deposition; resource extraction; petroleum activities; hydromodification; riparian vegetation removal; streambank destabilization; agricultural activities; rangeland activities. |

Source: NMED 2000.

The San Juan River system, to which all watersheds in the District outlet, is an alternating warm-water and cold-water fishery. Portions of the San Juan River below Navajo Dam are regularly stocked high quality trout waters.

The major cause of water quality impairment in perennial water bodies downstream from the District is sedimentation. While there are no state standards for sediment in these stream reaches, it can be assumed that additional sediment would add to the existing impairment. Erosion in the District contributes sediment to these reaches to varying degrees. The principal locations that generate erosion that is likely to affect downstream waters are hillsides with low amounts of ground cover on erodible soils and unpaved roads near drainageways.

It has been shown through a recent study (Phippen 2000) in the Rio Puerco watershed, in northwestern New Mexico east of the Continental Divide that contains similar vegetation and soil types, that sediment yields are highly sensitive to changes in the density of unpaved roads. As area occupied by unpaved roads increases, so does the sediment yield from a watershed. All erosion, whether sheet, rill, or gully, contributes to sediment yield if it results in sediment delivery to the surface water drainage system. Sediment yield is that portion of the total amount of soil erosion on the landscape that actually reaches surface water channels. The quantity of sediment yield is dependent on many factors, such as slope gradient, vegetative cover and type, and density of the drainage network, which affect the ability of the land to cause the sediment to be deposited before it reaches a drainageway (also called buffering).

The WEPP: Road model was used to predict the amount of sediment from the road network that is the most likely to affect downstream water quality. The WEPP model is a physically-based soil erosion model that estimates sediment yield using site-specific soil, climate, ground cover, and topographic data. The Road version of the WEPP model was developed by the Forest Service to simulate sediment transport along roads and other nonvegetated, compacted soil areas (Elliot 1999). In each simulation, the flow of sediment is modeled as it progresses along the length of the road, then migrates off the road and down the slope, or directly enters the stream system at a road/stream crossing. The model simulates roads that have gravel or native soil surfaces.

Unpaved roads that cross streams direct surface water runoff carrying sediment into the channel. Structures, such as culverts, water bars, and cross-drains that intercept the surface water flow before the sediment-laden water reaches the channel at the bottom of the slope function to divert sedimentation away from direct flows into drainageways. The length of the road between the lowest water control structure and the channel bottom is the area that contributes sediment directly to the channel. Roads that parallel and are within 200 feet of drainageways may contribute sediment to the channel from the outlet of the water control structures that direct water off the road and down a vegetated slope before reaching the channel. The steepness of the slope from the outlet to the channel, the vegetative cover type and density, and the erodibility of the soil, all affect the quantity of the sediment that reaches the drainageway. Once the sediment is deposited in the channel, it gets transported downstream to the San Juan River during runoff events (storms or snowmelt).

To determine the sediment yield for each of the roads in the District, the WEPP simulations were combined with a geographic information system (GIS) assessment. GIS was used to identify the locations of road-stream crossings, and all roads within 200 feet of a channel, and to associate each of these locations with a watershed. GIS was also used to identify the type and distribution of soils along the roads, the gradient along each road, the steepness of the slopes between the road and the channel, and the vegetative cover adjacent to the roads. All roads were considered, including those that are closed or decommissioned. Closed and decommissioned roads have not been obliterated, recontoured, or revegetated within the District, so they would still contribute sediment yield even though they are no longer used for vehicle traffic.

WEPP simulations were completed on sample 1 mile square sections that encompassed the range of existing soil, cover, vegetation, and slope conditions within each watershed, in order to predict the amount of sediment yield in tons per year. **Table 6** displays the results of the modeling by watershed, showing the number of road-stream crossings, the miles of roads determined to contribute sediment to the stream system, and the predicted sediment yield from these roads in each watershed. **Map 7** shows the location of the road-stream crossings in each watershed.

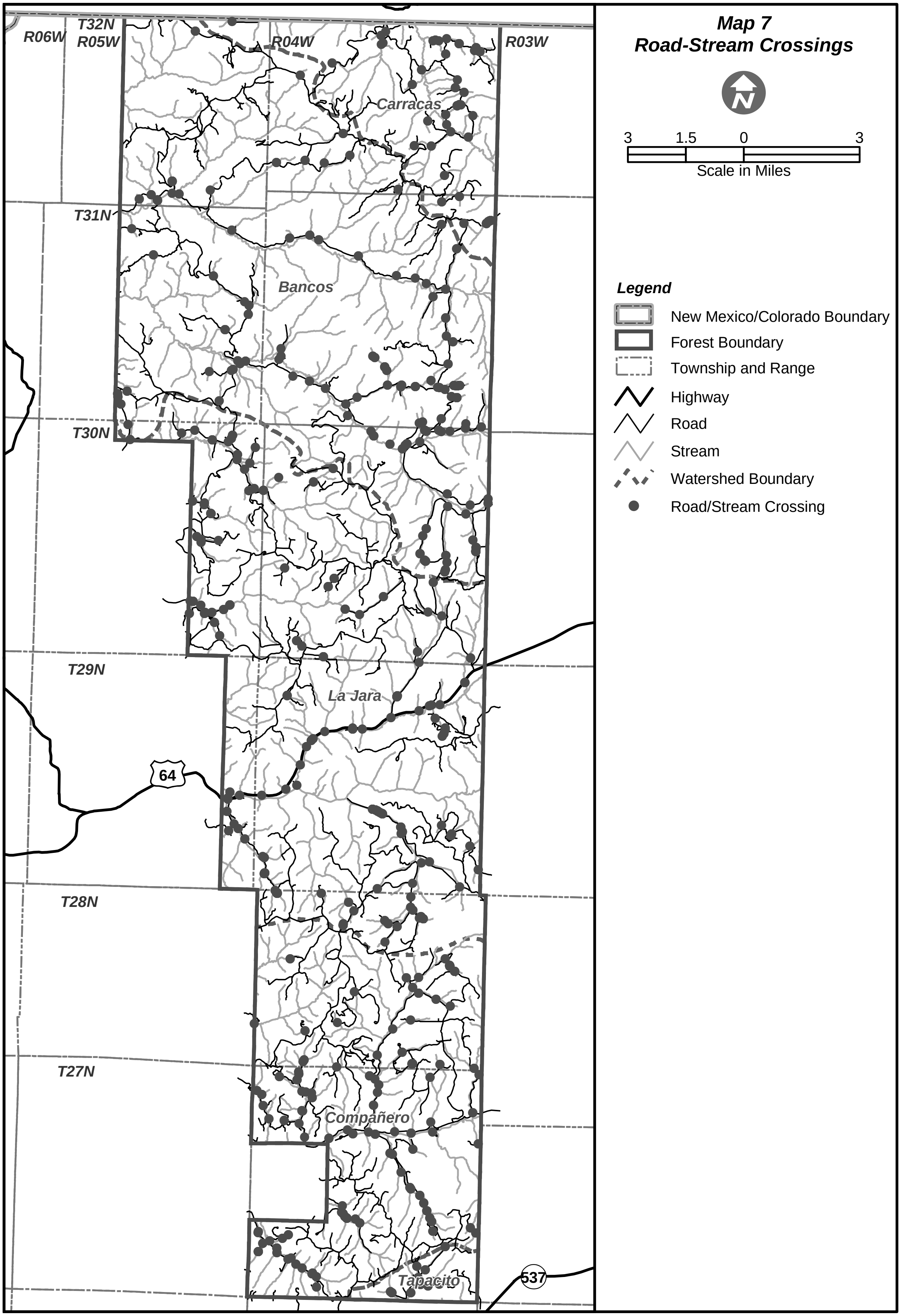

Map 7
Road-Stream Crossings
N
3 1.5 0 3
Scale in Miles
Legend
New Mexico/Colorado Boundary
Forest Boundary
Township and Range
Highway
Road
Stream
Watershed Boundary
Road/Stream Crossing
T32N
R06W
R05W
R04W
R03W
Carracas
T31N
Bancos
T30N
T29N
La Jara
64
T28N
T27N
Compañero
Tapacito
537

**Table 6. Annual Sediment Yield from Roads near Drainages in Each Watershed**

| Watershed | Road-Stream Crossings | Roads Contributing Sediment to Drainages (miles) | Predicted Annual Sediment Yield from Roads (tons/acre) |
|---|---|---|---|
| Bancos | 91 | 23 | 1,195 |
| Carracas | 30 | 7 | 363 |
| Compañero | 96 | 20 | 1,046 |
| La Jara | 100 | 23 | 1,174 |

### Groundwater

Relatively shallow groundwater in the San Juan Basin is found in the Quaternary alluvium deposits that fill stream channels; however, the primary source of groundwater are the Tertiary sandstones that compose the Uinta-Animas aquifer. The Uinta-Animas aquifer is a fluvial deposit that includes the San Jose formation, the underlying Animas formation and its lateral equivalent, the Nacimiento, and the Ojo Alamo sandstone. These fluvial deposits are heterogeneous in nature and contain localized variations in water quality and quantity (COGCC 2000). In the northeastern part of the San Juan Basin, the maximum thickness of the aquifer is approximately 3,500 feet (USGS 2001). The areal extent of the Uinta-Animas aquifer is shown in **Figure 1.**

Groundwater recharge to the Uinta-Animas aquifer generally occurs in the areas of higher altitude along the margins of the hydrologic units. The available data in the area nearest the District indicate recharge in the area of Durango, Colorado. Groundwater generally flows toward the San Juan River and its tributaries, where it is discharged to streamflow, to the alluvium that is locally present in canyons, or to evapotranspiration (USGS 2001a). Some water wells drilled to the San Jose, Nacimiento, and Ojo Alamo formations have demonstrated flow rates of 100 gallons per minute (gpm). Most wells display water yields of less than 20 gpm (BLM 1987).

Groundwater recharge for the District area is derived from the edges of the San Juan Basin, a geologic structure mainly in southern Colorado where the rock formations are closer to the surface. The primary groundwater quality concerns identified by the State of New Mexico (NMED 2001) in the San Juan River watershed are caused by releases from leaking storage tanks and from oil and gas production including pipelines, storage, distribution, and refining sites.

The Uinta-Animas aquifer contains fresh to moderately saline groundwater. Dissolved solids generally increase along the groundwater flow path toward the San Juan River. Although the chemical composition of the groundwater depends upon the characteristics of the producing aquifer and the location of discharge, groundwater is generally considered hard (BLM 1987). The total dissolved solids (TDS) content of the groundwater in the region exceeds 1,000 mg/L, and can range from 500 to 4,000 mg/L (BLM 1987; USGS 2001).

## Vegetation

The condition, type, and density of vegetation in each watershed affect soil stability, sedimentation in downstream surface water, groundwater recharge, and wildlife habitat condition and trends. The intent of this section is to answer the following question: *What are the distribution and current conditions of the dominant plant communities in each watershed?*


**Figure 1. Location of the Uinta-Animas Aquifer**

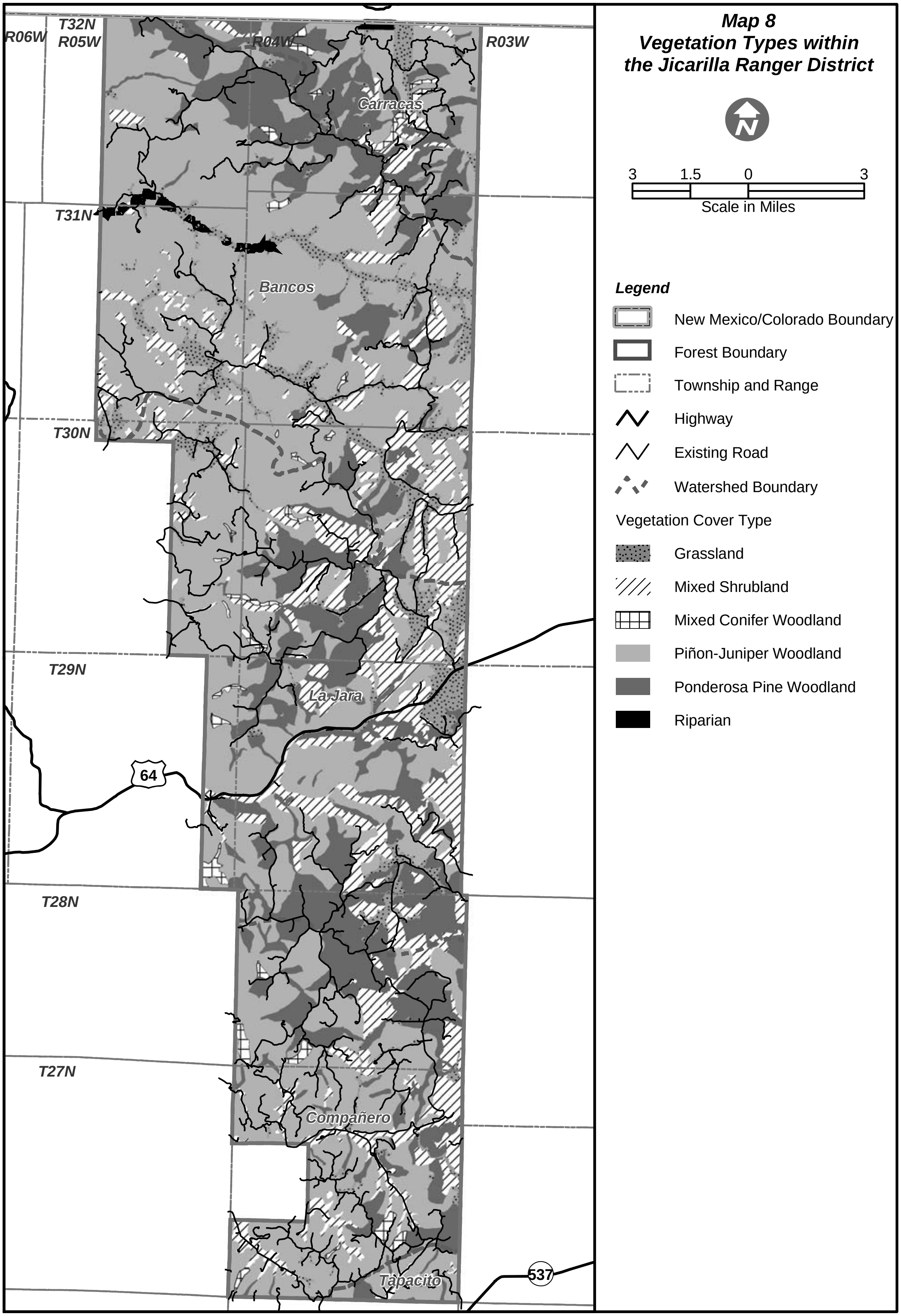
Source: USGS 2001.

The flora of the District correlates with elevation, temperature, and precipitation. The northwest part of the District is more arid and warmer in comparison to the southern and eastern portion (WRCC 2001). The vegetative communities in the District include grassland, mixed shrubland, mixed conifer woodlands, ponderosa pine forest, and riparian. The majority of the vegetation consists of trees, predominantly piñon-juniper. There are two types of grasslands: (1) Native Grasslands, and (2) Reclamation Grasslands, comprised of grasses seeded on disturbed ground. Unless otherwise noted, the category called grassland includes both types. The distribution of vegetation types is shown on **Map 8** and their representation within each watershed is listed in **Table 7**.

**Table 7. Vegetation Types in Each Watershed**

| Watershed | Grassland | Shrubland | Riparian | Mixed Conifer | Piñon-Juniper | Ponderosa Pine |
|---|---|---|---|---|---|---|
| Bancos | 10% | 11% | <0.1% | 0.4% | 65% | 14% |
| Carracas | 6% | 7% | 1% | 3% | 44% | 39% |
| Companero | 2% | 15% | 0% | 2% | 59% | 23% |
| La Jara | 7% | 19% | 0% | 1% | 47% | 25% |

Source: USFS 2002a.


Map 8
Vegetation Types within the Jicarilla Ranger District
3
1.5
0
3
Scale in Miles
Legend
New Mexico/Colorado Boundary
Forest Boundary
Township and Range
Highway
Existing Road
Watershed Boundary
Vegetation Cover Type
Grassland
Mixed Shrubland
Mixed Conifer Woodland
Piñon-Juniper Woodland
Ponderosa Pine Woodland
Riparian
T32N
R06W
R05W
R04W
R03W
T31N
T30N
T29N
T28N
T27N
Carracas
Bancos
La Jara
Compañero
Tapacito
64
537

Following are general descriptions of the current vegetation cover types and amounts within District boundaries.

## Grassland

The native grasslands are distributed primarily at low elevations (generally below 6,700 feet), with patchy distribution occurring among other vegetation community types (shrubland and coniferous woodlands) in the District. Warm season grasses and shrub species are the main component of this habitat. Native Grassland vegetation accounts for approximately 8,500 acres (6 percent) of National Forest land in the District. Species common to the native grassland cover type include blue grama (*Bouteloua gracilis*), big sagebrush (*Artemisia tridentata*), rubber rabbitbrush (*Ericameria nauseosa*), squirreltail (*Elymus elymoides*), common yarrow (*Achillea millefolium*), and prickly pear cacti (*Opuntia polyacantha*). Sedge species (*Carex* spp.) are common among grasslands with increased soil moisture. Understory species common to various other habitat types in the District include mutton grass, grama grass species, sedges, squirreltail, western wheatgrass, and June-grass. Abrupt ecotones are present along the fringes of grasslands with woody species such as Gambel's oak (*Quercus gambelii*), piñon pine (*Pinus edulis*), and juniper species (*Juniperus* spp.). Currently, the native grassland habitat comprises a portion of the District's Wild Horse Territory, and deer and elk winter range. In addition to wildlife grazing, native grasslands in the District are utilized for domestic livestock grazing. Grazing pressure has contributed to the degradation of native grassland habitat in the District, especially in the Wild Horse Territory. Current conditions of forage supply can be found in the Livestock Grazing section of this document. Presently, the native grassland habitat contains the highest density of existing gas wells and the second highest road density in the District.

## Riparian

The riparian habitat represents less than 1 percent of the entire District. This habitat is found in the northern portion of the District (Bancos Canyon watershed) and is primarily composed of willow (*Salix* spp.) and cottonwood (*Populus* spp.) species. Willow habitat is located in the northwestern portion of the District in Bancos Canyon. A mix of coyote (*S. exigua*), Gooding's (*S. goodingii*) willow, peachleaf (*S. amygdaloides*) willow, and Freemont cottonwood (*P. fremontii*) are found in the northeastern portion of the District. Other vegetation associated with this habitat includes sedges, rushes (*Juncus spp.*), blue grama, rubber rabbitbrush, squirreltail, and dropseed species (*Sporobolus spp.*). Riparian vegetation requires high soil moisture content, which is generally lacking in the District due to the absence of perennial waterways and few wetlands.

There are various wetland plants in small wetlands that are scattered across the district. Most are of limited ecological value because they contribute little to flood retention, sediment trapping, and groundwater recharge due to their small size. The majority of significant wetlands are along the Highway 64 corridor in the La Jara watershed.

## Shrubland

The mixed shrubland habitat comprises approximately 21,000 acres (13 percent) of National Forest land in the District. The primary shrubs of this habitat are Gambel's oak (approximately 3,200 acres), found at higher elevations (generally above 6,500 feet in elevation) and big sagebrush (approximately 7,200 acres, 25 percent of which occurs in Valencia Canyon, La Jara Canyon, and US 64 proposed special areas), found at lower elevations (generally below 6,900 feet in elevation). A variety of other shrub and/or forb species found in this habitat in the District include silvery lupine (*Lupinus argenteus*), antelope bitterbrush (*Purshia tridentata*), and mountain mahogany (*Cercocarpus montanus*). Piñon and juniper species are mixed in among this habitat along with understory grasses such as grama species, prairie June-grass (*Koeleria cristata*), mountain muhly (*Muhlenbergia montanus*), and mutton grass (*Poa fendleriana*). Black sagebrush (*Artemesia nova*) is found primarily on shallow, rocky soils that are derived from basalt. This habitat comprises a low to moderate percentage of the District's Wild Horse Territory, and deer and elk winter range. Current degradation of sagebrush communities in the District is attributed to mule deer utilization of this habitat type. The mixed shrub community contains relatively high gas well density and high road density.

## Piñon-Juniper

Piñon-juniper woodland dominates the District, comprising approximately 86,000 acres (57 percent) of the National Forest land. Trees in this habitat can form dense canopies or be fairly open. Canopy density generally increases with elevation; more open stands are found at lower elevations and referred to as Juniper-Savanna (Dick-Peddie 1993). Piñon pine density generally increases with increasing elevation, while juniper density decreases at higher elevations (NMPIF 2001). Juniper stands are more prevalent in the northwestern portion of the District due to the warmer arid conditions, while piñon species thrive in the wetter and cooler conditions characteristic of the southern and eastern portion. Dense stands of piñon-juniper woodland generally occur above 6,600 feet in elevation where the dominant tree species are Colorado piñon (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), one-seed juniper (*J. monosperma*), Rocky Mountain juniper (*J. scopulorum*), and Gambel's oak. Associated shrubs include mountain mahogany, big sagebrush, buckwheat species (*Eriogonum spp.*), and antelope bitterbush with an understory of mutton grass, grama grass species, sedges, squirreltail, western wheatgrass (*Agropyron smithii*), Indian paintbrush (*Castilleja spp.*), and dropseed species.

Piñon-juniper woodland comprises the major portion of the deer (68 percent) and elk (38 percent) winter range, as well as the Wild Horse Territory (67 percent). Current conditions of piñon-juniper woodlands in the northern portion of the District are degraded largely due to the high wild horse population. Over-utilization there has caused the decline in understory vegetation and has increased the amount of bare ground in this habitat type. Declining habitat trends in piñon-juniper woodlands (USFS 2003b) are also attributed to recent drought conditions in the western U.S. and bark beetle infestations. Current road and well densities are relatively low for this habitat type in the District.

## Ponderosa Pine

The ponderosa pine habitat occurs primarily above 7,000 feet in elevation on National Forest land, scattered throughout the District in deep canyons on north and east-facing slopes. This habitat accounts for approximately 33,300 acres (22 percent) of the National Forest land in the District. Common tree species include ponderosa pine and piñon-juniper woodland species. The shrub component is dominated by antelope bitterbush, mountain mahogany, Gambel's oak, big sagebrush, and kinnikinnick (*Arctostaphylos uva-ursi*) with a grass understory. Common grasses and forbs include mutton grass, grama species, squirreltail, Arizona fescue (*Festuca arizonica*), western wheatgrass, and silvery lupine. Ponderosa pine stands comprise a quarter of the habitat in the elk and deer winter range, as well as the Wild Horse Territory. Current gas development is low in this habitat compared to that of the rest of the District. Road density, however, is currently the third highest in this habitat.

## Mixed Conifer

The mixed conifer habitat is dominated by Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*). The mixed conifer habit comprises approximately 1,900 acres (1 percent) of National Forest land in the District and occurs generally above 7,000 feet in elevation. The lower boundary generally borders piñon-juniper woodland and the upper boundaries generally border ponderosa pine forest. Other vegetation associated with this habitat includes piñon and juniper species, Gambel's oak, snowberry (*Symphoricarpos oreophilus*), mountain mahogany, antelope bitterbush, grama grass species, common yarrow, and mutton grass. The mixed conifer habitat comprises a low percentage of the Wild Horse Territory and the deer and elk winter range (Table 3-28). Road density and gas well density are low in this habitat.

## Vegetative Conditions

The current conditions of the vegetation are influenced by factors such as gas development and livestock grazing, as well as recent drought conditions and ungulate grazing from deer, elk, and wild horses. The lack of precipitation in 2002 has resulted in less canopy cover and earth cover than normal. In general, grasses and forbs in the flatter areas (less than 20 percent slopes) are typically heavily grazed by cattle, elk, and wild horses.

There are no regular range transects to provide quantitative comparisons of forage conditions and trends over a period of years. However, the fact that cattle stocking rates in each allotment have decreased over the years, and that no allotment is currently permitted to be stocked at its maximum number identified on the grazing permit agreement, are indications that the vegetative condition is significantly poorer than the desired condition and the trend for forage quality and quantity is downward.

There is little or no grass and forb cover under current conditions in Bancos and Carracas watersheds, due to the drought and grazing pressure by the high population of wild horses, in addition to cattle and elk. Shrubs and trees had also been browsed in some areas of these watersheds by August because there was little else for the ruminants to eat.

La Jara and Compañero watersheds received a little more rainfall in the last 2 years than the northern part of the District, according to Forest Service staff, so the condition of the vegetation there was slightly better. The grasses also received less grazing pressure without the wild horses in this part of the District, which helped maintain higher amounts of vegetative ground cover.

Traffic on the many roads in the District facilitates the spread of invasive plants that compete with native vegetation. In a survey of noxious weeds conducted in 1992, nine different types of weeds were identified on less than 1 percent of the District. Another survey completed in 1998 in the District documented a trend of increasing but still low acreage of noxious weeds (NMSHTD 1998.)

When native plants are removed and the soil is disturbed, the potential for the establishment and spread of invasive plants increases. The relatively high number of roads and gas industry traffic that travels throughout the District enable the rapid spread of invasive plants. Weed management plans are required to be developed and implemented by the gas companies with infrastructure in the District. In a drought year like 2002, when many revegetation efforts failed, it can be expected that the noxious weed problem will be more severe and will require greater control and management in the near future.

The acreage of native vegetation removed to construct gas wells and roads in the District may be used as an indicator of the condition of wildlife habitat and forage production. In the watersheds with more wells and roads, there is less quality wildlife habitat and forage for livestock grazing. **Table 8** breaks down the acreage of each vegetation type in each watershed that has been removed for existing gas wells and roads.

**Table 8. Vegetation Types Removed for Wells and Roads (acres)**

| Watershed | Grassland | Riparian | Shrubland | Piñon-Juniper | Mixed Conifer | Ponderosa Pine |
|---|---|---|---|---|---|---|
| Bancos | 232 | 0 | 152 | 362 | 0 | 129 |
| Carracas | 15 | 0 | 18 | 110 | 7 | 89 |
| Companero | 58 | 0 | 298 | 610 | 10 | 176 |
| La Jara | 161 | 0 | 256 | 471 | 4 | 259 |
| **Totals** | **466** | **0** | **724** | **1,553** | **21** | **653** |

Source: USFS 2002a.

## Species and Habitats

Wildlife populations are not easily characterized by watershed, except by considering the vegetation comprising habitat. In this section, the current condition of the wildlife habitat is characterized using habitat loss, fragmentation, and disturbance as indicators. The species selected to characterize the District are also described, with the distribution and extent of associated vegetation types. The intent of this section is to answer the following question: *What are the current habitat conditions and trends for the species of concern that have been selected as indicators of watershed health?*

## Wildlife Habitat

Species are strongly affected by vegetation conditions and by any surface disturbance resulting in habitat fragmentation. Surface disturbance from gas well development is the main cause of habitat fragmentation in the District and occurs in the form of roads, well pads, and pipelines. Of all these structures, roads represent the greatest impact on wildlife habitat. Their impact is measured not only by the total acreage of surface disturbance in each watershed, but also fragmentation of habitat into small areas as well as effects of vehicle traffic. At the same time, any habitat modifications attributed to the road may be insignificant compared to other effects of gas development activities, for which the road was built.

Most ecological effects of roads are negative to wildlife (Forman et al. 1997). Roads can be a direct source of wildlife mortality. Road-related habitat fragmentation is the product of more than just a change in the landscape and the vegetation. It also involves dust, noise, and increased human activity. The dust generated can settle on plants and block photosynthesis, respiration, and transpiration, altering plant community structure, particularly where lichens and mosses are common (Trombulak and Frissell 2000). Roads can prevent or hinder the movements of smaller wildlife species such as amphibians, reptiles, and small mammals (Trombulak and Frissell 2000; Gibbs 1998).

Roads create edge habitat (Mader 1984, Reed et al. 1996). Increased edge habitat favors certain species while negatively affecting others, especially those that avoid edges or experience increased mortality near or along then (Marcot et al. 1994). The continuity of the road system creates a corridor through which edge-dwelling species of birds and animals can penetrate the previously closed environment of continuous forest cover. Habitat generalists, such as coyotes and brown-headed cowbirds, use road corridors to easily access the interior forest. These predators and nest parasites can have direct impacts on forest-adapted species populations.

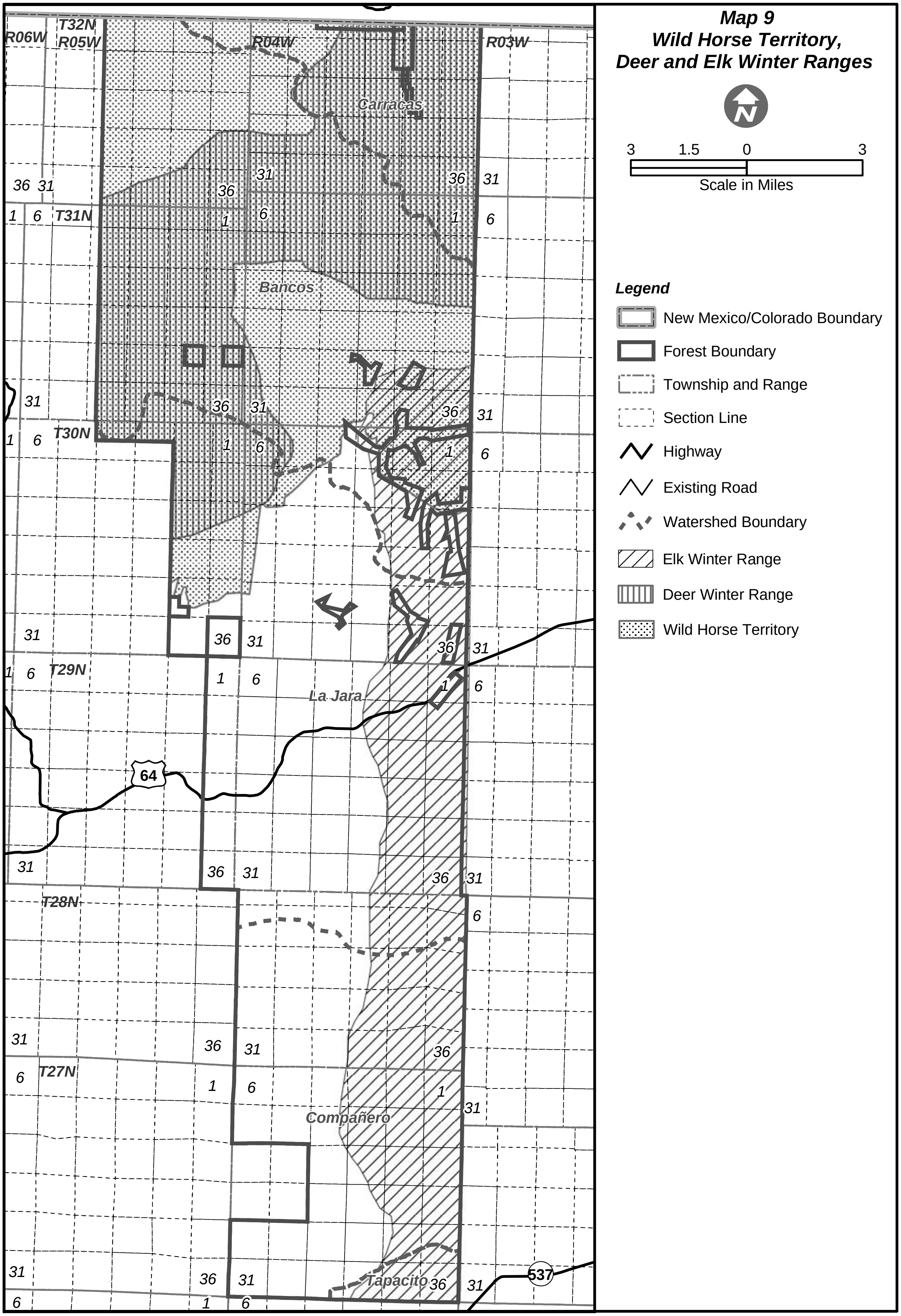
Species diversity can increase. Edge-dwelling species are generally not threatened, however, because the human-dominated environment has provided ample habitat for them. Conversely, species affected by a local increase in edge habitat are likely to be species affected over their entire range by habitat loss and listed as species of concern.

Habitat effects of roads on the landscape include dissecting vegetation patches, increasing the edge-affected area and decreasing interior area, and increasing the uniformity of patch characteristics, such as shape and size (Reed et al.). Whenever forest roads are built, changes in habitat and modified animal behavior would lead to changes in wildlife populations (Lyon 1983). Road-avoidance behavior is characteristic of large mammals such as elk, bighorn sheep, grizzly, caribou, and wolf. Avoidance distances of 100 to 200 meters are common for these species (Lyon 1983). The evidence is strong that forest roads displace some large mammals and certain birds (such as spotted owls) and that displaced animals may suffer habitat loss as a result.

Disturbed areas along roads act as corridor for the spread of invasive plants, thus requiring revegetation efforts. However, revegetation using similar seed mixtures over the entire district contributes to lower biodiversity.

The primary cause of habitat fragmentation in the southern Rocky Mountains is roads (Knight et al. 2000). The major activities in the District that result in vehicle use of the roads are 1) oil and gas development, 2) recreation, and 3) administrative and management work of District personnel. In general, traffic associated with gas development and extraction consists of vehicles traversing the roads to reach wells and other facilities. Few of these trips result in stops along the roads or result in individuals leaving their vehicles.

The density of open road affects the amount of vehicle traffic that may disturb wildlife at critical times of the year. Open road density within the deer winter range, located mainly in the northern part of the District in the Carracas and Bancos watersheds, is currently 0.6 miles per square mile (mi/mi$^2$). The open road density within the elk winter range, located in the Carracas and Bancos watersheds, is currently 1.1 mi/mi$^2$. The deer and elk winter range areas are shown on **Map 9**.


Map 9
Wild Horse Territory, Deer and Elk Winter Ranges
3
1.5
0
3
Scale in Miles
Legend
New Mexico/Colorado Boundary
Forest Boundary
Township and Range
Section Line
Highway
Existing Road
Watershed Boundary
Elk Winter Range
Deer Winter Range
Wild Horse Territory
R06W
T32N
R05W
R04W
R03W
Carracas
T31N
Bancos
T30N
T29N
La Jara
64
T28N
T27N
Compañero
Tapacito
537

The analysis of habitat fragmentation presented here is based on existing road and well densities. Road-effect zones and core areas were delineated using GIS mapping. A road-effect zone (effect zone) is defined by Forman (Weller et al. 2002) as the area extending away from a road and ecologically affected by it. The core area is a component of natural habitat composed of "contiguous blocks of uniform habitat types away from natural breaks or habitat edges" (Weller et al. 2002). As applied to the present analysis of habitat fragmentation, core areas represent some or all of the remaining habitat not ecologically affected by roads. The exact parameters used for the delineation of effect zones and core areas vary among species. The results presented below are for elk, with effect zones extending 0.5 mile from roads and core areas consisting of blocks of remaining habitat measuring at least 250 acres.

Species-specific responses to the size of effect zones that may occur from project actions are summarized below.

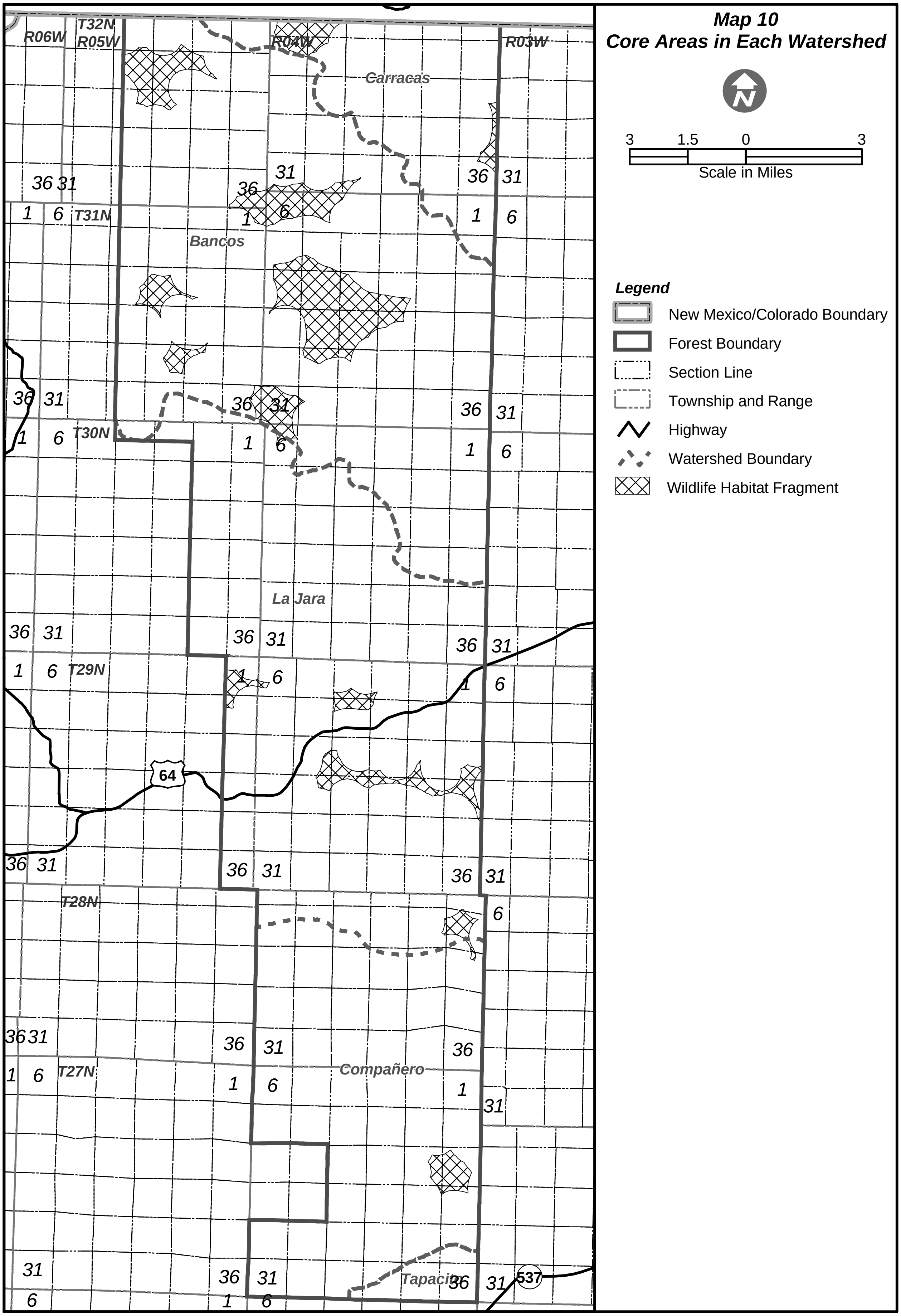
- Bird species (Brewer's and sage sparrows, and sagebrush obligates) were documented to have a 50 percent decline in guilds within 100 meters (328 feet) of roadways in the Upper Green River Basin (Weller et al. 2002).
- Roads that are approximately 10 meters wide (33 feet) may create a thermal road effect zone more than 100 meters (328 feet) into the adjacent habitat (Knight et al. 2000).
- Elk and mule deer require contiguous habitat areas at least 250 acres in size and at least 0.5 miles from a road (BLM 2003).
- Large ungulates (such as mule deer and elk) in Colorado were documented to be more numerous 200 meters (656 feet) away from road edges (Rost and Bailey 1979).
- Block and Lindzey found that elk in western Wyoming avoided relatively high-density oil and gas fields (Weller et al. 2002).
- Perry and Overly suggest that more that 640 acres of elk habitat can be affected by 1 mile of road (Weller et al. 2002).
- Hutto documented songbird affinities to road edges for edge-associated species (chipping sparrow, American robin) and interior forest associations (away from roads) for forest-interior species (western-tanager, golden crowned kinglets) in conifer forests in Montana (Hutto 1995).
- Knight et al. reported increased nest predation and nest parasitism along edge habitat compared to forest interior habitat in the Southern Rocky Mountains (Knight et al. 2000).
- Roads and other corridors, a primary cause of fragmentation in this region, allow species to expand their ranges (Beauvais reported coyotes, red foxes, and bobcats expanding their winter range), increase competition with forest-adapted species (non-generalists), and increase predator-prey interactions with increased access (Beauvais 2000).

**Table 9** lists the road density and the percentage of each watershed within core areas, as determined for elk. Parameters used for delineating core areas vary among species. **Map 10** displays the location and size of each core area within each watershed. The map shows the distribution of large versus small core areas in the District.

**Table 9. Wildlife Habitat Within Core Areas (Elk)**

| Watershed | Road Density ($mi/mi^2$) | Wildlife Habitat Core Areas (%) |
|---|---|---|
| Bancos | 1.6 | 12% |
| Carracas | 1.9 | 7% |
| Compañero | 2.6 | 2% |
| La Jara | 2.1 | 4% |

Source: USFS 2002b.


Map 10
Core Areas in Each Watershed
N
3 1.5 0 3
Scale in Miles
Legend
New Mexico/Colorado Boundary
Forest Boundary
Section Line
Township and Range
Highway
Watershed Boundary
Wildlife Habitat Fragment
R06W
T32N
R05W
R04W
R03W
Carracas
Bancos
La Jara
Compañero
Tapacito
T31N
T30N
T29N
T28N
T27N
64
537

As shown by Table 9, the Bancos watershed has the largest proportion of core area for elk. This watershed also has the smallest road density. Map 10 indicates that most large blocks of core area are also on the Bancos watershed. The Compañero watershed has only one, small core area.

The amount of edge area increases with the increase of fragments (Knight et al. 2000), and habitat connectivity decreases with increased fragmentation (Knight et al. 2000). Decreased connectivity may favor the habitat generalist wildlife species over the forest-adapted species, threatening species richness or diversity at regional scales (Knight et al. 2002).

When considering only the density of open roads, with higher traffic volumes, Carracas is the only watershed that meets the open road density limit of 0.5 mi/mi$^2$ set by the Forest Plan (USFS 1990) for deer and elk winter ranges. Both open and gated roads exist in each winter range area.

Most roads meet or exceed the traffic levels that may affect ungulate habitat listed above. This would be more limited from November through April, the period of closure for drilling operations. The high density of roads facilitates access to wildlife habitat for hunters. Traffic volumes increase on open roads in the District by 33 to 50 percent during the hunting season, mainly October and November, resulting in effects on wildlife such as increasing game movements and limiting habitat use to the most secure areas. Hunter use is described in more detail under Human Uses below.

## Wild Horses

The Jicarilla Wild Horse Territory (Map 9) encompasses 74,630 of federal land on three range allotments, Cabresto (26,377 acres federal), Bancos (15,762 acres federal), and Carracas (32,491 acres federal). Management of wild free-roaming horses is directed mainly by the Wild Horse Protection Act of 1959 and the Wild Horses and Burros Protection Act of 1971. A management plan developed in 1977 (based on a 1976 environmental assessment) called for maintenance of a herd of 60 horses because this was within the ecological limits of the land and was compatible with the elk herd and the permitted livestock. The wild horse population was estimated in the summer of 2002 as 193, far exceeding the number recommended in the management plan. A new plan is under development by District staff.

## Management Indicator Species

The Carson National Forest Plan (as amended) identifies 11 wildlife species as MIS, designated in order to monitor the conditions of the Forest's ecosystems (USFS 1990). The Forest Plan provides direction on managing quality habitat for MIS by MA. MIS are considered to be representative of a variety of species with similar life requirements and were determined to reflect the habitat needs for the majority of the Forest's species. MIS were selected because population changes are believed to indicate the effects of management activities that occur in the Forest. For this reason, the condition and trend for each MIS can be used as indicators of ecosystem health. A summary of the species, key habitat, vegetation managed for habitat, and the habitat condition and trends are summarized in **Table 10**. The amount of the vegetation types comprising MIS habitat within each watershed can be found in Table 8 above.

**Table 10. Management Indicator Species for the Jicarilla Ranger District**

| Management Indicator Species | Key MIS Habitat Component for Quality Habitat | Forest Plan Management Areas Within the Analysis Area Managed for Quality Habitat | Acreage of Habitat[1]; Habitat Condition[2]; Habitat Trend[2] |
|---|---|---|---|
| Brewer's Sparrow (*Spizella breweri*) | Sagebrush | MA 12 – Sagebrush | 7,703 acres;<br>Good, stable condition;<br>Upward trend of about 55%. |
| Plain (Juniper) Titmouse (*Baeolophus ridgwayi*) | Piñon-juniper canopies | MA 8 – Piñon-Juniper | 84,501 acres;<br>Quality habitat in decline;<br>Downward trend of about 2%. |

| Management Indicator Species | Key MIS Habitat Component for Quality Habitat | Forest Plan Management Areas Within the Analysis Area Managed for Quality Habitat | Acreage of Habitat[1]; Habitat Condition[2]; Habitat Trend[2] |
|---|---|---|---|
| Abert's Squirrel (*Sciurus aberti*) | Interlocking canopies | MA 4 – Ponderosa Pine < 40%<br>MA 5 – Mixed Conifer & Ponderosa Pine > 40%<br>MA 7 – Unsuitable Timber | 7,043 acres;<br>Poor to fair condition due to historical management activities;<br>Slight upward trend of almost 20%. |
| Hairy Woodpecker (*Picoides villosus*) | Snags | MA 1 – Spruce-fir < 40%<br>MA 3 – Mixed Conifer < 40%<br>MA 4 – Ponderosa Pine < 40%<br>MA 5 – Mixed Conifer & Ponderosa Pine > 40%<br>MA 6 – Aspen<br>MA 7 – Unsuitable Timber<br>MA 14 – Riparian | 344 acres of habitat;<br>Stable condition;<br>Upward trend of about 5%. |
| Red Squirrel (*Tamiasciurus hudsonicus*) | Mixed conifer | MA 3 – Mixed Conifer < 40%<br>MA 5 – Mixed Conifer & Ponderosa Pine > 40%<br>MA 6 – Aspen<br>MA 7 – Unsuitable Timber | 942 acres;<br>Good condition;<br>Upward trend of approximately 20%. |
| Rocky Mountain Elk (*Cervis elaphus canadensis*) | General forest | MA 1 – Spruce-fir < 40%<br>MA 3 – Mixed Conifer < 40%<br>MA 4 – Ponderosa Pine < 40%<br>MA 5 – Mixed Conifer & Ponderosa Pine > 40%<br>MA 6 – Aspen<br>MA 7 – Unsuitable Timber<br>MA 8 – Piñon-Juniper<br>MA 9 – High Elevation Grassland<br>MA 12 – Sagebrush<br>MA 14 – Riparian | 157,000 acres (approximately 4,400 acres privately owned);<br>Fair and stable condition;<br>Upward trend of almost 4% with a downward trend likely on high index sites where there is rapid forest succession and project work, such as thinning and prescribed burning, have not been implemented. |
| Merriam's Turkey (*Meleagris gallopavo*) | Old growth pine | MA 3 – Mixed Conifer < 40%<br>MA 4 – Ponderosa Pine < 40%<br>MA 5 – Mixed Conifer & Ponderosa Pine > 40%<br>MA 7 – Unsuitable Timber | Approximately 12,000 acres quality habitat;<br>Stable condition;<br>Slight upward trend of about 1%. |

Source: USFS 2003b.

Notes: (1) Acreage is within the District.

(2) Condition and trend are for the entire Carson National Forest, including the District.

# Human Uses

## Minerals

The primary human use of National Forest land in the District is the development and extraction of natural gas. Gas development activities are the main cause of surface disturbance in the District, the primary action that affects watershed vulnerability. There are 815 well pads, 676 of which are actively producing wells that are serviced by roads and pipelines on the National Forest land. Within the District boundaries, which include some private land, there are a total of 840 well pads, 698 of which are actively producing. Many of the roads in the District are single-use roads built specifically to serve well pads.

A drill "pad" (well site) ranging from 1.5 to 4 acres in size, depending on topography and specific well needs, is cleared of all vegetation and leveled for the drill rig, mud pumps, reserve pit, generators, pipe rack, and tool house. Topsoil and native vegetation are usually removed and stockpiled for use in the reclamation process. A depression (cellar) is dug at the bore hole location to accommodate the blow-out preventers, and a shallow bore hole is drilled near the cellar to facilitate some of the drilling operation. Reserve pits are dug for the mixing and storage of drilling mud. Reserve pits may be located in either cut or fill material. The depth of a reserve pit usually ranges from 6 to 15 feet. The dimensions of the pit vary according to well depth and size and shape of the location. Most reserve pits are unlined, but some are lined with reinforced plastic to prevent fluid loss and contamination of water resources if located in sensitive areas. Other facilities such as storage tanks for water and condensate are usually located on the pad unless the pad size is limited by topography.

Gas well development requires a supporting infrastructure that includes the construction and use of well pads, access roads, compressor stations, pipelines, and the installation of temporary and permanent equipment. Three compressor stations are located in the District. The stations generally contain two individual compressors and occupy approximately 2 acres each.

Sand and gravel are sometimes used for construction of well pads, compressor stations, roads, and pipelines. Sand and gravel pits are located on National Forest land where operators may obtain materials with which they build and maintain their roads. The Forest Service staff and Roads Committee provide oversight for these pits.

Natural gas pipelines (gathering or flow lines) transport gas from the wells to a trunk line, which connects to the main transmission line from the area. Flow lines vary from 2 to 4 inches in diameter and are usually buried. They are typically constructed adjacent to a well's access road within 20 feet of the road and within the 30 to 40-foot road ROW; however, pipelines are sometimes routed cross-country, not a preferred practice. Building a gathering line on National Forest land requires an approved Special Use permit.

Future hydrocarbon development in the District may include further development of the Pictured Cliffs, Mesa Verde, and Dakota Formations in addition to development of the Tertiary Sands of the Ojo Alamo, Nacimiento, and San Jose formations. It is likely that Tertiary sands could be spaced at 40 acres per well due to the discontinuous nature of the sandstone bodies in the reservoir. Approximately 694 new wells are projected to be developed from these formations in the District over the next 20 years (Engler et al. 2001).

A broad estimate of surface disturbance associated with existing gas development was made based on the assumptions used to develop the Farmington Draft RMP/EIS and accepted by the District staff. These and other basic assumptions used to determine the amount of surface disturbance related to mineral development are:

- The surface disturbance associated with each well pad averages 2 acres, after interim reclamation takes place.
- Initial surface disturbance, involving removal of native vegetation, adds another 1 acre to the surface disturbance for well pads.
- Roads and pipelines have generally been constructed within the same ROW.
- The gated roads have been developed primarily to serve the gas industry.

All disturbed ground within a watershed contributes to potential downstream impacts, without considering whether the land is part of the National Forest System, so the effects of bare ground from mineral development includes all wells and roads within the District boundaries. Over 2,000 acres have had native vegetation removed and soil disturbed for construction of the pads for the active and plugged wells in the District, one-third of which has been recontoured and revegetated according to Forest Service policy. The breakdown of existing wells and bare ground used for well pads by watershed is listed in **Table 11**.

**Table 11. Wells and Associated Amount of Bare Ground in Each Watershed**

| Watershed | No. of Existing Wells | Bare Ground (acres) | % of Land in Watershed[1] |
|---|---|---|---|
| Bancos | 178 | 356 | 1% |
| Carracas | 49 | 98 | 1% |
| Compañero | 331 | 662 | 2% |
| La Jara | 282 | 564 | 1% |
| **Totals** | **840** | **1,680** | |

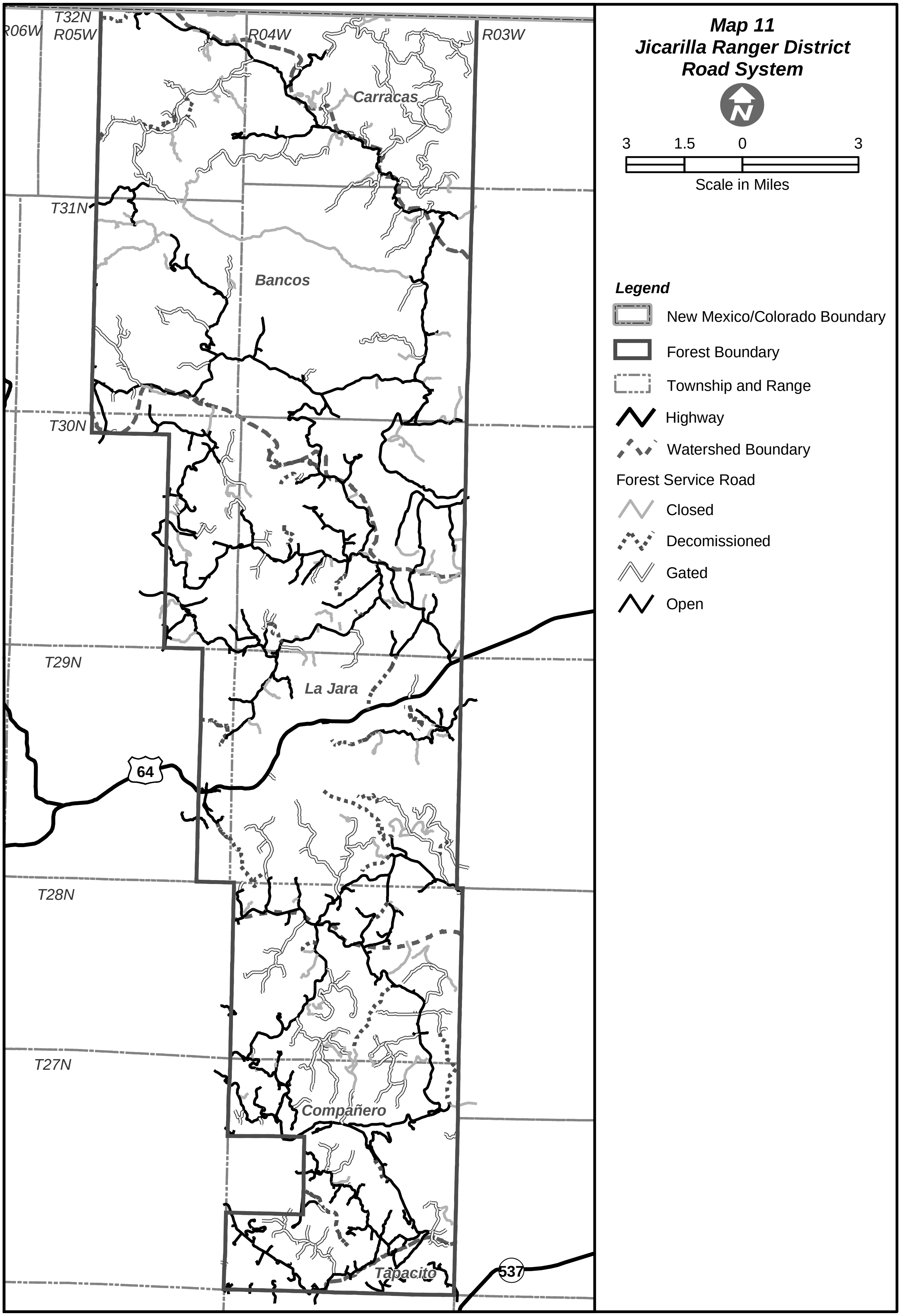
Note: (1) Percentage of National Forest land in each watershed.

In addition to well pads, sources of surface disturbance associated with gas development in the District includes roads, sandstone pits, roads, compressor stations, and pipelines. Roads are addressed in more detail under Transportation below. Approximately 10 to 20 sandstone pits used for excavating rock to stabilize roads and well pads, averaging 3 acres in size, are estimated to exist by District staff. The three compressor stations of approximately 2 acres each contribute an additional 6 acres of bare ground. There are some wells that have been plugged and abandoned, but not fully reclaimed. Because the number of plugged and abandoned wells is not known, it cannot be included in the total areas of surface disturbance. The major contributors to watershed disturbance from gas development activities are roads, pipelines, and well pads.

Water used in oil and gas exploration and development is obtained from wells drilled specifically for this purpose, from the San Juan or Animas Rivers, from the Navajo Reservoir, or from local municipalities. A small amount of water is used for dust suppression or equipment installation during other phases of exploration and development, such as for cleaning equipment and cooling engines. Drilling operations are responsible for most of the water consumed during the life of a producing well. The amount of water used while drilling depends on how much of the wellbore is drilled with mud. Different drilling objectives (formations) require different amounts to water. Wells that are drilled by using air or gas as the primary drilling medium require less water. Water used by gas operations is derived from several primary locations from legal water rights holders, many not within the watersheds that encompass the District. Some water sources used by water haulers for gas development come from east of the Continental Divide (BLM 2002). For these reasons, water usage for drilling operations has little effect on watershed condition.

## Transportation

There are 464 miles of roads on National Forest land, and a total of 485 miles within National Forest boundaries, including the roads on private land. The road system is shown on **Map 11**. When considering watershed condition, it is most useful to consider the effects of all roads in the area, even though the Forest Service can only make management decisions on those roads under its authority. Most of the of roads are constructed and used by the gas industry to serve its wells.


Map 11
Jicarilla Ranger District
Road System
3
1.5
0
3
Scale in Miles
Legend
New Mexico/Colorado Boundary
Forest Boundary
Township and Range
Highway
Watershed Boundary
Forest Service Road
Closed
Decomissioned
Gated
Open
T32N
R06W
R05W
R04W
R03W
Carracas
T31N
Bancos
T30N
T29N
La Jara
64
T28N
T27N
Compañero
Tapacito
537

These single-use roads, built specifically to serve well pads, are gated to limit vehicle traffic and public access. **Table 12** shows the miles of roads and the road density by watershed.

**Table 12. Road Miles and Density by Watershed[1]**

| Name | Total Roads (Miles) | Open Road Density (mi/mi$^2$) | Gated/Closed Road Density (mi/mi$^2$) | Total Density (mi/mi$^2$) |
|---|---|---|---|---|
| Bancos | 146 | 0.7 | 0.8 | 1.6 |
| Compañero | 38 | 1.5 | 1.1 | 2.6 |
| Carracas | 133 | 0.6 | 1.3 | 1.8 |
| La Jara | 168 | 1.2 | 0.9 | 2.1 |
| **Total Miles** | **485** | | | |

Source: USFS 2002b.

Note: (1) Road miles and density include all roads within District boundaries.

The amount of surface area needed for roads is dependent on topography and the type and level of vehicular traffic. Generally, main collector roads are 20 feet wide and access roads are 14 feet wide on the driving surface. The total width of surface disturbance, including the road ditch, berms, and pipelines that are frequently located parallel to roads ranges from 30 to 60 feet on main roads, and 20 to 40 feet on well service roads. Surface disturbance in excess of 130 feet wide is not unusual in steep terrain where slopes exceed 30 percent. **Table 13** provides a comparison of the percentage of all District roads within each watershed. These percentages also indicate the proportion of bare ground from roads in each watershed.

**Table 13. Amount of District Roads in Each Watershed**

| Watershed | District Roads in Watershed (%) |
|---|---|
| Bancos | 30% |
| Carracas | 8% |
| Compañero | 28% |
| La Jara | 34% |

Source: USFS 2002b.

Specifically related to the gas and oil industry, roads may be built in order to move a drill rig and well service equipment from one site to another and to allow access to each site. Bulldozers, graders, and other types of heavy equipment are used to construct and maintain the road system. Standard cut-and-fill construction techniques are used. The roads are typically ditched on one side with turnouts spaced at intervals to limit the length of surface water flows on the road**.** The surface of most roads is compacted soil, but a few roads are surfaced with crushed stone, usually sandstone. Major roads in the District are normally limited to one main route to serve the leases in a geographic area with a maintained and gated side access road to each well.

The main collector roads are the open roads that provide access to the gas service roads and also provide access to the campgrounds and hunting areas. Traffic is highest on the collector roads, ranging from 25 to 75 vehicles per day, depending on the season. During the primary hunting season, October and November, an additional 25 vehicles per day use the open roads. During the non-drilling, non-hunting season (December to April), traffic levels are estimated by District staff to be reduced by 50 percent on the gated roads and by 33 percent on the open roads. Recommendations in a recent Roads Analysis Plan (USFS 2003c) for the District include improving the main collector roads to Maintenance Level 3, which would enable the high seasonal traffic levels while facilitating safe access by all vehicle types.

## Livestock Grazing

Six grazing allotments are used by seven permittees and cover the entire District, shown on Map 5. All of the allotments cross watershed boundaries. Cattle are the only livestock using the allotments, with a maximum number allowed on all allotments of 779 head. **Table 14** displays current grazing allotments and corresponding watersheds.

**Table 14. Grazing Allotments**

| Grazing Allotment | Watersheds | Maximum No. of Cattle | Grazing Dates |
|---|---|---|---|
| Bancos | Bancos | 80 | 5/15-10/31 |
| Cabresto | Bancos, La Jara | 101 | 6/1-10/31 |
| Carracas | Carracas, Bancos | 12 | 5/16-10/15 |
| Laguna Seca | La Jara, Compañero | 237 | 5/1-9/30 |
| Valencia | Compañero | 92 | 6/1-10/31 |
| Vaqueros | Bancos, La Jara | 257 | 5/1-9/30 |

Source: USFS 2002c.

The usual stocking rate in recent years has been approximately 80 percent of the maximum number of cattle listed in Table 14. During this drought year of 2002, Forest Service staff have worked with permittees to encourage them to remove their cattle early in the season due to the poor rangeland forage condition in order to minimize overgrazing and resulting damage to watershed condition.

## Recreation

Recreation in the District is estimated in terms of RVDs. The northeastern part of the New Mexico Game and Fish Department's Unit 2B covers the District. Hunting in the District is estimated to be almost 16,000 RVDs during September, October, November, and January, and includes some use of the campgrounds. General day use recreation, mostly during the summer months, accounts for approximately 900 RVDs.

According to district staff, hunting is the most popular recreational activity in the District. Hunting accounts for an estimated 15,900 RVDs per year. Developed facilities for camping, found only at Buzzard Park and Cottonwood campgrounds, receive about 1,600 RVDs per year (mostly by hunters). Another 800 RVDs are estimated for camping throughout the forest. Non-hunter day-use for recreation is estimated at about 900 RVDs per year.

Mountain biking is increasing in popularity in the region, but not so much in the district due to its isolation. However, closed lease roads (about 118 miles) provide opportunities for nonmotorized uses (mountain biking, hiking, and horseback riding) throughout the district.

The District has two developed recreation sites, the Buzzard Park and Cedar Springs campgrounds, which include four units each and are open from May through November (USFS n.d.). The Buzzard Park campground is located in the Bancos watershed and the Cedar Springs campground is located in the La Jara watershed. Both are primitive campgrounds that require some maintenance work on roads and facilities, which are in moderate to poor condition.

Gas Buggy Interpretive Site is the location of an experimental use of a nuclear explosion to fracture a gas well in the 1960s. Visitors come to see the information posted on a marker near the well, but no visitor numbers are available.

## Cultural Resources

There are 862 recorded archaeological sites in the database maintained by the District, which is based on the Archaeological Records Management Section (ARMS) of the New Mexico Office of Cultural Affairs. The distribution of these sites is shown on Map 6. In these recorded sites there are approximately 1,184 cultural components (USFS 2003a). The majority of recorded sites contain early Pueblo and Navajo habitation sites, limited activity sites and Navajo pueblitos. The number of recorded sites and the site density are shown in **Table 15**.

**Table 15. Recorded Archaeological Sites in Each Watershed**

| Watershed | Recorded Archaeological Sites | Site Density/ 100 Acres |
|---|---|---|
| Carracas | 60 | 7.6 |
| Bancos | 365 | 12.5 |
| La Jara | 267 | 7.0 |
| Compañero | 170 | 7.3 |
| **Totals** | **862** | 8.4 |

Source: USFS 2003a.

Traditional cultural properties are most likely located on the district, but the locations and uses have not been documented by the Forest Service staff. Permits are issued by the Forest Service for some traditional uses of the land, including firewood cutting and the collection of oak leaves for ceremonial purposes.

This section presents the numbers of cultural affiliations/components from the recorded archaeological sites in each watershed only on National Forest land. **Table 16** shows the number of components by watershed and time period.

**Table 16. Frequency of Components and Sites by Watershed and Cultural Affiliation in the Jicarilla Ranger District**

| Period | Watersheds | | | | Total |
|---|---|---|---|---|---|
| | Bancos | Compañero | Carracas | La Jara | |
| PaleoIndian | 0 | 0 | 0 | 0 | 0 |
| Archaic | 2 | 0 | 2 | 0 | 4 |
| Basketmaker II-Los Pinos | 65 | 7 | 2 | 18 | 92 |
| Basketmaker III-Sambrito | 65 | 9 | 2 | 18 | 94 |
| Pueblo I-Rosa | 94 | 42 | 23 | 75 | 234 |
| Pueblo I-Piedra | 48 | 36 | 18 | 24 | 126 |
| Pueblo II-Arboles | 39 | 35 | 4 | 17 | 95 |
| Pueblo III-Largo/Gallina | 1 | 0 | 2 | 2 | 5 |
| Navajo-Dinétah | 8 | 43 | 1 | 30 | 82 |
| Navajo-Gobernador | 16 | 32 | 0 | 20 | 68 |
| Anglo-Hispanic | 6 | 2 | 2 | 4 | 14 |
| Unknown | 59 | 22 | 7 | 47 | 135 |
| **Total Components** | **403** | **228** | **63** | **255** | **949** |
| **Total Sites** | **365** | **170** | **60** | **267** | **862** |

Source: USFS 2003a.

**Table 17** summarizes the modal, or most common, types of sites likely to be found in each watershed. This table provides a snapshot of the kinds of sites that archaeologists would be likely to encounter as they work in each watershed, based on currently recorded sites and components. Each site contains a variety of features. Among these, hearths, hogans, roomblocks, middens, and mounds are most common.

**Table 17. Modal Site Types in Each Watershed**

| Watershed | Modal Types of Sites Likely to be Encountered |
|---|---|
| Bancos | Disproportionately prehistoric P I sites (51%) with smaller proportions of prehistoric BM III sites (13%) and prehistoric P II (13%) sites |
| Compañero | Disproportionately prehistoric P I sites (35%), with smaller proportions of historic Dinétah/Gobernador phase Navajo sites (23%) and prehistoric P II sites (19%) |
| Carracas | Disproportionately prehistoric P II sites (42%) with smaller numbers of prehistoric P III (20%) sites |
| La Jara | Disproportionately prehistoric P I (45%) sites with smaller proportions of historic Dinétah/Gobernador phase Navajo sites (16%) |

Source: USFS 2003a.

The density of recorded sites in each watershed is presented in Table 15, showing that the Bancos watershed has the highest site density. The current condition of all archaeological sites in each watershed is unknown. The most is known about the sites within Bancos Canyon, especially near the now-abandoned and heavily eroded Bancos Canyon road. There are a total of 15 recorded sites that are intersected by this road and one site within the ROW. Six sites were capped with earth to protect them some years ago, prior to a short exploration for gas wells in the Bancos Canyon area. Since then, this road has not received any use, but the road has eroded considerably in the intervening years, with deep ruts making it unusable in its current condition.

Erosion controls were constructed at eight sites in Bancos Canyon in the 1990s to attempt to protect the sites from further damage. The erosion control measures consisted of filling borrow ditches and constructing berms to divert water away from the sites. Gabion baskets were installed in areas where arroyo cutting was damaging sites, and brush was placed in several areas to stabilize eroding soil and promote seed germination.

All surface disturbing activities, such as gas well development and road construction, are required to have archaeological clearances before any work begins. Surveys meeting federal and state standards are conducted to identify and record all sites in the area, after searching for recorded sites. Surface disturbing activities are required to avoid or mitigate archaeological sites or other cultural resources that could be affected. Following this approach, all sites considered to be eligible for the National Register of Historic Places (NRHP) are protected from approved surface disturbing activities.

Forest Service staff generally consults with The Navajo Nation, Southern Ute, Ute Mountain Ute, Jicarilla Apache, and Comanche Tribes, as well as the Hopi and the Pueblos of Zuni, Jemez, Taos, Picuris, San Juan, Pojoaque, Nambe, Tesuque, San Ildefonso, and Santa Clara, due to their ties to the area. This ongoing tribal consultation is conducted to help the Forest Service make decisions that do not negatively affect the traditional cultural uses of the District, such as the collection of oak leaves and other materials for ceremonies, as well as to request assistance in determining the impacts on other traditional cultural properties.