Chapter 3. Affected Environment and Environmental Consequences

Oil-Gas Leasing

Introduction

The oil-gas study area of the Santa Fe National Forest is in the easternmost part of the San Juan Basin, outside of the most productive oil and gas formations. Based on the most recent and site-specific projections of new wells, few new wells would be developed over the next 20 years (USFS 2004a). Historically, most leases are never drilled on the Santa Fe National Forest, with nearly 150 leases resulting in a total of 80 wells. Between 1983 and 2003, only three wells were drilled in the study area (USFS 2004a). Although there are currently seven expressions of interest to lease new oil or gas parcels, the Forest Service's supplemental Reasonably Foreseeable Development Scenario (RFDS) (USFS 2004a) does not project any development in these areas because the RFDS is based on proven geology and known production, regardless of lease status. The RFDS assumes that industry expenditures are more likely to be spent in areas that are known to be productive.

The action alternatives propose lease stipulations that can only be implemented on newly issued leases. Therefore, while the proposed new lease stipulations are intended to provide the Forest Service with better tools to protect surface resources in key locations than is possible under current Forest Plan standards and guidelines, these benefits would not occur until new leases are issued and wells drilled. No effect on surface resources would directly result from any leasing decision to be made under either action alternative for the following two primary reasons:

1. There is a lack of foreseeable development on new leases during the 20-year planning period.
2. The decision to be made would impose specific stipulations to new leases that limit surface disturbance, but would not directly result in well drilling, or construction of well pads, roads, or pipelines under those new stipulations.

This chapter summarizes the physical, biological, social, and economic environments of the study area and the effects of implementing each alternative on that environment. It also presents the scientific and analytical basis for the comparison of alternatives presented in the alternatives chapter. Brief descriptions of the regional climate and geology are presented first to characterize the setting of the affected environment and impacts on resources.

Climate and Meteorology

The climate of the region is classified as arid Continental, characterized by cool, dry winters and warm, dry summers. The large distance from any source of oceanic moisture creates a climate of abundant sunshine and large diurnal variations in temperature.

Due to its location in the Southern Rocky Mountains, wintertime Pacific storm systems borne by westerly winds lose much of their moisture prior to passing through the region. The peak precipitation season occurs during late summer and early fall, when moisture moves into the region from the Gulf of Mexico in association with the western extension of the Bermuda High. Data from Cuba, New Mexico, from 1941 through 2004 are used to characterize the project region climate (WRCC 2004). However, the more mountainous and elevated portions of the project region experience wetter and colder conditions than those that occur at Cuba.

The average annual precipitation at Cuba is 13.1 inches. The driest and wettest months are February and August, when 0.7 and 2.3 inches of rain occur, respectively. The average high and low temperatures at Cuba in August are 83 and 49 degrees Fahrenheit, respectively. The January average high and low temperatures are 42 and 10 degrees Fahrenheit.

The large-scale winds within the region tend to prevail from the southwest and westerly directions during the daytime hours for much of the year. However, local wind conditions can vary substantially from this general pattern throughout the project region, due to the effects of topographic channeling and mountain-valley circulations.

Geology

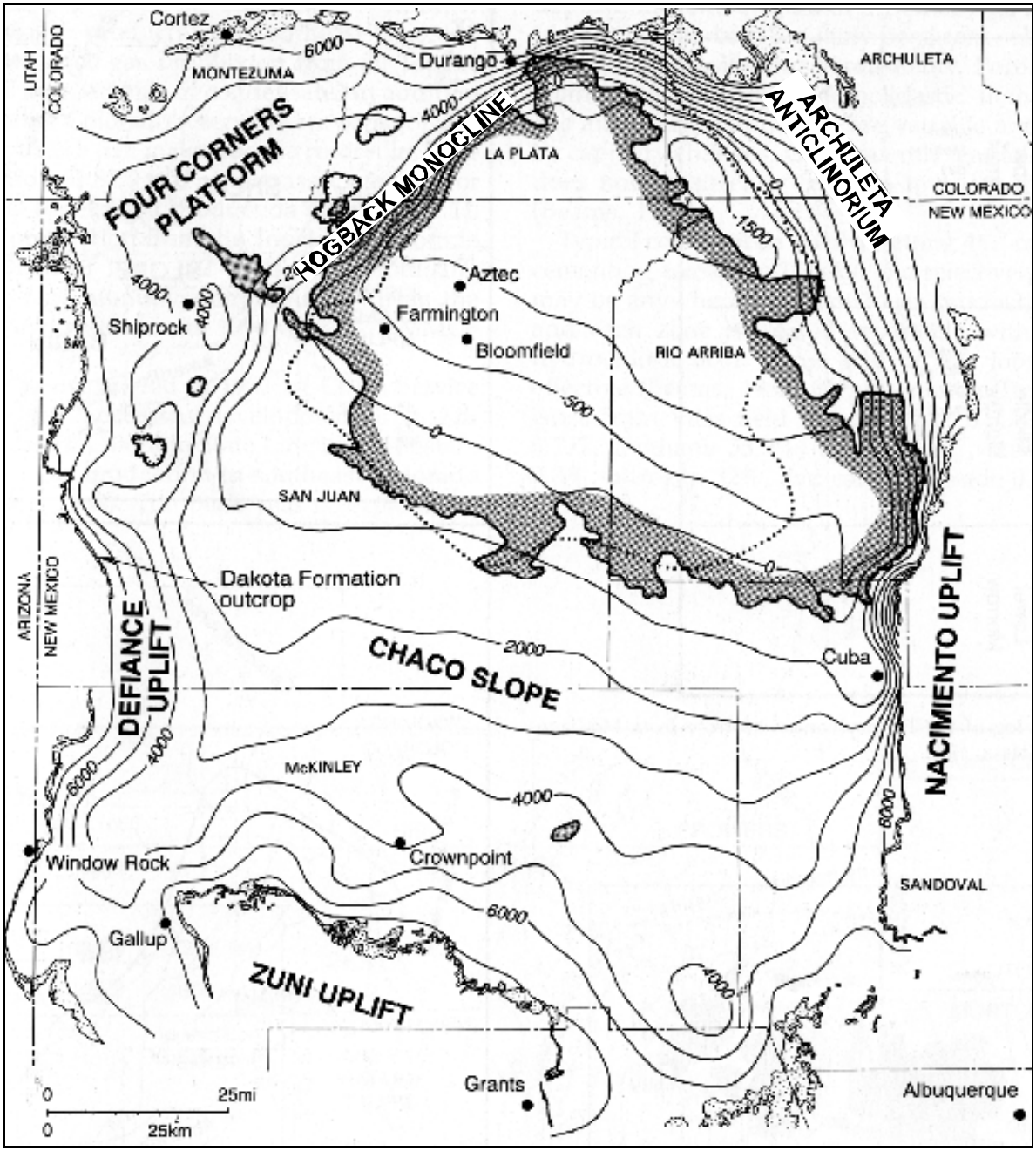
The oil-gas study area is located on the eastern edge of the San Juan Basin. The San Juan Basin is an asymmetrical syncline that extends from northwestern New Mexico into southwestern Colorado. Roughly oval in shape, it is about 200 miles long (north to south) and 130 miles wide, including its Colorado portion, covering about 15 to 25,000 square miles. The San Juan Basin displays an asymmetrical layering of sedimentary rocks that range in age from Cambrian to Quaternary, underlain by Precambrian rocks.

The eastern part of the basin near the oil-gas study area is bordered by the Nacimiento Uplift, which was formed during the Laramide orogeny spanning late Cretaceous time through the early Tertiary. The uplift consists of a block tilted eastward and bounded on the west by reverse and thrust faults. The uplift trends north-south, is about 50 miles long and about 6 to 10 miles wide. The uplift has a core consisting of Precambrian rocks and Paleozoic marine and continental clastics dipping to the east. Mesozoic clastic terrestrial deposits, Paleocene and Eocene terrestrial deposits, and Quaternary volcanics complete the composition of the strata composing the uplift. Structural relief is at least 10,000 feet between the highest part of the uplift and the adjacent San Juan Basin. The strata include as much as 17,500 feet of deposits (Woodward 2003). Younger strata appear on the surface toward the western part of the oil-gas study area. Figure OG-14 displays the structural features defining the San Juan Basin and the Nacimiento Uplift.

The surficial geology of the San Juan Basin in the oil-gas study area consists primarily of Tertiary alluvium (unconsolidated silts, sands, clays, and gravels) surrounded by north-south trending Tertiary and Cretaceous sandstones and shales. They are underlain by the pink-tinted Tertiary San Jose Formation, which consists of layers of arkosic sandstone, siltstone, shale, and conglomerate, and the Nacimiento Formation. In areas where it is exposed, the San Jose Formation erodes as irregular ledges and slopes and has the ability to form caves. There are some areas that show evidence of past landslides (D'Alberto 2001). The Pennsylvanian Madera Limestone outcrops in limited areas in the eastern boundary of the study area. The Cretaceous Greenhorn Limestone underlies the western part of the study area.

Slow decomposition of plant and animal material within source rocks resulted in the development of hydrocarbon deposits in the strata beneath the surface. The primary hydrocarbon producing formations beneath the oil-gas study area include the Pictured Cliffs Sandstone and the Mancos Formation. 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 oil in the Mancos Formation is sourced from the organically rich Mancos Shale and is primarily produced from three fractured dolomitic siltstone beds. These brittle reservoirs fracture when subjected to structural deformation, creating permeability conduits that facilitate production (Advanced Resources

International 2000). Surficial and subsurface formations relevant to the San Juan Basin are displayed in Figure OG-15 as a geologic column.



Source: Engler et al. 2001

Figure OG-14. Plan view of the San Juan Basin showing structural features

Era	System		Formation		Thickness	Production
CENOZOIC	TERTIARY		San Jose Formation		2500 ft.	Gas
			Nacimiento Formation		500-1300 ft.	Gas
			Ojo Alamo Sandstone		250 ft.	Gas
MESOZOIC	CRETACEOUS		Kirtland Shale	Farmington Sandstone	1500 ft.	Gas/Oil
			Fruitland Formation		500 ft.	Gas
			Pictured Cliffs Sandstone		250 ft.	Gas
			Lewis Shale	Huerfanito Bentonite	500-1900 ft.	Gas
		Mesaverde Group	Cliff House Sandstone		0-800 ft.	Gas
			Menefee Formation		350-2200 ft.	Gas
			Point Lookout Formation		100-300 ft.	Gas
		Mancos Shale	Upper Mancos Shale/Tocito Sandstone		2300-2500 ft.	Gas/Oil
			Gallup Sandstone/Carlile Shale			Gas/Oil
			Greenhorn Limestone			
			Graneros Shale			
			Dakota Sandstone		150-200 ft.	Gas/Oil
	JURASSIC		Morrison Formation		400-900 ft.	
			Wanakah Formation	Todilto Limestone	50-200 ft.	
			Entrada Sandstone		100-300 ft.	Oil
	TRIASSIC		Chinle Formation		500-1600 ft.	
PALEOZOIC	PERMIAN		Cutler Formation		1500-2500 ft.	
	PENNSYLVANIAN	Hermosa Formation	Honaker Trail Formation			
			Paradox Formation		200-3000 ft.	Gas?
			Pinkerton Trail Formation			
			Molas Formation		0-100 ft.	
	MISSISSIPPIAN		Leadville Limestone		0-165 ft.	
	DEVONIAN		Elbert Formation		0-325 ft.	
	CAMBRIAN		Ignacio Quartzite		0-100 ft.	
PRECAMBRIAN						

Source: Engler et al. 2001

Figure OG-15. Geologic time column of the San Juan Basin

Minerals

Affected Environment

Minerals development in and near the oil-gas study area consists of mining for locatable and salable minerals and the development of leasable minerals. Locatable minerals typically consist of precious metals and/or base metals and the rocks that contain them. They are developed on mining claims. Salable minerals in the study area consist of sand, gravel, decorative stone, humate, and most pumice. Leasable minerals consist of oil, gas, coal, and geothermal resources.

Minerals Management

The Santa Fe National Forest cooperates with the BLM Farmington Field Office (FFO) to ensure that management goals and objectives are achieved where minerals, such as oil and gas, underlie lands managed by the Forest Service. The Forest Service is responsible for approving the surface use plan of operations (SUPO) that is submitted to the BLM as part of the application for permit to drill (APD) by the operator. The SUPO outlines how the operator will use the land, including the well site layout, the locations of roads and pipelines, methods of handling waste disposal, and water sources. The Forest Service can add requirements to the SUPO to protect surface resources and to ensure the mineral extraction activity complies with the Forest Plan. Reclamation plans are required for all proposed surface-disturbing activities to return the land to productive uses consistent with the ecological capability of the area in accordance with land management goals.

The BLM is responsible for approving the drilling plan, which consists of technical specifications for drilling and completing a well, including drilling and casing specifications, cementing requirements, and ground water protection. BLM Onshore Oil and Gas Orders, Notices to Lessees/Operators (NTL), Conditions of Approval (COA), and general requirements constitute the range of standard operating procedures and environmental protection measures that are applied to individual operators and projects, as applicable, and are authorized by 43 CFR 3160.

The relevant Onshore Oil and Gas Orders include:

- Onshore Order #1 Approval of Operations;
- Onshore Order #2 Drilling Operations;
- Onshore Order #3 Site Security;
- Onshore Order #4 Measurement of Oil;
- Onshore Order #5 Measurement of Gas;
- Onshore Order #6 Hydrogen Sulfide Operations;
- Onshore Order #7 Disposal of Produced Water;
- Onshore Order #8 Workovers and Subsequent Well Operations (Proposed Rule) (includes abandonment, currently draft status but is being used as interim guidance); and
- Onshore Order #9 Waste Prevention and Beneficial Use of Oil and Gas.

The New Mexico BLM has issued a number of NTLs to those companies that operate on Federal and Indian leases. The NTLs are consistent with or exceed the minimum standards specified in the 43 CFR 3160 regulations or Onshore Orders. The following list of NTLs is applicable to oil and gas operations in the Santa Fe National Forest:

- Cultural Resource Surveys, NTL 85-1
- Painting of Oil Field Facilities, NTL 87-1
- Requirements to Operate on a Federal Lease and Notice of Change of Operator, NTL 89-1
- Standards for Use of Electronic Flow Computers and Electronic Gas Measurement Systems, NTL 89-2

- Requirements to Operate on Federal and Indian Leases: Casing and Cementing Requirements, NTL 90-1
- Waste Disposal, NTL 92-1
- Limits for Accumulation of Oil in Water Disposal Pits and Tanks, NTL 92-3
- Limits for Accumulation of Oil in Water Disposal Pits and Tanks, NTL 92-3A
- Non-Mechanical Temperature/Gravity Compensation on LACT Units, NTL 92-4
- Standards for Meters Measuring Low Gas Volumes, NTL 92-5
- Modification of Production Equipment to Prevent Bird and Bat Losses, NTL 93-2
- Management of Sound Generated by Oil and Gas Production and Transportation, NTL 03-1 FFO

Oil-Gas Development

The oil-gas study area contains all of the current oil-gas development in the Santa Fe National Forest. It consists of wells producing hydrocarbons from the Pictured Cliffs and the Mancos formations. The seven New Mexico Oil Conservation Commission (NMOCD) designated oil and gas pools beneath the oil-gas study area include Gavilan Nacimiento, Blanco (Ballard) Pictured Cliffs, South Blanco Pictured Cliffs, Gavilan Pictured Cliffs, Rio Puerco Mancos, West Puerto Chiquito Mancos, and East Puerto Chiquito Mancos. Two other oil and gas pools, the Mesaverde Point Lookout Pool and Dakota Pool, are located adjacent to the Santa Fe National Forest boundary. Five companies currently operate wells on the forest.

Spacing. The location of a well drilled to a specified formation is determined by the spacing of that formation. Spacing is regulated by the NMOCD. Spacing regulations are intended to define the boundaries within which an operator must drill within a section. The spacing of a formation essentially defines windows within a section in which it is permissible to drill. Spacing rules are intended to provide minimum offsets between wells and from section boundaries so that reserves are not drained by adjacent wells. Spacing requirements help to determine the location of wellheads on the surface because wells are typically drilled vertically. The Pictured Cliffs produces natural gas from wells spaced at 160 acres per well. The Mancos produces oil from wells spaced at 160 acres per well.

Leases. Current and historic leases extend about 6 miles to the east of the geologic boundary of the San Juan Basin, as defined by the Nacimiento Fault Zone. About 42 percent of the acreage contained in the oil-gas study area is currently leased for oil-gas development. Table OG-4 displays the amount of acreage leased in the Santa Fe National Forest on a watershed basis.

Development History. Historically, about 70 wells have been drilled in the Santa Fe National Forest, not including wells that were plugged and abandoned prior to creation of the database maintained by the NMOCD. Thus, the actual number of wells that may have been drilled within the oil-gas study area may be higher than 70 (USFS 2003b). About 78 percent of the wells were drilled to pools associated with the Mancos Formation. These wells produce oil, gas, and small amounts of water. About 22 percent of the wells were drilled to pools associated with the Pictured Cliffs. These wells primarily produce gas with a small amount of associated water and no liquid hydrocarbons. One wildcat (exploratory) well in the oil-gas study area produces from the Greenhorn Limestone Member of the Mancos Shale. One well was completed to the Gavilan

Nacimiento Pool and subsequently plugged. Gas injection is used to maintain subsurface pressures in the eastern part of the West Puerto Chiquito Mancos pool.

Table OG-4. Leased acreage by watershed

Watershed	Acres Leased	Acres Not Leased	Total Acres	Percent Leased
Arroyo Balcon-Rio Puerco	0	4,904	4,904	0
Arroyo Chijuilla-Rio Puerco	7,152	35,917	43,069	17
Canada Larga	7,396	528	7,924	93
Rio Chama	194	—	194	100
Rio Gallina	55,946	48,840	104,786	53
Rio Guadalupe	0	9,678	9,678	0
Rio Nutrias	10,208	14,479	24,687	41
Rio Puerco	0	564	564	0
Tapicito Creek	2,633	7	2,640	99
Totals	**83,529**	**114,917**	**198,446**	**42.1**

Table OG-5. Santa Fe National Forest historical well status

Well Status	Number of Wells	Percent of Total
Producing	41	59
Plugged	16	23
Injection well (gas or water)	3	4
Monitor well	6	8
Shut in	4	6
Total	**70**	**100**

Source: USFS 2003b

About 59 percent of the wells in the Santa Fe National Forest are active and producing. About 29 percent of the wells are either plugged or shut in. Well status of the 70 wells is shown in Table OG-5.

Between 1983 and 2003, only three wells were drilled on Santa Fe National Forest land. During the period from 2000 to 2003, at least eight wells were plugged on Santa Fe National Forest land, indicating that more wells are being plugged than are being drilled in the study area (USFS 2003b).

The oil-gas study area currently contains 49 active wells, 5 of which are located on private land within the study area boundary. These wells are displayed on Figure OG-16. The average lifespan of a well in the San Juan Basin can extend as long as 50 years (BLM 2003a). Future hydrocarbon development in the oil-gas study area may include further development of the Pictured Cliffs and

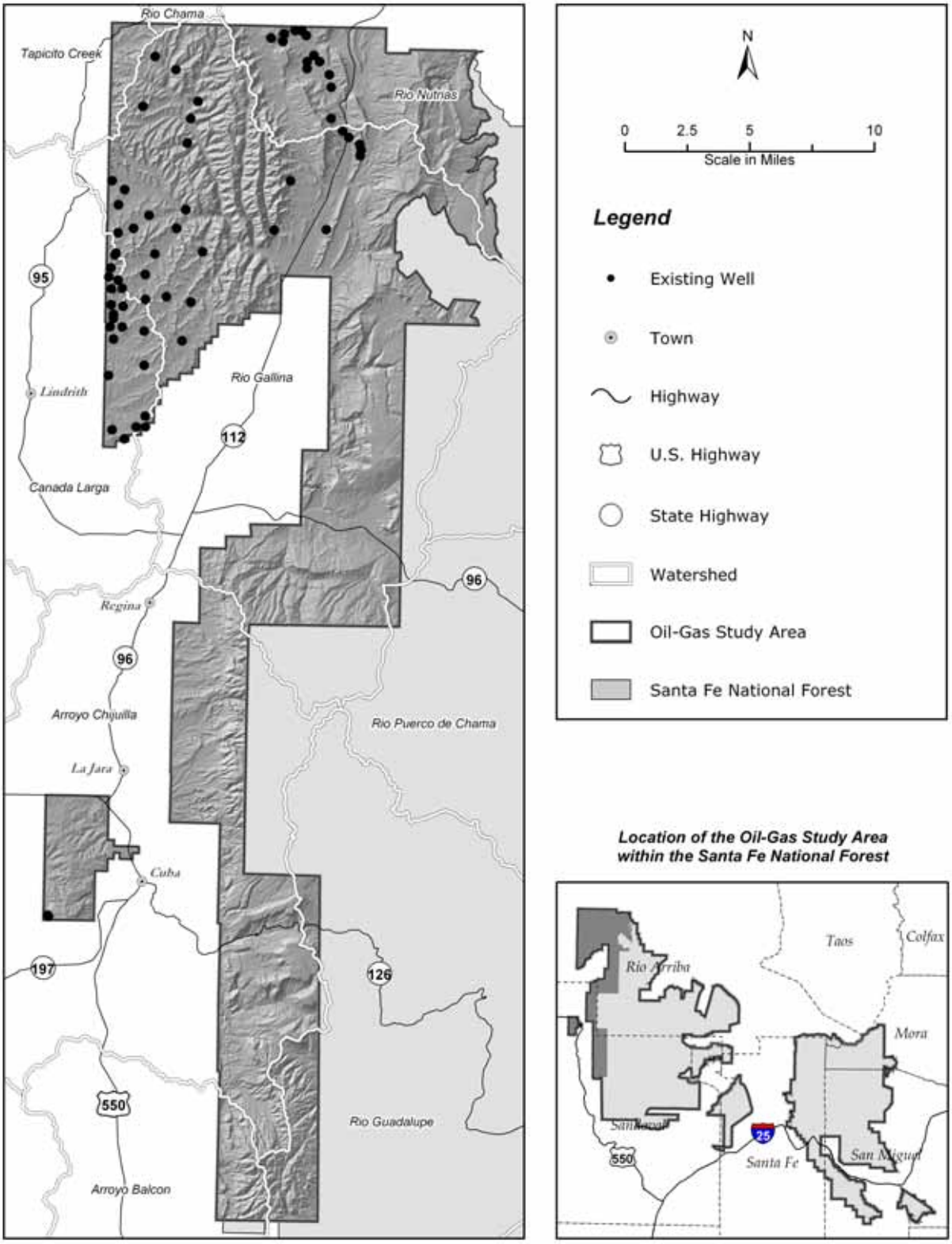


Figure OG-16. Existing wells in the study area

Mancos formations in addition to possible development of the Entrada Sandstone, which is currently on 640-acre spacing (Engler et al. 2001).

Development Operations. Oil-gas development requires a supporting infrastructure that includes the construction and use of well pads, access roads, pipelines, and the installation of temporary and permanent equipment. Development of wells and the associated infrastructure occurs only after a site-specific NEPA evaluation is performed at the location of each facility, road, or well pad.

Roads have been built in order to provide access to the well site and to move a drill rig and well service equipment from one site to another. Sand and gravel is sometimes used for construction and maintenance of roads, well pads, compressor stations, and pipelines. Although sand and gravel pits are located on Santa Fe National Forest land, operators currently obtain road building and maintenance materials from private sources.

In the oil-gas study area, well pads have been constructed so that each accommodates one well. A well pad ranges from 1.5 to 4 acres in size but averages 3 acres, depending on topography and specific well needs. Each well pad is cleared of all vegetation and leveled for the drill rig, mud pumps, reserve pit, generators, pipe rack, and tool house. Topsoil is usually removed and stockpiled for use in the reclamation process. A depression (cellar) is dug at the borehole 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. 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. If located in sensitive areas, reserve pits that were constructed from the 1990s onward were lined with reinforced plastic to prevent fluid loss and contamination of water resources. Reserve pits were not lined prior to that time. Reserve pits must be filled after drilling is complete and reclaimed within 120 days of closure.

Following construction of the access road and well pad, a mobile drilling rig is transported to the well site in sections and erected on the well pad. Drilling operations are conducted inside the conductor pipe. Routine drilling operations normally include: (1) keeping a sharp bit on bottom to penetrate the subsurface; (2) adding new joints of pipe at the surface as the hole deepens; (3) removing the drill string from the hole to install a new bit and running the drill pipe back to the bottom ("tripping the hole"); and (4) installing and cementing casing. Surface casing is installed to protect fresh water aquifers. Production casing must be cemented in place to provide coverage and prevent interzonal communication between oil and gas horizons and usable water zones. Stimulation is required if formation pressure cannot raise oil/gas to the surface or if formation permeability requires enhancement. A gas well may be flared for a short period to measure the amount of gas per day the well can produce, then shut in or connected to a gas pipeline. The flared gas is almost pure methane with minor amounts of other gases such as nitrogen or carbon dioxide.

Water used in oil and gas exploration and development is obtained from water rights holders or from wells drilled specifically for this purpose, located adjacent to the well location. Permits to drill water wells on the Santa Fe National Forest are obtained from the Office of the State Engineer. Drilling a water well on the Santa Fe National Forest surface also requires a special use permit from the Forest Service, and water wells typically revert to the Santa Fe National Forest after the oil or gas well is developed. Drilling operations consume most of the water used during well development. The amount of water used while drilling depends on how much of the wellbore

is drilled with mud. Different formations require different amounts of water for drilling purposes. Wells that are drilled by using air or gas as the primary drilling medium require less water.

Wells in the Santa Fe National Forest produce small amounts of water. Produced water is either transported by truck for disposal off the Santa Fe National Forest or to a permitted injection well.

Facilities or equipment needed for well development, such as storage tanks for water and liquid hydrocarbons, are usually located on the pad unless the pad size is limited by topography. About half of the locations have one to three tanks on site. The steel tanks hold about 500 barrels of water or oil or both. The oil-gas study area contains one tank farm. It is located on a 5-acre parcel and consists of three tanks, two of which are open-topped and cannot be used. The remaining tank is a 3,000-barrel oil tank.

Natural gas pipelines (gathering or flow lines) transport gas from the wells to trunk lines, which connect to PNM's Farmington to Los Alamos transmission pipeline. Flow lines vary from 2 to 4 inches in diameter and are 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 right-of-way (ROW); however, pipelines are sometimes routed cross country. Oil is also transported via buried pipelines. Building a gathering line on Santa Fe National Forest land requires an approved special use permit from the Forest Service.

Four compressor stations, containing three individual compressors and occupying about 5 acres each, are located in the oil-gas study area, in Township 25N/Range 1W, Sections 13 and 14 along Forest Road 313 and in Township 25N/Range 1W, Section 30 in Simon Canyon. To maintain reservoir pressures, gas is currently being re-injected into gas-producing formations.

Locatable and Salable Minerals

Mining activities occur both within and outside of the oil-gas study area. Mines result in commercial development while prospects are smaller disturbances that do not result in commercial production.

There are several small copper prospects and two inactive copper mines within the oil-gas study area, including the:

- Eureka, located in Township 21N/Range 1E, Section 32. It utilizes less than 3 acres of private land; and
- San Miguel, located in Township 19N/Range 1W, Section 24. It utilizes about 10 acres of private land. The prospects show only limited mineralization and are owned by individuals with no means to develop them.
- Eureka and San Miguel Mines are both located primarily on private property (patented mining claims) within the Santa Fe National Forest. Neither has been active since the early 1960s.
- Nacimiento Mine, located in Township 20N/Range 1W, Section 1, utilized about 80 acres of Federal, private, and State land. The Nacimiento Mine, which was active episodically from about 1880 to 1991, is now a hazardous waste (CERCLA) site, and the Forest Service and State agencies are currently reclaiming it.

Historical records indicate the oil-gas study area was prospected for uranium, so small uranium prospects may exist throughout the oil-gas study area. None of these prospects was developed to the extent of recording (Gore 2003).

A coal mine was operated in Section 21 in Township 25N/Range 1E between 1944 and 1984. It is now closed, and the site has been reclaimed. There are no current coal leases in the oil-gas study area, and no future coal mining is expected. Coal seams within the study area are too small to be commercially productive.

The rock fragments that comprise a large part of the surface make them suitable for removal from small pits as salable minerals. There are five active sand and gravel pits in the study area (see Table OG-6) that were developed for use by the timber industry. The amount of materials extracted for use in road construction varies according to the demand on a yearly basis. There are numerous other sites within the study area from which sand and gravel have been mined in the past. The BLM and Forest Service are working jointly to designate additional sand and gravel sites for use by the oil and gas industry in the future.

Table OG-6. Sand and gravel pits in the oil-gas study area

Mineral	Pit Location	Pit Size	Use	Amount Removed
Sand	T21N/R2W, Section 12	<0.1 acre	Sold to general public (no commercial sales)	<10 cubic yards annually
Gravel	T23N/R1E, Section 33	5 acres	Used by Forest Service for road surface	0 – 1,000 cubic yards annually
Gravel	T20N/R1W, Section 36	1 acre	Used by Forest Service for road surface	0 – 1,000 cubic yards annually
Sand/Soil	T20N/R1E, Section 18	5 acres	Used by Forest Service for road surface	0 – 500 cubic yards annually
Sand/Soil	T20N/R1E, Section 19	0.5 acre	Used by Forest Service for road surface	0 – 500 cubic yards annually

Source: Gore 2003

Humate, an organically rich shale and/or a very dirty, decomposed coal used as a soil enhancement, has been removed from pits in the past in the oil-gas study area. The pits disturb less than 5 acres of surface and are not currently active.

Outside of the oil-gas study area but within the Santa Fe National Forest, there are four active pumice mines and several decorative rock sites. The active mines are small, employing from 3 to 15 persons each. A volcanic cinder pit is located on Santa Fe National Forest and adjoining BLM land, administered by the BLM.

High and low temperature geothermal resources are present on the Santa Fe National Forest outside of the oil-gas study area. Currently, none of the resources on the Santa Fe National Forest is developed, but several of the natural hot springs provides recreational opportunities. High temperature geothermal resources can be used to generate electricity. While these resources occur on the Santa Fe National Forest, their utilization would require constructing a power plant and power distribution lines which cause large surface disturbances. Low temperature geothermal resources in some regions are used as heat sources for buildings, greenhouses, or hot spring spas,

but are rarely developed on national forest lands because the facilities to use the heat are rarely constructed on the forest.

Surface Disturbance Associated with Minerals Development

Minerals development is not the primary cause of disturbance in the oil-gas study area. Disturbance resulting from oil-gas development is, however, the primary source of surface disturbance in the northwestern part of the Cuba Ranger District.

An estimate of surface disturbance associated with current gas development was made based on the assumptions used to develop the Farmington RMP/EIS and accepted by the Santa Fe National Forest staff. Roads were not included because the majority of the roads in the study area were not constructed specifically for oil and gas development. These assumptions are:

- Initial surface disturbance, involving removal of native vegetation, averages about 3 acres per well pad.
- The long-term surface disturbance associated with each well pad averages 2 acres, after interim reclamation is completed.

The amount of long-term surface disturbance within each watershed resulting from current oil-gas development activities, exclusive of roads and pipelines, is shown in Table OG-7.

Table OG-7. Existing surface disturbance from well pad construction by watershed

Watershed	Number of Wells	Long-Term Disturbance (acres)
Arroyo Balcon-Rio Puerco	0	0
Arroyo Chijuilla-Rio Puerco	2	4
Rio Chama	0	0
Rio Gallina	34	68
Rio Guadalupe	0	0
Rio Nutrias	13	26
Rio Puerco	0	0
Total Disturbance, All Watersheds	**49**	**98**

About 98 acres within the oil-gas study area have had soil disturbed for construction of the pads for the 49 active wells, using the assumptions listed above. Surface disturbance associated with oil-gas development also includes areas needed for construction of compressor stations and tank farms.

Long-term disturbance associated with current minerals development, exclusive of road construction, is shown in Table OG-8. Although well development requires the use of Santa Fe National Forest roads for access, most roads were constructed for and are used for other purposes and are, therefore, not included in the disturbance figures. Long-term disturbance comprises less than 1 percent of the oil-gas study area, excluding private land. Surface disturbance associated with copper mining is not included in Table OG-8 because most of the disturbance occupies private inholdings within the oil-gas study area.

Table OG-8. Long-term disturbance associated with existing minerals activities

Type of Disturbance	Number of Facilities	Acres Disturbed
Oil and Gas Activities		
Well pads, long-term	49	98
Tank farm	1	5
Compressor stations	4	20
Total	**—**	**123**
Salable and Locatable Minerals		
Sand and gravel pits	5	12
Humate pit	1	5
Total	6	17
Total	**—**	**34**

Noise Related to Minerals Development

Noise is defined as unwanted or annoying sound that is typically associated with human activities and that interferes with or disrupts normal activities. Sound and noise are measured as sound pressure levels in units of decibels (dB). Response to noise varies according to its type, its perceived importance, its appropriateness in the setting and time of day, and the sensitivity of the individual receptor. Human hearing is simulated by measurements in the A-weighting (dBA) network, which de-emphasizes lower frequency sounds to simulate the response of the human ear. The phon is a true measure of the response of the human ear. Measurements made in dBA approximate the loudness level in phons. Noise values are logarithmic measurements, and every 10-dBA increase is perceived by the human ear as about twice the previous noise level. Sound level intensity decreases by about six dBA for each doubling of distance from the source. Further reduction occurs when sound energy travels far enough to be appreciably reduced by absorption. Some typical A-weighted sound levels from common noise sources and sources associated with oil and gas drilling and production activities and mining activities are presented in Table OG-9.

The oil-gas study area is not regulated by Federal, State, or local noise regulations, but oil and gas activities are regulated by the Occupational Safety and Health Administration (OSHA) noise regulations and guidelines for worker exposure. These regulations and guidelines focus on noise from machinery, equipment, and tools. The BLM Farmington Field Office has developed a noise policy for application to Federal oil and gas wells it administers, which limits noise levels from long-term sources (like wellhead compressors) near raptor nests, residences, and designated noise sensitive areas or points. However, the Cuba Ranger District does not currently contain any noise sensitive areas. Noise from mining activities is regulated by the Mine Safety and Health Administration whose standards for the occupational noise exposure of miners are contained in 30 CFR Part 62.

Existing Noise Levels and Sources

The acoustic environment within the oil-gas study area is typical of a rural location, with day-night average sound levels ranging from 35 to 56 dBA (DOE 1998). Background noise levels on

a wind-free day in the oil-gas study area range from 30 to 35 dBA. Actual noise levels in and around the oil-gas study area are affected by specific noise events, intervening topography, vegetation, and meteorological conditions, including wind speed and direction.

Highway traffic creates noise in the vicinity of U.S. Highway 550 and State Highways 126, 112, and 96. Roadway noise depends upon vehicle type, speed, traffic volume, surface conditions, surface gradient, and distance to receptors.

Oil and gas operations generate noise during well drilling and operation activities. Compressor stations are the greatest producers of noise associated with oil and gas operations. The noise generated by drilling operations is almost as loud. There is also intermittent but infrequent construction noise associated with access road building and maintenance.

Traffic on well access roads contributes intermittently to noise in their vicinity. Access roads provide access for passenger cars as well as high-clearance vehicles. Recreational vehicular noise sources tend to be seasonal (late August to December and sometimes in January) when hunting increases traffic levels on oil-gas study area roads. Recreational noise is often associated with unmuffled engines used on dirt bikes and ATVs.

Mining activities can generate noise at about the same intensity as oil and gas operations; however, since oil-gas study area mines are inactive, they do not contribute to the noise environment. Operations at salable minerals pits generate noise during materials extrication, loading, and transport.

Table OG-9. Sound levels associated with gas and oilfield operations

Noise Source (at 50 feet, unless noted)	Scale of A-weighted Sound Level (dBA)	Human Perception of Noise Loudness (relative to reference loudness of 60 dBA)
Diesel truck, 40 miles per hour	90	8 times as loud
Gas compressor operations	89	About 8 times as loud
Mining activities	85 – 95	About 6 to 12 times as loud
Well drilling operations/pumpjack operation	82 – 83	About 4 times as loud
Produced water injection facility	71	About 2 times as loud (moderately loud)
Traffic at 65 miles per hour	64	About 1.5 times as loud
Normal speech	60	Reference loudness
Light traffic, rural highway	55	About 3/4 as loud
Bird calls (distant)	40	1/4 as loud (quiet)

Source: Compiled from SAIC 2002, BLM 2000, BLM 2003a

Noise Receptors

Recreational users of the oil-gas study area are the primary human noise receptors. Human receptors include hunters, fishermen, dispersed campers, mountain bikers, horseback riders, and hikers. Some of these activities are primarily day use recreational activities, occurring mostly during the summer months.

Environmental Consequences

Alternative 1—No Action

Under the No Action Alternative, no change would be made to current minerals management activities. Oil and gas lease development would be managed under two lease categories, as identified in the current Forest Plan. Standard leases include restrictions or information notices alerting lessees to potential restrictions. Standard lease conditions apply to most of the study area except in specific areas where exceptional resource values exist. Leases in those areas (Management Areas C, D, I, and L) are limited with respect to surface occupancy, but represent a small acreage within the study area, all without existing leases.

Oil and gas operations would be managed through the APD process on a site-specific basis, in which a SUPO would be evaluated to provide protection of resource values. Resource values include:

- Visual quality objectives;
- Water quality;
- Watershed values;
- Reclamation to original or characteristic contours, or adapted to serve further surface resource uses;
- Revegetation or reforestation with appropriate species to attain soil stability;
- Heritage resources; and
- Threatened and endangered species and other wildlife habitats.

The removal of sand and gravel would continue to be located in areas consistent with current management emphasis for such extraction after an appropriate level of environmental analysis.

All mineral development would be subject to reclamation activities that would restore resource damage and ensure public safety. Abandoned mine sites would be evaluated with respect to alternative forms of reclamation.

The Santa Fe National Forest received expressions of interest from oil and gas companies with respect to potential future leases. Under the No Action Alternative, each of the seven expressions of interest would be managed under standard lease terms and conditions or limited surface use, depending on its location. Table OG-10 displays the total existing leased and unleased acreage under different stipulations for each alternative, and lists the acreage of lease stipulations within each expression of interest shown in Figure OG-17.

Implementation of the existing standards and guidelines are inadequate to provide protection of sensitive surface resources, while allowing additional minerals development. Although conditions of approval (COAs) are applied to APDs during site-specific NEPA evaluations before drilling an oil and gas well, the existing standards and guidelines may result in an insufficient level of protection to some sensitive resource values. There is no direction in the guidance that would result in the accomplishment of the goals as stated in the Forest Plan for all management areas.

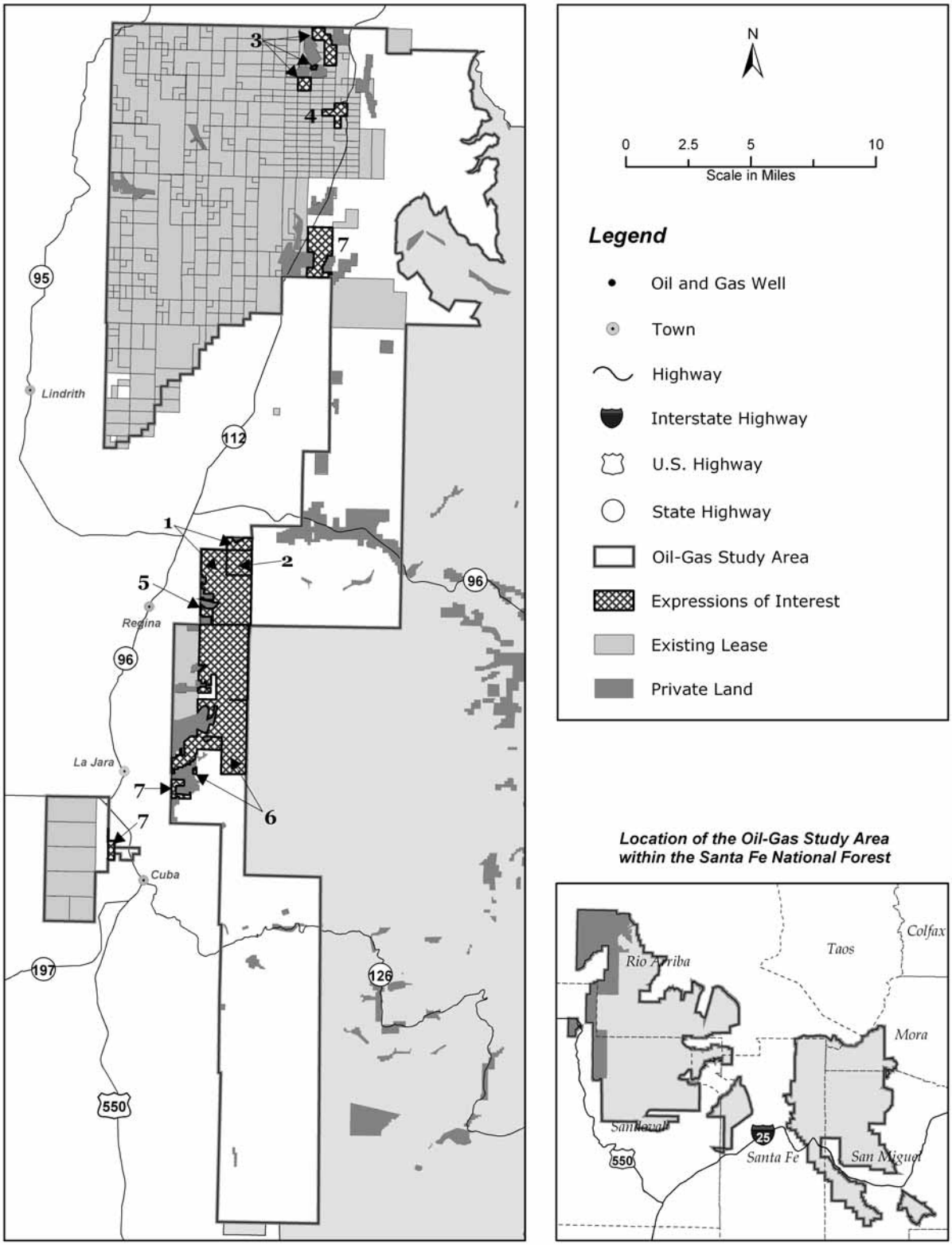


Figure OG-17. Expressions of interest within the oil-gas study area

Table OG-10. New lease stipulations by lease status and expressions of interest

New Lease Stipulation	All Unleased Areas	All EOIs	EOI 1	EOI 2	EOI 3	EOI 4	EOI 5	EOI 6	EOI 7
Alternative 1—No Action									
NSO	0	0	0	0	0	0	0	0	0
Limited	10,308	3,256	0	0	0	0	0	3,256	0
Standard	103,933	10,369	3,838	636	673	321	135	3,474	1,337
TL	0	0	0	0	0	0	0	0	0
Alternative 2—Proposed Action									
NSO	16,194	1,610	28	19	190	312	0	349	712
CSU	15,268	3,907	199	18	97	9	0	3,480	104
Standard	80,815	8,108	3,608	600	384	0	134	2,864	518
TL	1,964	0	0	0	0	0	0	0	0
Alternative 3									
NSO	17,297	1,610	28	19	190	312	0	349	712
CSU	15,226	3,907	199	18	97	9	0	3,480	104
Standard	79,755	8,108	3,608	600	384	0	134	2,864	518
TL	1,964	0	0	0	0	0	0	0	0

Alternative 2—Proposed Action

Valid leases in effect at the time of implementation of the Proposed Action would not be affected by the proposed constraints to oil-gas development. Only leases, including current EOIs, issued after a decision to implement the Proposed Action would be subject to the new stipulations.

The Proposed Action contains resource management prescriptions that determine the availability of the Santa Fe National Forest surface for use to produce hydrocarbons. The application of stipulations associated with defined areas may affect a company's ability to access the surface to drill a well. Some lease stipulations preclude the use of the surface for development, such as the conditions of no surface occupancy (NSO). The minerals beneath an area with an NSO restriction may not be accessible unless the reserves can be accessed through directional drilling. Controlled surface use (CSU) or timing limitations (TLs) would be incurred to protect many surface resources, including wildlife use and habitat. In addition, the Proposed Action would require consistency with established BLM policies for managing noise and air quality.

NSO restrictions would apply to specified areas of steep slopes (40 percent or greater), Management Area L, and Management Area I. The Forest Plan does not specifically address areas with steep slopes. Management Area L is currently managed for roadless recreation, and Management Area I is managed to protect significant heritage resources. Without an assessment of subsurface geologic conditions, the ability to develop minerals underneath an NSO surface by directional drilling is speculative.

Management Area D includes areas of high scenic integrity to be protected to retain this Visual Quality Objective. The Proposed Action would allow disturbance under a CSU stipulation.

Minerals development would need to meet the Visual Quality Objective of retention or would need to meet that objective within 3 years of reclamation.

The Proposed Action identifies riparian areas and wetlands as areas where minerals development would be subject to CSU restrictions, primarily avoidance by relocating an oil-gas facility up to 656 feet (200 meters). If there were no practical alternatives to locating facilities in these areas, COAs and BMPs would be instituted to minimize adverse impacts.

Timing limitations that would restrict minerals development activities during specified times of the year, depending upon the protected wildlife species, would apply in specific areas within the oil-gas study area under the Proposed Action. Threatened and endangered species are currently protected in the Forest Plan by the implementation of limited surface use and through compliance with other State and Federal laws.

All of the restrictions proposed for new leases under the Proposed Action would be subject to exceptions, modifications, or waivers. In order to be able to develop minerals under an exception, modification, or waiver, a company must demonstrate on a site-specific basis that adverse impacts would be completely avoided or the site in question would not affect the resource the restriction is intended to protect. Exceptions, modifications, or waivers involving an issue of major concern would be subject to a public review and comment period.

An RFDS (Engler et al. 2001) and revised RFDS (USFS 2003b; USFS 2004a) were developed by the Santa Fe National Forest in order to estimate future drilling for hydrocarbon resources within the oil-gas study area. Although the exact locations of the predicted new wells would not be known until proposed by a company, the RFDS estimated the number of locations on a township and range basis. The locations were predicted using current and anticipated spacing units for formations beneath the study area, in addition to the locations of wells drilled prior to the initiation of this planning process.

Some of the conceptual well locations predicted by the RFDS lie in areas that would be restricted by the proposed lease stipulations. Some areas in or near the historical oil-gas development would be subject to timing limitations, and CSU or NSO stipulations on new leases. If such stipulations were applied to future leases in the areas of interest, it may still be possible to extract the mineral resource by taking protective measures that ensure the integrity of the resource. However, all of the projected new wells are located on existing leases and could be developed under standard terms and conditions unless an existing lease was relinquished and a new lease issued.

The Santa Fe National Forest received expressions of interest from companies with respect to potential future leases. Under the Proposed Action, NSO stipulations would apply to areas of steep slopes within the expressions of interest and one area of interest may be subject to CSU stipulations. If these areas of interest were leased, access to the surface would be limited to areas not designated NSO or would require nonstandard construction techniques.

The proposed lease stipulations would allow oil-gas development to proceed while providing a greater level of protection to the forest's surface resources than currently exists as outlined in the Forest Plan. Because all foreseeable new wells are projected to be developed on existing leases, the proposed stipulations on new leases would not affect future oil-gas development in the study area unless market or other factors considered during preparation of the RFDS change in the future.

The BLM noise policy would be implemented under this alternative; however, noise sensitive areas (NSAs) are not designated under the Proposed Action and no existing NSAs have been

designated previously. Therefore, no buffers to minimize noise would be applied to wellhead compressors or other kinds of oil-gas facilities. Oil and gas development activity is likely to take place away from existing trails and the Boy Scout camp, which are located considerably south in the oil-gas study area.

Sand and gravel may continue to be mined on private inholdings within the oil-gas study area, but they are small and used only occasionally. The inactive nature of copper mining on private inholdings indicates that future copper extraction is unlikely.

Alternative 3

Alternative 3 would increase the amount of acreage designated as NSO. One area is located outside and adjacent to Management Area L, as described in the Proposed Action. The other area proposed for NSO under Alternative 3 consists of a one-half mile buffer adjacent to the San Pedro Parks Wilderness boundary. All other proposed lease stipulations would remain the same as described in the Proposed Action.

The impacts under Alternative 3 would be identical to the analysis presented under Alternative 2, the Proposed Action. However, an additional 5,350 acres would not allow surface development, including an area near San Pedro Parks Wilderness that has shown oil and gas leasing activity in the past. The acreage surrounding Management Area L has not been drilled for oil and gas previously and is less likely to be developed within the next 20 years.

The oil and gas beneath an area with an NSO restriction can be accessed through directional drilling from outside the NSO area. Without an assessment of subsurface geologic conditions, the ability to develop minerals underneath an NSO surface is speculative.

All of the restrictions proposed for new leases under the Proposed Action would be subject to exceptions, modifications, or waivers. In order to be able to develop minerals under an exception, modification, or waiver, a company must demonstrate on a site-specific basis that adverse impacts would be completely avoided or the site in question would not impact the resource the restriction is intended to protect.

The BLM noise policy would be implemented under this alternative. Although no NSAs would be designated, the one-half mile buffer around San Pedro Parks Wilderness would lessen the perceived noise level of a compressor in the wilderness area. Because all foreseeable new wells are projected to be developed on existing leases, the proposed stipulations on new leases would not affect future oil-gas development in the study area under Alternative 3 unless market or other factors considered during preparation of the RFDS change in the future.

Cumulative Impacts

It is reasonably foreseeable that the number of wells projected by the Santa Fe National Forest RFDS would be developed under any alternative, most likely under standard terms and conditions unless an existing, undeveloped lease were relinquished and reissued under the new lease stipulations proposed under either Alternative 2 or 3. The revised RFDS (USFS 2004a) for the oil-gas study area was developed using input from oil and gas companies currently drilling in the Santa Fe National Forest and projected 27 completions on Santa Fe National Forest lands utilizing 20 well pads. Table OG-11 displays the projected oil-gas development on Santa Fe National Forest lands by formation and by NMOCD-designated pool.

Table OG-11. Projected well development in the study area

Formation	Projected Subsurface Development	Projected Well Pads	Pool	Projected Location	Projected Well Pads
Pictured Cliffs	15	11	South Blanco Pictured Cliffs	T24N/R1W	2
			Gavilan Pictured Cliffs	T24N/R1W	1
				T25N/R1W	8
Mancos (oil)	12	9	West Puerto Chiquito Mancos	T25N/R1W	2
				T26N/R1W	3
			East Puerto Chiquito Mancos	T26N/R1E	4
Total	**27**	**20**			**20**

Long-term surface disturbance would be unavoidable if the predicted wells were drilled on the Santa Fe National Forest. Long-term surface disturbance was estimated based upon assumptions used in the development of the 2001 RFDS (Engler et al. 2001) developed by New Mexico Tech for use in development of the BLM 2003a Resource Management Plan and EIS that analyzed oil-gas development throughout the New Mexico portion of the San Juan Basin. The 2001 BLM RFDS assumed that 75 percent of new well development would occur on a one well per pad basis while 25 percent of the wells would be dual completions or commingled with two completions per pad. These assumptions were also used to estimate existing surface disturbance due to oil-gas development, as explained above in the section, "Surface Disturbance Associated with Minerals Development."

Surface disturbance due to oil-gas development consists of disturbance from well pads and associated facilities, such as compressor stations, roads, and pipelines. To be conservative, surface disturbance due to new road construction is included in the estimate, whereas roads were not included in the disturbance estimate for existing oil-gas development. It is assumed that the predicted wells would require the construction of about 3 miles of roads to serve the 20 new well locations projected by the Santa Fe National Forest RFDS (USFS 2004a). Pipeline construction is assumed to be short term because all the pipelines would be buried and revegetated after installation. To be consistent with other analyses completed in the region, disturbance assumptions for roads and pipelines were taken from the BLM Farmington Resource Management Plan and EIS (BLM 2003a). Assumptions used for this estimate include the following:

- When an existing well pad is used to locate a new well bore, the size of the pad would increase by one-half acre for the long term. No new road construction would occur from co-located wells.
- Road and pipeline disturbance associated with each new well pad would average 1.5 acres initially (short term) and 1 acre for the long term, after interim reclamation is completed.
- No new compressor station would be constructed because any increase in compression capacity is expected to be slight (Gore 2003).

- No new tank farms are anticipated because the existing tank farm has been largely unserviceable and unnecessary.

Long-term surface disturbance associated with oil-gas development in the Santa Fe National Forest is shown in Table OG-12. About 44 acres would be disturbed (stripped of vegetation) for the life of the wells if all predicted wells were drilled, with an additional 20 acres disturbed for road construction. Oil-gas development in the Santa Fe National Forest would be very small in comparison to the anticipated development of about 12,000 new well locations north and west of the forest in the New Mexico portion of the San Juan Basin.

Table OG-12. Disturbance associated with predicted oil-gas development and other minerals

Type of Disturbance	Number of New Locations	Short-term Disturbance Well Locations (acres)	Long-term Disturbance Well Locations (acres)	Short-term Disturbance Roads and Pipelines (acres)	Long-term Disturbance Roads and Pipelines (acres)
Oil and Gas Development					
Well pads, long term	20	70	44	30	20
Tank farm	0	0	0	0	0
Compressor stations	0	0	0	0	0
Total	**20**	**70**	**44**	**30**	**20**
Salable and Locatable Minerals					
Sand and gravel pits	3	15	15	0	0
Humate pit	0	0	0	0	0
Total	**3**	**15**	**15**	**0**	**0**

Locatable and Salable Minerals. Future development of locatable and salable minerals in the oil-gas study area that could contribute to the acreage of surface disturbance appears to be limited. Disturbance projected to occur from salable and locatable minerals development is shown in Table OG-12. About 15 acres would be disturbed for the long term, in the form of sand and gravel pits.

An increase in the number of wells drilled within the oil-gas study area may create a need for development of more pits to accommodate infrastructure development. The BLM in cooperation with the Santa Fe National Forest are planning to open two or three small gravel pits from which road materials would be extracted. The pits would probably be located in the northern portion of the oil-gas study area where materials would be readily available for use by oil and gas companies. Each gravel pit would disturb less than 5 acres and would access the more resistant sandstones of the San Jose Formation.

There are several pumice mines on the Santa Fe National Forest outside of the oil-gas study area. The mines range in size from 5 to 80 acres, and are the largest minerals related disturbances on

the forest. Pumice mining is likely to continue as most of the pumice is used in lightweight cinder block products, which are in great demand as communities continue to grow throughout northern New Mexico.

Geothermal resources, humate pits, and coal mines are not anticipated to be developed within the study area. Total long-term bare ground associated with oil and gas and other minerals development is estimated to total about 64 acres or less than 1 percent of the oil-gas study area.

Other foreseeable surface disturbance within the study area would be associated with road decommissioning in the Cuba and Coyote Ranger Districts. Roads anticipated to be needed for future well development would remain on the National Forest System road network. Hundreds of miles of other roads would be identified for decommissioning over the next 20 years, 10 to 20 percent of which would require recontouring, grading, seeding, and other surface-disturbing activities.

Soils and Watershed Management

Affected Environment

The region of influence for soils includes all land within the oil-gas study area. The description of the soils is based on terrestrial ecosystem survey (TES) data (USFS 1993) mapped by the Santa Fe National Forest and Southwestern Region staff. TES units are mapped in the field based on soil, vegetation, and climatic properties, and classified according to a standardized system. Forest wide, they are generalized units that include up to six components or soil subtypes that may be distinctly different from others in the map unit but that cannot be shown at the scale of mapping used. The TES incorporates spatial data in Geographic Information System (GIS) that delineates the mapping units and an associated database that describes for each component the soil properties, natural and current erosion rates, potential success of specific activities like revegetation, and interpretations that include limitations or hazards for a variety of land uses. The interpretations are presented in the form of ratings intended to assist planners and engineers in selecting appropriate sites and soils for designated uses and identifying potential hazards to be further investigated in the field before projects are finalized.

There are 66 TES units within the study area, each of which contains 1 to 5 components, for a total of 246 components. Most soils in the study area are deep and well drained, formed from alluvial or residual materials derived from sandstone, limestone, or granite.

Soil Characteristics and Interpretations for Use

Soil characteristics such as susceptibility to erosion and the potential for revegetation are important to consider when planning for construction activities and stabilization of disturbed areas. These are a function of many physical and chemical characteristics of each soil, in combination with the climate and vegetation.

Table OG-13 summarizes some important soil characteristics to be considered when evaluating the effects of surface-disturbing activities. Explanations of the meanings of each column follow the table. The acreage was calculated using the ratings of the primary soil types or components within each map unit, intended to represent the soil characteristics within the study area. Because some soil map units are not rated for a specific limitation or hazard, the acreage totals for each category characterize between 32 percent and 55 percent of the entire study area.

Table OG-13. Selected characteristics and use ratings of soil map units within the oil-gas study area

Rating	Hazards/Problems Due to Soil Characteristics (acres)			Revegetation Potential—Likely Success (acres)
	Sheet/Rill Erosion	Mass Wasting	Unsurfaced Road Suitability	
Slight/Low	0	38,504	1,181	36,814
Moderate	73,398	21,708	36,808	41,315
Severe/High	37,735	5,764	74,100	33,960

The natural soil loss rate is the minimum rate and predicts the amount of erosion that would occur under well established climax natural vegetative conditions. The current soil loss rate provides a measure of the erosion occurring with existing ground cover, mainly vegetation and litter. Soil loss tolerance is the maximum rate of soil loss that can occur while sustaining productivity. When current soil loss is greater than the tolerance threshold, erosion is considered excessive. This generally happens due to human activities that remove the ground cover and loosen the soil, exposing soil to wind and water, and accelerating the erosion process.

Other factors to be considered when determining whether soil erosion is too high include the quality of the downstream water bodies and their reasons for impairment, discussed further under "Water Resources." Existing problems with sedimentation or turbidity in streams downstream from the district would be exacerbated by accelerated soil erosion. Every map unit within the study area has current soil loss rates that exceed natural soil loss rates. About 28,270 acres of primary components, or about 13 percent of the study area, have current erosion rates that exceed tolerance levels (USFS 1993).

Erosion hazard indicates the relative susceptibility of the soil to erode if the ground cover were removed. Factors that affect this include climate, soil texture, soil structure, and slope length and gradient. Primary soil map unit components with severe erosion hazard ratings total about 18 percent and primary components with a moderate rating comprise about 35 percent of the study area (USFS 1993). Figure OG-18 shows the distribution of moderate and severe erosion hazard ratings within the study area.

Mass wasting describes a variety of processes that result in large masses of soil moved by gravity from one place to another. It is used as an indicator of stability of the land. Mass wasting is most visible along slopes like roadbanks or streambanks where cut slopes have fallen away or slowly moved downhill. Mass wasting is rated high in about 3 percent and moderate in about 10 percent of the study area (USFS 1993). Figure OG-19 shows the areas with moderate and high mass wasting hazards.

Unsurfaced road suitability describes the soil limitations that would cause problems for roads of minimal design and construction. This category is used to alert managers to areas where roads should be rerouted or where mitigation measures would be needed to minimize long-term damage to soils. Approximately 35 percent of the soils in the study area have severe limitations and 18 percent have moderate limitations for unsurfaced road suitability (USFS 1993). Figure OG-20 shows the distribution of moderate and severe unsurfaced road suitability ratings within the study area.

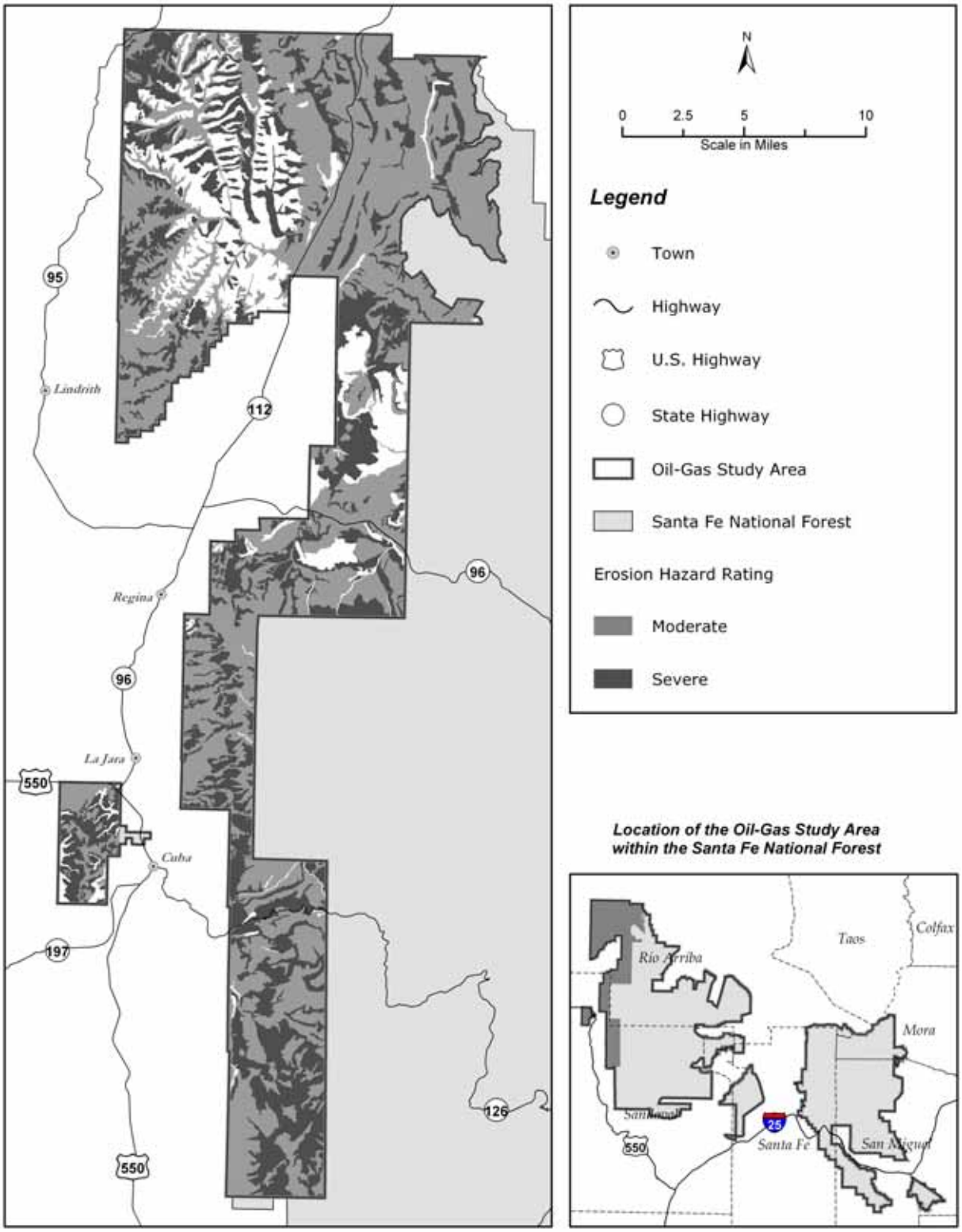


Figure OG-18. Moderate and severe erosion hazard ratings in the study area

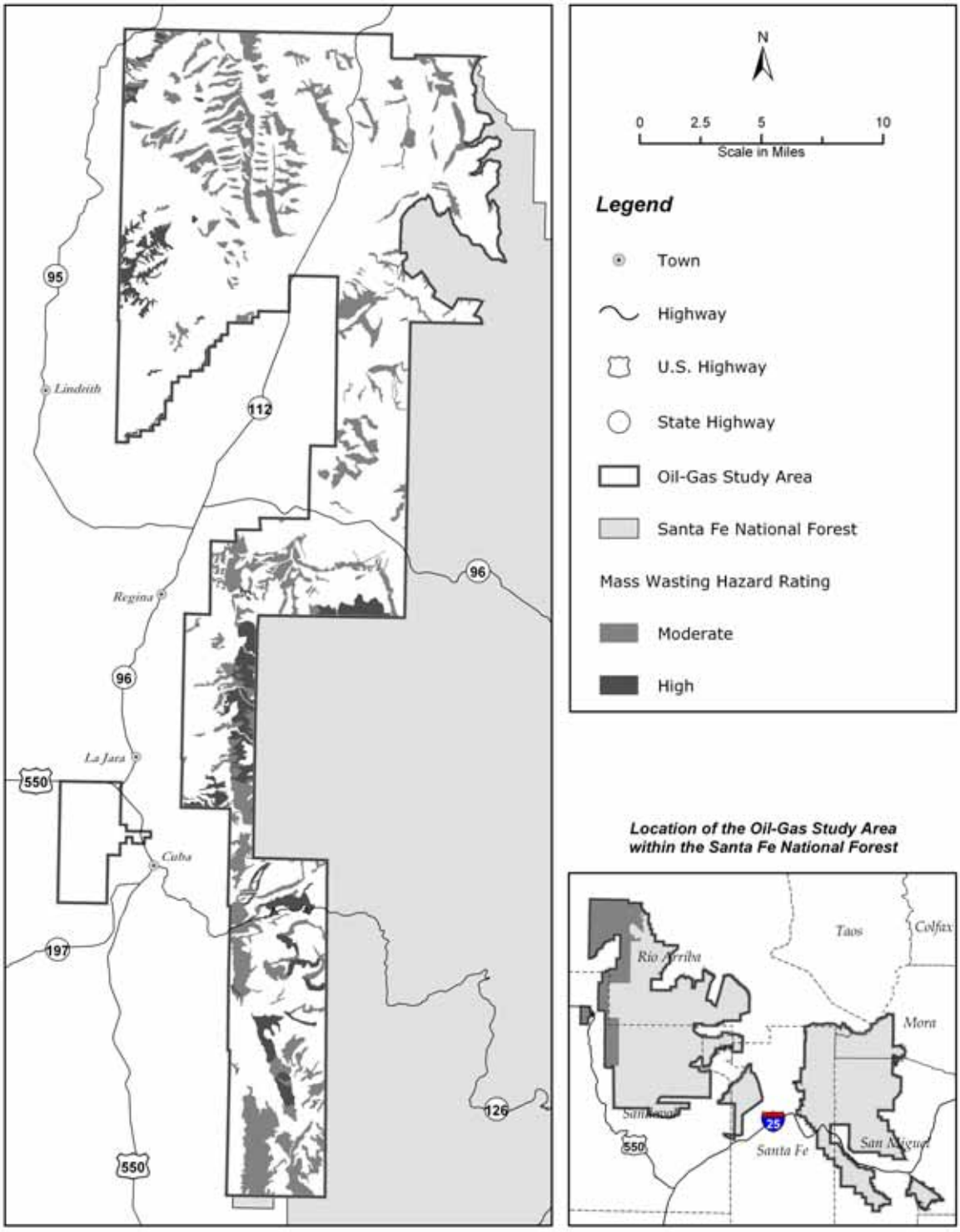


Figure OG-19. Moderate and high mass wasting hazards

Revegetation potential provides an indication of the likelihood of success and ease of establishment of native grasses, based primarily on climate, soil characteristics, and topography. Other factors such as timing, precipitation, and site preparation would affect revegetation success but are not considered in this rating. If soils are disturbed by human activities or wildfires, revegetation is necessary to keep soil in place to maintain productivity and to minimize sedimentation in downstream surface water bodies. About 18 percent of the study area contains soils that have low potential for successful revegetation of disturbed areas, and 20 percent are classified as moderate revegetation potential. Figure OG-21 displays the distribution of soils with low and moderate revegetation potential. Site-specific soil characteristics, as well as climatic conditions, should be taken into account when planning for stabilization of newly constructed well pads, roads, and pipelines.

Some of the mitigation measures or best management practices (BMPs) used as COAs during the APD process that can be selected to minimize the effects of construction or surface disturbance on soils with these hazards are listed in Appendix B. To be effective, the BMPs selected must be appropriate for the site and soil type, determined during site-specific evaluations, usually during the APD process or other NEPA documentation of a project.

Watershed Management

The overall ability of the soil to function properly and retain its productivity is categorized as satisfactory, unsatisfactory, or unsuited in the TES soil condition ratings. The soil condition rating system uses indicators for soil function such as infiltration, erosion, litter, and vegetative community composition (Towns 2000). The amount of each watershed in each condition rating (Table OG-14) was calculated by determining the acreage of the primary components of the map units in each category from the TES. All watersheds but the Rio Chama and Tapicito, a small portion of which is in the study area, have a majority in satisfactory condition.

Table OG-14. Soil condition by watershed

Watershed	Satisfactory	Unsatisfactory	Unsuited
Arroyo Balcon	97%	3%	—
Arroyo Chijuilla	84%	13%	1%
Cañada Larga	62%	23%	12%
Rio Chama	6%	89%	<1%
Rio Gallina	50%	28 %	1%
Rio Guadalupe	99%	—	—
Rio Nutrias	76%	20%	—
Rio Puerco de Chama	100%	—	—
Tapicito Creek	37%	37%	16%

Source: USFS 1993

Soil erosion can be accelerated by construction activities that remove ground cover and canopy cover. Any surface disturbance degrades soil quality and productivity because it damages the biological soil crust and exposes the bare soil to the erosive forces of wind and water until

revegetation or other ground cover is established. Healthy biological soil crust and vegetative cover help to maintain good soil health by reducing soil erosion, increasing surface water infiltration into the soil for use by plants, and decreasing surface water runoff that would carry sediment from soil erosion downstream.

As described in the "Geology and Minerals" section, 157 acres of bare ground currently exist due to active oil and gas facilities and salable minerals pits, primarily in the northern portion of the study area within the Rio Gallina and Rio Nutrias watersheds. The other primary source of bare ground is unsurfaced roads, discussed further in the "Roads Management" portion of this EIS.

Erosion can be expected to be greater where ground cover is the least, although this would be minimized by the installation and maintenance of BMPs appropriate for the site and soil type, determined during site-specific planning.

Sediment delivery to the surface water drainage system of arroyos and streams may result from any type of erosion, whether sheet, rill, or gully. That portion of the soil detached by erosion that actually reaches surface water channels is called sediment yield. 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. As surface disturbance, soil compaction, and vehicular traffic increase in a watershed, the overall watershed condition is adversely affected.

Environmental Consequences

Surface-disturbing activities from construction would directly affect the soils at the construction sites primarily through the loss of protective vegetation accelerating erosion, soil compaction, reduction of surface water infiltration, increase in surface water runoff, and loss of soil productivity through removal of productive acreage for use by roads and wells. Indirect effects that may be caused by earthmoving include sediment entering drainageways eventually transported to perennial water bodies, increased surface waterflows due to reduced infiltration from soil compaction, and disruption of topsoil and biological crusts that would reduce the potential to successfully reseed disturbed areas.

The significance of the direct effects on soils from the surface-disturbing activities (soil displacement, compaction, erosion, loss of productivity), if they occur, can be assessed mainly in relation to the indirect effects on other resources. For example, if surface-disturbing activities cause erosion that leaves the construction site and enters waterways that already have identified impairment due to high volumes of sediment, turbidity, and excessive stream bottom deposits, a small increase in sediment entering this water system may be considered significant. If removal or compaction of topsoil damages soil protecting vegetative cover and limits the success of revegetation to stabilize soils, accelerated erosion would result that would reduce feed and cover for wildlife, forage for livestock, and downstream water quality.

In compliance with Forest Service standards and guidelines and other State and Federal permits like the National Pollutant Discharge Elimination System (NPDES), Storm Water General Permit for Small Construction Program, surface-disturbing activities would be accompanied by site-specific best management practices (BMPs) and measurable goals for implementation and maintenance of stormwater management and erosion control measures. The selection of the

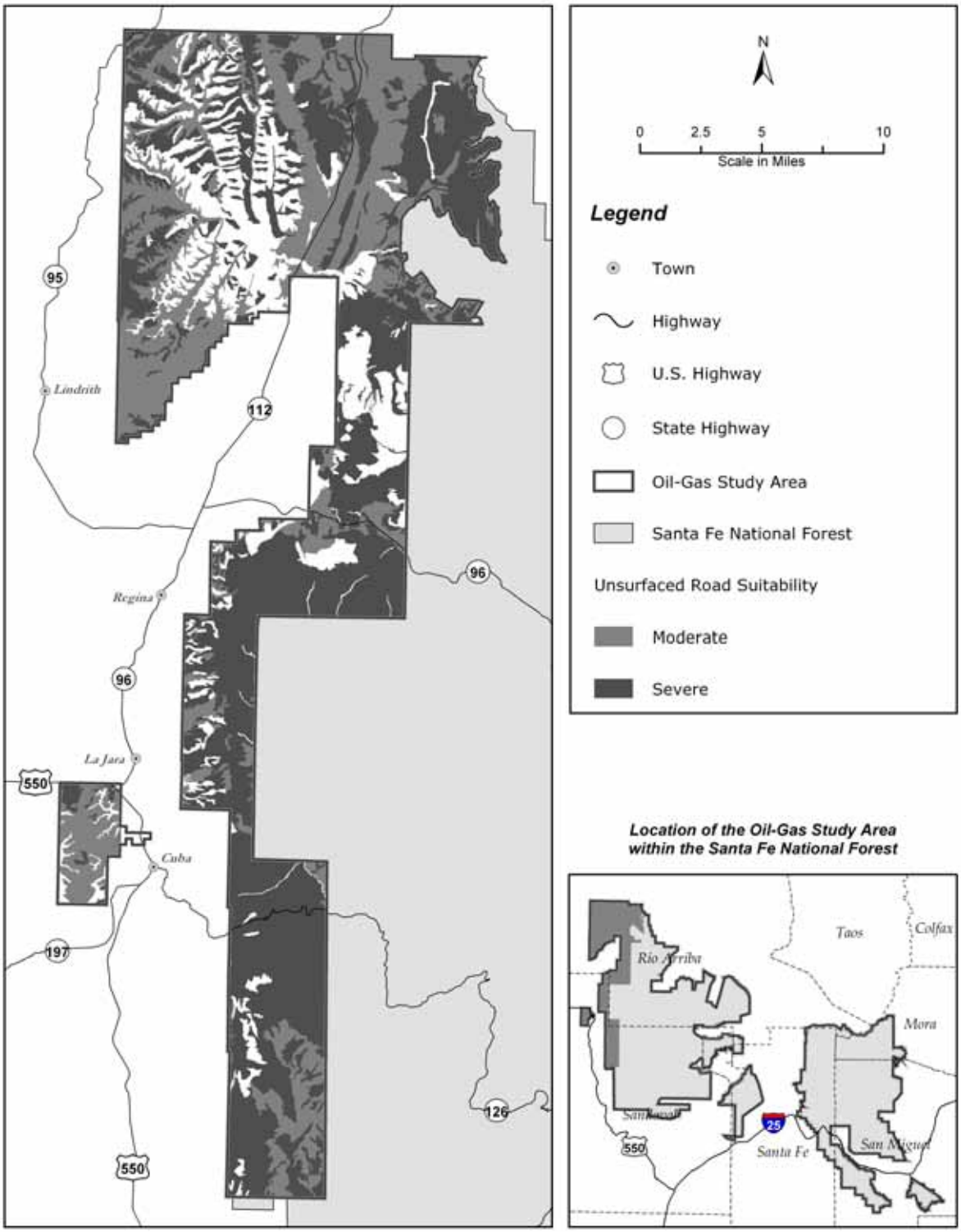


Figure OG-20. Moderate and severe unsurfaced road suitability

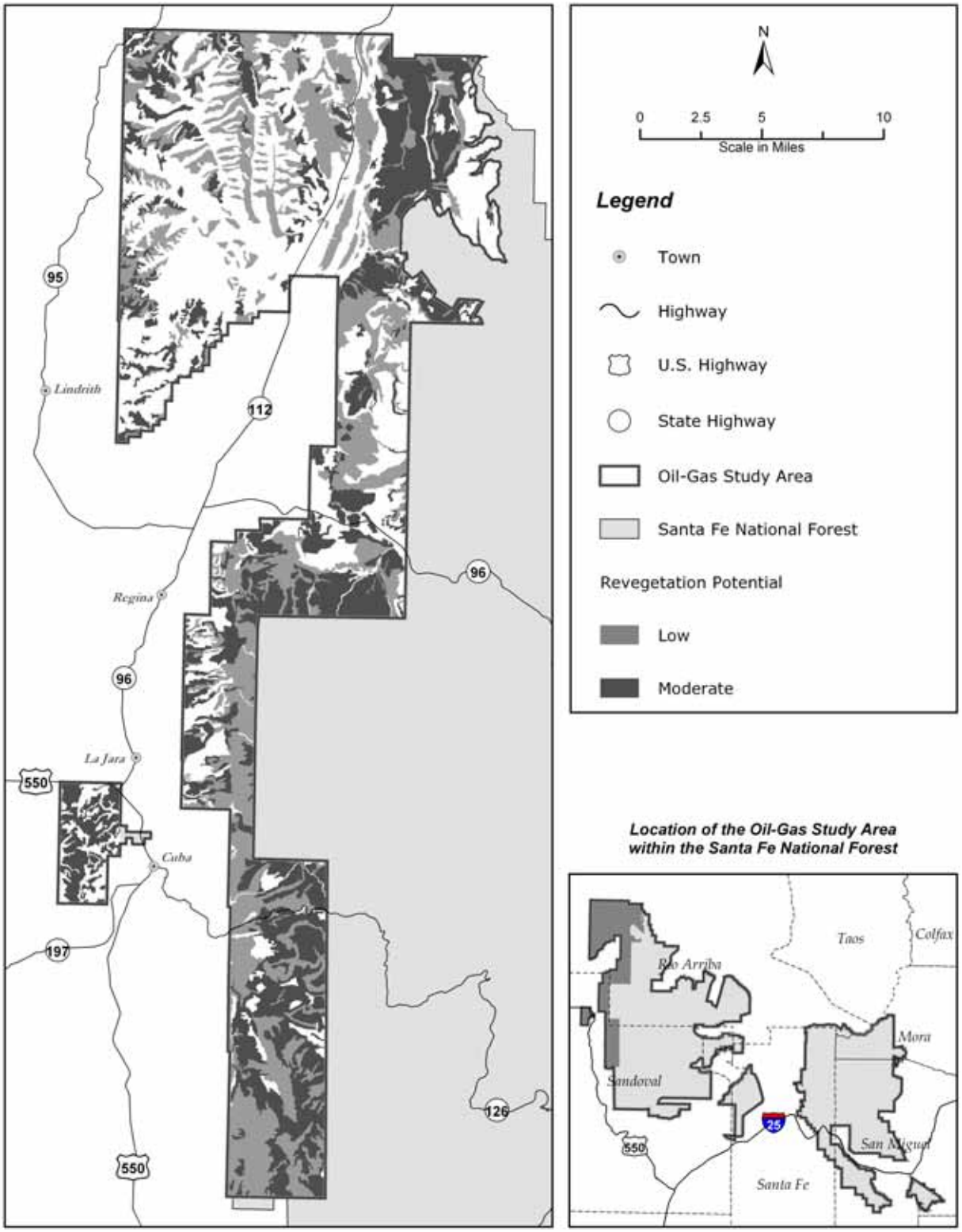


Figure OG-21. Low and moderate revegetation potential soils

BMPs to be used on the ground would be determined during site-specific NEPA analysis conducted at the time the exact location of a proposed project is known. BMP selection would be based on the effectiveness of specific BMPs and site characteristics including the type of project, soil type, location on the landscape, slope steepness and gradient, climatic information, whether the site is near sensitive areas or resources, and whether they would be selected for shorter term well pad use or long-term pad rehabilitation and reclamation.

Alternative 1—No Action

Under the No Action Alternative, the Forest Plan would not be amended and oil-gas leases would continue to be issued under standard terms and conditions. This decision and the issuance of mineral leases would not, by itself, result in surface disturbing activities nor have any direct effect on soils or watershed conditions. Development of the oil-gas leases including construction of wells, roads, and associated structures would be evaluated for impacts to soils and watersheds, with site-specific mitigation measures, through environmental assessments during the APD process.

Alternative 2—Proposed Action

Under the Proposed Action alternative, the proposed Forest Plan amendment and issuance of oil-gas leases would not result in surface-disturbing activities or have direct effects on soils or watershed conditions. Development of the oil-gas leases including construction of wells, roads, and associated structures would be evaluated for impacts to soils and watersheds, with site-specific mitigation measures, through NEPA analysis during the APD process. However, the addition of NSO lease stipulations would provide for future protection of soils through prohibiting development on almost 26,000 acres of steep slopes (≥40 percent) that would be the most likely to erode and the most difficult to implement and maintain erosion control measures.

Alternative 3

Under Alternative 3, the proposed Forest Plan amendment and issuance of mineral leases would not result in surface-disturbing activities or have direct effects on soils or watershed conditions. Development of the oil-gas leases including construction of wells, roads, and associated structures would be evaluated for impacts to soils and watersheds, with site-specific mitigation measures, through NEPA documentation during the APD process. NSO areas in addition to those proposed under Alternative 2 would provide for future protection of soils through prohibiting development on about 4,000 additional acres, if oil-gas development were implemented on new leases.

Cumulative Impacts

The cumulative effects on soils should take into account all surface-altering actions that have occurred or are reasonably foreseeable. The most frequent effects of surface disturbance on soils in this region are decreases in soil quality and productivity through compaction during construction activities and accelerated erosion due to the removal of vegetation, which would affect downstream water bodies. The relevant areas to consider when discussing cumulative effects of multiple surface-disturbing activities would be those on all land within the watersheds in which the national forest land is located (see “Water Resources” section).

Construction activities related to oil-gas development and road decommissioning within these watersheds would be the primary cause of the known and foreseeable surface-disturbing activities to consider cumulative effects. The extraction of salable minerals occurs in scattered small acreage and may increase associated with oil-gas development. All of the 20 well pads projected in the RFDS are located on existing valid oil-gas leases, so none would be developed under the new lease stipulations proposed under Alternatives 2 and 3. All would be developed under standard terms and conditions, with implementation of site-specific mitigation measures to minimize soil erosion, documented in an environmental analysis during the APD process. As presented in the "Geology and Minerals" section, total short-term surface disturbance associated with oil-gas development within the next 20 years is projected to be about 100 acres within the entire study area, and 64 acres of long-term bare ground. If any existing leases were relinquished, and if oil or gas wells were developed under new lease terms in compliance with either Alternative 2 or 3, the proposed lease stipulations would protect erodible soils on steep slopes and contribute to improved management of surface resources.

A summary of Forest Service projects planned in the near future in or near the study area is included in Table OG-15. All of these projects have the potential for short-term adverse impacts to soils and water resources because they involve surface disturbances or disruption of vegetative cover. All projects listed in Table OG-15 are planned to be implemented in 2005 or 2006, but it is likely that similar projects would be completed throughout the 20-year period considered in this DEIS. In all Forest Service projects, appropriate BMPs would be implemented to minimize offsite erosion, fugitive dust, and sedimentation.

Table OG-15. Foreseeable Forest Service projects planned in the near future in or near the project area other than oil and gas well development

Foreseeable Future Projects	Description of Work to Be Done	Project Location
1. Coyote District Road Closure and Decommissioning Project	Closure and decommissioning of about 466 miles of Forest Service system roads district wide.	Coyote Ranger District
2. Cerro Pelon Forest Health Thinning and Prescribed Fire Project	Approximately 250 acres of salvage thinning to improve forest health, restore wildlife habitat, improve forage conditions and protect watershed conditions.	Coyote Ranger District
3. Deer Lake Estates Fuels Reduction Phase II	A 1,035-acre project to reduce the risk of high intensity wildfire. Project includes thinning on 600 acres and prescribed fire on all 1,035 acres.	Cuba Ranger District: South and west of the community of Deer Lake Estates
4. Invasive Plant Control Project	Control treatments of invasive nonnative plants through manual, mechanical, biological, controlled grazing with goats/sheep, herbicides, and prescribed fire.	Santa Fe National Forest, all units forest wide
5. East Puerto Chiquito Mancos Unit Gathering System Pipeline Extension	Extend the East Puerto Chiquito Mancos Unit gathering system to the EPCMU #34/K 5 well. A 3-inch oil line and 2-inch gas line will be laid immediately adjacent to the existing road in the same trench.	Cuba Ranger District: approximately 2 miles north of the town of Llaves

Table OG-15. Foreseeable Forest Service projects planned in the near future in or near the project area other than oil and gas well development

Foreseeable Future Projects	Description of Work to Be Done	Project Location
6. Laguna Simon Cedar and Sagebrush Thinning	Commercial thinning, slash treatment, and prescribed burning for vegetation management on about 300 acres in the Llaves Valley.	Cuba Ranger District: two project areas located west of Llaves, NM in the Rio Gallinas watershed
7. Ojitos Meadow Restoration and Wildlife Habitat Improvement Project	Thinning and prescribed fire on about 200 acres.	Cuba Ranger District: Ojitos Mesa
8. Forest Road 103 Vegetation Management	Thinning and prescribed fire on approximately 3,500 acres to change the existing vegetation structure so that the landscape is more resilient to disturbances, primarily fire and insect and disease.	Cuba Ranger District: adjacent to Forest Road 103 near Deer Lake Estates and Miller Estates

Surface-disturbing activities other than oil-gas development that may cause accelerated erosion, affecting soil stability and quality, may occur on land not managed by the Forest Service within the study area, but are currently unknown. These activities include, but are not limited to, construction of buildings, roads, and other facilities; road maintenance like grading and ditch-cleaning; cross-country travel by off-highway vehicles (OHVs); installation of trenches for utilities; vegetation management activities; and agricultural activities like plowing, planting, and livestock grazing.

Water Resources

Affected Environment

The oil-gas study area is located primarily in the greater Rio Grande watershed with parts of two other watersheds (about 5 percent of the study area) draining to the San Juan River. The study area is varied in ecosystem type and land use management. Dominant upstream land uses include oil-gas leasing, mining, irrigated crop production, livestock grazing, and forestry (NMED 2004). These activities affect the chemical and physical characteristics of the watersheds.

Surface Water

Within the study area, seven 5th-level hydrologic units or watersheds[1] drain into the Rio Grande, comprising the majority of the area. They are included in three 4th-level hydrologic units: Rio Chama (Rio Chama, Rio Nutrias, Rio Gallina, and Rio Puerco de Chama), Rio Puerco (Arroyo Chijuilla and Arroyo Balcon), and Jemez River (Rio Guadalupe). Tapicito Creek and Cañada Larga watersheds are located west of the Continental Divide, drain to the San Juan River and are

[1] Watersheds are hierarchical in nature and are defined as "any area of land that drains to a common point" (USFS 1995). The 5th-level watersheds are based on subdivisions of the 4th-level hydrologic unit codes (HUC) delineated by the U.S. Geological Survey (USGS).

part of the Colorado River Basin. These two watersheds comprise a very small part (5 percent) of the total study area. Table OG-16 and Figure OG-22 display the portions of each watershed within the study area.

Table OG-16. Watersheds within the study area

Subwatershed	HUC[1]	Drains to Downstream River	Total Acres of Watershed	Acres of NFS Land	Percent of Watershed in Study Area
Arroyo Balcon	1302020402	Rio Puerco	111,870	4,902	4%
Arroyo Chijuilla	1302020401	Rio Puerco	164,998	43,051	28%
Cañada Larga	1408010302	San Juan River	189,941	7,921	4%
Rio Chama	1302010202	Rio Chama	250,435	194	<1%
Rio Gallina	1302010204	Rio Chama	179,528	102,289	61%
Rio Guadalupe	1302020201	Jemez River	171,121	9,674	6%
Rio Nutrias	1302010203	Rio Chama	229,483	25,646	12%
Rio Puerco de Chama	1302010205	Rio Chama	130,550	564	<1%
Tapicito Creek	1408010303	San Juan River	213,917	2,639	1%

[1] Hydrologic Unit Code, defined by USGS. HUCs listed are 5th-level watersheds. NFS refers to National Forest System lands.

Surface waters within the nine watersheds in the study area include mainly ephemeral and intermittent drainages, with a few perennial streams, including Rio Capulin, Cecilia Creek, and Rio Gallina. Storms may create high flows due to surface water runoff that are commonly of limited duration and extent. Peak streamflows within each watershed are affected by the type, distribution, and condition of vegetation, precipitation, soil characteristics, and slopes. Structures on the landscape, such as roads, ponds, and well pads, modify the flow of surface water runoff. Roads intercept surface water runoff on the landscape and often direct water to drainageways through ditches and culverts. Construction areas such as well pads and roads are compacted or surfaced, causing rainfall to run off the surface where it originally infiltrated the soil. Stock tanks and wetlands represent artificial or natural water impoundments that slow down surface water runoff, reducing peak flows and increasing infiltration into the ground.

Stormflows and normal streamflow in the arroyos, canyons, and streams in the oil-gas study area often cut into streambanks, soil, and other unconsolidated materials, contributing sediment to the downstream river system.

A water quality standard defines water quality goals by designating uses for the water, setting minimum standards to protect the designated uses, and establishing the intent to prevent degradation of water quality. The intent of a state antidegradation policy is to maintain a water body in a condition suitable to serve its intended purpose. For example, New Mexico waters used as a source of fish must meet the strict “fish consumption” standards for benzo(a)pyrene. Actions that would cause levels of this contaminant to exceed the allowable level for the “fish consumption” designation would not be allowed. This would be true even if the water remained

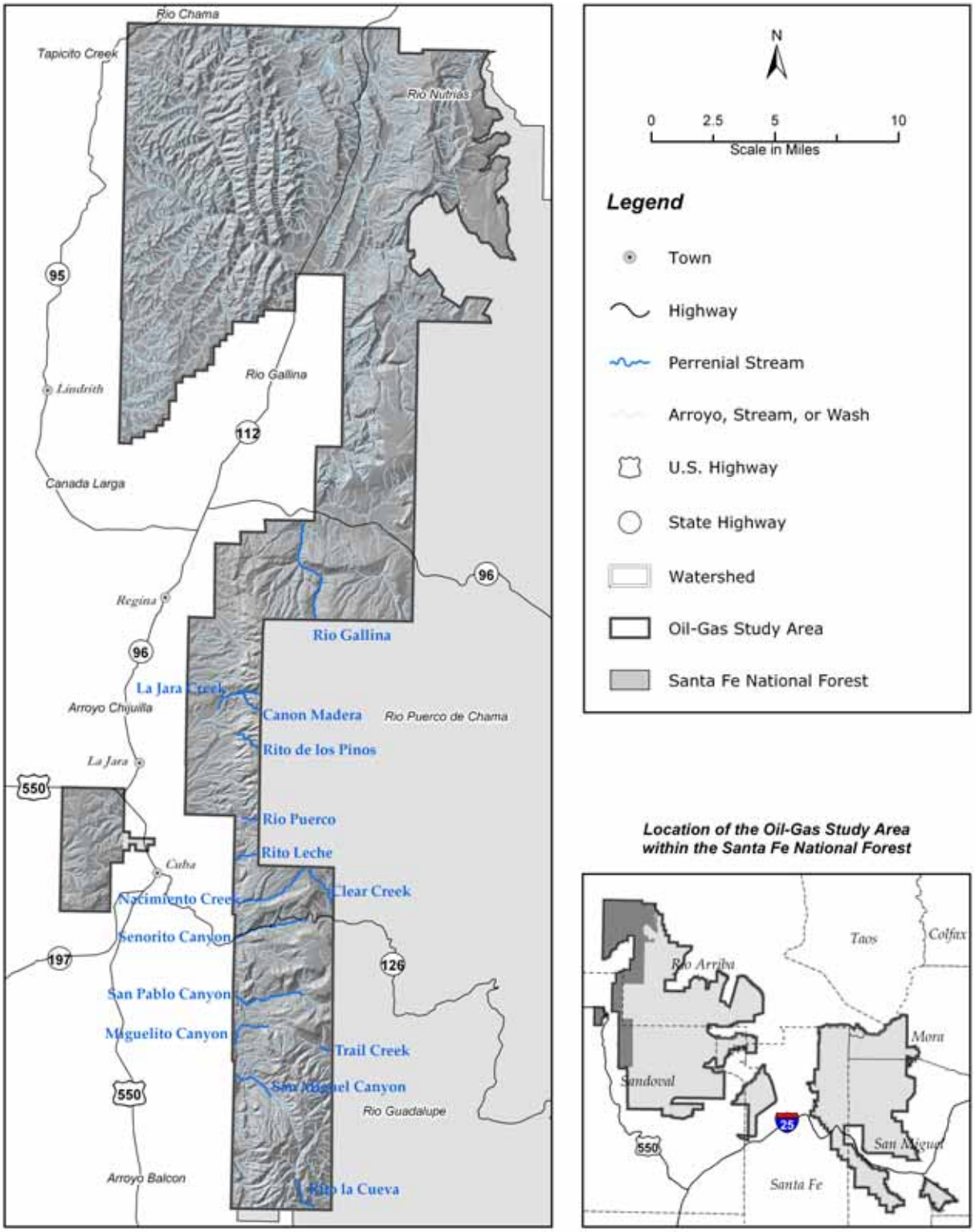


Figure OG-22. Watersheds and streams in the study area

of adequate quality to serve other uses for which it was designated, such as a drinking water source or for swimming (NMWQCC 2004).

Antidegradation policies are intended to maintain water quality at existing levels even if it is already better than the minimum standard necessary to protect designated uses. Antidegradation should not be interpreted to mean that no degradation can or will occur, as degradation may be allowed for certain pollutants in even the most pristine waters. However, that degradation must be demonstrated to be temporary and short term in nature.

Several stream or river segments in and adjacent to the study area are on New Mexico's 2004 303(d) list of impaired water bodies (NMED 2004). Most of these impaired waters have turbidity, stream bottom deposits, and/or temperature listed as causes of impairment. Potential sources of surface water quality impairment come from erosion from bare soil due to surface-disturbing activities such as construction, loss of riparian habitat, streambank modifications, timber harvesting, overgrazing, some farming activities, and roads. The streams in Table OG-17 are designated as an impaired use by the New Mexico Environment Department for water quality (NMED 2004). They are displayed in Figure OG-23.

Table OG-17. Streams in the oil-gas study area listed as impaired waters

Watershed	HUC	Stream	Uses Not Supported	Probable Causes—Sources of Impairment
Arroyo Balcon; Arroyo Chijuilla	1302020402 1302020401	Rio Puerco (Rito Olguin to headwaters)	Coldwater Fishery	Sedimentation/Siltation, Water Temperature— Highway/road/bridge runoff (non-construction related) Loss of riparian habitat Rangeland grazing Streambank Modifications/destabilization
Arroyo Balcon; Arroyo Chijuilla	1302020402 1302020401	San Pablo Canyon (Rio Puerco to headwaters)	Coldwater Fishery	Nutrient/Eutrophication, Sedimentation/Siltation— Habitat modification Abandoned mine lands Loss of riparian habitat Rangeland grazing
Arroyo Chijuilla	1302020401	Nacimiento Creek (USFS boundary to San Gregorio Reservoir)	Coldwater Fishery	Nutrient Eutrophication— Sediment/siltation Loss of riparian habitat Rangeland grazing Streambank Modifications/destabilization
Arroyo Chijuilla	1302020401	Rito Leche (Perennial reaches above Rio Puerco)	Coldwater Fishery	Sedimentation/Siltation— Loss of riparian habitat Rangeland grazing Streambank Modifications/destabilization

Table OG-17. Streams in the oil-gas study area listed as impaired waters

Watershed	HUC	Stream	Uses Not Supported	Probable Causes—Sources of Impairment
Rio Chama; Rio Nutrias	1302010202 1302010203	Rio Nutrias (Rio Chama to headwaters)	High Quality Coldwater Fishery	Turbidity— Crop production Loss of riparian habitat Rangeland grazing Streambank Modifications/destabilization
Rio Gallina	1302010204	Cecilia Canyon Creek (Rio Capulin to USFS boundary)	High Quality Coldwater Fishery	Sedimentation/Siltation— Loss of riparian habitat Recreational pollution Rangeland grazing Streambank Modifications/destabilization
Rio Gallina	1302010204	Clear Creek (Rio Gallina to headwaters)	High Quality Coldwater Fishery	Sedimentation/Siltation— Forest roads (construction and use) Rangeland grazing Streambank Modifications/destabilization
Rio Guadalupe	1302020201	Calaveras Creek (Rio Cebolla to headwaters)	High Quality Coldwater Fishery	Sedimentation/Siltation— Highway/road/bridge runoff (non-construction related)
Rio Guadalupe	1302020201	Rio Guadalupe (Jemez River to confluence with Rio Cebolla)	High Quality Coldwater Fishery	Aluminum, Sedimentation/Siltation, Turbidity— Habitat modification Loss of riparian habitat Other recreational pollution sources Rangeland grazing
Rio Puerco de Chama	1302010205	Poleo Creek (Rio Puerco de Chama to headwaters)	High Quality Coldwater Fishery	Turbidity— Forest roads (construction and use) Loss of riparian habitat Natural sources Streambank Modifications/destabilization
Rio Puerco de Chama	1302010205	Rio Puerco de Chama (Abiquiu Reservoir to Poleo Creek)	Coldwater Fishery, Warmwater Fishery, Secondary Contact	Fecal Coliform, Water Temperature— Loss of riparian habitat Onsite treatment systems Rangeland grazing
Rio Puerco de Chama	1302010205	Rio Puerco de Chama (Poleo creek to headwaters)	High Quality Coldwater Fishery	Sedimentation/Siltation— Loss of riparian habitat Natural sources Silviculture harvesting Streambank Modifications/destabilization

Table OG-17. Streams in the oil-gas study area listed as impaired waters

Watershed	HUC	Stream	Uses Not Supported	Probable Causes—Sources of Impairment
Rio Puerco de Chama	1302010205	Rito Resumidero (Rio Puerco de Chama to headwaters)	High Quality Coldwater Fishery	Sedimentation/Siltation— Forest roads (construction and use) Loss of riparian habitat Rangeland grazing Silviculture harvesting Streambank Modifications/destabilization

Source: NMED 2004

Ground Water

In the study area, water depths in domestic wells are shallow, ranging from 6 feet deep in the southern part (Arroyo Chijuilla watershed) to 304 feet in the Rio Gallina watershed (NMOSE 2003). The deepest wells occur in the San Jose Formation in the Rio Gallina watershed, where there are few active water wells. Most domestic wells occur in alluvium overlying bedrock (USGS 1997). The majority of wells provide yields of less than 25 gallons per minute (gpm) (USFS 1986).

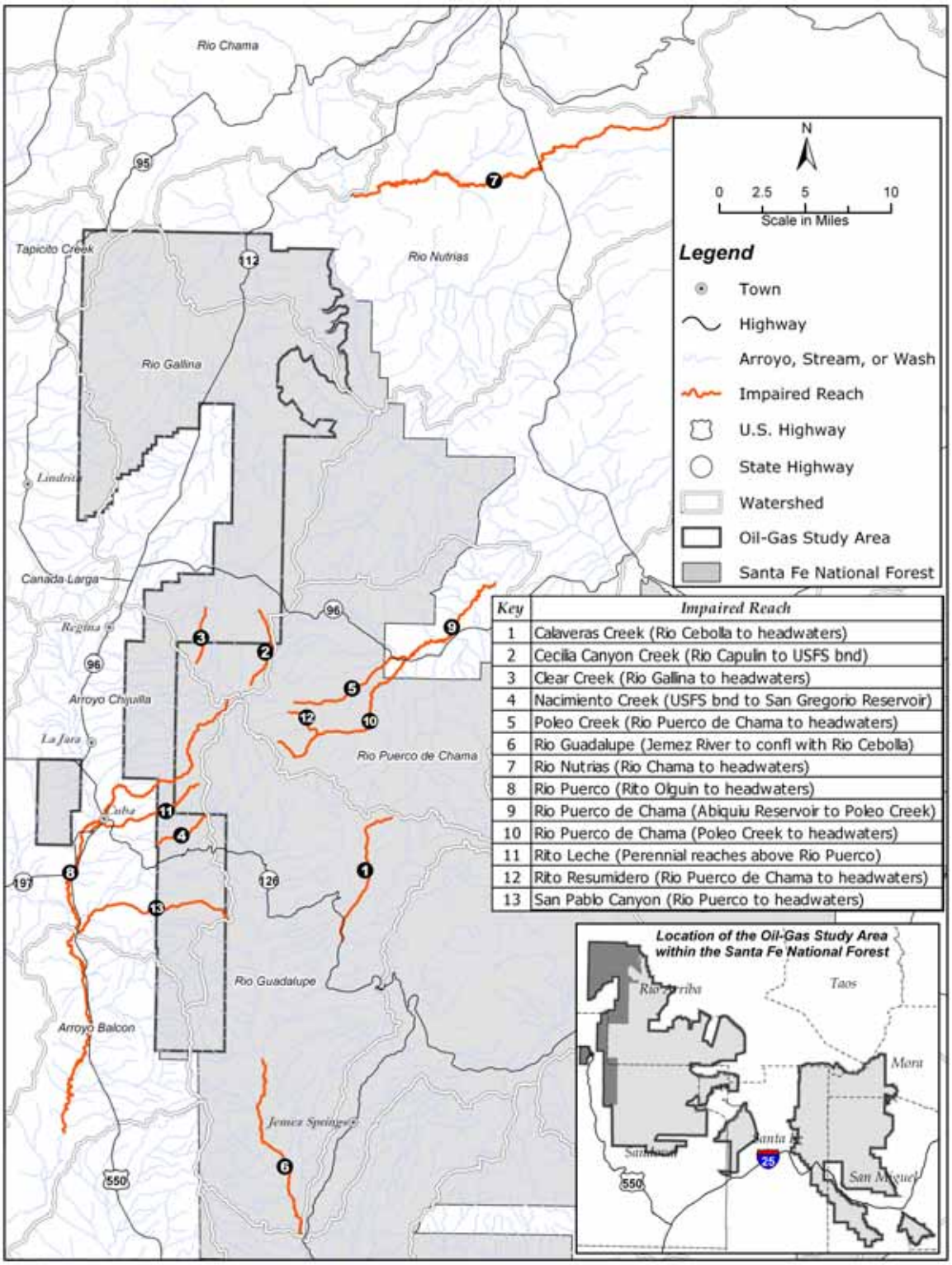
Ground water recharge to the deep, high quality San Jose formation occurs in areas of higher elevation from precipitation on sandstones present near the surface along the boundaries of the Nacimiento Uplift (USFS 2004a).

The primary ground water quality concerns identified by the State of New Mexico (NMWQCC 2004) in the upper Rio Grande watershed are caused by releases from leaking underground storage tanks, abandoned mine sites, sewage treatment plants, and landfills. Point sources are typically from oil and gas production including pipelines, storage, distribution, and refining sites.

Environmental Consequences

This section provides a description of potential effects on water resources from oil and gas leasing and development, and the direct, indirect and cumulative effects on water resources are evaluated. Comparisons are drawn between the effects on water resources under the action alternatives and the No Action Alternative.

In all alternatives, areas of existing leases could be developed and may affect water resources. The degree that each alternative could eventually affect water resources would be dependent on the stipulations under which new leases are issued.



Key	Impaired Reach
1	Calaveras Creek (Rio Cebolla to headwaters)
2	Cecilia Canyon Creek (Rio Capulin to USFS bnd)
3	Clear Creek (Rio Gallina to headwaters)
4	Nacimiento Creek (USFS bnd to San Gregorio Reservoir)
5	Poleo Creek (Rio Puerco de Chama to headwaters)
6	Rio Guadalupe (Jemez River to confl with Rio Cebolla)
7	Rio Nutrias (Rio Chama to headwaters)
8	Rio Puerco (Rito Olguin to headwaters)
9	Rio Puerco de Chama (Abiquiu Reservoir to Poleo Creek)
10	Rio Puerco de Chama (Poleo Creek to headwaters)
11	Rito Leche (Perennial reaches above Rio Puerco)
12	Rito Resumidero (Rio Puerco de Chama to headwaters)
13	San Pablo Canyon (Rio Puerco to headwaters)

Figure OG-23. Impaired stream reaches within the watersheds encompassing the study area

Alternative 1—No Action

Under Alternative 1, standard lease terms and conditions and small areas of limited surface use stipulations would continue to be implemented on all new leases within the study area. The 20 new well locations and associated access roads projected by the RFDS (USFS 2004a) would be located on existing leases. Even if an existing lease were relinquished and re-issued, there would be no change in the lease stipulations that would have a potential effect on water resources.

Under the standard lease terms, where development on steep slopes or unstable soils cannot be avoided, surface disturbance in these areas could contribute to sedimentation in surface waters. Surface disturbance causing vegetation removal and drainage alterations that could increase sediment delivery to streams would be minimized using conditions of approval and standard BMPs identified during the site-specific APD process. Potential impacts to surface waters would be minor and short term for temporary or exploratory activities and minor to moderate and long term for oil and gas field development and operations.

Adverse impacts to waters of the U.S. would be minimized in accordance with requirements of Sections 401 and 404 of the Clean Water Act and the Forest Service Soil and Water Conservation Practice Handbook 2509.22.

Risk from accidental spill or leakage from oil and gas production operations or storage facilities would be low should a spill occur. In compliance with state law, oil and gas production and storage facilities would develop and implement adequate spill prevention control plans. Potential impacts to surface water and ground water would be minor and short term for exploratory activities and could increase to moderate and larger oil and gas field development and long-term operations. Impacts would be limited to those that may occur from operations currently being conducted on existing oil and gas leases. Existing requirements in the regulations governing the drilling of wells and disposal of produced water provide sufficient mitigation to ensure that adverse impacts to ground water would not occur.

Alternative 2—Proposed Action

Under this leasing alternative, potentially undesirable locations for well sites and other facilities on new leases would be avoided through NSO and CSU lease stipulations. The 20 new well pads and associated access roads projected for the study area are on existing leases, so this alternative would only affect the potential impacts to water resources on new leases; however, current EOIs would be subject to the proposed lease stipulations.

Under the Proposed Action, NSO stipulations on new leases would apply on steep, unstable soils and would minimize surface-disturbing activities that interfere with natural drainage and vegetative cover, resulting in the potential for minimal erosion and sedimentation if new leases, such as the current EOIs, were developed. Risks from accidental spill or leakage from oil and gas production operations or storage facilities would be the same as described for Alternative 1, except for areas subject to the proposed CSU stipulations that specify avoidance of wetland and riparian areas, generally located near streams and arroyos. Increased protection of riparian and wetland areas would reduce the probability for adverse impacts to surface waters from sedimentation along stream channels and spills near drainageways. Timing limitations on drilling operation and construction activities would also reduce the risk of accidental spill or leakage into streams during winter and spring periods, providing short-term beneficial protection of water resources and aquatic habitats.

There would be no difference in the potential for impacts to ground water resources under this alternative, compared to Alternative 1.

Alternative 3

Under Alternative 3, impacts would be the same as described under Alternative 2 except there would be increased NSO stipulations on new leases. The increased acreage of NSO would provide more protection against surface disturbance and associated sedimentation in surface water bodies. As under Alternatives 1 and 2, the proposed lease stipulations would not likely affect impacts on water resources from the projected 20 new well pads and associated access roads projected to occur on existing leases or from the lands currently under EOIs.

Cumulative Impacts

Incremental increases in surface disturbance and development activity are expected to continue to occur in the study area, primarily due to the projected development of 20 well pads and associated roads under standard terms and conditions, as well as road decommissioning and extraction of salable minerals on National Forest System lands. The projects listed in Table OG-15 have the potential to affect surface water quality. Short-term adverse impacts are likely to result from all eight projects, but all would have long-term beneficial impacts to surface water quality due to improvements in vegetative cover and road decommissioning. These known and foreseeable surface-disturbing activities, combined with other actions on private land within the study area and on land in the watersheds downstream from the Santa Fe National Forest, have the potential to contribute to degradation of streams downstream, primarily through sedimentation. The other actions may include construction of buildings, roads, oil-gas wells, and other facilities; road maintenance like grading and ditch cleaning; cross-country travel by off-highway vehicles (OHVs); installation of trenches for utilities; vegetation management activities; and agricultural activities like plowing, planting, and livestock grazing.

Alternative 1 could have the greatest potential to affect surface water quality because it would provide the least protection for sensitive resources from oil-gas development if wells on new leases were developed in the future. The Proposed Action offers more protection for surface water quality through the proposed CSU lease stipulations that would limit surface disturbance in areas most likely to increase sediment delivery while limiting development in wetland and riparian areas near drainageways. Alternative 3 has the greatest potential for beneficial cumulative effects on surface water quality because it proposes the most acreage prohibited from surface disturbance under new leases.

Ground water quality is not likely to be affected by Forest Service actions, but may be adversely affected by other activities in the region, such as drilling of domestic water wells and oil-gas development.

Air Quality

Affected Environment

This section describes the existing air resource for the study area and applicable air quality regulations that could apply to the project. At the present time, the project region attains all national and New Mexico ambient air quality standards and air quality has not been a substantial constraint to oil-gas development in the region.

Air quality in a given location is defined by pollutant concentrations in the atmosphere and is generally expressed in units of parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$). One aspect of air quality significance is a pollutant's concentration in comparison to a national and/or state ambient air quality standard. These standards represent the maximum allowable atmospheric concentrations that may occur and still protect public health and welfare, and include a reasonable margin of safety to protect the more sensitive individuals in the population. National standards, established by the U.S. Environmental Protection Agency (EPA), are termed the National Ambient Air Quality Standards (NAAQS). The NAAQS represent maximum acceptable concentrations that generally may not be exceeded more than once per year, except the annual standards, which may never be exceeded. State standards, established by the New Mexico Environmental Improvement Board (EIB) and enforced by the New Mexico Environment Department, Air Quality Bureau (NMED-AQB), are termed the New Mexico Ambient Air Quality Standards (NMAAQS). The NMAAQS are at least as restrictive as the NAAQS and include standards for total suspended particulate matter (TSP) for which there are no national standards. Table OG-18 presents the national and state ambient air quality standards.

The pollutants of primary concern that are considered in this air quality analysis include volatile organic compounds (VOCs), nitrogen oxides (NOx), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 microns in diameter (PM_{10}), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). Although VOCs and NOx (other than nitrogen dioxide) have no established ambient standards, they are important as precursors to ozone formation. Standards for $PM_{2.5}$ have been promulgated, but are not yet enforceable.

Region of Influence

Identifying the region of influence for air quality effects requires knowledge of the types of pollutants being emitted, pollutant emission rates, topography, and meteorological conditions. The region of influence for inert pollutants (pollutants other than ozone and its precursors) is generally limited to a few miles downwind from a source.

The region of influence for ozone can extend much farther downwind than for inert pollutants. Ozone is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants, or precursors (i.e., VOCs and NOx). In the presence of solar radiation, the maximum effect of VOCs and NOx emissions on ozone levels usually occurs several hours after they are emitted and many miles from the source. Therefore, the region of influence for ozone may include much of the north-central portions of New Mexico and southern portions of Colorado.

Baseline Air Quality

The EPA has designated all areas of the United States as having air quality better than (attainment) or worse than (nonattainment) the NAAQS. A nonattainment designation generally means that a primary NAAQS has been exceeded more than once per year in a given area. Areas without sufficient data to determine the attainment/nonattainment status are designated as "unclassified." At the present time, the entire study area (and all of Rio Arriba County and Sandoval County) is in attainment or unclassified for all national and state ambient air quality standards. The only nonattainment areas in New Mexico are in the southern part of the state.

Table OG-18. National and New Mexico ambient air quality standards

Pollutant	Averaging Time	New Mexico Standards	National Standards (a)	
			Primary (b,c)	Secondary (b,d)
Ozone	8-hour	—	0.084 ppm	Same as primary
	1-hour	—	0.124 ppm	Same as primary
Carbon monoxide	8-hour	8.7 ppm	9 ppm	—
	1-hour	13.1 ppm	35 ppm	—
Nitrogen dioxide	Annual	0.05 ppm	0.053 ppm	Same as primary
	24-hour	0.10 ppm	—	—
Sulfur dioxide	Annual	0.02 ppm	0.03 ppm	—
	24-hour	0.10 ppm	0.14 ppm	—
	3-hour	—	—	0.5 ppm
PM_{10}	Annual (arithmetic mean)	Same as Federal	50 $\mu g/m^3$	Same as primary
	24-hour	Same as Federal	150 $\mu g/m^3$	Same as primary
$PM_{2.5}$	Annual (arithmetic mean)	Same as Federal	15 $\mu g/m^3$	Same as primary
	24-hour	Same as Federal	65 $\mu g/m^3$	Same as primary
Total Suspended Particulates (TSP)	Annual (geometric mean)	60 $\mu g/m^3$	—	—
	30-day Average	90 $\mu g/m^3$	—	—
	7-day	110 $\mu g/m^3$	—	—
	24-hour	150 $\mu g/m^3$	—	—
Lead	Quarterly Average	—	1.5 $\mu g/m^3$	Same as primary

Notes:(a) Standards other than the 1-hour ozone, 24-hour PM_{10}, and those based on annual averages are not to be exceeded more than once a year. The 8-hour ozone standard will eventually replace the 1-hour ozone standard and the $PM_{2.5}$ standard (particulate matter with a 2.5 micron diameter) will be implemented over an extended timeframe. The EPA is in the process of developing policies on how to implement these standards.

(b) Concentrations are expressed in units in which they were promulgated. $\mu g/m^3$ = micrograms per cubic meter and ppm = parts per million. Units shown as $\mu g/m^3$ are based upon a reference temperature of 25 °C and a reference pressure of 760 mm of mercury.

(c) Primary Standards: The levels of air quality necessary, with an adequate margin of safety to protect the public health.

(d) Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

$\mu g/m^3$ = micrograms per cubic meter; ppm = parts per million

Generally, concentrations of photochemical smog, or O_3, are highest during the summer months and coincide with the season of maximum solar insolation. Inert pollutant concentrations tend to be the greatest during periods of light winds, stable atmospheric conditions, and surface-based temperature inversions. These conditions limit atmospheric dispersion. However, in the case of PM_{10} impacts from fugitive dust episodes, maximum dust impacts within the study area often occur during high wind events and/or in proximity to manmade ground-disturbing activities, such as agricultural tilling, vehicular activities on unpaved surfaces, and mining operations.

Presently, there is one monitoring station within the study area, the IMPROVE aerosol station on Eureka Mesa, is maintained by the Santa Fe National Forest to monitor visibility in San Pedro Parks Wilderness. There are no other air quality monitoring stations in Rio Arriba County or the study area. However, the overall air quality of the region can be conservatively represented by data measured at the Bloomfield and Farmington stations in nearby San Juan County to the west, as well as by data from monitoring stations located in southeast Sandoval County. The Bloomfield station occurs within the highly industrialized Bloomfield gas corridor and the NMED-AQB uses this station to monitor ambient pollutant levels from gas-producing sources and power plants (NMAQB 2001a). Table OG-19 presents the maximum pollutant levels monitored at the San Juan and Sandoval County stations from 2000 through 2004 (EPA 2004a). The data in Table OG-19 shows that, with one exception, pollutant levels have not exceeded any ambient air quality standard during the 2000 through 2004 monitoring period. The 8-hour ozone standard was slightly exceeded in Bloomfield in 2000.

Regulatory Setting

The Federal Clean Air Act of 1969 and its subsequent amendments (CAA) established air quality regulations and the NAAQS and delegated the enforcement of these standards to the states. The NMED-AQB enforces air pollution regulations and sets guidelines to attain and maintain the national and state ambient air quality standards within the State of New Mexico, except for tribal lands and Bernalillo County. The NMED-AQB guidelines are found in the New Mexico State Implementation Plan (SIP). The following is a summary of Federal and State air quality rules and regulations that may apply to emission sources associated with the DEIS alternatives. However, this is not an all-inclusive summary, as the programmatic nature of the project and alternatives does not provide the level of detail needed to identify all applicable rules and regulations.

Federal Regulations

In September 1997, the EPA promulgated 8-hour O_3 and 24-hour and annual $PM_{2.5}$ national standards. However, due to a lawsuit in May 1999, the U.S. Court rescinded these standards and EPA's authority to enforce them. Subsequent to an appeal of this decision by the EPA, the U.S. Supreme Court in February 2001 upheld these standards. As a result, this action initiated a new planning process to monitor and evaluate emission control measures for these pollutants. The EPA promulgated attainment status designations of the 8-hour O_3 standard on April 15, 2004 (EPA 2002). An area will attain this standard if its 3-year running average of the annual fourth highest daily maximum 8-hour O_3 concentration remains below 0.084 ppm. Implementation of the 1-hour O_3 standard will not be revoked in a given area until that area achieves this standard. Otherwise, as is the case for the project region, implementation of the 8-hour standard will replace the existing 1-hour standard.

Table OG-19. Maximum pollutant concentrations monitored in areas near the study area: 2000–2004

Pollutant/ Monitoring Station/ County	Averaging Time/ Measurement	Limiting Standard	Maximum Concentration by Year				
			2000	2001	2002	2003	2004 [1]
Ozone							
Bloomfield, San Juan	8-hour (ppm)	0.084 ppm	0.085	0.077	0.080	0.077	0.073
	1-hour (ppm)	0.124 ppm	0.096	0.094	0.091	0.089	0.078
Farmington, San Juan	8-hour (ppm)	0.084 ppm	0.074	0.077	0.080	0.078	0.070
	1-hour (ppm)	0.124 ppm	0.093	0.087	0.087	0.091	0.080
Rio Rancho, Sandoval	8-hour (ppm)	0.084 ppm	0.080	0.071	0.082	0.079	0.072
	1-hour (ppm)	0.124 ppm	0.087	0.079	0.093	0.091	0.080
Near Bernalillo, Sandoval	8-hour (ppm)	0.084 ppm	0.078	0.074	0.079	0.079	0.072
	1-hour (ppm)	0.124 ppm	0.093	0.091	0.087	0.090	0.087
Carbon Monoxide							
Farmington, San Juan	8-hour (ppm)	8.7 ppm	1.9	ND	ND	ND	ND
	1-hour (ppm)	13.1 ppm	5.4	ND	ND	ND	ND
Rio Rancho, Sandoval	8-hour (ppm)	8.7 ppm	1.0	1.2	1.4	1.2	1.3
	1-hour (ppm)	13.1 ppm	2.3	3.8	1.9	1.8	2.1
Nitrogen Dioxide							
Bloomfield, San Juan	Annual (ppm)	0.05 ppm	0.011	0.012	0.014	0.013	0.013
	24-hour [2] (ppm)	0.10 ppm	0.029	0.027	0.026	0.025	0.023
Farmington, San Juan	Annual (ppm)	0.05 ppm	0.009	0.009	0.009	0.009	0.007
	24-hour [2] (ppm)	0.10 ppm	0.028	0.025	0.024	0.034	0.020
Rio Rancho, Sandoval	Annual (ppm)	0.05 ppm	0.010	0.014	ND	0.008	0.010
	24-hour [2] (ppm)	0.10 ppm	0.026	0.026	ND	0.032	0.025
Sulfur Dioxide							
Bloomfield, San Juan	Annual (ppm)	0.02 ppm	0.003	0.002	0.002	0.002	0.002
	24-hour (ppm)	0.10 ppm	0.010	0.010	0.006	0.019	0.009
	3-hour (ppm)	0.5 ppm	0.019	0.024	0.035	0.090	0.025
Farmington, San Juan	Annual (ppm)	0.02 ppm	0.008	0.004	0.003	0.003	0.003
	24-hour (ppm)	0.10 ppm	0.033	0.020	0.017	0.019	0.009
	3-hour (ppm)	0.5 ppm	0.144	0.058	0.060	0.090	0.042

Table OG-19. Maximum pollutant concentrations monitored in areas near the study area: 2000–2004

Pollutant/ Monitoring Station/ County	Averaging Time/ Measurement	Limiting Standard	Maximum Concentration by Year				
			2000	2001	2002	2003	2004 [1]
PM_{10}							
Farmington, San Juan	Annual Arithmetic Mean (µg/m^3)	50 µg/m^3	16	16	ND	ND	15
	24-hour (µg/m^3)	150 µg/m^3	27	30	ND	ND	26
Bernalillo, Sandoval	Annual Arithmetic Mean (µg/m^3)	50 µg/m^3	17	16	17	18	14
	24-hour (µg/m^3)	150 µg/m^3	41	39	49	61	29
$PM_{2.5}$							
Farmington, San Juan	Annual Arithmetic Mean (µg/m^3)	15 µg/m^3	6.1	6.1	6.9	6.7	6.0
	24-hour (µg/m^3)	65 µg/m^3	19.0	15.0	36.0	27.0	17.0
Rio Rancho, Sandoval	Annual Arithmetic Mean (µg/m^3)	15 µg/m^3	5.0	4.7	5.0	5.2	4.6
	24-hour (µg/m^3)	65 µg/m^3	18.0	9.0	21.0	15.0	11.0
Zia Pueblo, Sandoval	Annual Arithmetic Mean (µg/m^3)	15 µg/m^3	6.4	5.8	ND	9.3	8.1
	24-hour (µg/m^3)	65 µg/m^3	15.0	12.0	ND	25.0	30.0

Notes: (1) Data for year 2004 are as of November 2, 2004.

(2) 24-hour nitrogen dioxide concentrations for the years 2002-2004 were conservatively estimated as one half the maximum 1-hour concentration.

ND = No Data

µg/m^3 = micrograms per cubic meter

Ppm = parts per million

Source:NMAQB 2001b and 2002; EPA 2001, 2002, and 2004a.

The existing air quality of the study area is in attainment with all ambient air quality standards, as demonstrated by the relatively low concentration levels presented in Table OG-18. Given this current attainment status, future oil-gas development projects (under any alternative) that have the potential to emit more than 250 tons per year of any criteria pollutant (or certain listed sources that have the potential to emit more than 100 tons per year) would be required to submit a pre-construction Prevention of Significant Deterioration (PSD) permit application, including a

regulatory PSD Increment Consumption Analysis under the Federal New Source Review and permitting regulations. Development projects subject to the PSD regulations must also demonstrate the use of Best Available Control Technology (BACT) and show that the combined impacts of all applicable sources would not exceed the PSD increments for nitrogen dioxide (NO_2), PM_{10}, or SO_2. Finally, the permit applicant must demonstrate that cumulative impacts from all existing and proposed sources would comply with the applicable ambient air quality standards throughout the operational lifetime of the permit applicant's project.

Mandatory Federal Class I areas were designated by the U.S. Congress on August 7, 1977, including those existing wilderness areas greater than 5,000 acres and national parks greater than 6,000 acres. All other locations in the country where ambient air quality is within the NAAQS (including attainment and unclassified areas) were designated as PSD Class II areas with less stringent requirements. Sources subject to the PSD permit review procedures are required to demonstrate that impacts to Air Quality Related Values (AQRV) will be below Federal Land Managers' Air Quality Related Values Workgroup (FLAG) "Limits of Acceptable Change" (FLAG 2000). The AQRVs to be evaluated include degradation of visibility, deposition of acidic compounds in mountain lakes, and effects on sensitive flora and fauna within the PSD Class I areas. For example, the San Juan National Forest supervisor and Rocky Mountain Regional Forester are the Federal land managers directly responsible for the lands within the Weminuche Wilderness Class I area. Under the Clean Air Act, they are charged with "… an affirmative responsibility to protect the air quality related values (including visibility) of any such lands within a Class I area…".

Therefore, although most of the analysis area is currently designated as PSD Class II, Mesa Verde National Park, Weminuche Wilderness in Colorado, and San Pedro Parks Wilderness in New Mexico are protected by more stringent NO_2, PM_{10}, and SO_2 PSD Class I increment thresholds, as shown in Table OG-20.

Table OG-20. Applicable Prevention of Significant Deterioration increment values

Pollutant	Averaging Time	PSD Class I Increments (µg/m^3)	PSD Class II Increments (µg/m^3)
Nitrogen Dioxide	Annual	2.5	25
PM_{10}	24-hour	8	30
	Annual	4	17
Sulfur Dioxide	3-hour	25	512
	24-hour	5	91
	Annual	2	20

New Mexico AQB Rules and Regulations

The NMED-AQB enforces National and State ambient air quality standards by developing rules to regulate and permit stationary sources of air emissions. The New Mexico air quality regulations are found in the New Mexico Administrative Code (NMAC) Title 20, Chapter 2. Any new emission source proposed for the Santa Fe National Forest would have to comply with the NMED-AQB regulations and ambient air quality standards. The following summarizes the more pertinent state air quality regulations that could apply to project emission sources.

*20NMAC2.33—Gas Burning Equipment—NO*2. New/existing natural gas burning equipment that has a heat input of greater than 1,000,000 million British Thermal Units (BTUs) per hour shall not produce NO_2 emissions that exceed 0.2/0.3 pounds per million BTUs of heat input.

20NMAC2.35—Natural Gas Processing Plant - Sulfur. Part 35 regulates sulfur emissions from existing/new gas processing facilities.

20NMAC2.60—Open Burning. Part 60 outlines the process to obtain permits for open burning, such as fire management activities.

20NMAC2.70—Operating Permits. Part 70 provides permitting requirements for stationary sources that exceed 100 tons per year (TPY) of a regulated pollutant, 10 TPY of a hazardous air pollutant (HAP), or 25 TPY of combined HAPs. Requirements include emission calculations, dispersion modeling analyses to ensure that the proposed source does not exceed any ambient air quality standard, and annual reporting.

20NMAC2.72—Construction Permits. Part 72 applies to new or modified stationary sources that (1) have a potential emission rate greater than 10 pounds per hour or 25 TPY of any air pollutant for which there is a national or state ambient air quality standard or (2) exceed hourly HAPs emission levels outlined in subpart 502. Requirements of Part 72 may include: (1) emission calculations; (2) dispersion modeling analyses to demonstrate that the proposed source would not contribute to an exceedance of an ambient air quality standard or Prevention of Significant Deterioration increment; (3) a determination that the proposed source would not significantly impact air quality within pristine Federal Class I areas (such as national parks greater than 6,000 acres or wilderness areas greater than 5,000 acres); and (4) public notifications.

20NMAC2.73—Notice of Intent and Emissions Inventory Requirements. Part 73 requires new or modified stationary sources that have potential emission rates greater than 10 TPY of any regulated air contaminant or one TPY of lead to file a Notice of Intent prior to construction. Sources subject to this part shall submit annual emissions inventories.

20NMAC2.74—Permits—Prevention of Significant Deterioration (PSD). The PSD requirements apply to (1) 28 identified source types that emit more than 100 TPY of any pollutant for which there is a national ambient air quality standard or (2) any other source that emits 250 TPY or more. Requirements include air monitoring, emission calculations, dispersion modeling analyses, implementation of best available control technologies (BACT), and a determination that the proposed source will not significantly impact air quality within pristine Federal Class I areas. Within the project region of influence, these areas could include Mesa Verde National Park and Weminuche Wilderness in Colorado, and San Pedro Parks Wilderness in New Mexico.

The main purpose of this air quality analysis is to evaluate compliance with the National and State ambient air quality standards. The programmatic nature of the EIS and decision to be made does not require the level of detail needed to determine compliance with all applicable rules and regulations. Nevertheless, due to the proximity of Class I areas to the study area, the cumulative air quality analysis will qualitatively evaluate the impact of projected emissions to these areas.

Regional Air Emissions

The NMED-AQB compiles countywide emission inventories for stationary sources that emit more than 10 TPY of a pollutant. Additionally, the EPA estimates point, area, and mobile source

emissions, which are part of their National Emission Trends database. Table OG-21 summarizes the mobile and stationary source emissions that occurred in Rio Arriba County during 1999 (EPA 2004b).

Table OG-21. Summary of 1999 annual emissions by source category for Rio Arriba County (in tons per year)

Source Category	VOC	CO	NOx	SOx	PM_{10}
Fuel Combustion—Electric Utilities	3.2	37.4	28.6	—	—
Fuel Combustion—Industrial	1,220	3,351	2,723	27.6	26.5
Fuel Combustion—Other	265	915	79.5	4.3	126
Petroleum and Related Industries	528	18.3	8.6	—	—
Solvent Utilization	432	—	—	—	—
Storage and Transport	189	—	—	—	—
Other Industrial Processes	—	—	13.3	—	0.1
Waste Disposal and Recycling	113	747	29.9	2.5	142
Highway Vehicles	1,421	18,548	2,277	85.9	58.0
Off-Highway Vehicles	652	2,549	285	36.1	46.0
Miscellaneous	606	12,813	280	76.7	8,105
Total Source Emissions	**5,429**	**38,978**	**5,725**	**233**	**8,504**

Source: EPA 2004b

Table OG-22 provides the same information for Sandoval County. Natural gas production and transmission is the largest stationary source category in the project region, while fugitive dust, an area source, produces the majority of PM_{10} in the region. The on-road vehicles mobile source category also produces a large percentage of combustive emissions in the region and is the main source of carbon monoxide.

Environmental Consequences

Impacts Common to All Alternatives

The actions under all three alternatives would not directly result in the development of new wells in the study area, as the decision to be made is programmatic, establishing leasing categories and stipulations for new leases to be implemented as a Forest Plan amendment but authorizing no site-specific oil-gas drilling activities.

As projected by the RFDS prepared for the Santa Fe National Forest (USFS 2004a), none of the alternatives would eventually result in an increase or decrease in the number of wells that would potentially be constructed and operated in the study area because they do not directly result in any oil-gas development. There would be no direct impacts to air quality as a result of the implementation of any alternative.

Table OG-22. Summary of 1999 annual emissions by source category for Sandoval County (tons per year)

Source Category	VOC	CO	NOx	SOx	PM_{10}
Fuel Combustion – Industrial	113	282	703	96.8	68.7
Fuel Combustion – Other	149	368	141	9.3	52.0
Chemical and Allied Product Mfg.	—	—	—	—	46.6
Petroleum and Related Industries	7.9	—	—	—	—
Solvent Utilization	835	—	—	—	—
Storage and Transport	169	—	—	—	12.9
Other Industrial Processes	60.5	8.7	14.4	—	12.9
Waste Disposal and Recycling	186	1,950	64.6	2.1	259
Highway Vehicles	2,384	31,609	3,525	131	105
Off-Highway Vehicles	406	4,539	716	69.7	56.0
Miscellaneous	379	7,997	175	47.8	33,676
Total Source Emissions	**4,690**	**46,754**	**5,338**	**357**	**34,286**

Source: EPA 2004b

Cumulative Impacts

The development of 20 new locations and 27 completions is projected by the RFDS (USFS 2004a) to be reasonably foreseeable in the study area. Impacts associated with this well development would be adverse, but less than significant. Modeling performed for a high density well development scenario for the "Surface Management of Gas Leasing and Development, Jicarilla Ranger District, Carson National Forest" (USFS 2003b) indicated that (1) maximum modeled impact concentrations would be less than the National or New Mexico ambient air quality standards and (2) risks from exposure to hazardous air pollutants would be less than significant. Impacts for well development in the San Juan Basin on the Santa Fe National Forest would be even less because there are no high-density well areas (up to eight wells per square mile). Furthermore, the Carson National Forest modeling analysis included a large 10,000-Hp central compressor station that would not be needed for the lower density well operations in the San Juan Basin.

Air quality impacts would occur during both well construction (due to surface disturbance by earth-moving equipment, vehicle traffic fugitive dust, well testing, and drilling rig and vehicle engine exhaust) and well production (including natural gas separation and dehydration heaters, compressors, and small well-head engine exhausts). The maximum predicted "near-field" air pollutant concentrations associated with well development and production would occur close to the actual well location; so close that adding additional wells in other field locations would not increase the maximum predicted "near-field" concentrations (BLM 2002).

Emissions from oil and gas well operation sources could disperse for long distances downwind and contribute to cumulative visibility impacts in PSD Class I areas and/or ozone impacts in ozone nonattainment areas. Even though the contribution of impacts would be small and less than

significant within the study area, the impact would be considered significant on a cumulative basis if it would cause or add to a new or existing problem of visibility degradation or ozone nonattainment. Cumulative impacts could be reduced to less than significant with application of recommended mitigation measures.

Federal land managers (BLM and Forest Service) are currently considering a range of small wellhead engine and other mitigation strategies to reduce the magnitude and extent of adverse cumulative air quality impacts in the region. Additional air quality monitoring may be necessary in areas where adverse impacts were predicted, primarily to the west of the study area. An underestimate of background visibility could lead to an overestimate of potential visibility impacts from proposed NOx emission sources. Therefore, direct optical monitoring in Mesa Verde National Park, Weminuche Wilderness, South San Juan Wilderness, Rio Chama Wilderness, and San Pedro Parks Wilderness (using a transmissometer or nephelometer) may be needed to establish background conditions and future trends, regardless of chemical/physical constituents.

Other foreseeable future Santa Fe National Forest projects planned in or near the study area that may affect air quality, in combination with current and projected oil or gas well construction and production, are those that would result in surface disturbance, causing temporary decreases in air quality by increasing particulates. Projects 2, 3, 4, 6, 7, and 8 listed in Table OG-15 are likely to result in temporary air quality impacts that would add to those projected from local and regional oil and gas development. Due to the temporary nature of the air quality impacts from these Forest Service projects, the cumulative effects would not be significant over the long term.

Vegetation

Affected Environment

The flora of the oil-gas study area is determined by the elevation (6,590 to 9,940 feet), temperature, and precipitation. The vegetative communities[2] in the study area include grassland, mixed shrubland, piñon-juniper mixed conifer woodlands, ponderosa and Southwestern white pine forest, spruce and fir forest, and riparian, as described in Table OG-23.

Most of the national forest land in the study area is dominated by wooded communities, mainly ponderosa pine forest (37 percent) and piñon-juniper woodland (28 percent). The third vegetation type well represented in the study area is another wooded community, the high montane coniferous forest (21 percent), which primarily contains the spruce, fir, and aspen vegetation types listed in Table OG-23. Oak communities, sagebrush, and grassland are present in the study area but are less extensive. Grassland occurs typically in the form of small meadow openings, about 50 acres or less in the higher elevations, larger at lower elevations. Riparian vegetation communities occupy less than 1 percent of the study area.

[2] All acreage pertains to Santa Fe National Forest lands only unless otherwise indicated.

Table OG-23. Vegetation types within the study area boundary

Vegetation Type	National Forest Land (acres)	Private Land (acres)	Total Acres	Percent of National Forest Land
Aspen	1,287	0	1,287	0.7%
Badlands	319	0	319	0.2%
Blue Spruce	10	0	10	<0.1%
Douglas-Fir	25,683	185	25,869	13.0%
Engelmann Spruce	645	0	645	0.3%
Grassland	15,340	8,344	23,684	7.8%
Oak Woodland	9,412	143	9,555	4.8%
Other Non-vegetated Sites	1,294	533	1,827	0.7%
Piñon-Juniper	54,706	622	55,328	27.8%
Ponderosa Pine	73,926	750	74,676	37.5%
Riparian	114	0	114	0.1%
Rockland, Talus, and Scree	605	0	605	0.3%
Sagebrush	2,894	664	3,558	1.5%
Southwestern White Pine	172	0	172	0.1%
Strip-mines, Quarries, and Gravel Pits	83	23	106	<0.1%
Unidentified	0	60	60	0%
White Fir	10,825	0	10,825	5.5%

Source: USFS 2005

The descriptions of vegetation types within the study area boundaries take into account the relative importance of vegetation as wildlife habitat, especially in the key areas of deer and elk winter range, and fawning and calving areas, discussed in the “Wildlife” section. The current vegetation conditions are influenced by human-caused factors such as mineral development, wildlife and livestock grazing, timber harvest, fuels reduction treatment, and fire suppression, as well as recent drought conditions. Figure OG-24 displays the distribution of vegetative communities within the study area.

Riparian Areas and Wetlands

Riparian areas and wetlands represent only a very small percentage of the study area. Riparian areas within the study area are located along the Rio Gallina, Clear, Nacimiento, and Cecilia Creeks, as well as intermittent streams and washes.

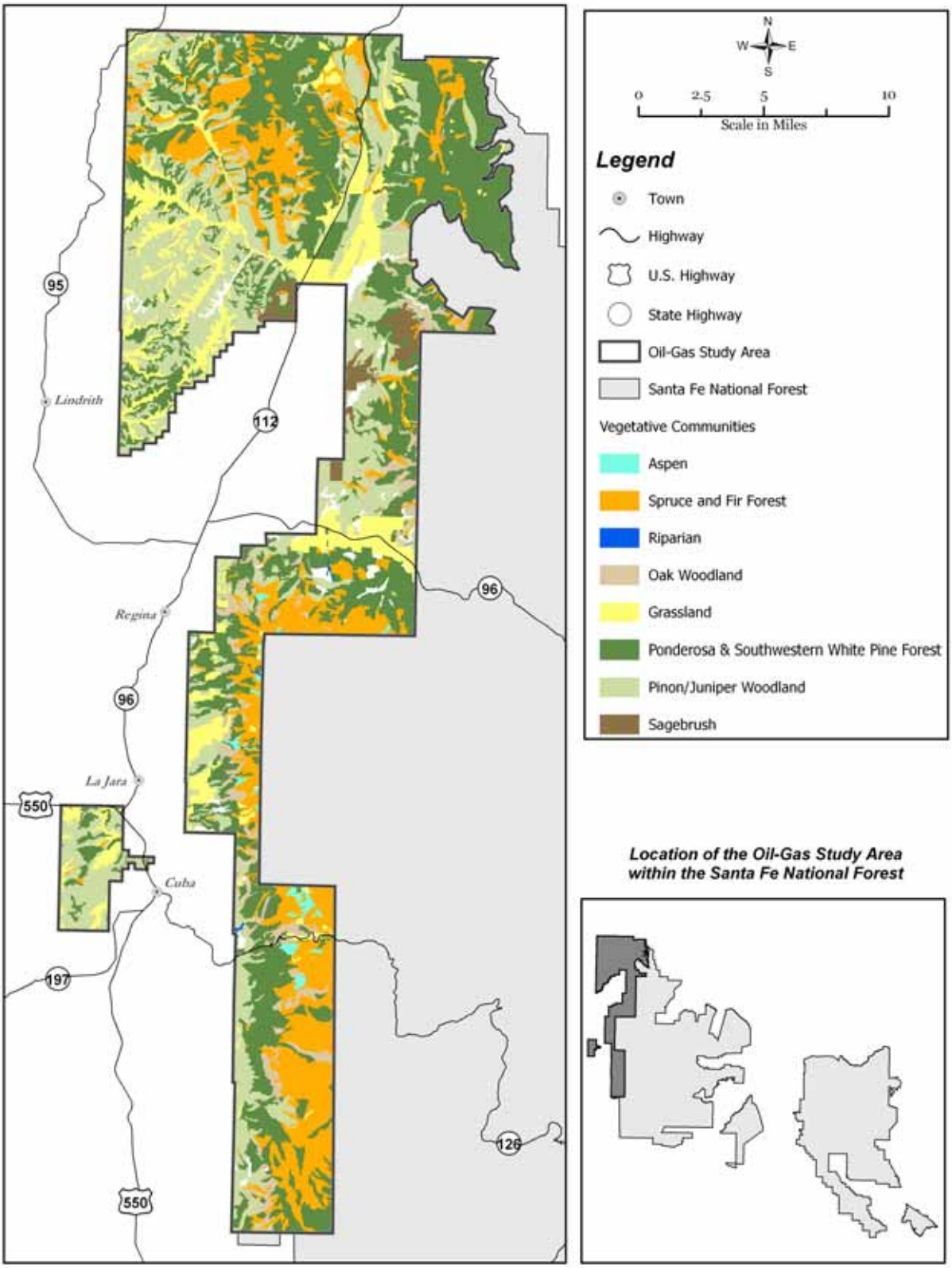


Figure OG-24. Vegetative communities within the oil-gas study area

The vegetation associated with riparian areas varies based on elevation, gradient, and valley bottom. Wooded riparian areas may be composed of willow (*Salix* spp.), narrow-leaf cottonwood (*Populus angustifolia*), and alder (*Alnus*). Other riparian areas are dominated by grass and *Carex* spp. Coniferous trees (Douglas-fir, white fir, ponderosa pine) dominate in areas characterized by a high gradient and a confined valley bottom. Tamarisk (*Tamarix ramossissima*), also called salt cedar, occurs in low numbers along some drainages at the lower elevations.

Within mixed conifer forest, Rio Capulin is lined by a narrow band of riparian vegetation including Bebb willow (*Salix bebbiana*), alder, snowberry (*Symphoricarpos* sp.), and wild rose (*Rosa* sp.). Riparian vegetation along Cecilia Creek (a tributary to Rio Capulin) includes narrowleaf cottonwood, willow, Kentucky bluegrass, sleepy grass, and dandelion, with an overstory of ponderosa pine.

Currently, loss of riparian vegetation and wet meadows, along with associated coniferous tree encroachment, is an important issue due to the limited amount of this habitat type within the study area. Loss of riparian vegetation is, in part, due to cattle grazing and elk browsing. Contributing to the loss of wet meadows is the decline in beaver populations observed along streams of the Santa Fe National Forest. Beaver dams help control seasonal flooding and prevent downcutting in the stream. Over time, reservoirs created upstream from beaver dams may turn into wet meadows used by wildlife. Currently, stream downcutting is occurring and wet meadows have declined.

Grasslands

Grasslands have a very patchy distribution and typically cover small areas within a larger mosaic of habitats. At lower elevations and up into the ponderosa pine zone, areas with mixed communities of shrubland-grassland occur, typically in swales and valley bottoms, with piñon-juniper woodland or ponderosa pine forest on surrounding slopes. Those shrubland-grassland communities are dominated by sagebrush, rabbitbrush and crested wheatgrass (*Agropyron cristatum*). Other grasses besides crested wheatgrass include western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), Indian ricegrass (*Achnatherum hymenoides*), cheatgrass (*Bromus tectorum*; on disturbed sites), muhly (*Muhlenbergia* spp.), Arizona, sheep, and Thurber's fescue (*Festuca arizonica, F. thurberi,* and *F. ovina*), timber oatgrass (*Danthonia intermedia*), and sleepy grass (*Stipa robusta*; often in more mesic sites). Nongrass species found in patches of grassland include mustard (*Brassica* spp.), trailing fleabane (*Erigeron flagellaris*) or sand dropseed (*Sporobolus cryptandrus*). Grasses and forbs dominate following wildfires.

At higher elevations, grasslands occur as small montane meadows surrounded by aspen or stands of mixed conifer forest. They are dominated typically by Kentucky bluegrass (*Poa pratensis*). Other taxa found in montane meadows include native bunchgrass (fescue (*Festuca*)) and dandelion (*Taraxacum officinale*). Areas characteristic of mesic soils are likely to include Arizona fescue as the dominant grass species.

Sagebrush

Sagebrush occurs chiefly in association with rabbitbrush (*Chrysothamnus*) and crested wheatgrass (*Agropyron cristatum*). Areas of big sagebrush (*Artemisia tridentata*) and silver sagebush (*Artemisia cana*) are also common. The dominant sagebrush species is big sagebrush, but sand sage (*A. filifolia*) is also present in the area. Sagebrush patches occur in piñon-juniper woodland

and ponderosa pine forest. At the landscape level, sagebrush occupies a relatively small percentage (1.5 percent) of the study area.

Piñon-Juniper

The second largest vegetation type is piñon-juniper woodland, with a total of about 54,700 acres. The majority of the piñon-juniper woodland occurs in the northern portion of the study area.

Two-needle piñon (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*) are the dominant, co-occurring tree species. Toward high elevations they both typically increase in size, but whereas piñon also increases in density, juniper may become scarcer. The change in densities is a result of piñon species requiring more available moisture (which generally occurs at higher elevations), while juniper species tend to require less available moisture (thus dominating more at lower elevations where generally less moisture is available). Gambel oak (*Quercus gambelii*) is also often present. In some areas one-seed juniper may be replaced by Utah juniper (*J. osteosperma*), often in association with big sagebrush.

Oak Woodland

Oak woodland occupies a small portion of the study area (4.9 percent). Oak woodland in the study area is an example of prolonged mid-succession dominance (Dick-Peddie 1993). The establishment of large trees has been promoted by a combination of low fire periodicity (7 to 21 years) and poor soils (very rocky, shallow, or very heaving clays) (Phillips 2003). The dominant hardwood species of this vegetation type is Gambel oak (*Quercus gambelii*). Occurring with the oak are various coniferous, grass, and forb species. Small, typically less than 50 acres, patchy distribution occurs within the study area.

Ponderosa Pine

Ponderosa pine forest occurs in higher areas than piñon-juniper woodland, at elevations ranging from about 7,000 to 8,500 feet. At the upper end of the elevation range, it transitions into mixed conifer forest (higher montane forest).

Ponderosa pine forest is dominated by ponderosa pine, but juniper (primarily Rocky Mountain juniper), piñon, and oak species are also present.

With a total of over 73,900 acres, ponderosa pine forest represents the main vegetation type in the study area. In particular, ponderosa pine forests dominate the northern half of the study area. Gambel oak is present in some patches of ponderosa pine forest, in some cases associated with two-needle piñon.

High Montane Forests

High montane forest occurs typically above 8,500 feet (Dick-Peddie 1993). In the study area, dominant tree species consist typically of Englemann spruce (*Picea englemannii*) at the highest elevations, and white fir (*Abies concolor*), Rocky Mountain Douglas-fir (*Pseudotsuga menziesii*), southwestern white pine (*Pinus strobiformis*), and ponderosa pine lower on the slopes. Stands dominated by white fir cover fairly large areas in the central and southeastern portions of the study area, and Douglas-fir occurs in the southeastern and north-central portions. Small patches of high montane forest dominated by southwestern white pine are found in the central and

southeastern portions of the study area. Gambel oak is often present in association with white fir, Rocky Mountain Douglas-fir, and ponderosa pine.

Montane meadows represent an early seral stage in high montane forests but are described here with other grasslands. Seral aspen forests are present in the study area, though they typically do not cover extensive areas. The south-central portion of the study area contains the majority of the aspen stands.

Invasive Plants

Invasive plants are found in the study area, especially on disturbed ground. The highest concentration (63 percent) of noxious weeds is located in the central portion of the study area. Noxious plants displace native plant communities and degrade wildlife habitat by competing with and often choking out native vegetation. Weed management is governed under the Federal Noxious Weed Act, Public Law 93-629, 1974, and the Forest Service's March 1996 interagency document "Forest Service Weed Strategy." Currently, nine invasive plants, listed in Table OG-24, are found in the study area. Their locations are shown on Figure OG-25.

Table OG-24. Invasive plant species within the study area

Common Name	Scientific Name	Life Cycle	Origin	Acres
Bull Thistle	*Cirsium vulgare*	Biennial	Eurasia	56
Canada Thistle	*Cirsium arvense*	Perennial	Eurasia	308
Diffuse Knapweed	*Centaurea diffusa*	Perennial	Europe	109
Musk Thistle	*Carduus nutans*	Biennial	Europe	259
Nodding Plumeless Thistle	*Carduus nutans*	Biennial	Europe	88
Russian Knapweed	*Centaurea repens*	Perennial	Eurasia	14
Scotch Thistle	*Onopordum acanthium*	Biennial	Europe	1
Spotted Knapweed	*Centaurea maculosa*	Perennial	Europe	10
Salt Cedar	*Tamarix ramosissima*	Perennial	Eurasia	13
Total Acreage				**858**

Sources:USFS 2005

Environmental Consequences

Effects to the vegetative communities are generally a result of surface-disturbing activities, such as road building, timber sales, fuel reduction treatments, mineral development, wildlife and livestock grazing, and OHV recreation. These activities are likely to result in direct impacts to vegetative resources in the study area. None of the alternatives would directly result in surface-disturbing activities, if selected. Therefore, the analysis below will focus primarily on the indirect impacts to vegetative resources. Restrictions on oil and gas development proposed as stipulations on new leases, such as controlled surface use (CSU) and no surface occupancy (NSO), may have indirect impacts to vegetative resources and weed management within the study area.

Alternative 1—No Action

Under the No Action Alternative, vegetation resources would be managed under the existing authority of the current Forest Plan. No additional leasing stipulations would be required to allow for more restricted surface activities. Currently about 8 percent of the study area (national forest land only) is under limited surface use leasing restrictions. The leasing decision itself would not result in any surface-disturbing activities and, thus, would not have direct impacts to vegetative communities. However, the existing leases would be developed under all alternatives, resulting in surface disturbance to build the projected 20 new wells and associated access roads and pipelines on existing leases.

Under the No Action Alternative, leasing restrictions would continue on 16,506 acres (Table OG-25), but these would have little or no effect on vegetation and weed management in the study area. The No Action Alternative would not result in any direct impacts to vegetative resources due to the absence of surface-disturbing activities resulting from the leasing decision to be made. The No Action Alternative would provide the smallest acreage of leasing restrictions, thus resulting in the least amount of indirect surface protection for vegetative resources and protection from the proliferation of noxious weeds.

Table OG-25. Proposed leasing restrictions that may affect vegetation within the study area

Alternative	Lease Stipulation (Acres)		
	Limited Surface Use/CSU	NSO	Timing Limitation
1—No Action	16,506	0	0
2—Proposed Action	35,742	36,566	35,596
3	35,742	46,483	35,596

CSU: controlled surface use lease stipulation; NSO: no surface occupancy lease stipulation

Notes: Because the projected new wells are likely to occur on the approximately 45 percent of national forest lands in the study area already leased, and the acreage listed above only applies to new leases, the actual acreage of new lease stipulations under Alternatives 2 and 3 would be less than that shown in this table.

Limited Surface Use applies only under the No Action Alternative to Management Areas C, P, I, and L.

Source: USFS 2005

Alternative 2—Proposed Action

Under the Proposed Action Alternative, the area of proposed stipulations on new leases would increase about 47 percent compared to the No Action Alternative, for a total of about 55 percent of the national forest land in the study area. The proposed lease stipulations that may help vegetative resource management include no surface occupancy and controlled surface use. No surface occupancy lease stipulations would eliminate or reduce surface disturbance on steep slopes; controlled surface use would enable the Forest Service to move well pads and roads up to 200 meters (656 ft) to avoid damage to important vegetation communities, both providing

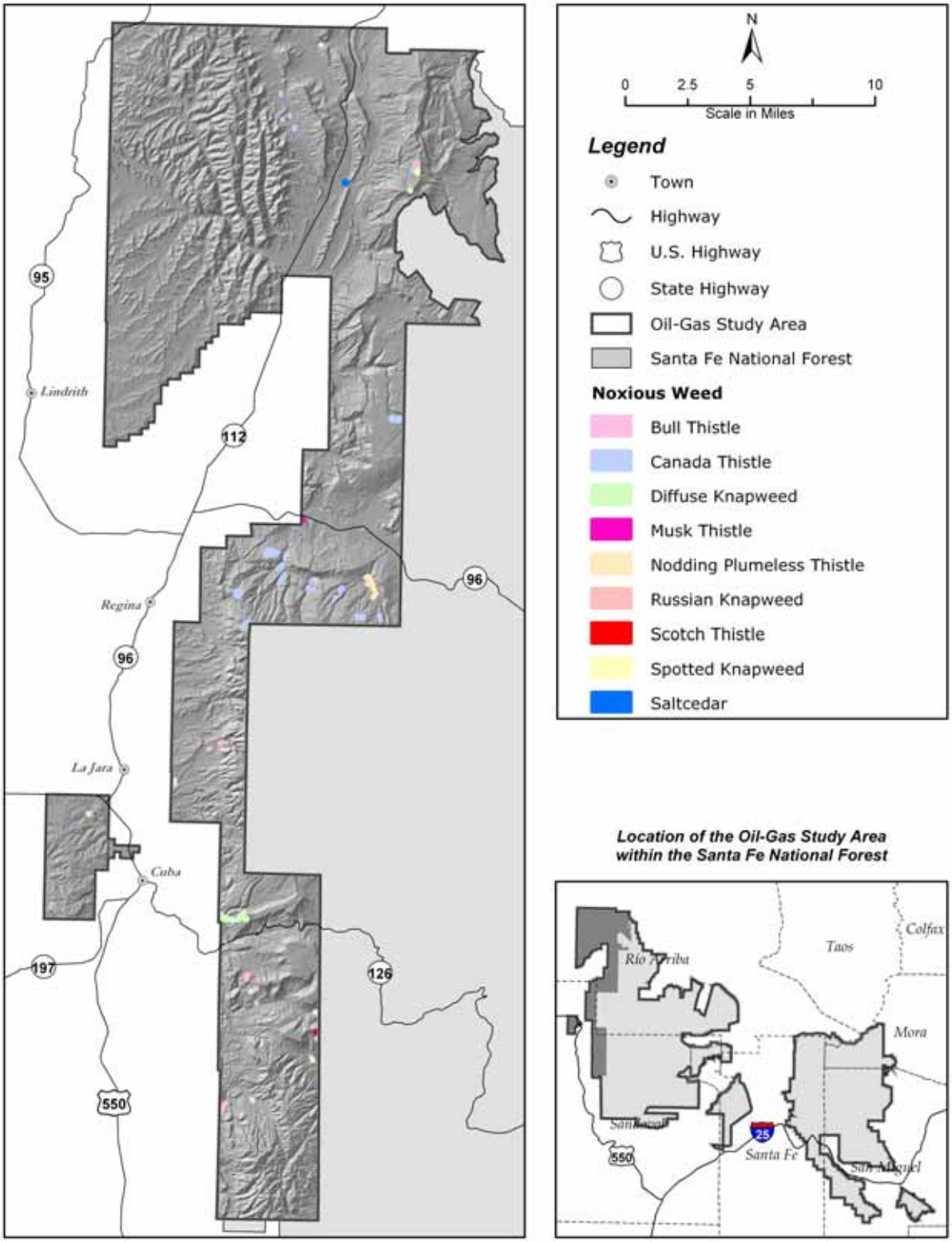


Figure OG-25. Location of invasive plants within the study area

beneficial impacts for vegetation resources. Under the Proposed Action Alternative, proposed lease stipulations for oil-gas development would be the second highest, potentially providing the second highest amount of protection to vegetative resources.

Alternative 3

Potential impacts to vegetative resources under Alternative 3 are similar to, but slightly less than, those described above for the Proposed Action because slightly higher acreage of no surface occupancy lease stipulations would be implemented. Under Alternative 3, areas with proposed lease stipulations would increase about 52 percent compared to the No Action Alternative, for a total of about 60 percent of the national forest land in the study area.

Cumulative Impacts

The analysis area for cumulative effects on vegetative resources and the proliferation of nonnative invasive plants is the area in and immediately adjacent to the oil-gas study area, and includes both national forest and non-Federal lands. In all alternatives, cumulative impacts to vegetative resources would stem from the combination of forest management activities, public land uses, and activities on other public and private lands.

Development of leases for oil and gas resources is a reasonably foreseeable action that requires analysis under the cumulative effects section. Through consultation with industry and constraints on oil-gas development, such as topography, the Forest Service projects oil-gas development over the next 20 years to be about 20 new well locations and almost 3 miles of associated roads within the study area. All of the projected development would occur in the northern portion of the study area. The majority of the projected wells would occur within piñon-juniper and ponderosa pine habitat (10 and 7 wells, respectively). The remaining three wells are projected to occur within grassland habitat. Associated new roads projected to be built with the projected new wells include about 1.3 miles of road within ponderosa pine habitat, 0.8 mile of road within piñon-juniper habitat, and 0.7 mile of road within grassland habitat. All of the projected wells and associated projected roads would occur within existing leases. Therefore, neither of the Proposed Action alternatives would influence the development of the projected wells or roads, unless existing leases were relinquished and re-issued under proposed lease stipulations. The potential oil-gas development would most likely occur under standard terms and conditions, providing minimal surface protection for vegetative resources. The amount of projected development is minimal and, therefore, impacts to vegetative resources would likely be negligible.

Surface disturbance that may affect vegetation is expected to continue in the study area from other Forest Service activities listed in Table OG-15. Short-term adverse impacts are likely to result from all projects, but all would have long-term benefits to vegetative cover. These known and foreseeable surface-disturbing activities, combined with other actions on private land within the study area and on land in the watersheds downstream from the Santa Fe National Forest, have the potential to affect vegetation in the region. The other actions on non-Federal land that may affect vegetation include construction of buildings, roads, oil-gas wells, and other facilities; road maintenance like grading and ditch cleaning; cross-country travel by off-highway vehicles (OHV); installation of trenches for utilities; vegetation management activities; and agricultural activities like plowing, planting, and livestock grazing.