ENERGYQUEST II, LLC

PROPOSAL FOR REMEDIATION – RP #4359

STATE A0 AND STATE C LEASES – GRASS FIRE FROM LIGHTNING

CONTENTS:

PROPOSAL FOR REVEGETATION OF STATE AO/STATE C LEASE LOCATIONS

EnergyQuest proposes applying an approved seed mixture to two (2) delineated areas where poly lines were damaged by a grass fire on July 17, 2016, with minimal disturbance to recovering vegetation and following published BLM guidance. The primary area of work (highlighted in magenta on the site map) begins on the south side of the tank battery, runs east towards the road, then turns south and continues to the State AO#2 well. This area encompasses approximately .89 acre. The north plot for over-seeding (highlighted in yellow on the site map) is located just east of the State AO #1 well and runs due east; this area is about 340 feet long and 45 feet wide. This north plot encompasses approximately .35 acre to be over-seeded. Therefore, the total area proposed for over-seeding is approximately 1.24 acres. **See site maps in Appendix 1.**

- Site map 1 depicts an overview of the two (2) delineated areas;
- Site maps 2 and 3 provide a zoomed view and GPS coordinates for each area.

The Bureau of Land Management specifies using **Seed Mixture #2** for this ecoregion. This is a defined ratio seed mixture of the following grasses:

- Sand dropseed (Sporobolus cryptandrus)
- Sand lovegrass (Eragrostis trichodes)
- Plains bristlegrass (Setaria macrostachya)

BLM authorizes this mixture to be spread via broadcasting method and specifies that, when broadcasting, the mixture will contain pounds of pure live seed (PPLS) at the rates shown below:

- Sand dropseed 2 PPLS / acre
- Sand lovegrass 2 PPLS / acre
- Plains bristlegrass 4 PPLS / acre

The burned areas already show vigorous regrowth of native grasses; evidence is presented in **Appendix 6.** The proposed over-seeding is intended to supplement the recovering vegetation, if required. Over-seeding will be done via the broadcasting method without disturbing new growth. We will apply certified seed at the rates specified by the BLM, and lightly rake by hand to cover the seed. Separate BLM guidance for Seed Mix #2 is in **Appendix 5.** In accordance with guidance from NMOCD and NMSLO, we will verify at purchase that the seed mix contains only certified or registered seed, with no primary or secondary noxious weeds.

ANALYSIS AND DISCUSSION

BACKGROUND.

On July 17, 2016, a lightning strike to the southwest of the State AO #2 ignited grass fires in the Bagley Field, Lea County, New Mexico. Winds pushed the fire north and east across the STATE AO and STATE C Lease areas, damaging poly lines and causing loss of product. Poly lines were damaged in two (2) areas: the primary area of damage extended from the tank battery adjacent to the State AO #1 all the way southward to the State AO #2; a second area of lesser damage ran from field road at the State AO #1 eastwards towards the State C #1. **See site maps in Appendix 1.** Collectively, the fire damaged approximately 1100 feet of inactive 3" poly lines, 500 feet of active 3" poly lines, and 1100 feet of active 2" poly lines. All product in the active lines was consumed by the fire. Damaged inactive lines were removed; damaged active lines were replaced.

ECOREGION ANALYSIS.

The EPA classifies Lea County within Ecoregion 25k, the Arid Llano Estacado, Southern High Plains, Southeast portion of the Southern Shortgrass Prairie. This ecoregion receives approximately 14-16 inches of precipitation per year. According to the EPA, the predominant flora include: blue, black, and hairy grama, buffalo grass, silver bluestem, sand dropseed, threeawn, Arizona cottontop, hairy tridens, muhly, bottlebrush squirreltail, and sand sagebrush. Invasive shrubs include mesquite, narrowleaf yucca, juniper, ephedra, and tarbush. **See EPA maps in Appendix 2.**

EnergyQuest consulted with the U.S. Bureau of Land Management to validate this analysis, even though this location is a State Lease, not a BLM Lease. This decision was based upon prior interaction with and guidance from the BLM regarding seeding of another site in the same ecoregion. Mr. James Amos of the U.S. Bureau of Land Management, Carlsbad Office, concurs with this identification and analysis of the ecoregion. **See memo in Appendix 2**.

SOIL SAMPLE ANALYSIS.

Three soil samples were taken within areas where fire had damaged poly lines; these samples were submitted to Cardinal Laboratories for analysis. Two (2) of the samples were taken between the State AO #1 and State C #1; a third sample was taken between State AO #1 and State AO #2. Sample locations are depicted on the **map** in **Appendix 3;** photos with **GPS coordinates** of the locations also are in **Appendix 3**. Overall, the lab analysis showed no analyte detected above the reporting level in any of the three (3) samples; therefore remediation of the soil is not necessary. The detailed results are in the **lab report** in **Appendix 3**. Below is a summary of the results:

	Result	Reporting Limit
Total BTEX	<0.300	0.300
Total Chloride	<16.0	16.0
TPH Analytes		
GRO C6-C10	<10.0	10.0
DRO >C10-C28	<10.0	10.0

GROUND WATER RESOURCES.

The subject leases are located in Section 4, Township 12S Range 33E. As required by NMOCD, research was done to determine the depth of groundwater in the lease area. Search efforts using specified parameters – UTMNAD83 coordinates with radius of 2000 meters and 5000 meters – were unsuccessful; the New Mexico Water Rights Reporting System website would not permit a UTMNAD83 search using the specified radius. Subsequently, a PLSS search, employing a radius of 10,000 meters, was accepted. This search identified only three (3) water wells in Section 4, Township 12S Range 33E. These were drilled under permits L-20981, L-05009, and L-06521. All three wells have since been plugged and abandoned. **Search results** are located in **Appendix 4**.

The *Lea County Water Supply Plan 2016* provides further analysis of water resources within the county. The complete report is not included in this proposal. Applicable portions specifically about the Water Supply are presented in an **18 page extract**, included in **Appendix 4.** Section 1 of the extract (Section 5 of the full report) discusses the water supply in terms of the "Water Column/Average Depth to Water." In the full report, Section 5.3.2, entitled "Aquifer Condition," points out that groundwater levels in the Ogallala Aquifer have "declined 50 to 100 feet, with rates of decline up to 4 feet per year and averaging 0.59 feet per year for wells in Lea County." Additionally, the report states "water levels have declined and the direction of groundwater flow has shifted" with the "median water column…estimated to be about 100 feet…" Both observations are found in **Section 1 of the extract on pages 1 and 9, Appendix 4**.

For the water wells referenced above, the deepest well, drilled in 1955, found water at 70 feet deep; the shallowest well shows depth-to-water at 40 feet; the third and most recent well, drilled in 1969, showed depth-to-water at 60 feet. Using the depth-to-water of this well and an average water level decline of 0.59 feet per year, the calculated depth-to-water now would be approximately 100 feet, consistent with the reported median water column. However, if the water column in this area declined at a rate of 4 feet per year as suggested in the *Water Supply Plan 2016*, the calculated depth-to-water could be as much as 260 feet. Based on the soil analysis report and the calculations above, it is unlikely that the fire and flow line damage threatened the groundwater.

SURFACE WATER RESOURCES.

Section 5.2 of the *Lea County Water Supply Plan 2016* states "No major surface water supplies are available in Lea County, only intermittent streams, lakes, stock ponds, and small playas that collect runoff during thunderstorms." Furthermore, the Plan states that "no lakes and reservoirs with storage capacities greater than 5,000 acre-feet…are present in the region." Both of these observations can be found on **pages 6 and 7 of the extract in Appendix 4**. A topographical analysis of Section 4, Township 12S Range 33E – the general location of the STATE A0 and STATE C Leases – found no intermittent streams and no evidence of surface water collection within the leases themselves.

A broader search, expanded to 20,000 meters, identified only two surface water resource locations:

1) House Lake, Four Lakes Ranch, in Section 15, Township 11S Range 34E, located approximately 8 miles (12, 875 meters) northeast of the leases; and
2) Lane Salt Lake, in Section 7, Township 10S Range 33E, located approximately 10 miles (16,100 meters) north of the leases.

A **map** of locations and distances to these surface water resources can be found in **Appendix 4**. These resources were too remote to have been affected.

South of the leases are several playas that exhibit evidence of short-term collection of runoff water; however, none were identified as anything other than temporary and seasonal surface water locations. Therefore, no surface water resources were threatened by the grass fire and damage to the lines.

REVEGETATION AND NOXIOUS WEED MANAGEMENT.

Currently, the entire lease area – including all locations where poly lines were replaced – shows vigorous natural revegetation and regrowth. As evidenced by photos at the end of **Appendix 6**, over-seeding may be unnecessary.

As noted, the site is within the Arid Llano Estacado, High Plains area, Southern Shortgrass Prairie. Mr. James Amos of the U.S. Bureau of Land Management, Carlsbad Office, verified BLM Seed Mixture #2 as appropriate for the project. While the incursion of invasive plant species in this region normally would be of concern, Mr. Amos stated that the fire did a better job of clearing and controlling invasive plants than anything he could recommend, indicating that the over-seeding proposal need not include plans for controlling noxious/invasive vegetation. The BLM response can be found in **Appendix 5.**

CONDLUDING EXPLANATIONS.

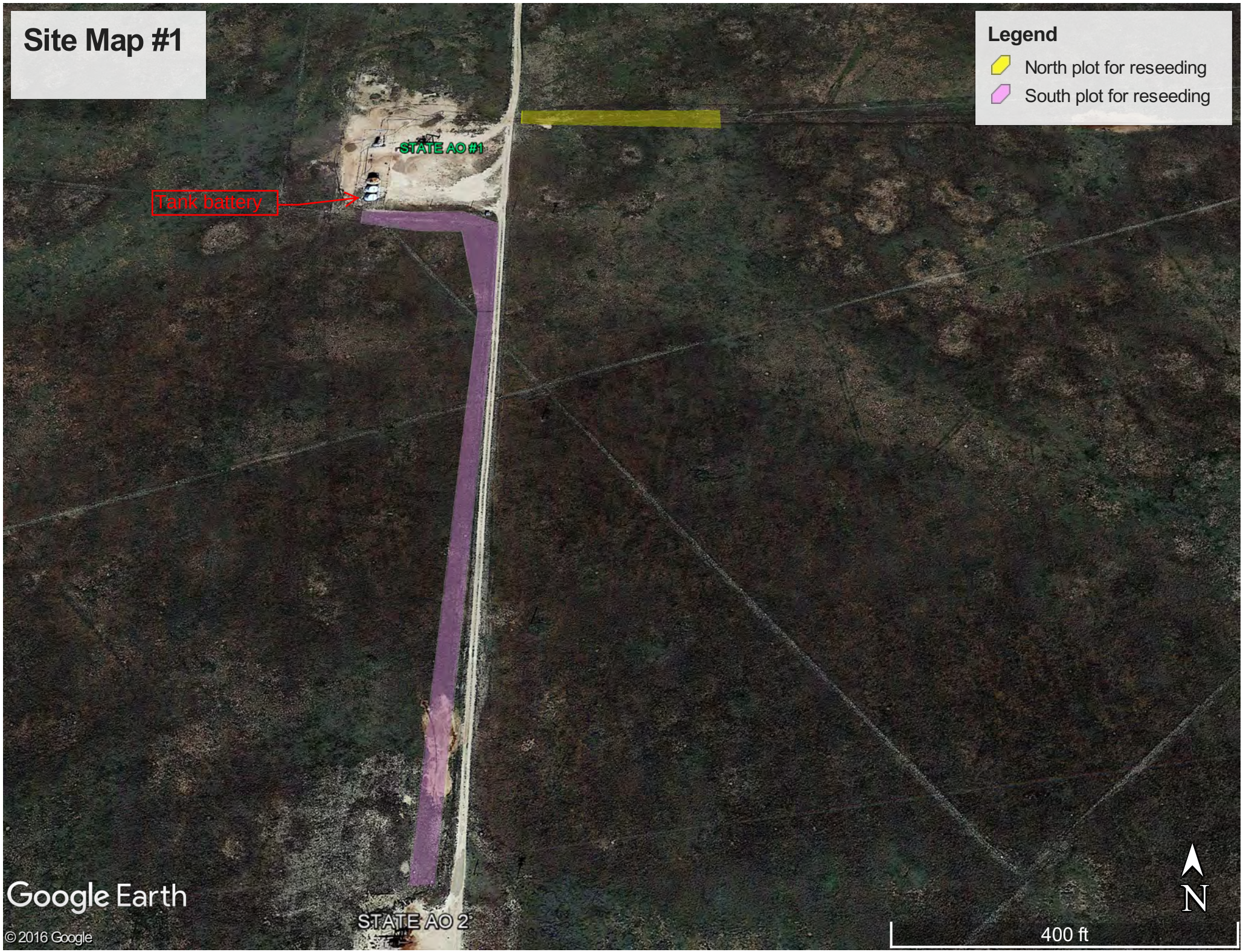
An acceptance memo dated July 26, 2016 from Jamie Keyes, EMNRD, regarding Form C-141, states: "The C-141 has been received and the RP # for this event is 4359. The C-141 will be accepted as Initial only at this time. In order to close this RP out sampling should be done around where the active poly lines were located." This was the only requirement stipulated. The accepted C-141 was not attached to the July 26, 2016 memo, nor were instructions included about accessing the accepted form. Therefore, EnergyQuest was unaware of the requirement to "Delineate and remediate per NMOCD guidelines"; this annotation was discovered only after a later inquiry by NMOCD. Since soil samples were submitted per the EMNRD requirement and the report had showed analytes within allowed parameters, EnergyQuest considered the report "**Closed**."

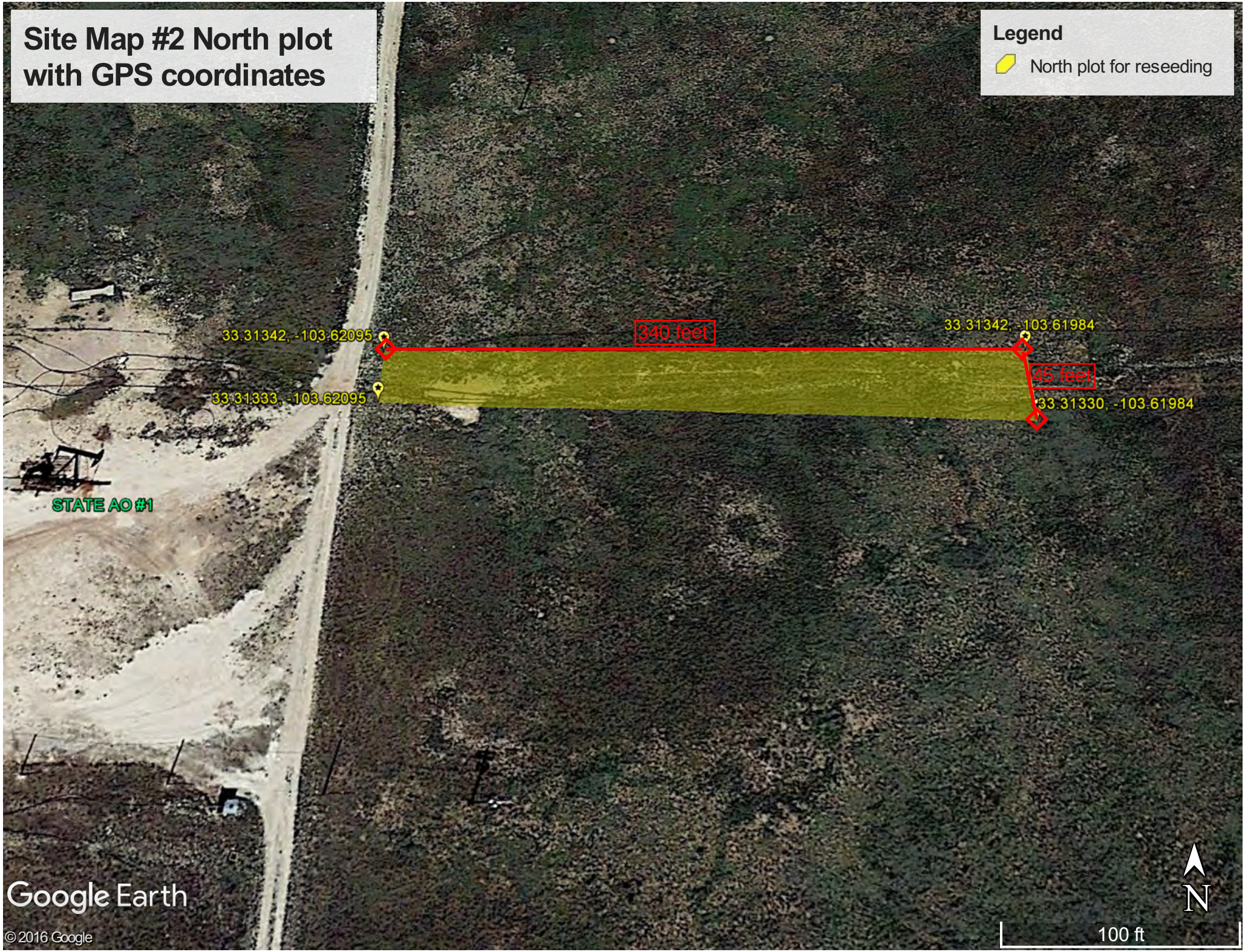
On January 23, 2017, an inquiry about report closure arrived from NMSLO; in it, Amber Groves of that office stated that while a revegetation plan normally would be required, "…in the case of a fire it might not be necessary." Prior to this, EnergyQuest was unaware that the report had not been closed. Then, on February 22, 2017, NMOCD inquired about a work plan. This query was the first indication of additional requirements. No inquiry was received from EMNRD. Research for work plan requirements on the NMOCD website yielded no results, nor could information be found elsewhere. Lacking specifics for a work plan, an updated Form C-141 was submitted on March 1, 2017, incorporating a proposal to reseed the locations and photos of natural revegetation. On March 20, 2017, NMOCD informed EnergyQuest that the incorporated proposal was unsatisfactory; Olivia Yu of NMOCD then specified minimum guidelines for a work plan. Revegetation and noxious weed management information was not included nor available online; this had to be requested separately from NMSLO.

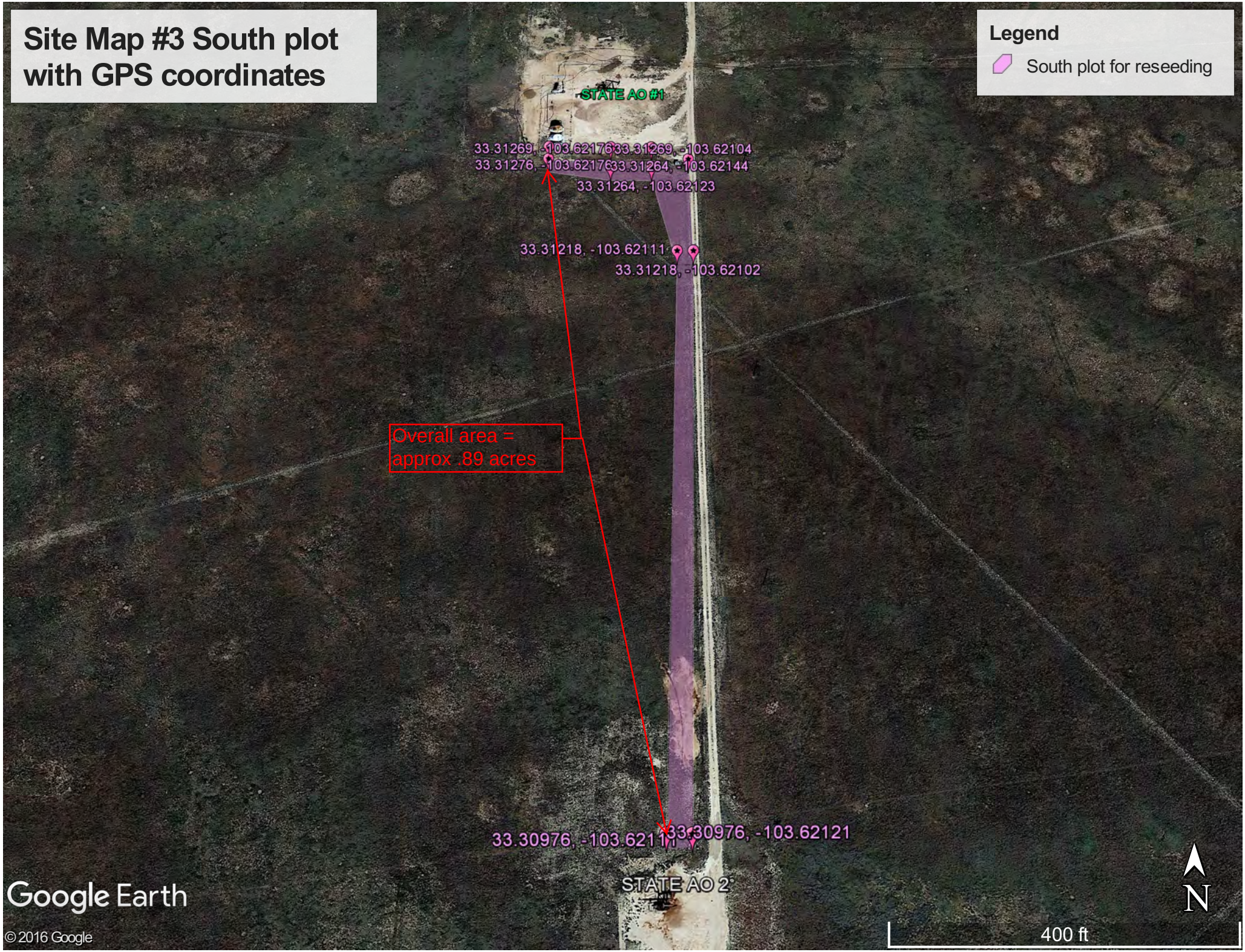
This proposal, analysis, and discussion are submitted per the additional requirements. Referenced memos and photos can be found in **Appendix 6**.

Appendix 1 – Site Maps

Map 1 – Overview map of site with proposed over-seeding plots highlighted
Map 2 – Proposed over-seeding plot #1 (northern plot) with GPS coordinates
Map 3 – Proposed over-seeding plot #2 (southern plot from tank battery to State AO #2) with GPS coordinates


Site Map #1
Legend
North plot for reseeding
South plot for reseeding
STATE AO #1
Tank battery
STATE AO 2
Google Earth
© 2016 Google
N
400 ft

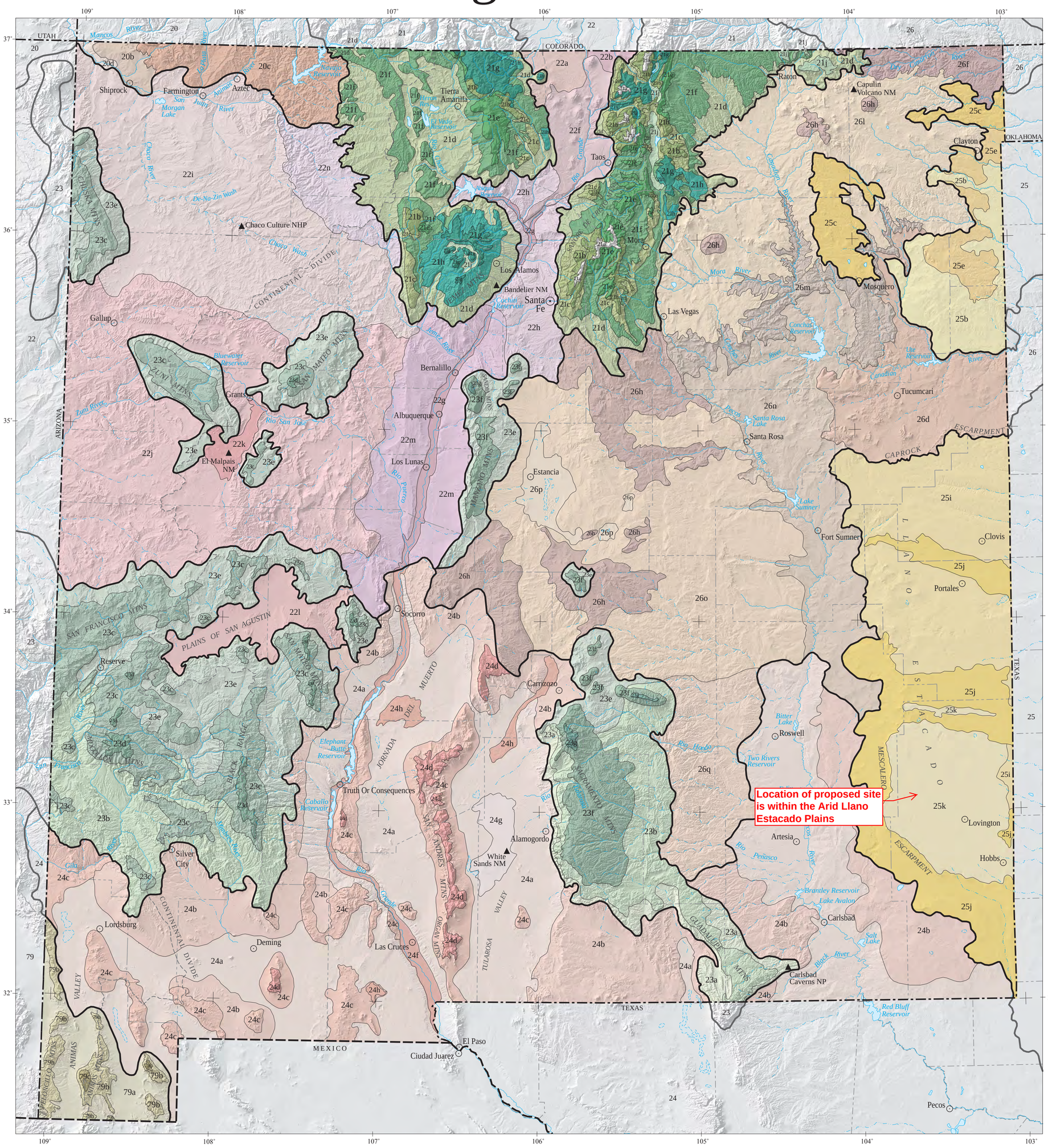

Site Map #2 North plot with GPS coordinates
Legend
North plot for reseeding
33.31342, -103.62095
340 feet
33.31342, -103.61984
45 feet
33.31333, -103.62095
33.31330, -103.61984
STATE AO #1
Google Earth
© 2016 Google
N
100 ft


Site Map #3 South plot with GPS coordinates
Legend
South plot for reseeding
STATE AO #1
33.31269, -103.62176
33.31269, -103.62104
33.31276, -103.62176
33.31264, -103.62144
33.31264, -103.62123
33.31218, -103.62111
33.31218, -103.62102
Overall area = approx .89 acres
33.30976, -103.62111
33.30976, -103.62121
STATE AO 2
Google Earth
© 2016 Google
N
400 ft

Appendix 2 – Ecoregion Analysis

EPA Map 1 – Ecoregions of New Mexico
EPA Map 2 – Ecoregions of New Mexico with descriptions of ecoregions
Memo – Inquiry to BLM, Carlsbad Office

Ecoregions of New Mexico



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- 20b Shale Deserts and Sedimentary Basins
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- 26l Upper Canadian Plateau
- 26m Canadian Canyons
- 26n Conchas/Pecos Plains
- 26o Central New Mexico Plains
- 26p Pluvial Lake Basins
- 26q Southern New Mexico Dissected Plains

79 Madrean Archipelago
- 79a Apachian Valleys and Low Hills
- 79b Lower Madrean Woodlands
- 79c Madrean Pine-Oak and Mixed Conifer Forests

- Level III ecoregion
- Level IV ecoregion
- County boundary
- State boundary
- International boundary
- Continental divide

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources; they are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance. These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas.

The New Mexico ecoregion map was compiled at a scale of 1:250,000. It revises and subdivides an earlier national ecoregion map that was originally compiled at a smaller scale. The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of the spatial patterns and the composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level.

New Mexico contains semiarid shrub- and grass-covered plains, forested mountains, glaciated peaks, woodland- and shrubland-covered hills, lava fields and volcanic plateaus, river floodplains, and arid deserts. Ecological diversity is enormous. There are 8 level III ecoregions and 55 level IV ecoregions in New Mexico and many continue into ecologically similar parts of adjacent states.

This map is part of a collaborative project primarily between USEPA Region VI, USEPA National Health and Environmental Effects Research Laboratory (Corvallis, Oregon), New Mexico Environment Department (NMED), U.S. Department of Agriculture (USDA)–Natural Resources Conservation Service (NRCS), and U.S. Geological Survey (USGS)–National Center for Earth Resources Observation and Science (EROS). The project is associated with an interagency effort to develop a common framework of ecological regions. Reaching that objective requires recognition of the differences in the conceptual approaches and mapping methodologies applied to develop the most common ecoregion-type frameworks, including those developed by the USDA–Forest Service, the US EPA, and the NRCS. As each of these frameworks is further refined, their differences are becoming less discernible. Collaborative ecoregion projects, such as this one in New Mexico, are a step toward attaining consensus and consistency in ecoregion frameworks for the entire nation.

PRINCIPAL AUTHORS: Glenn E. Griffith (Dynamac Corporation), James M. Omernik (USGS), Maryann M. McGraw (NMED), Gerald Z. Jacobi (Jacobi and Associates), Christopher M. Canavan (NMED), T. Scott Schrader (NMSU), David Mercer (NMED), Robert Hill (NRCS), and Brian C. Moran (Indus Corporation).

COLLABORATORS AND CONTRIBUTORS: Shann Stringer (NMED), David McCraw (NM Bureau of Geology and Mineral Resources), Ken Scheffe (NRCS), Paul Neville (EDAC/UNM), Phil Crocker (USEPA), Shannen Chapman (Dynamac Corporation), Sandy Bryce (Dynamac Corporation), Mark Gruber (New Mexico Department of Game and Fish), John Hutchinson (Science Applications International Corporation), Jack Wittmann (USGS), and Tom Loveland (USGS).

REVIEWERS: Steve Cary (NM State Parks), Michael DeMers (New Mexico State University), and Esteban Muldavin (University of New Mexico).

CITING THIS MAP: Griffith, G.E., Omernik, J.M., McGraw, M.M., Jacobi, G.Z., Canavan, C.M., Schrader, T.S., Mercer, D., Hill, R., and Moran, B.C., 2006, Ecoregions of New Mexico (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,400,000).

Ecoregion maps, publications, GIS files, and contact information are available at www.epa.gov/wed/pages/ecoregions.htm.

SCALE 1:1 400 000

15 10 5 0 30 60 mi
30 20 10 0 60 120 km

Albers equal area projection
Standard parallels 33˚ N and 36˚ N

NM_eco_map_fnl3.ai GG 1/23/07

Ecoregions of New Mexico

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources; they are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance (Bryce and others, 1999). These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas (Omernik and others, 2000).

The New Mexico ecoregion map was compiled at a scale of 1:250,000. It revises and subdivides an earlier national ecoregion map that was originally compiled at a smaller scale (USEPA, 2006; Omernik, 1987). The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of the spatial patterns and the composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity (Wiken, 1986; Omernik, 1987, 1995). These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level.

A Roman numeral hierarchical scheme has been adopted for different levels of ecological regions. Level I is the coarsest level, dividing North America into 15 ecological regions. Level II divides the continent into 52 regions (Commission for Environmental Cooperation Working Group, 1997). At level III, the continental United States contains 104 ecoregions and the conterminous United States has 84 ecoregions (United States Environmental Protection Agency [USEPA], 2006). Level IV is a further subdivision of level III ecoregions. Explanations of the methods used to define the USEPA's ecoregions are given in Omernik (1995, 2004), Omernik and others (2000), and Gallant and others (1989).

New Mexico contains semiarid shrub- and grass-covered plains, forested mountains, glaciated peaks, woodland- and shrubland-covered hills, lava fields and volcanic plateaus, river floodplains, and arid deserts. Ecological diversity is enormous. There are 8 level III ecoregions and 55 level IV ecoregions in New Mexico and many continue into ecologically similar parts of adjacent states (Griffith and others, 2004; Woods and others, 2005; Chapman and others, 2006).

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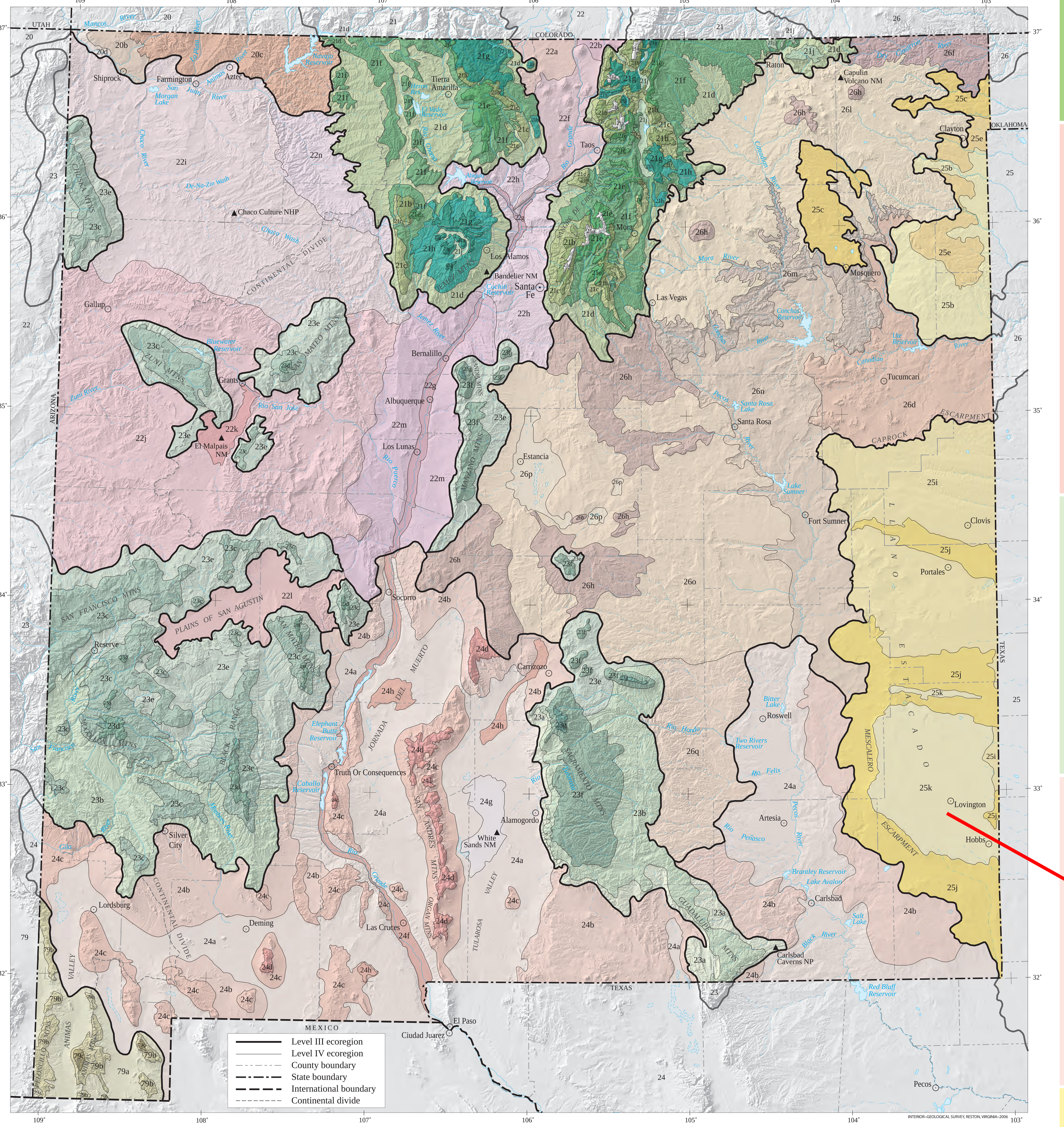

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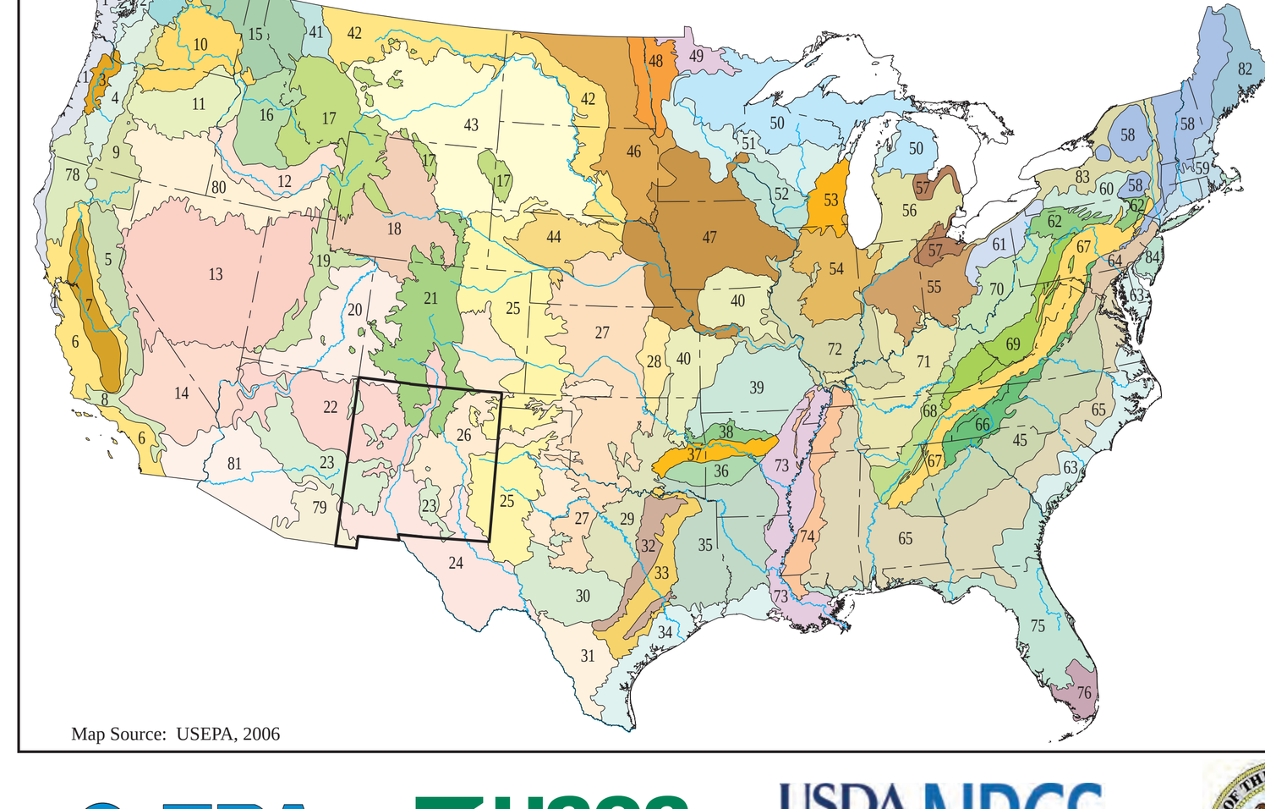
- 26n Conchas/Pecos Plains
- 26o Central New Mexico Plains
- 26p Pluvial Lake Basins
- 26q Southern New Mexico Dissected Plains

79 Madrean Archipelago
- 79a Apachian Valleys and Low Hills
- 79b Lower Madrean Woodlands
- 79c Madrean Pine-Oak and Mixed Conifer Forests

Level III Ecoregions of the Conterminous United States



1 Coast Range
2 Puget Lowland
3 Willamette Valley
4 Cascades
5 Sierra Nevada
6 Southern and Central California Chaparral and Oak Woodlands
7 Central California Valley
8 Southern California Mountains
9 Eastern Cascades Slopes and Foothills
10 Columbia Plateau
11 Blue Mountains
12 Snake River Plain
13 Central Basin and Range
14 Mojave Basin and Range
15 Northern Rockies
16 Idaho Batholith
17 Middle Rockies
18 Wyoming Basin
19 Wasatch and Uinta Mountains
20 Colorado Plateaus
21 Southern Rockies
22 Arizona/New Mexico Plateau
23 Arizona/New Mexico Mountains
24 Chihuahuan Deserts
25 High Plains
26 Southwestern Tablelands
27 Central Great Plains
28 Flint Hills
29 Central Oklahoma/Texas Plains
30 Edwards Plateau
31 Southern Texas Plains
32 Texas Blackland Prairies
33 East Central Texas Plains
34 Western Gulf Coastal Plain
35 South Central Plains
36 Ouachita Mountains
37 Arkansas Valley
38 Boston Mountains
39 Ozark Highlands
40 Central Irregular Plains
41 Canadian Rockies
42 Northwestern Glaciated Plains
43 Northwestern Great Plains
44 Nebraska Sand Hills
45 Piedmont
46 Northern Glaciated Plains
47 Western Corn Belt Plains
48 Lake Agassiz Plain
49 Northern Minnesota Wetlands
50 Northern Lakes and Forests
51 North Central Hardwood Forests
52 Driftless Area
53 Southeastern Wisconsin Till Plains
54 Central Corn Belt Plains
55 Eastern Corn Belt Plains
56 Southern Michigan/Northern Indiana Drift Plains
57 Huron/Erie Lake Plains
58 Northeastern Highlands
59 Northeastern Coastal Zone
60 Northern Appalachian Plateau and Uplands
61 Erie Drift Plain
62 North Central Appalachians
63 Middle Atlantic Coastal Plain
64 Northern Piedmont
65 Southeastern Plains
66 Blue Ridge
67 Ridge and Valley
68 Southwestern Appalachians
69 Central Appalachians
70 Western Allegheny Plateau
71 Interior Plateau
72 Interior River Valleys and Hills
73 Mississippi Alluvial Plain
74 Mississippi Valley Loess Plains
75 Southern Coastal Plain
76 Southern Florida Coastal Plain
77 North Cascades
78 Klamath Mountains
79 Madrean Archipelago
80 Northern Basin and Range
81 Sonoran Basin and Range
82 Laurentian Plains and Hills
83 Eastern Great Lakes and Hudson Lowlands
84 Atlantic Coastal Pine Barrens

Map Source: USEPA, 2006

SCALE 1:1 400 000

15 10 5 0 30 60 mi
30 20 10 0 60 120 km

Albers equal area projection
Standard parallels 33˚ N and 36˚ N

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20. Colorado Plateaus

Horizontal sedimentary rocks carved into relief of broad mesas, valleys, and canyons typify Ecoregion 20. Most of the flow of the San Juan River originates in Colorado.

Rugged tableland topography is typical of the Colorado Plateaus ecoregion. Canyons, mesas, plateaus, and mountains expose a long geologic history of rock formations. Precipitous side-walls mark abrupt changes in local relief, often of 1000 to 2000 feet or more. The region contains more pinyon-juniper and Gambel oak woodlands than the Wyoming Basin (18) to the north. However, the region also has large low-lying areas containing saltbrush-greasewood communities, and in Utah, blackbrush communities typical of hotter, drier areas. These communities are generally not found in the higher Arizona/New Mexico Plateau (22) to the south where grasslands were typically more common.

20b The arid **Shale Deserts and Sedimentary Basins** ecoregion consists of nearly level basins and valleys, benches, low rounded hills, and badlands. Rock outcrops occur; it is sparsely vegetated with mat saltbush, fourwing saltbush, greasewood, and shadscale. Native grasses included alkali sacaton, galleta grass, poverty threeawn, sand dropseed, and Indian ricegrass. It is lower in elevation with less pinyon-juniper woodland than the adjacent Semiarid Benchlands and Canyonlands (20c).

20c Broad, grass-, shrub-, and woodland-covered benches and mesas characterize the **Semiarid Benchlands and Canyonlands** ecoregion. Areas of high relief alternate with areas of low relief. Bedrock exposures are common along rims, escarpments, and on steep dip slopes. Pinyon and juniper occur on shallow, stony soils with scattered areas of Gambel oak at higher elevations. On deeper soils, warm season grasses, sagebrush, fourwing saltbush, winterfat, and Mormon tea occur. The vegetation is not as sparse as in drier areas such as Ecoregions 20b and 20d.

20d Occurring primarily in Utah, the **Arid Canyonlands** ecoregion includes the inner gorge of the Colorado River and its major tributaries, such as the San Juan River. Much of this ecoregion is bounded by nearly vertical canyon walls that separate it from the adjacent, higher benchlands of Ecoregion 20c. Exposed bedrock is common. The New Mexico portion lacks the relief of most of the region in Utah. Soils are shallower with a drier moisture regime than those of Ecoregion 20c. Shadscale, saltbush, some sand sagebrush, and drought tolerant grasses including galleta grass and Indian ricegrass occur. This is the driest area of New Mexico, receiving less than 8 inches of annual rainfall.

79. Madrean Archipelago

Also known as the Sky Islands in the United States, this is a region of basins and ranges with medium to high local relief, typically 3000 to 5000 feet. Native vegetation in the region is mostly grama-tobosa shrubsteppe in the basins and oak-juniper woodlands on the ranges, except at higher elevations where ponderosa pine is predominant. The region has ecological significance as both a barrier and bridge between two major cordilleras of North America: the Rocky Mountains and the Sierra Madre Occidental.

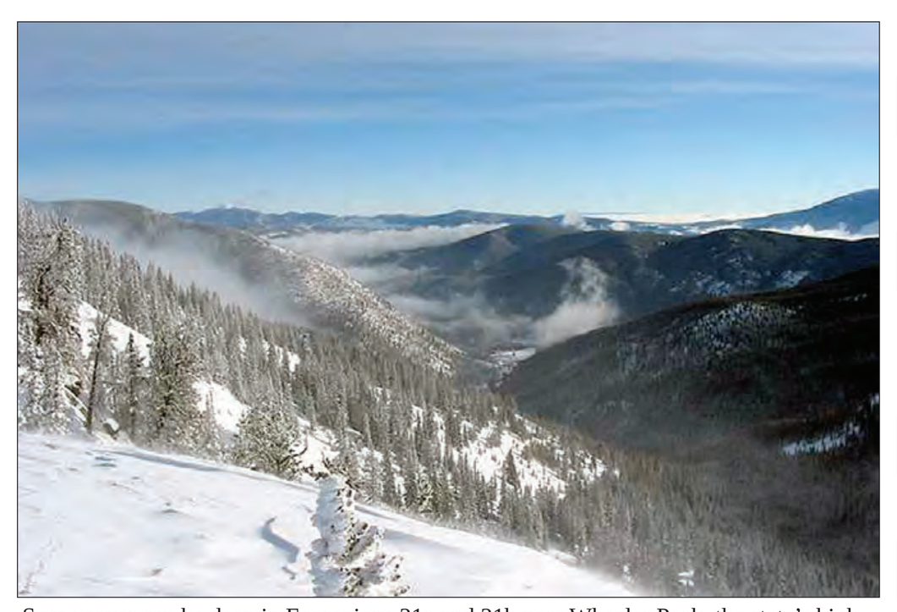
79a With valley plains, alluvial fans, and some low hills, the **Apachian Valleys and Low Hills** ecoregion is generally similar physiographically to the Chihuahuan Basins and Playas (24a). This region, however, has greater precipitation with more monsoonal influence, and has more grassland than Ecoregion 24a. The present vegetation is mostly sideoats grama, black grama, cane beardgrass, plains lovegrass, blue grama, hairy grama, sand dropseed, vine mesquite, curly mesquite, false mesquite, Mormon-tea, mimosa, yucca, ocotillo, cacti, and agave. Encroachment of honey mesquite has been significant in some areas.

79b The **Lower Madrean Woodlands** occur at intermediate elevations, generally above 5000 feet. It is a mild winter-wet summer woodland, shrubby in places. The Madrean encinal, or evergreen oak woodlands, have a mosaic of savannas, denser woodlands, and grassy openings. Emory, silverleaf, Tourney, and Arizona white oaks occur, along with scattered pinyon, juniper, mesquite, and chaparral species. Riparian areas of cottonwood, sycamore, and willow are valuable to neotropical birds and other wildlife of the area.

79c In contrast to the lower elevation woodlands of Ecoregion 79b, at elevations above about 7000 feet are the **Madrean Pine-Oak and Mixed Conifer Forests**. These include ponderosa pine-oak forests, ponderosa pine forests, montane fir forests, and mixed conifer forests. Some very small areas of subalpine forest occur in Arizona. Ponderosa pine, southwestern white pine, Apache pine, and Chihuahuan pine are found here, along with some Douglas-fir. Gambel oak and alligator juniper are also components of these pine forests.

Complex dynamics among climate change, seasonal precipitation, fire, grazing, desert shrub expansion, and grasslands occurs in the Animas Valley of Ecoregion 79a. *Photo: Dan Imhoff*

21. Southern Rockies



Snow cover can be deep in Ecoregions 21a and 21b near Wheeler Peak, the state's high point at 13,161 feet. The alpine and subalpine regions are important snow collection areas, providing water supplies to lower, more arid ecoregions. Average annual snowfall at the higher elevations is often over 100 inches and can exceed 300 inches in a few areas of New Mexico's Southern Rockies.

The Southern Rockies are composed of high elevation, steep, rugged mountains. Although coniferous forests cover much of the region, as in most of the mountainous regions in the western United States, vegetation, as well as soil and land use, follows a pattern of elevational banding. The lowest elevations are generally grass or shrub covered and heavily grazed. Low to middle elevations are also grazed and covered by a variety of vegetation types including juniper-oak woodlands, ponderosa pine, aspen, and Douglas-fir. Middle to high elevations are largely covered by coniferous forests and have little grazing activity. The highest elevations have alpine characteristics. Numerous perennial mountain streams with decidous riparian vegetation support coldwater fisheries and serve as wildlife corridors.

21a The **Alpine Zone** occurs on mountain tops above treeline, beginning at about 11,000 to 11,500 feet in New Mexico. It includes alpine meadows as well as steep, exposed rock, talus, and glaciated peaks. Annual precipitation ranges from 25 to greater than 50 inches, falling mostly as snow. Vegetation includes low shrubs, cushion plants, and wildflowers and sedges in wet meadows. The forest-tundra interface is sparsely colonized by stunted, deformed Englemann spruce, subalpine fir, and sometimes bristlecone pine and snow willow (krummholz vegetation). Ecoregion 21a is snow-free only 8 to 10 weeks annually. Snow cover is a major source of water for lower, more arid ecoregions.

21b The **Crystalline Subalpine Forests** ecoregion occupies a narrow elevational band on the steep, forested slopes of the mountains, becoming more extensive on the north slopes. The elevation range in New Mexico is generally 9000 to 11,500 feet, just below the Alpine Zone (21a). Dense forests are dominated by Englemann spruce and subalpine fir; aspen locally dominates some areas. Subalpine meadows also occur. Forest blowdown, insect outbreaks, fire, and avalanches affect the vegetation mosaic. Soils are weathered from a variety of crystalline and metamorphic materials, such as gneiss, schist, and granite, as well as some areas of igneous intrusive rocks. Recreation, logging, mining, and wildlife habitat are the major land uses.

21c The **Crystalline Mid-Elevation Forests** are found mostly in the 8000 to 10,000 feet elevation range on crystalline and metamorphic substrates. Natural vegetation includes ponderosa pine, aspen, Douglas-fir, and areas of limber pine. A diverse understory of shrubs, grasses, and wildflowers occurs. The variety of food sources supports a diversity of bird and mammal species. Forest stands have become denser in many areas due to decades of fire suppression. Land use includes wildlife habitat, livestock grazing, logging, mining, and recreation.

21d The **Foothill Woodlands and Shrublands** ecoregion is the low elevation portion of the Southern Rockies, and extends from southern Wyoming through Colorado and into New Mexico. In New Mexico, it is a transition area from the higher elevation forests to drier and lower plains (Ecoregion 26) and plateaus (Ecoregions 20, 22). Within the region, some flora and fauna species on the east side (Great Plains) may differ from those found to the west (Great Basin influence). This semiarid region has rolling to irregular terrain of hills, ridges, and footslopes, with elevations mostly 6000 to 8500 feet, and a variety of rock and soil types. In New Mexico, pinyon-juniper and oak woodlands are dominant.

21e The **Sedimentary Subalpine Forests** ecoregion occupies much of the western half of the Southern Rockies in Colorado, areas of the Sangre de Cristo Range in Colorado and New Mexico, and the western part of the Tusas Mountains in New Mexico. The region occurs on sandstone, siltstone, shale, and limestone substrates. Stream water quality, water availability, and aquatic biota are affected in places by carbonate substrates that are soluble and nutrient rich. Some streams support the endemic Rio Grande cutthroat trout. Soils are generally finer-textured than those found on crystalline or metamorphic substrates of Ecoregion 21b. Subalpine forests dominated by Englemann spruce and subalpine fir are typical, often interspersed with aspen groves or mountain meadows. Some Douglas-fir forests are at lower elevations.

21f The **Sedimentary Mid-Elevation Forests** ecoregion occurs in the western and southern portions of the Southern Rockies in Colorado and in several areas of the Rockies in New Mexico at elevations generally below Ecoregion 21e. The elevation limits and vegetation of this region are similar to the crystalline (21c) and volcanic (21h) mid-elevation forests; however a larger area of Gambel oak woodlands and forest is found in this region. Carbonate substrates in some areas affect water quality, hydrology, and biota. Abundant aquatic insects support a reproducing trout fishery. Soils are generally finer-textured than those found on crystalline and metamorphic substrates typical of Ecoregion 21c.

21g The steep, mountainous **Volcanic Subalpine Forests** ecoregion is composed of Tertiary or Quaternary volcanic rocks, primarily in the southern extension of the San Juan Mountains from Colorado and in parts of the Brazos, Jemez, and Taos mountains of New Mexico. Relatively young geologically, the high, rugged mountains still contain some large areas of intact habitat. Englemann spruce, subalpine fir, and aspen forests support a variety of wildlife.

21h The **Volcanic Mid-Elevation Forests** ecoregion occurs at elevations of about 7500 to 10,000 feet and is composed of igneous rocks of andesite and basalt. The majority of the region is found in the Jemez Mountains with smaller, scattered areas to the north and east. Forests of ponderosa pine, Douglas-fir, and aspen occur. Land use includes wildlife habitat, livestock grazing, logging, and recreation.

21j The **Grassland Parks** ecoregion, occurring primarily in Colorado, consists of high intermontane valleys with sufficient water availability to support grasslands and wet meadows. In New Mexico, the ecoregion is found in the Valle Grande/Valle San Antonio area in the Jemez Mountains, in the Moreno Valley and Costilla-Comanche-Valle Vidal areas in the Sangre de Cristo Mountains, and on top of Johnson Mesa near Raton. Grasslands with bunchgrasses are dominant, and include Parry's oatgrass, Arizona fescue, Idaho fescue, Thurber fescue, mountain muhly, bluebunch wheatgrass, needle-and-thread grass, Junegrass, and slender wheatgrass. There are only a few trees or shrubs, and if present, they are widely scattered and mature. Some springs and wetlands occur. Large elk herds are found in the valley parklands.

The New Mexico state fish, the Rio Grande Cutthroat Trout is found in high mountain coldwater streams. Populations are being restored into historic headwater streams. *Photo: Mark Gruber, NMDGF*

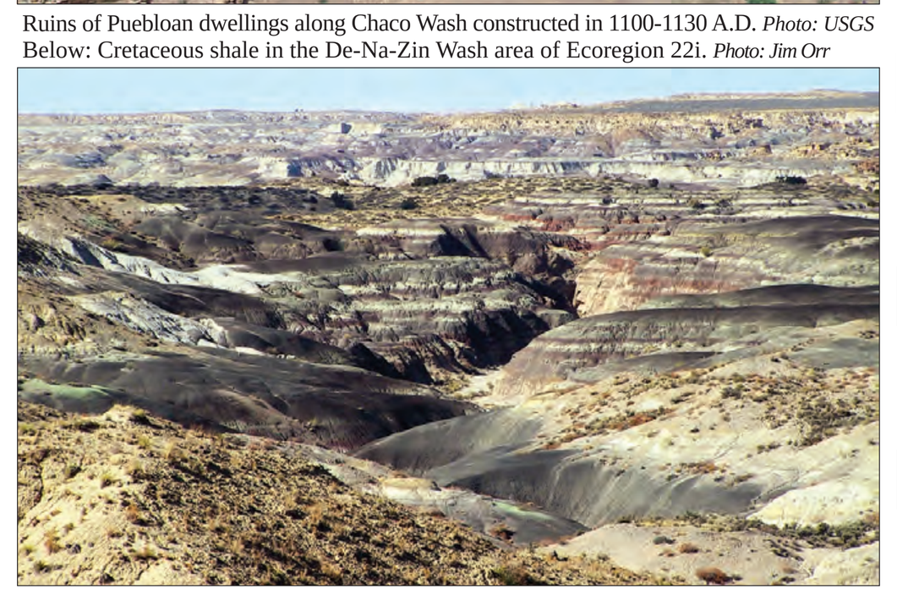
Aquatic insects, such as this recently emerged stonefly (*Pteronarcys californica*) comprise the fish food base in high quality coldwater streams such as the upper Pecos River. *Photo: Steve Cary, NM State Parks*

North American elk, or wapiti, are found in many parts of Ecoregion 21. They move to lower elevations in winter for better forage. *Photo: Jeff Vanuga, NRCS*

Balancing demands for cattle, elk, fish, recreation, and stream water quality is a land management challenge in the Valles Caldera in Ecoregion 21j. *Photo: Mouser Williams*

22. Arizona/New Mexico Plateau

Ruins of Puebloan dwellings along Chaco Wash constructed in 1100-1130 A.D. *Photo: USGS*
Below: Cretaceous shale in the De-Na-Zin Wash area of Ecoregion 22i. *Photo: Jim Orr*



The Arizona/New Mexico Plateau represents a large transitional region between the drier shrublands and wooded higher relief tablelands of the Colorado Plateaus (20) in the north, the lower, hotter, less vegetated Mojave Basin and Range (14) in the west, and forested mountain ecoregions that border the region on the northeast (21) and south (23). Local relief in the region varies from a few feet on plains and mesa tops to well over 1000 feet along tableland side slopes. The Continental Divide splits the region, but is not a prominent topographic feature. The region extends across northern Arizona, northwestern New Mexico, and into Colorado in the San Luis Valley. Gunnison prairie dogs are a keystone species in many of the sagebrush ecosystems and their burrows provide habitat for other wildlife including burrowing owls, weasels, badgers, and a variety of snakes.

22a The **San Luis Shrublands and Hills** ecoregion, occurring mostly in Colorado, includes the higher relief foothill edges and low mountain areas within the San Luis basin. It includes the San Luis Hills in Colorado, a series of low mountains, hills, and tilted mesas. The New Mexico portion includes the area northwest of the Taos Plateau Ecoregion (22f). Big sagebrush, rabbitbrush, and winterfat occur as well as grasslands of western wheatgrass, green needlegrass, blue grama, and needle-and-thread.

22b This region occurs primarily in Colorado, barely extending across the state line into New Mexico. Although precipitation in the **San Luis Alluvial Flats and Wetlands** ecoregion is low, water availability from mountain runoff, a high water table, and associated springs and wetlands have made cropland irrigation possible. The ecoregion was once dominated by shadscale, saltbush and greasewood, but most of the native vegetation has been removed for agriculture. Irrigated cropland is common in the Colorado portion, with barley malt, potatoes, alfalfa, small grains, and hay, and smaller areas of vegetables such as spinach, head lettuce, and carrots. In the New Mexico portion, sagebrush is more common, with some irrigated areas for hay.

22f The **Taos Plateau** is a region of mostly Pliocene basaltic lavas with distinct cones of Pliocene composite volcanoes. This region has higher elevation volcanic cones than the San Luis Hills of 22a in Colorado; several cones are over 9000 feet and Ute Mountain is higher than 10,000 feet. The plateau surface has more sagebrush than Ecoregion 22a in Colorado. The plateau surface has only minor dissection, but the Rio Grande is confined to a deep canyon or gorge, 800 to 1000 feet deep in places. The ecoregion extends south to include the basalt-capped Black Mesa.

22g Once containing a perennially flowing, meandering, braided river, the **Rio Grande Floodplain** ecoregion has undergone many human alterations to its landscape and hydrology over the past 400 years. The once-shifting Rio Grande had mosaics of riparian woodlands and shrublands along with a variety of wetland meadows, ponds, and marshes. The gallery forest, or bosque, of cottonwood and willow with understories of coyote willow, New Mexico olive, false indigo, and seepwillow depended on this dynamic system. A long history of irrigation and drainage canals, levees and jetty jacks, and upstream dams have altered river flows and narrowed and straightened the stream channel. Conversion to cropland, orchards, small rural farms and ranchos, and urban and suburban uses have also altered the region. Cottonwood and willow, dependent on spring flooding, have been widely replaced by invasive saltcedar and Russian olive.

22h The **North Central New Mexico Valleys and Mesas** is an area of mostly pinyon pine and juniper savanna, and mesa and valley topography similar to some other parts of Ecoregion 22. Situated between portions of the Southern Rockies (21) to the east and west, and dominated by young geologic features of the Espanola rift basin and ancestral Rio Grande floodplain, ecological differences are apparent. It has a cooler climate with slightly greater precipitation, streams tend to have more water flow, and there is a different species mix of flora and fauna compared to 22i, 22j, or 22m. It differs from 22f in geology, topography, and vegetation; from 22i and 22m in elevation, climate, and vegetation. It has a mix of geology, mostly Tertiary sedimentary or Tertiary and Quaternary volcanic rocks.

22i The **San Juan/Chaco Tablelands and Mesas** ecoregion of plateaus, valleys, and canyons contains a mix of desert scrub, semi-desert shrub-steppe, and semi-desert grasslands. Shadscale, fourwing saltbush, mormon tea, Indian ricegrass, galleta, and blue and black gramas are typical. It is more arid, has generally lower elevations, and less pinyon-juniper than the Semiarid Tablelands (22j) to the south or Ecoregion 22n to the east. It is mostly composed of gently dipping Tertiary and Cretaceous sedimentary rocks. Oil and gas production occurs mostly in the northern part of the region. It contains the upper reaches of the Rio Puerco, an area of severe erosion due to geology, topography, and human influences.

22j With some similarities to Ecoregion 20c, the **Semiarid Tablelands** consists of mesas, plateaus, valleys, and canyons formed mostly from flat to gently dipping sedimentary rocks, along with some areas of Tertiary and Quaternary volcanic fields. The region contains areas of high relief and some low relief plains. Bedrock exposures are common. Grass, shrubs, and woodland cover the tablelands. The vegetation is not as sparse as in Ecoregion 22i to the north or 22m to the east. It lacks the denser pine forests of the higher and more mountainous Ecoregion 23. Scattered junipers occur on shallow, stony soils, and are dense in some areas. Pinyon-juniper woodland is also common in some areas. Saltbush species, alkali sacaton, sand dropseed, and mixed grama grasses occur.

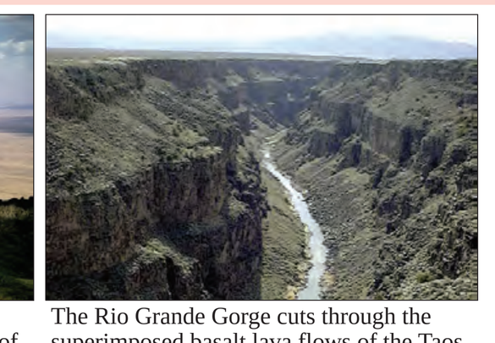
22k Part of the much larger Zuni-Bandera volcanic field, the **Lava Malpais** covers some of the younger Holocene volcanic flows with the least soil development. The youngest flow, called the McCartys flow, dates from about 3000 years ago. Different types of lava flows are found here, as well as lava tubes and ice caves. Some unique flora and fauna not found in surrounding areas occur here, and some species that are more widespread have made adaptations to survive in the specialized habitats here. The lava substrate has the ability in places to trap and retain moisture, allowing for a more mesophytic vegetation, such as stunted Douglas-fir and ponderosa pine, to occur in some areas. The region is an important area for understanding recent ecological successions, as well as longer term climatic changes.

22l The **Plains of San Agustin** are mostly a topographically closed basin, with some alluvial fans and piedmont slopes near the surrounding mountains of Ecoregion 23. Beach and lacustrine deposits mark various stages of Pleistocene Lake San Agustin. Clay to fine-grained sand lake bed sediments, linear beach-ridge sand deposits, and some sand sheets and dune sand deposits occur. The sandy areas are mostly stabilized by grasses and low shrubs. Vegetation of alkali sacaton, fourwing saltbush, and greasewood is found in the low areas. Some western wheatgrass, vine-mesquite, areas of blue grama and sand dropseed occur. Higher elevation slopes have some pinyon-juniper savanna with an understory of blue grama, dropseeds, Indian ricegrass, and bottlebrush squirreltail grasses. Livestock grazing is the predominant land use.

22m Part of one of the deeper physiographic basins of the Rio Grande rift, the **Albuquerque Basin** ecoregion is lower in elevation, drier, and warmer than surrounding ecoregions to the north, east, and west. The basin is filled with thick sediments of mostly Quaternary and some Tertiary age, with a few areas of volcanic rocks and lava-capped mesas. Extending from the La Bajada Escarpment on the north to near Socorro in the south, the region contains some diverse features and transitional characteristics. Unlike most of Ecoregion 22 which has mesic soils, 22m has a largely thermic soil temperature regime. There is a mix of sand scrub and desert grassland vegetation. Native vegetation includes black grama, sand dropseed, mesa dropseed, blue grama, galleta, sand sage, alkali sacaton, threeawns, and scattered yucca. Juniper occurs primarily in the north. Urban and suburban land uses are spreading. The Santa Fe Group aquifer, the drinking water source for Albuquerque and most of the Middle Rio Grande Valley, has seen some groundwater declines in recent years, along with increases in contaminants.

22n Similar to Ecoregion 22h, the **Near-Rockies Valleys and Mesas** ecoregion is an area of mostly pinyon-juniper woodland, juniper savanna, and mesa and valley topography, with influences of higher elevation vegetation in drainages from the adjacent Southern Rockies (21). Its geology differs from Ecoregion 22h, with older Tertiary and Cretaceous sedimentary rocks. It has generally higher elevations, greater precipitation, and more juniper than Ecoregion 22i to the west. Canyon streams flow intermittently out of the Rockies into the Canon Largo watershed, a tributary to the San Juan River.

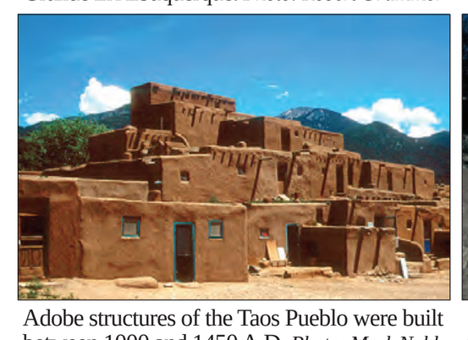
Ship Rock, a classic volcanic neck with radiating dikes, is in the western portion of Ecoregion 22i. Known as *Tse Bit' a'í*, or the Rock with Wings, it is a sacred site to the Navajo people. *Photo: L.J. Maher*



The Rio Grande Gorge cuts through the superimposed basalt lava flows of the Taos Plateau (22f). Canyon walls provide habitat for eagles, osprey, hawks, owls, and falcons. *Photo: Mouser Williams*

Urban land cover sprawls across the Rio Grande in Albuquerque. *Photo: Robert Grammer*

Pikeminnows in the San Juan River are endangered. *Photo: USFWS*

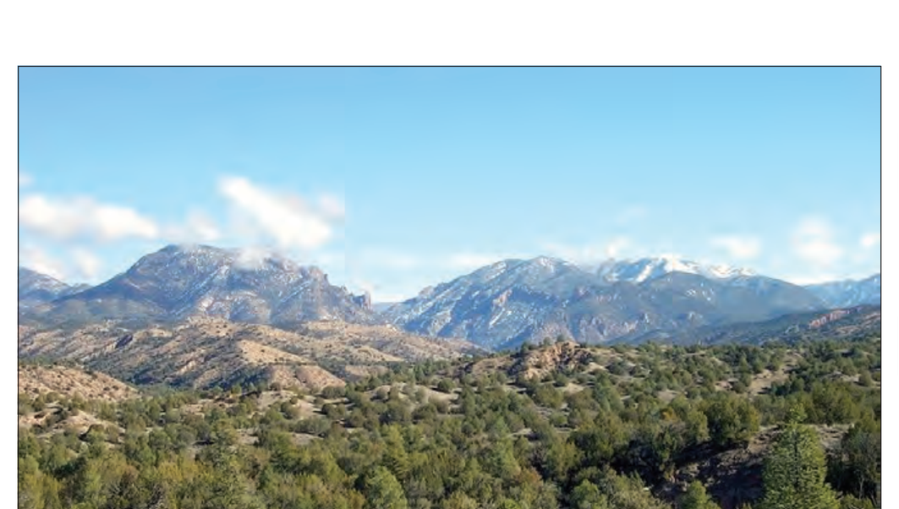


Adobe structures of the Taos Pueblo were built between 1000 and 1450 A.D. *Photo: Mark Nohl*

Soil erosion and high sediment loads are typical in the Rio Puerco basin. *Photo: USGS*

23. Arizona/New Mexico Mountains

The Arizona/New Mexico Mountains are distinguished from neighboring mountainous ecoregions by their lower elevations and associated vegetation indicative of drier, warmer environments, due in part to the region's more southerly location. Forests of spruce, fir, and Douglas-fir, common in the Southern Rockies (21) and the Wasatch and Uinta Mountains (19), are only found in limited areas at the highest elevations in this region. Chaparral is common at lower elevations in some areas, pinyon-juniper and oak woodlands are found at lower and middle elevations, and the higher elevations are mostly covered with open to dense ponderosa pine forests. These mountains are the northern extent of some Mexican plant and animal species. Surrounded by deserts or grasslands, these mountains in New Mexico can be considered biogeographical islands.



The Madrean Lower Montane Woodlands (23b), foreground, contrast with the more rugged Mogollon Mountains of Ecoregions 23c and 23d. The Mogollon Mountains include peaks over 10,000 feet in elevation and form the core of the Gila Wilderness. Created in 1924 at the urging of conservationist Aldo Leopold, the Gila Wilderness was the world's first designated wilderness area. *Photo: April Sterling*

23a The **Chihuahuan Desert Slopes** are found on the Guadalupe and Sacramento mountains. The lower slopes of these mountains represent a continuation of the Chihuahuan Desert ecosystem; soils and vegetation in much of Ecoregion 23a are similar to those in the Low Mountains and Bajadas (24c) of the Chihuahuan Deserts (24). The lower slopes were once mostly grasslands overgrazed in the late 19th century and subsequently invaded by desert shrubs. Yucca, sotol, lechuguilla, ocotillo, and cacti now dominate the rocky slopes below 5500 feet. Grasslands persist near alluvial fans and on gentle slopes with deeper, sandstone-derived soils. Water is scarce; the few streams that originate from springs at higher elevations do not persist beyond the mouths of major canyons.

23b The **Madrean Lower Montane Woodlands** ecoregion covers the slopes of the Guadalupe, Sacramento, Mimbres, Big Burro, and Mogollon mountains, generally between 5500 to 7200 feet, with densities of juniper, pinyon pine, and oak varying according to aspect. There are some similarities to Ecoregion 23e; however, Ecoregion 23b has milder winters, wetter summers, and inclusions of alligator juniper and Madrean evergreen oak species. At middle elevations, dense thickets of shrubs such as desert ceanothus, alderleaf mountain mahogany, and catclaw mimosa form chaparral communities. Other areas are grassy and park-like with scattered trees. A few small areas of ponderosa pine, Douglas-fir, or southwestern white pine occur at the highest elevations, outliers of Ecoregions 23c or 23f. In the west, the Gila River and tributaries have many endemic aquatic organisms including fish, amphibians, and insects.

23c The **Montane Conifer Forests** are found west of the Rio Grande at elevations from about 7000 to 9500 feet. Ponderosa pine and Gambel oak are common, along with mountain mahogany and serviceberry. Some Douglas-fir, southwestern white pine, and white fir occur in a few areas. Blue spruce may occasionally be found in cool, moist canyons. The influence of the Sierra Madre flora is seen mostly in the southern mountains and diminishes to the north. In the far south, other oaks appear, such as silverleaf oak, netleaf oak, Arizona white oak, and Emory oak. The summer rains are especially important for herbaceous plants. The region is geologically diverse with volcanic, sedimentary, and some intrusive and crystalline rocks. Endemic Gila trout occur in some of the region's streams. Livestock grazing, logging, and recreation are the primary land uses. Wildfire is an important feature influencing the forested ecosystems in this region.

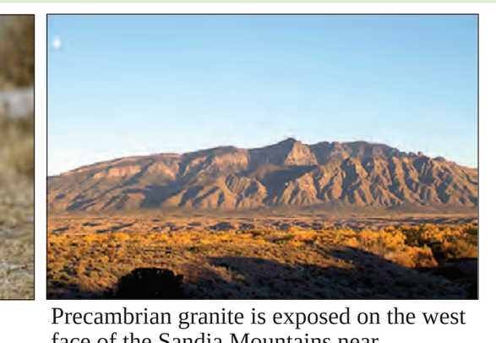
23d The **Arizona/New Mexico Subalpine Forests** occur west of the Rio Grande at the higher elevations, generally above 9500 feet. The region includes parts of the Mogollon Mountains, Black Range, San Mateo Mountains, Magdalena Mountains, and Mount Taylor. The peak elevations are mostly above 10,000 feet. Although there are some vegetational differences from mountain range to mountain range within Ecoregion 23d, the major forest trees include Engelmann spruce, corkbark fir, blue spruce, white fir, and aspen. Some Douglas-fir occurs at lower elevations. Cryic soils developed on the mixed geology of mostly Tertiary volcanics and Tertiary intrusives, with only minor areas of Precambrian rocks in the Black Range.

23e The **Conifer Woodlands and Savannas** ecoregion is an area of mostly pinyon-juniper woodlands, with some ponderosa pine at higher elevations. It often intermingles with grasslands and shrublands. Although elevations are higher than surrounding Ecoregion 22 areas, the boundaries tend to be transitional. The region is generally cooler, with more uniform winter and summer seasonal moisture compared to Ecoregion 23b. It lacks the milder winters, wetter summers, chaparral, Madrean oaks, and other species of Ecoregion 23b.

23f The **Rocky Mountain Conifer Forests** are found at elevations from about 7000 to 9600 feet in the mountains east of the Rio Grande. With similarities to Ecoregion 23c, ponderosa pine and Gambel oak are common, with mountain mahogany and a dense understory. Some Douglas-fir, southwestern white pine, and white fir occur in a few areas. Blue spruce may occasionally be found in cool, moist canyons. In the Sandia and Manzano mountains, white fir and Douglas-fir are more extensive than in other parts of the region. Current forests have been shaped by fire and fire suppression. It differs from Ecoregion 23c by some of the flora, fauna, and water quality characteristics that more closely resemble the Southern Rockies (21). The region is geologically diverse with volcanic, sedimentary, and some intrusive and crystalline rocks.

23g The **Rocky Mountain Subalpine Forests** ecoregion occurs east of the Rio Grande at high elevations, generally above 9500 feet. It includes parts of the Sandia Mountains, Capitan Mountains, and Sierra Blanca. The peak elevations are mostly above 10,000 feet, with Sierra Blanca Peak nearing 12,000 feet. There are some differences in flora, fauna, geology, and water quality from the subalpine ecoregion (23d) to the west. The major forest trees include Engelmann spruce, corkbark fir, blue spruce, white fir, and aspen. Some Douglas-fir occurs at lower elevations. There are a few small inclusions of montane grassland. A mix of geology occurs in the region. Sierra Blanca and the Capitan Mountains are composed of Tertiary volcanics and Tertiary intrusives, while the Sandia Mountains to the north have a core of Precambrian rocks capped by Pennsylvanian sedimentary rocks.

The endangered Mexican gray wolf has been reintroduced in parts of the Gila National Forest. The often controversial recovery effort has been opposed by some livestock ranchers. *Photo: USFWS*



Precambrian granite is exposed on the west face of the Sandia Mountains near Albuquerque. Pennsylvanian limestones cap the 10,678-foot crest and the gentler eastern slope. *Photo: Ken Scheffe, NRCS*

Pinyon pine, the state tree of New Mexico, is found mostly between 5000 and 8000 feet. Pine nuts have been a subsistence crop in the Southwest for more than 7000 years.

Once abundant, Gila trout are now listed as threatened. They are found in a few small headwater streams in Ecoregion 23, mostly in the Gila River basin. *Photo: USFWS*

24. Chihuahuan Deserts

This desert ecoregion extends from the Madrean Archipelago (79) in southeast Arizona to the Edwards Plateau (30) in south-central Texas. It is the northern portion of the southernmost desert in North America that extends more than 500 miles south into Mexico. The physiography is generally a continuation of basin and range terrain that is typical of the Mojave Basin and Range (14) and the Central Basin and Range (13) ecoregions to the west and north, although the pattern of alternating mountains and valleys is not as pronounced as it is in Ecoregions 13 and 14. The mountain ranges (sky islands) are a geologic mix of Tertiary volcanic and intrusive granitic rocks, Paleozoic sedimentary layers, and some Precambrian granitic plutonic rocks. Outside the major river drainages, such as the Rio Grande and Pecos River, the landscape is largely internally drained. Vegetative cover is predominantly desert grassland and arid shrubland, except for high elevation islands of oak, juniper, and pinyon pine woodland. The extent of desert shrubland is increasing across lowlands and mountain foothills due to gradual desertification caused in part by historical grazing pressure.

Chihuahuan Desert vegetation can range from areas of very sparse scrub and shrublands, to dense shrublands, desert grasslands, and at higher elevations, some woodland. These are dynamic systems, influenced greatly by precipitation, soil erosion, fire frequency, and human land use. *Photo: Nathan Newcomer*

24a The **Chihuahuan Basins and Playas** include alluvial fans, internally drained basins, and river valleys mostly below 4500 feet. The major Chihuahuan basins formed during Tertiary Basin and Range tectonism when the Earth's crust stretched and fault collapse resulted in sediment-filled basins. These low elevation areas are some of the hottest and most arid habitats in the state. The playas and basin floors have saline or alkaline soils and areas of salt flats, dunes, and windblown sand. The typical desert shrubs and grasses, the dominant creosotebush, along with tarbush, fourwing saltbush, acacias, gyp grama, and alkali sacaton, must withstand large seasonal and diurnal ranges in temperature, low available moisture, and a high evapotranspiration rate. Horse crippler and other cacti are common. Bitter Lake near Roswell is a biologically significant wetland area. It has a high diversity of dragonflies and damselflies, including the continent's largest and smallest dragonfly species.

24b The **Chihuahuan Desert Grasslands** occur in areas of fine-textured soils, such as silts and clays, that have a higher water retention capacity than coarse-textured, rocky soil. The grasslands occur in areas of somewhat higher annual precipitation (10 to 15 inches) than the Chihuahuan Basins and Playas (24a), such as elevated basins between mountain ranges, low mountain benches and plateau tops, and north-facing mountain slopes. Grasslands were once more widespread, but heavy grazing in the late 19th and early 20th centuries was unsustainable, and desert shrubs invaded where the grass cover became fragmented. In grassland areas with lower rainfall, areal coverage of grasses may be sparse, 10% or less. Some areas are now mostly shrubs as grasslands continue to decline due to erosion, drought, and climatic change. Typical grasses are black, blue, and sideoats grama, dropseeds, bush muhly, and tobosa, with scattered creosotebush, and prickly pear and cholla cacti.

24c The **Low Mountains and Bajadas** include several disjunct hilly areas that have a mixed geology. The mountainous terrain has shallow soil, exposed bedrock, and coarse rocky substrates. Alluvial fans of rubble, sand, and gravel build at the base of the mountains and often coalesce to form bajadas. Vegetation includes mostly desert shrubs, such as sotol, lechuguilla, yucca, ocotillo, lotebush, tarbush, and pricklypear, with a sparse intervening cover of black grama and other grasses. At higher elevations, there may be scattered one-seeded juniper and pinyon pine. Strips of gray oak, velvet ash, and little walnut etch the patterns of intermittent and ephemeral drainages, and oaks may spread up north-facing slopes from the riparian zones. The varied habitats provide cover for mule deer, bobcat, javelina, and Montezuma quail.

24d The **Chihuahuan Montane Woodlands** ecoregion comprises the higher elevation mountainous areas, generally above 5000 or 6000 feet. These include the Chisos, Davis, Glass, and Apache mountains of Texas and the Organ, Florida, San Andres, and Oscura mountains of New Mexico. Increased precipitation in the mountains supports woodland areas except on sunny, exposed slopes that may have grass and chaparral only. Oaks, junipers, and pinyon pines predominate on all these mountain ranges. At lower elevations they occur in canyons and shaded hollows, and with increasing elevation and moisture levels, form more dense woodlands. Coniferous forests are limited in extent; some ponderosa pine, southwestern white pine, and relict Douglas-fir grow at the highest elevations in a few areas. In these higher ranges, trees sometimes grow with a grassy understory, or with a brush cover of bigtooth maple, madrone, little walnut, oak chaparral, and grapevines. The higher mountainous areas are a major refuge for larger ungulates, such as mule deer and desert bighorn sheep.

24f The Chihuahuan Desert portion of the **Rio Grande Floodplain** has some similarities to Ecoregion 22g upstream. Hydrology has been altered by upstream impoundments, by Elephant Butte and Caballo reservoirs, and by channelization in this region. Annual flooding of terraces and benches has been eliminated. Riparian woodlands and shrublands have been greatly reduced and invasive salt cedar has expanded. Narrow bands of cropland, orchards, vineyards, and small farms occur in portions of Ecoregion 24f. The southern Rio Grande valley in New Mexico is still an important wintering area for sandhill cranes, snow geese, and other migratory waterfowl. Urban land uses are spreading in the Las Cruces and El Paso areas. Drought, aquifer depletion, and agricultural irrigation create water supply concerns in Texas and Mexico.

24g The **Gypsiferous Dunes** ecoregion is one of the largest dune fields in the United States, and is the world's largest expanse of gypsum sand dunes. The gypsum was dissolved in runoff mostly from the San Andres Mountains, carried into the Tularosa Basin, and then crystallized in playa lake deposits. Fine white grains of gypsum are blown by the winds to form a variety of dune types: dome-shaped, barchan, transverse, and parabolic. Several types of small animals have evolved a white coloration to help camouflage them in the dunes. In many areas, the dunes are mostly barren; interdune flats tend to be more vegetated. Soaptree yucca, sand verbena, mormon tea, skunkbush sumac, fourwing saltbush, gyp moonpod, gyp grama, alkali sacaton, sandhill muhly, hoary rosemary mint, and a few Rio Grande cottonwoods occur.

24h The **Lava Malpais** region includes three separate areas: the impressively long Carrizozo Lava flow in the northern part of the Tularosa Basin, an area of Quaternary lava in the Jornada del Muerto, and, in the south, the Aden-Afton basalt flow. The Carrizozo lava, one of the younger volcanic features in New Mexico, flowed from a small cinder cone or vent called Little Black Peak, located at the northern end. Pahoehoe lava texture, collapse pits, lava tubes, and other volcanic features are found here. Mixed shrubs and grasses occur on the lava, taking advantage of available moisture and warmer ground temperatures created by solar absorption. Similar to Ecoregion 22k, some species of rodents and reptiles found here have developed abnormally dark coloration, called melanism, for camouflage against the dark lava. Several species of bats occupy some of the intact lava tubes. The Jornada del Muerto field formed where a small central volcano produced multiple lava flows. The topography of the combined vent and surrounding lava flows form a shield-type volcano profile. Large lava tubes occur south of the central vent. These tubes were mined for bat guano early in the century. Aden Crater on the Aden-Afton field is also a well-preserved small shield volcano.

Native populations of desert bighorn sheep have been drastically reduced from historical levels. Captive breeding and reintroduction programs for the subspecies have established some individuals in southwest New Mexico. *Photo: Robert Shantz*

The state bird of New Mexico, roadrunners are well-adapted to desert environments. Their varied diet includes insects, spiders, lizards, snakes, fruits, and seeds. They often prefer to walk or run rather than fly. *Photo: Marcus Martin*

Bosque del Apache National Wildlife Refuge, south of Socorro, attracts one of the world's largest winter concentrations of sandhill cranes. *Photo: Dan Monaghan*

Chile pepper production occurs in several parts of the Chihuahuan Deserts ecoregion. New Mexico is the leading state in pungent chile production. *Photo: National Park Service*

25. High Plains

Higher and drier than the Central Great Plains (27) to the east, and in contrast to the irregular, mostly grassland or grazing land of the Northwestern Great Plains (43) to the north, much of the High Plains is characterized by smooth to slightly irregular plains with a high percentage of cropland. Grama-buffalo grass is the potential natural vegetation in this region as compared to mostly wheatgrass-needlegrass to the north, Trans-Pecos shrub savanna to the south, and taller grasses to the east. The ecoregion includes the plains area of the Llano Estacado. Thousands of playa lakes (seasonal depressional wetlands) occur in this area, many serving as recharge areas for the important Ogallala Aquifer. These playa lakes are also essential for waterfowl during their yearly migration along the Central Flyway of North America. Oil and gas production occurs in parts of the region.

Playa lakes occur in many of the agricultural landscapes of the Llano Estacado (25i). Many playas have been affected by plowing, sedimentation, or use for irrigation. Protection of these shallow, seasonal wetlands is important for waterfowl habitat, recharge of the Ogallala Aquifer and, ultimately, the health of the High Plains economy. In some areas, about 85-90% of the aquifer's recharge is focused through the playa lakes. *Photo: NRCS*

25b The **Rolling Sand Plains** expand northward from the lip of the Canadian River trough, and are composed of flat sandy plains, sand hills, depressions, and mostly stabilized dunes. Soils developed from mostly eolian sand and silt deposits. In northern Texas and New Mexico, the vegetative cover of the Rolling Sand Plains is transitional between the Shinnery Sands (25j) to the south and the sandsage prairies of Oklahoma, Colorado, and Kansas. Havard shin oak, the characteristic shrub cover of the Shinnery Sands, still grows in parts of Ecoregion 25b in Texas, but it is at the northern limit of its distribution. However, both Havard shin oak and sand sagebrush perform the same important function of stabilizing sandy areas subject to wind erosion. The sandsage association includes grasses such as big sandreed, little bluestem, sand dropseed, and sand bluestem. Other native range plants include sideoats grama, blue grama, buffalograss, switchgrass, yellow Indiangrass, and yucca. Lesser prairie-chickens use shin oak and sandsage prairie habitats, but are presently imperiled due to agricultural practices as well as intensive grazing. Land use in the New Mexico portion is primarily rangeland, although some areas have irrigated cropland using deep wells.

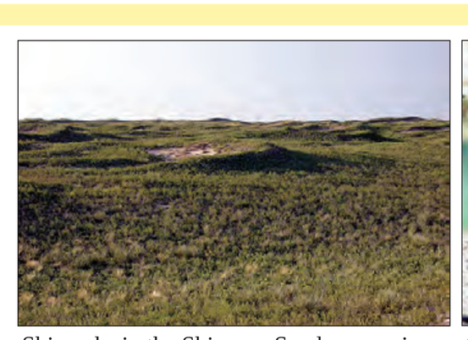
25c The **Moderate Relief Plains** ecoregion is composed of irregular, rolling to broken plains, transitional to Ecoregion 26. Slopes are greater than in the adjacent cropland-dominated flat and rolling plains of Ecoregion 25d in Colorado or Ecoregion 25e in Oklahoma and Texas. Land use is predominantly rangeland, in contrast to the cropland or mosaic of cropland and rangeland of surrounding High Plains (25) ecoregions. Soils formed primarily from loamy eolian sediments. In New Mexico, Ecoregion 25c occurs mostly on the Tertiary Ogallala Formation. Blue grama-buffalograss or blue grama-western wheatgrass was the natural prairie type, different from the sand sagebrush-mixed bluestem prairie of Ecoregion 25b. Soils have a mesic temperature regime, in contrast to the thermic soils to the south in Ecoregion 25.

25e The **Canadian/Cimarron High Plains** ecoregion includes the portion of the High Plains north of the Canadian River, primarily in the Texas and Oklahoma panhandles and in southeast Kansas, that has similarities to the Llano Estacado. Only a small portion of the region occurs in New Mexico. Winters are more severe than on the Llano Estacado (25i) to the south; the increased snow accumulation delays summer drought conditions because snowmelt saturates the ground in spring. Although the topography of Ecoregion 25e is just as flat as the Llano Estacado, this northern region has fewer playas and is more deeply dissected by stream channels. There is also more grazing land in Ecoregion 25e compared to 25i; the rougher terrain near the stream incisions tends to be grazed rather than tilled. In cultivated areas, corn, winter wheat, and grain sorghum are the principal crops. Many areas in the New Mexico portion that had cropland decades ago have now reverted to rangeland.

25i The **Llano Estacado** ecoregion, translated as the "Staked Plain", is a level, treeless, elevated plain surrounded by escarpments on three sides. Geologically, the Llano Estacado began as an apron of Miocene-Pliocene sediments (Ogallala Formation) eroded from the Rocky Mountains. Several caliche horizons developed in the Ogallala sediments, including a hardened caprock caliche in the uppermost layer. The caprock was eventually covered by Pleistocene wind-borne sand and silt, the Blackwater Draw Formation. The smooth surface of the plain holds seasonal rainfall in numerous playas. The Llano Estacado was once covered with shortgrass prairie, composed of buffalograss, blue and sideoats grama, and little and silver bluestem. Bison were once prominent elements of a prairie ecosystem that no longer functions as an interdependent web of bison, black-tailed prairie dog, black-footed ferret, snake, ferruginous hawk, coyote, swift fox, deer, pronghorn, mountain lion, and gray wolf. About 80-90% of the Llano Estacado in Texas and New Mexico is presently tilled for agriculture, with more rangeland to the west. Farmers produce cotton, corn, and wheat under dryland agriculture or irrigated with water pumped from the Ogallala Aquifer. The capacity of the Ogallala Aquifer is limited, particularly under drought conditions. Withdrawals from the aquifer usually exceed recharge.

25j The **Shinnery Sands** ecoregion includes sand hills and dunes as well as flat sandy recharge areas. These sand beds lie at the western edge of the High Plains where rising winds drop heavier sand grains and carry finer material further east onto the flat expanse of the Llano Estacado (25i). The ecoregion is named for the Havard (shin) oak brush that stablizes sandy areas subject to wind erosion. Although the shin oak rarely grows higher than 4 feet, its extensive root system can reach over 50 feet through dune sand to reach water. The largest area of sand dunes, at the southern edge of the Llano Estacado (25i), is composed of sands blown out of the Pecos River Basin against the Mescalero Escarpment of the Llano Estacado by prevailing southwesterly winds. These dunes serve as a major recharge area for the Pecos River. While sandsage and prairie grasses may create a continuous plant cover in portions of Ecoregion 25j, the vegetative cover is vulnerable to overgrazing and subsequent wind blowouts which may begin a cycle of dune formation. In dune areas, anchoring shrubs such as Havard shin oak, fourwing saltbush, and yucca stabilize the dune sand for herbaceous grasses and forbs such as sand verbenas, sunflowers, fringed sagewort, and hoary rosemary-mint. Ephemeral ponds and swales between the dunes support rushes, sedges, and sandbar willow. The shinnery sands are habitat for the lesser prairie-chicken and sanddune lizard, two species that are in serious decline. The shrubs offer cover and shade for nesting prairie-chickens, and shin oak acorns are a staple food source. Parts of the sand plains and dune fields of Ecoregion 25j contain dense arrays of oil fields.

25k The **Arid Llano Estacado** ecoregion is drier than the main portion of the Llano Estacado (25i) to the north. Its climate is transitional to the arid Chihuahuan Desert region (24) to the southwest. Across the region in New Mexico and Texas, yearly precipitation is less than that of the Llano Estacado (25i); there is also less winter precipitation and an absence of snow cover to provide soil moisture. This can cause the caliche layer to be closer to the surface in Ecoregion 25k, increasing the general droughty condition of the soil and making tilled agriculture more difficult than in the Llano Estacado (25i). The arid conditions are reflected in the land use, which is dominated by livestock grazing. The shortgrass prairie of grama and buffalo grasses is susceptible to overgrazing, and a broken grass cover allows the invasion of shrubs such as mesquite and lotebush. Oil and gas production activities are widespread.



Shin oaks in the Shinnery Sands ecoregion (25j) are seldom taller than two or three feet. They have a large underground stem and root system that helps stabilize the sandy soils.

Sanddune lizards, a threatened species, are found in the Mescalero Sands of Ecoregion 25j. The decline of the lizard is a signal that the sand/shinnery oak ecosystem is being altered. *Photo: Don Sias*

Lesser prairie-chickens, a unique grouse of the High Plains, inhabit shinnery oak and sand sagebrush habitats. Their population has been greatly reduced due to rangeland alteration, drought, livestock grazing, and other land use practices. *Photo: Marcus Miller, NRCS*

Oil and gas production is common in the southern portion of Ecoregion 25 in New Mexico's Permian Basin. The state ranks 6th in in oil production and 2nd in gas production in the U.S. Increasing energy development can affect air, water, and habitat resources.

26. Southwestern Tablelands

The Southwestern Tablelands flank the High Plains (25) with red hued canyons, mesas, badlands, and dissected river breaks. Unlike most adjacent Great Plains ecological regions, little of the Southwestern Tablelands is in cropland. Much of this region is in sub-humid grassland and semiarid rangeland. The eastern boundary represents a transition from the more extensive cropland within the High Plains (25) to the generally more rugged and less arable land within the Southwestern Tablelands (26) ecoregion. The natural vegetation in this region is mostly grama-buffalograss, with some juniper-scrub oak-grass savanna on escarpment bluffs. Prairie fires were likely important in maintaining the grasslands and suppressing encroachment of shrub and woody species. Pronghorn antelope is the most common large native mammal of the region.

The southwestern part of the Great Plains of the U.S. contains a diversity of landscapes and vegetation patterns. Dissected tablelands, canyons, and flat to rolling plains are found here. A few volcanic cones occur in the New Mexico portion. Shortgrass prairie covers the majority of the region in New Mexico, particularly in the flatter portions, with juniper and shrubs common on steeper terrain. Livestock grazing is a primary land use. *Photo: New Mexico State Parks*

26d The **Semiarid Canadian Breaks** ecoregion is similar to the Canadian Breaks (26a) to the east in Texas with its deep valley trough and moderate-relief tablelands, but it is drier. This ecoregion also has large areas of Triassic mudstones and shales exposed, whereas Ecoregion 26a in Texas has a more homogeneous substrate of the Tertiary Ogallala Formation. The mudstones and shales create badlands that are not productive, and plant growth is sparse, increasing the look of aridity to the landscape. Some of the taller grasses and eastern riparian species found in the Canadian Breaks (26a) also tend to disappear towards the west in Ecoregion 26d as conditions become drier and the soils become less productive. The shrub and midgrass prairie vegetation includes one-seed juniper, sand sagebrush, skunkbush sumac, and yucca, along with sideoats grama, little bluestem, western wheatgrass, blue grama, buffalograss, galleta, and alkali sacaton.

26f The **Mesa de Maya/Black Mesa** ecoregion covers a small portion of southeast Colorado, northeast New Mexico, and northwest Oklahoma. It includes basalt-capped mesas as well as deep canyons, knobs, dissected plains, and breaks that have been cut into sandstone, shale, and limestone. In New Mexico, the valley of the Dry Cimarron River is a canyon of these exposed Triassic, Jurassic, and Cretaceous strata. As Black Mesa extends east into Oklahoma, it supports many end-of-range flora and fauna species. Great Plains vegetation intergrades with foothill flora of the Rocky Mountains. Mesa tops are covered with shortgrass prairie. Shrubs and small trees, mainly pinyon and oneseed juniper, occur in canyons and on north-facing slopes. The vegetation mosaic contrasts with the grassland of adjacent, less rugged plains.

26h Scattered, dissected areas with pinyon and juniper woodlands on the uplands characterize the **Pinyon-Juniper Woodlands and Savannas** ecoregion. Occurring in Colorado and New Mexico, the region is a continuation or an outlier of the pinyon-juniper woodlands found in Ecoregion 21d in the Southern Rockies (21). Soils tend to be thin, and for most of the region are formed in materials weathered from limestone, sandstone, and shale. Rock outcrops are common. In central New Mexico, much of the region is often associated with the Paleozoic Glorieta Sandstone and other limestone and shale rocks. In the north, the region includes a few hills and peaks of volcanic or mixed geology that have some small areas of montane coniferous forest. Annual precipitation in the New Mexico portion ranges from 12 to 16 inches, with the highest precipitation found in areas closest to the mountains. Land use is primarily wildlife habitat and rangeland.

26l The **Upper Canadian Plateau** is heterogeneous relative to relief, geologic substrates, and vegetation patterns. Parts of the region are influenced by proximity to mountainous regions, and there are other east to west differences within the region. The ecoregion contains mesic soils, higher elevations, and areas of greater relief compared to the thermic soils and lower elevations to the south in Ecoregion 26n. It is underlain mostly by Cretaceous sandstone and shale, with some Tertiary and Quaternary volcanic rocks. It includes parts of the Raton-Clayton and Ocate volcanic fields. Cover types include shortgrass prairie, some midgrass prairie, scattered juniper savanna, and juniper woodland on hills.

26m The **Canadian Canyons** ecoregion includes parts of the Canadian Escarpment, Canadian River Gorge, and associated canyons where coniferous and mixed woodland occurs and Jurassic rocks have been exposed by water and wind erosion. Its higher relief and different vegetation distinguishes it from surrounding ecoregions 26l, 26n, and 26d. Vegetation is dominated by pinyon pine, one-seed juniper, and some ponderosa pine at higher elevations. The Canadian River Gorge is one of the biggest and deepest canyons on the American Great Plains.

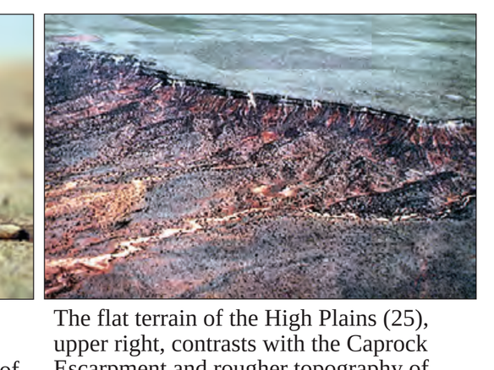
26n Broad, rolling plains, tablelands, and piedmonts characterize the **Conchas/Pecos Plains**, broken by drainages to the Pecos, Conchas, and a small portion of the Canadian rivers. The region has lower elevations and thermic soils compared to the higher elevations and mix of mesic and thermic soils of Ecoregion 26o to the west. Livestock grazing is the dominant land use. Soils formed in material primarily from Quaternary, Triassic, and Permian sediments. The natural vegetation of these plains included blue grama, galleta, sand dropseed, threeawns, ring muhly, broom snakeweed, cacti, yucca, and cholla. Some areas of sideoats grama and little bluestem, with blue grama, western wheatgrass, galleta, and buffalograss also occurred.

26o The **Central New Mexico Plains** are slightly drier than Ecoregion 26n to the east, with more shortgrass steppe and less midgrass prairie. It has generally higher elevations and more mesic soils than the somewhat lower elevations and thermic soils of 26n. The region is composed of mostly Permian rocks compared to the Triassic materials of Ecoregion 26n. Livestock grazing is the dominant land use. Pronghorn antelope are common as well as coyote and a variety of raptors.

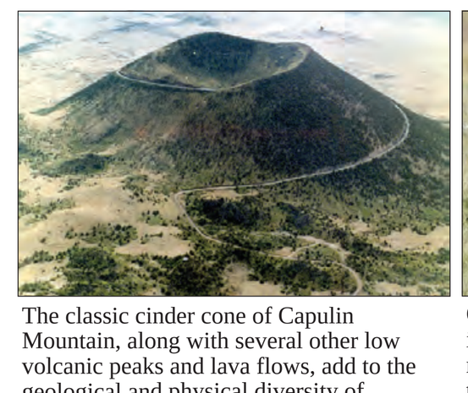
26p The **Pluvial Lake Basins** ecoregion includes the Estancia, Pinos Wells, and Encino lake basins near the center of the state. Permanent lakes occupied several large closed basins in New Mexico during the last ice age. Today, annual evaporation is greater than the inflow to the basins from rainfall, runoff, and groundwater discharge. Annual precipitation is only 12 to 13 inches. Natural vegetation includes fourwing saltbush and alkali sacaton. The region was an historical trade route for salt between Rio Grande pueblos and Plains tribes. Some agriculture and cropland occurs today in the Estancia basin, irrigated by groundwater.

26q The **Southern New Mexico Dissected Plains** is a transitional area between the shortgrass prairies of Ecoregion 26 and the Chihuahuan Desert grasslands of Ecoregion 24. It is also influenced by the proximity to the Sacramento Mountains of Ecoregion 23. Geology is mostly Paleozoic limestone, dolomite, shale, and sandstone. Rock outcrops are common. It is characterized by well-dissected topography with numerous draws and shallow canyons, and a rather sparse vegetative cover. Annual precipitation averages only 12 to 13 inches, lower than most of Ecoregion 26 to the north. The eastern portion has more Chihuahuan scrub, while to the west at higher elevations, some juniper savanna occurs. Native vegetation is short and mid grasses with some low desert shrubs. Grasses are mainly blue grama, black grama, hairy grama, sideoats grama, triden, or threeawn. Shrubs include juniper, lotebush, yucca, dalea, and a variety of acacias.

Swift foxes in New Mexico are found primarily in the shortgrass prairies of Ecoregions 25 and 26. They prefer areas of soft soils that support burrowing and foraging for large rodent populations. *Photo: NMDGF*



The flat terrain of the High Plains (25), upper right, contrasts with the Caprock Escarpment and rougher topography of Ecoregion 26d south of the Canadian River. *Photo: R.D. Miller, USGS*



The classic cinder cone of Capulin Mountain, along with several other low volcanic peaks and lava flows, add to the geological and physical diversity of Ecoregion 26l. *Photo: R.D. Miller, USGS*

Once nearly extinct, pronghorn now occur in several parts of New Mexico. They are most abundant on the rolling, wide-open terrain of shortgrass or midgrass prairies, typical of many parts of Ecoregion 26. *Photo: Robert Shantz*

Larry Davis

From: Amos, James <jamos@blm.gov>
Sent: Wednesday, March 29, 2017 3:56 PM
To: Bryson, Tye
Cc: Larry Davis
Subject: Re: BLM Recommendation - Seed mix

Mr. Davis, you have done your homework. BLM Seed Mix No.2 will suffice. As for noxious weeds, the fire may have helped better than anything we would recommend. I don't see a problem with noxious weeds taking over. thanks

On Wed, Mar 29, 2017 at 8:10 AM, Bryson, Tye <tbryson@blm.gov> wrote:

Jim:

can you help Mr> Davis with this request?
---------- Forwarded message ----------
From: **Larry Davis** <Larry.Davis@energyquest.us>
Date: Tue, Mar 28, 2017 at 3:34 PM
Subject: BLM Recommendation - Seed mix
To: "tbryson@blm.gov" <tbryson@blm.gov>

Mr. Bryson,

My company operates oil/gas wells in the Bagley Field, Lea County, New Mexico. I am preparing a surface remediation proposal to submit to the New Mexico State Land Office for a site in the Bagley Field, located about 8 miles SE of Caprock, New Mexico. A while back, a lightning strike caused a grass fire in the area where we operate wells on State Leases. NMOCD and the State Land Office are requiring that the area be re-seeded with an appropriate mix of native seed for that area. I asked Ms. Amber Groves of the NMSLO for remediation guidance, but the information did not include specifications for a seed mix. I know that the BLM and New Mexico state agencies generally work closely together to protect the environment of New Mexico, so I thought you might be able to help me.

I have a printed copy of the recommended mix for use in the Loco Hills area of Eddy County, provided by the Roswell District of the BLM. The recommended mix for that location was BLM Seed Mix #2 consisting of sand dropseed, sand lovegrass, and Plains bristlegrass, with ratios of pounds of pure live seed per acre provided for different application methods. If I have analyzed the ecoregion correctly, the Loco Hills area and the Bagley Field site are both within the Arid Llano Estacado, Southern High Plains, Southeast part of the Southern Shortgrass Prairie. Based upon my research, Seed Mix #2 appears to be the appropriate mix for re-seeding the burned area. We do not wish to disturb the native grasses that already are recovering, so we intend to distribute the seed via the broadcasting method and lightly rake to cover the seed.

Additionally, I would ask your advice about determining if there are noxious weeds/plants in the area that might need controls incorporated into my proposal.

I realize that State Leases not under your normal area of concern, but the BLM has provided me with reliable, straight forward guidance in the past. Any assistance you can offer would be appreciated.

Thank you,

Larry D. Davis

Environmental Quality Manager

EnergyQuest

Telephone: 281-651-5201 (direct)

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Ty Bryson

Pecos District
Fire Management Officer
575.234.5960 (O)
575.361.5960 (C)

--

James A. Amos
Bureau of Land Management

Carlsbad Field Office
Supervisory Petroleum Engineering Tech
620 East Greene Street
Carlsbad, NM. 88220
Office: (575) 234-5909
Fax: (575) 234-5927
Cell: (575) 361-2648
E-mail: jamos@blm.gov

Appendix 3 – Soil Sample Analysis

Soil Sample Analysis Report from Cardinal Laboratories
Map - Sample locations
Photos - Sample locations

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

October 27, 2016

GREG MCWILLIAMS

ENERGY QUEST

P. O. BOX 420

WHITEFACE, TX 79379

RE: SOIL SAMPLES

Enclosed are the results of analyses for samples received by the laboratory on 10/24/16 12:00.

Cardinal Laboratories is accredited through Texas NELAP under certificate number T104704398-16-8. Accreditation applies to drinking water, non-potable water and solid and chemical materials. All accredited analytes are denoted by an asterisk (*). For a complete list of accredited analytes and matrices visit the TCEQ website at www.tceq.texas.gov/field/qa/lab_accred_certif.html.

Cardinal Laboratories is accreditated through the State of Colorado Department of Public Health and Environment for:

Method EPA 552.2	Haloacetic Acids (HAA-5)
Method EPA 524.2	Total Trihalomethanes (TTHM)
Method EPA 524.4	Regulated VOCs (V1, V2, V3)

Accreditation applies to public drinking water matrices.

This report meets NELAP requirements and is made up of a cover page, analytical results, and a copy of the original chain-of-custody. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Celey D. Keene

Celey D. Keene

Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

ENERGY QUEST
GREG MCWILLIAMS
P. O. BOX 420
WHITEFACE TX, 79379
Fax To: (806) 287-1101

Received:	10/24/2016	Sampling Date:	10/24/2016
Reported:	10/27/2016	Sampling Type:	Soil
Project Name:	SOIL SAMPLES	Sampling Condition:	** (See Notes)
Project Number:	NONE GIVEN	Sample Received By:	Jodi Henson
Project Location:	NOT GIVEN		

Sample ID: STATE C LEASE (H602382-01)

BTEX 8021B mg/kg Analyzed By: CK

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	10/25/2016	ND	1.82	90.9	2.00	0.937	
Toluene*	<0.050	0.050	10/25/2016	ND	2.18	109	2.00	1.70	
Ethylbenzene*	<0.050	0.050	10/25/2016	ND	2.26	113	2.00	1.31	
Total Xylenes*	<0.150	0.150	10/25/2016	ND	6.90	115	6.00	1.38	
Total BTEX	<0.300	0.300	10/25/2016	ND					

Surrogate: 4-Bromofluorobenzene (PID *105 %* *73.6-140*

Chloride, SM4500Cl-B mg/kg Analyzed By: AC

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<16.0	16.0	10/24/2016	ND	416	104	400	0.00	

TPH 8015M mg/kg Analyzed By: MS

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	10/26/2016	ND	197	98.3	200	3.72	
DRO >C10-C28	<10.0	10.0	10/26/2016	ND	213	107	200	5.60	

Surrogate: 1-Chlorooctane *80.6 %* *35-147*

Surrogate: 1-Chlorooctadecane *100 %* *28-171*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

ENERGY QUEST
GREG MCWILLIAMS
P. O. BOX 420
WHITEFACE TX, 79379
Fax To: (806) 287-1101

Received:	10/24/2016	Sampling Date:	10/24/2016
Reported:	10/27/2016	Sampling Type:	Soil
Project Name:	SOIL SAMPLES	Sampling Condition:	** (See Notes)
Project Number:	NONE GIVEN	Sample Received By:	Jodi Henson
Project Location:	NOT GIVEN		

Sample ID: STATE A-O LEASE (H602382-02)

BTEX 8021B mg/kg **Analyzed By: CK**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Benzene*	<0.050	0.050	10/25/2016	ND	1.82	90.9	2.00	0.937	
Toluene*	<0.050	0.050	10/25/2016	ND	2.18	109	2.00	1.70	
Ethylbenzene*	<0.050	0.050	10/25/2016	ND	2.26	113	2.00	1.31	
Total Xylenes*	<0.150	0.150	10/25/2016	ND	6.90	115	6.00	1.38	
Total BTEX	<0.300	0.300	10/25/2016	ND					

Surrogate: 4-Bromofluorobenzene (PID *104 %* *73.6-140*

Chloride, SM4500Cl-B mg/kg **Analyzed By: AC**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	<16.0	16.0	10/24/2016	ND	416	104	400	0.00	

TPH 8015M mg/kg **Analyzed By: MS**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	10/26/2016	ND	197	98.3	200	3.72	
DRO >C10-C28	<10.0	10.0	10/26/2016	ND	213	107	200	5.60	

Surrogate: 1-Chlorooctane *77.1 %* *35-147*

Surrogate: 1-Chlorooctadecane *85.6 %* *28-171*

Cardinal Laboratories *=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Notes and Definitions

ND	Analyte NOT DETECTED at or above the reporting limit
RPD	Relative Percent Difference
**	Samples not received at proper temperature of 6°C or below.
***	Insufficient time to reach temperature.
-	Chloride by SM4500Cl-B does not require samples be received at or below 6°C
	Samples reported on an as received basis (wet) unless otherwise noted on report

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

101 East Marland, Hobbs, NM 88240
(575) 393-2326 FAX (575) 393-2476

Company Name:	Energy Quest
Project Manager:	Greg McWilliams
Address:	P.O. Box 420
City:	Whiteface State: TX Zip: 79379
Phone #:	806-445-1728 Fax #:
Project #:	Project Owner:
Project Name:	soil samples
Project Location:	
Sampler Name:	Greg

BILL TO

P.O. #:	
Company:	
Attn:	
Address:	
City:	
State:	Zip:
Phone #:	
Fax #:	

ANALYSIS REQUEST

FOR LAB USE ONLY Lab I.D.	Sample I.D.	(G)RAB OR (C)OMP.	# CONTAINERS	MATRIX: GROUNDWATER	WASTEWATER	SOIL	OIL	SLUDGE	OTHER :	PRESERV.: ACID/BASE:	ICE / COOL	OTHER :	SAMPLING: DATE	TIME	BTEX	TPH	Cl
H602382																	
1	State C Lease	G	1			✓							10/24/16	10:00	✓	✓	✓
2	State A-O Lease	G	1			✓							"	"	✓	✓	✓

PLEASE NOTE: Liability and Damages. Cardinal's liability and client's exclusive remedy for any claim arising whether based in contract or tort, shall be limited to the amount paid by the client for the analyses. All claims including those for negligence and any other cause whatsoever shall be deemed waived unless made in writing and received by Cardinal within 30 days after completion of the applicable service. In no event shall Cardinal be liable for incidental or consequential damages, including without limitation, business interruptions, loss of use, or loss of profits incurred by client, its subsidiaries, affiliates or successors arising out of or related to the performance of services hereunder by Cardinal, regardless of whether such claim is based upon any of the above stated reasons or otherwise.

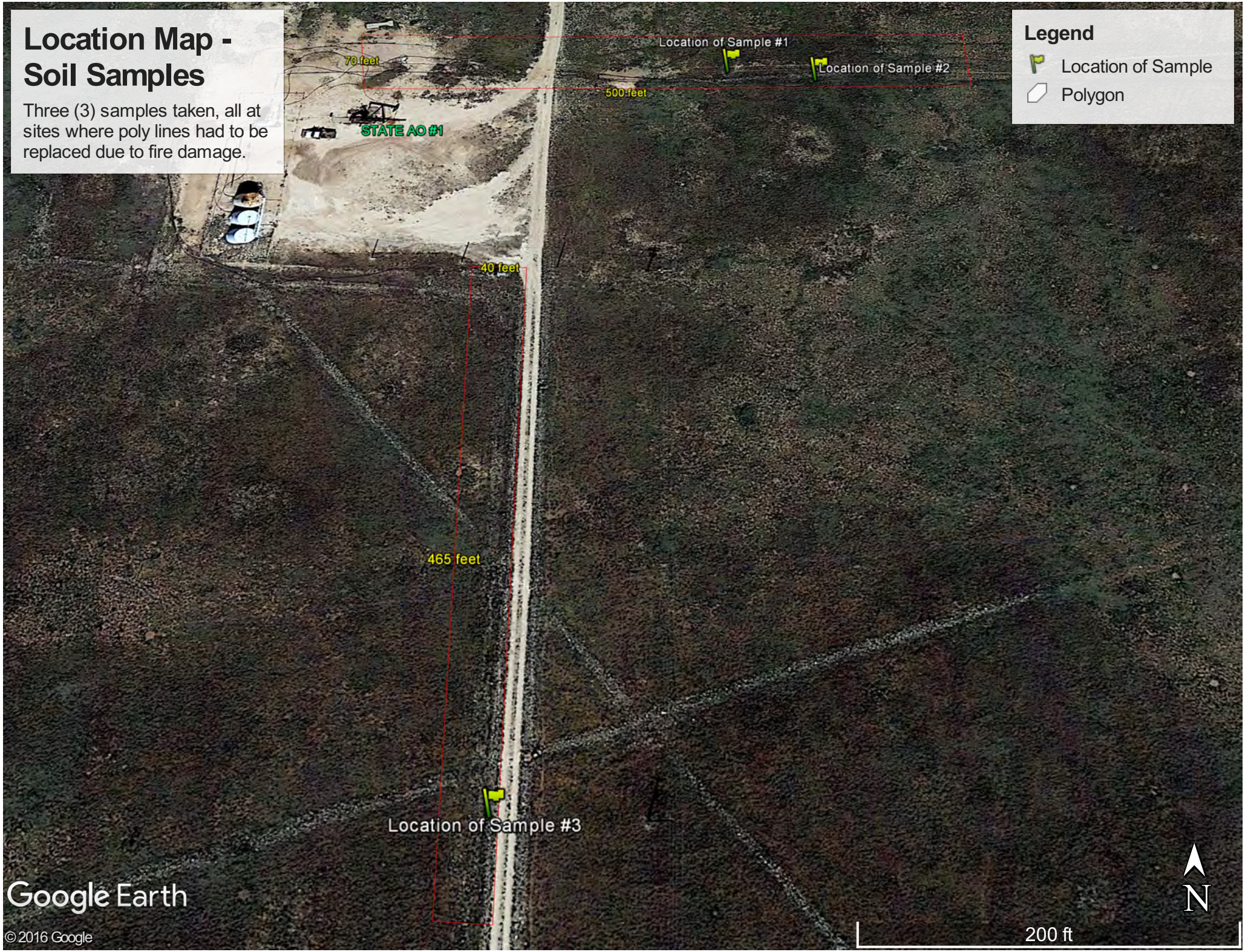
Relinquished By:	Date:	Received By:	
	Time:		
Relinquished By:	Date: 10/24/16	Received By: Jodi Henson	
	Time: 12:00		
Delivered By: (Circle One)		Sample Condition: Cool ☐ Yes ☐ No; Intact ☐ Yes ☐ No	CHECKED BY: (Initials)
Sampler - UPS - Bus - Other:	16.0°C		

Phone Result: ☐ Yes ☐ No Add'l Phone #:
Fax Result: ☐ Yes ☐ No Add'l Fax #:
REMARKS:

greg.mcwilliams@energyquest.us

† Cardinal cannot accept verbal changes. Please fax written changes to (575) 393-2326

#75


Location Map - Soil Samples
Three (3) samples taken, all at sites where poly lines had to be replaced due to fire damage.
Legend
Location of Sample
Polygon
Location of Sample #1
Location of Sample #2
Location of Sample #3
70 feet
500 feet
40 feet
465 feet
STATE AO #1
Google Earth
© 2016 Google
N
200 ft

Sample Location # 1 – Single Flag
Lat 33.3133556°, Long -103.6205222°

Sample Location # 2 – Two (2) Flags
Lat 33.3133278°, Long -103.6202917°

Sample Location # 3 – Three (3) Flags
Lat 33.3116306°, Long -103.6210417°

NOTE:

Three (3) Soil Samples taken. All were within the fire damaged areas where lines were replaced. In photos of Sample Locations 1 and 3, evidence of melted poly line still can be seen near the sample site.