ENSOLUM

CLOSURE AND POST-CLOSURE PLAN

February 17, 2023

Bisti Landfarm

Permit NM-02-0010

Western Refining Southwest LLC

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Attachments:

1.0 INTRODUCTION

Ensolum, LLC (Ensolum) has prepared the following *Closure and Post-Closure Plan* (Plan) for the Bisti Landfarm (Landfarm) for Western Refining Southwest LLC (Western). This Plan has been prepared in accordance with the requirements of 19.15.36 of the New Mexico Administrative Code (NMAC). The Plan is organized with section headings referencing each applicable requirement.

1.1 SITE DESCRIPTION

The Landfarm occupies approximately 28 acres of land in Section 16, Township 25 North, Range 12 West in San Juan County, New Mexico (Figure 1). It is located on a 640-acre parcel of land which is privately owned by Western. In 1998, Giant Industries, Arizona (Giant) permitted the Landfarm as a surface waste management facility through the New Mexico Oil Conservation Division (NMOCD) under former Rule 711. Petroleum hydrocarbon impacted soil was originally disposed at the Landfarm in three treatment cells based on the origin of the soil: the API Cell, Crude Cell, and Cell 1 (Figure 2). The Crude Cell is further divided into four source zones containing material originating from Pettigrew, East Line, West Line, and Bisti. No new cells or soil lifts had been added to the Landfarm since 2004, prior to Western's purchase of the property. Cell 1 is no longer tilled or monitored based on a letter from the NMOCD, dated March 8, 2004, to Giant stating Cell 1 was approved for discontinued maintenance.

In 2007, the NMOCD promulgated a new rule, 19.15.36 NMAC (also referred to as Rule 36), pertaining to surface waste management facilities and required compliance with the new transitional provisions. Western acquired the Landfarm from Giant in June 2007. Western has continued to monitor and maintain the API Cell and the Crude Cell using Rule 711 and provisional requirements of Rule 36.

The following sections reference applicable subsections of Rule 36 for closure of a surface waste management facility with responses specific to the Landfarm in support of closing the Landfarm.

2.0 19.15.36.18(A) SURFACE WASTE MANAGEMENT FACILITY CLOSURE BY OPERATOR

(1) The operator shall notify the division's environmental bureau at least 60 days prior to cessation of operations at the surface waste management facility and provide a proposed schedule for closure. Upon receipt of such notice and proposed schedule, the division shall review the current closure and post closure plan (post closure is not required for oil treating plants) for adequacy and inspect the surface waste management facility.

The submittal date of this Plan serves as notification of the cessation of operations of the Landfarm and closure activities. As such, cessation of operations at the Landfarm will be 60 days following the submittal of this document.

(2) The division shall notify the operator within 60 days after the date of cessation of operations specified in the operator's closure notice of modifications of the closure and post closure plan and proposed schedule or additional requirements that it determines are necessary for the protection of fresh water, public health, or the environment.

Within 60 days after the date of cessation of operations at the Landfarm (120 days following submittal of this Plan), NMOCD should notify Western of modifications of the Plan or additional requirements that NMOCD determines necessary for the protection of fresh water, public health, safety, or the environment.

(3) If the division does not notify the operator of additional closure or post closure requirements within 60 days as provided, the operator may proceed with closure in accordance with the approved closure and post closure plan; provided that the director may, for good cause, extend the time for the division's response for an additional period not to exceed 60 days by written notice to the operator.

If Western does not receive notification from NMOCD within 120 days after submittal of this Plan, Western will proceed with closure of the Landfarm in accordance with this Plan unless NMOCD extends their review time of the Plan by a period not to exceed 60 days for a total of 120 days. NMOCD will notify Western in writing of any needed extension of the review time, the latest of which could be 180 after the submittal of this Plan.

(4) The operator shall be entitled to a hearing concerning a modification or additional requirement the division seeks to impose if it files an application for a hearing within 10 days after receipt of written notice of the proposed modifications or additional requirements.

Western acknowledges that they will be entitled to a hearing concerning a modification or additional requirements NMOCD seeks to impose on the Plan at the time of cessation of operations. In order to receive a hearing, Western must file an application for a hearing within 10 days after receipt of written notice of the proposed modifications or additional requirements.

(5) Closure shall proceed in accordance with the approved closure and post closure plan and schedule and modifications or additional requirements the division imposes. During closure operations the operator shall maintain the surface waste management facility to protect fresh water, public health, and the environment.

Upon approval, closure of the Landfarm shall proceed in accordance with this Plan, as well as any modifications or additional requirements Western and NMOCD have agreed upon at the time of cessation of operations.

At the time of closure, Western will evaluate the current site and surrounding conditions to determine the appropriate actions required to maintain the site during closure activities to protect fresh water, public health, safety, and the environment. Evaluation factors include, but are not limited to, volume of remaining soil, compliance monitoring results, and current surrounding land use. A Closure Inspection Checklist (Appendix A) will be used during closure activities. A Closure Report will be submitted to the NMOCD via the E-Permitting website. This report will provide documentation to demonstrate that Western has completed all closure protocols and complied with the NMOCD approved *Closure and Post-Closure Plan.*

(6) Upon completion of closure, the operator shall re-vegetate the site unless the division has approved an alternative site use plan as provided in Subsection F of 19.15.36.18 NMAC. Re-vegetation, except for landfill cells, shall consist of establishment of a vegetative cover equal to seventy percent of the native perennial vegetative cover (un-impacted by overgrazing, fire or other intrusion damaging to native vegetation) or scientifically documented ecological description consisting of at least three native plant species, including at least one grass, but not including noxious weeds, and maintenance of that cover through two successive growing seasons.

Western will revegetate the Landfarm, including roads within the Landfarm boundary (fenced area shown on Figure 2) and treatment cell berms, once closure activities are complete. Roads outside of the fenced area of the Landfarm, and not associated with Landfarm activities, are located on private surface and will not be revegetated. A site-specific *Post-Closure Revegetation Plan* has been prepared for the Landfarm and is included in Appendix B. Western, or another responsible entity, will inspect and maintain the progress of revegetation in accordance with the site-specific Revegetation Plan.

3.0 19.15.36.18 (B): RELEASE OF FINANCIAL ASSURANCE

(1) When the division determines that closure is complete it shall release the financial assurance, except for the amount needed to maintain monitoring wells for the applicable post closure care period, to perform semi-annual analyses of such monitoring wells and to re-vegetate the site. Prior to the partial release of the financial assurance covering the surface waste management facility, the division shall inspect the site to determine that closure is complete.

NMOCD shall release the financial assurance, except for the amount needed to revegetate the surface waste management facility site (including areas outside of the treatment cells disturbed by the construction and/or maintenance of the Landfarm) and maintain the vegetative cover through the three year post-closure period.

(2) After the applicable post closure care period has expired, the division shall release the remainder of the financial assurance if the monitoring wells show no contamination and the re-vegetation in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC is successful. If monitoring wells or other monitoring or leak detection systems reveal contamination during the surface waste management facility's operation or in the applicable post closure care period following the surface waste management facility's closure the division shall not release the financial assurance until the contamination is remediated in accordance with 19.15.30 NMAC and 19.15.29 NMAC, as applicable.

As stated above, the NMOCD will release the financial assurance once the post closure care period has expired, assuming that re-vegetation of the Landfarm is successful as specified in 19.15.36.18(A)(6) NMAC. Groundwater monitoring provisions of 19.15.36.18(B)(2) do not apply, as there are no monitoring wells and/or other monitoring or leak detection systems present at the Landfarm.

If other monitoring reveals contamination during the surface waste management facility's operation or in the applicable post-closure care period following the surface waste management facility's closure, the division shall not release the financial assurance until the contamination is remediated in accordance with 19.15.30 NMAC and 19.15.29 NMAC, as applicable.

(3) In any event, the division shall not finally release the financial assurance until it determines that the operator has successfully re-vegetated the site in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC, or, if the division has approved an alternative site use plan, until the landowner has obtained the necessary regulatory approvals and begun implementation of the use.

NMOCD shall release the remainder of the financial assurance after the applicable post-closure care period has expired, assuming revegetation of the site is successful according to the approved Revegetation Plan.

4.0 19.15.36.18 (C): SURFACE WASTE MANAGEMENT CELL AND FACILITY CLOSURE STANDARDS

The following minimum standards shall apply to closure and post closure of the installations indicated, whether the entire surface waste management facility is being closed or only a part of the surface waste management facility.

(4) Landfarm closure. The operator shall ensure that:

(a) disking and addition of bioremediation enhancing materials continues until soils within the cells are remediated to the standards provided in Subsection F of 19.15.36.15 NMAC, or as otherwise approved by the division;

After the cessation of operations at the Landfarm (60 days after the submittal of this plan, or up to 120 days after the date of cessation of operations at the Landfarm if the NMOCD requests an extension to review this document), a single composite soil sample, consisting of four discrete samples, will be collected from each Landfarm cell (Cell 1, API Cell, and Crude Cell) and compared to the Treatment Zone Closure Performance Standards below. If constituent concentrations exceed the Treatment Zone Closure Performance Standards, Western will continue disking the Landfarm API and Crude Cells biweekly (once every two weeks) and monitoring treatment zone soils semi-annually and vadose zone soils quarterly from these cells until treatment zone closure samples are collected and meet the standards provided below. An exception to 19.15.36.15(F) is requested for the standards for constituents listed in subsection A and B of 20.6.2.3103 NMAC by United States Environmental Protection Agency (EPA) SW-846 Methods 6010B and 6020. Additional information regarding the exception request as required in 19.15.36.19 NMAC is presented in Section 8.0.

Treatment Zone Closure Performance Standards [19.15.36.15(F)]

Constituent	Lab Method	Limit
Benzene	EPA SW-846 Method 8021B or 8260B	0.2 milligrams per kilogram (mg/kg)
Benzene, toluene, ethylbenzene, and total xylenes (BTEX)	EPA SW-846 Method 8021B or 8260B	50 mg/kg
Gasoline range organics (GRO) plus diesel range organics (DRO) combined fractions	EPA SW-846 Method 8015M	500 mg/kg
Total petroleum hydrocarbons (TPH)	EPA Method 418.1 or 8015M	2,500 mg/kg
Chloride concentration	EPA Method 300.1	1,000 mg/kg[a]
The constituents listed in subsections A and B of 20.6.2.3103 NMAC by EPA SW-846 methods 6010B and 6020	EPA Methods 6010B and 6020	Limits presented in attached Table 1

[a] 1,000 mg/kg is the limit due to groundwater being located greater than 100 feet below the lowest elevation where Western has placed oil field waste at the Landfarm.

(b) soils remediated to the foregoing standards and left in place are re-vegetated in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC;

Assuming treatment zone closure samples meet the standards presented above, soils will be left in place and revegetated in accordance with the Revegetation Plan included as Appendix B of this Plan.

(c) landfarmed soils that have not been or cannot be remediated to the standards in Subsection F of 19.15.36.15 NMAC are removed to a division-approved surface waste management facility and the landfarm remediation area is filled in with native soil and re-vegetated in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC;

Treatment zone soils that have not been, or cannot be, remediated to the treatment zone closure performance standards will be removed to a NMOCD-approved disposal facility. Removed soil will be replaced with native soil and revegetated in accordance with 19.15.36(A)(6), as specified in Section 2.0.

(d) if treated soils are removed, the cell is filled in with native soils and re-vegetated in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC;

Western does not intend to remove treatment-zone soils for use at a different location.

(e) berms are removed; and

(f) buildings, fences, roads and equipment are removed, the site cleaned-up and tests conducted on the soils for contamination;

Western will remove all berms, buildings, fences, roads, and equipment from the Landfarm during closure activities. Any areas of soil staining outside of the Landfarm cells will be sampled for benzene, BTEX, TPH, and chloride. Specifically, at least one discrete soil sample will be collected from any observed stained soil area. If sample results exceed the NMOCD-approved background and/or laboratory practical quantitation limits (PQL) presented in Table 1, the potential impacts to soil will be assessed and addressed in accordance with 19.15.29 and/or 19.15.30.

(g) annual reports of vadose zone and treatment zone sampling are submitted to the division's environmental bureau until the division has approved the surface waste management facility's final closure; and

Western will continue to perform compliance sampling of the vadose zone until final closure approval. Vadose zone sampling will be conducted as presented in attached Table 2 in accordance according with the existing permit requirements and transitional provisions of 19.15.36.20.A NMAC, as well as the August 2015 NMOCD approval to use the sum of GRO, DRO, and MRO determined by EPA Method 8015 for TPH. Western will submit annual reports of vadose zone sampling activities and results until NMOCD has approved the Landfarm's final closure.

Assuming treatment zone closure samples meet the standards presented above, Western will report the treatment zone closure and vadose zone sampling results in one annual report. If additional treatment zone closure sampling is necessary because the initial samples do not meet standards presented above,

Western will submit treatment zone sampling activities and results in subsequent annual reports until NMOCD has approved the Landfarm's final closure.

> ***(h) for an operator who chooses to use the landfarm methods specified in Subsection H of 19.15.36.15 NMAC, that the soil has an ECs of less than or equal to 4.0 mmhos/cm (dS/m) and a SAR of less than or equal to 13.0.***

Western is not pursuing the environmentally acceptable bioremediation endpoint approach for management or closure of the Landfarm at this time.

5.0 19.15.36.18 (E): LANDFARM AND POND AND PIT POST-CLOSURE

The post-closure care period for a landfarm or pond or pit shall be three years if the operator has achieved clean closure. During that period the operator or other responsible entity shall regularly inspect and maintain required re-vegetation. If there has been a release to the vadose zone or to ground water, then the operator shall comply with the applicable requirements of 19.15.30 NMAC and 19.15.29 NMAC.

Western will perform post-closure monitoring at the Landfarm for the care period of three years. During the three-year care period, Western, or another responsible entity, will inspect and maintain the required revegetation coverage in accordance with the Landfarm Revegetation Plan. Post-closure care will include semi-annual monitoring of the site to assess weed management/treatment, percent vegetative cover, and erosion control measures. Any necessary corrective measures will be conducted per the Revegetation Plan. A Post-Closure Inspection Checklist will be used during post-closure monitoring events (Appendix C).

Additionally, if a release to the vadose zone is discovered at the Landfarm during the closure and/or post-closure period, Western will comply with the applicable requirements of 19.15.29 and/or 19.15.30 NMAC. However, the discovery of a release will not preclude the continuation of closure and/or post-closure activities.

A Post-Closure Report will be submitted to the NMOCD via the E-Permitting website. This report will provide documentation to demonstrate that Western has completed all post-closure protocols, established at least 70% vegetative cover at the Landfarm and maintained coverage through two successive growing seasons, and complied with the NMOCD approved *Closure and Post-Closure Plan.*

6.0 19.15.36.18 (F): ALTERNATIVES TO REVEGETATION

If the landowner contemplates use of the land where a cell or surface waste management facility is located for purposes inconsistent with re-vegetation, the landowner may, with division approval, implement an alternative surface treatment appropriate for the contemplated use, provided that the alternative treatment will effectively prevent erosion. If the division approves an alternative to re-vegetation, it shall not release the portion of the operator's financial assurance reserved for post-closure until the landowner has obtained necessary regulatory approvals and begun implementation of such alternative use.

To use the Landfarm for purposes inconsistent with revegetation, Western may request NMOCD approval to implement an alternative surface treatment, provided the alternative treatment will effectively prevent erosion. Western will prepare an alternative site-use plan for the Landfarm and obtain NMOCD approval prior to deviating from this Plan or the Revegetation Plan.

Western acknowledges that, if NMOCD approves an alternative to revegetation, the NMOCD shall not release the portion of Western's financial assurance reserved for post-closure until Western has obtained necessary regulatory approvals and begun implementation of such alternative use.

7.0 19.15.36.18 (G): CLOSURE INITIATED BY NMOCD AND FINANCIAL ASSURANCE FORFEITURE

(1) For good cause, the division may, after notice to the operator and an opportunity for a hearing, order immediate cessation of a surface waste management facility's operation when it appears that cessation is necessary to protect fresh water, public health or the environment, or to assure compliance with statutes or division rules and orders. The division may order closure without first having a hearing in the event of an emergency, subject to Section 70-2-23 NMSA 1978, as amended.

Because the Landfarm is an active facility and Western is requesting cessation of operations 60 days after the submittal of this Plan, Western does not believe that the provisions in 19.15.36.18(G)(1) NMAC apply to this facility. However, Western understands that the NMOCD may order immediate closure and cessation of the operations before this date, or during its review period which, if an extension is noticed by NMOCD, could extend up to 180 days after the submittal date of this Plan if it is determined to be necessary to protect fresh water, public health or the environment, or to assure compliance with statutes or division rules and orders.

(2) If the operator refuses or is unable to conduct operations at a surface waste management facility in a manner that protects fresh water, public health and the environment; refuses or is unable to conduct or complete an approved closure and post closure plan; is in material breach of the terms and conditions of its surface waste management facility permit; or the operator defaults on the conditions under which the division accepted the surface waste management facility's financial assurance; or if disposal operations have ceased and there has been no significant activity at the surface waste management facility for six months the division may take the following actions to forfeit all or part of the financial assurance:

> ***(a) send written notice by certified mail, return receipt requested, to the operator and the surety, if any, informing them of the decision to close the surface waste management facility and to forfeit the financial assurance, including the reasons for the forfeiture and the amount to be forfeited, and notifying the operator and surety that a hearing request or other response shall be made within 20 days of receipt of the notice; and***
>
> ***(b) advise the operator and surety of the conditions under which they may avoid the forfeiture; such conditions may include but are not limited to an agreement by the operator or another party to perform closure and post closure operations in accordance with the surface waste management facility permit conditions, the closure and post closure plan (including modifications or additional requirements imposed by the division) and division rules, and satisfactory demonstration that the operator or other party has the ability to perform such agreement.***

If Western is unable to conduct or complete this Plan after NMOCD approval, NMOCD may take the following actions to forfeit all or part of the financial assurance:

1) Send written notice by certified mail, return receipt requested, to Western and the surety, if any, informing them of the reason for the forfeiture and the amount to be forfeited, and notifying Western and surety that a hearing request or other response shall be made within 20 days of receipt of the notice.

2) Advise Western and the surety of the conditions under which they may avoid the forfeiture. Such conditions may include, but are not limited to, an agreement by Western or another party to perform closure and post-closure operations in accordance with this Plan (including modifications or additional requirements imposed by NMOCD), and NMOCD rules, and satisfactory demonstration that Western or other party has the ability to perform such agreement.

Western will follow all applicable requirements included in 19.15.36.18(G) NMAC as presented below.

(3) The division may allow a surety to perform closure and post closure if the surety can demonstrate an ability to timely complete the closure and post closure in accordance with the approved plan.

(4) If the operator and the surety do not respond to a notice of proposed forfeiture within the time provided, or fail to satisfy the specified conditions for non-forfeiture, the division shall proceed, after hearing if the operator or surety has timely requested a hearing, to declare the financial assurance's forfeiture. The division may then proceed to collect the forfeited amount and use the funds to complete the closure and post closure, or, at the division's election, to close the surface waste management facility and collect the forfeited amount as reimbursement.

(a) The division shall deposit amounts collected as a result of forfeiture of financial assurance in the oil and gas reclamation fund.

(b) In the event the amount forfeited and collected is insufficient for closure and post closure, the operator shall be liable for the deficiency. The division may complete or authorize completion of closure and post closure and may recover from the operator reasonably incurred costs of closure and post closure and forfeiture in excess of the amount collected pursuant to the forfeiture.

(c) In the event the amount collected pursuant to the forfeiture was more than the amount necessary to complete closure and post closure, including remediation costs, and forfeiture costs, the division shall return the excess to the operator or surety, as applicable, reserving such amount as may be reasonably necessary for post closure operations and re-vegetation in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC. The division shall return excess of the amount retained over the actual cost of post closure operations and re-vegetation to the operator or surety at the later of the conclusion of the applicable post closure period or when the site re-vegetation in accordance with Paragraph (6) of Subsection A of 19.15.36.18 NMAC is successful.

(5) If the operator abandons the surface waste management facility or cannot fulfill the conditions and obligations of the surface waste management facility permit or division rules, after notice and an opportunity for hearing, the state of New Mexico, its agencies, officers, employees, agents, contractors and other entities designated by the state shall have all rights of entry into, over and upon the surface waste management facility property, including all necessary and convenient rights of ingress and egress with all materials and equipment to conduct operation, termination and closure of the surface waste management facility, including but not limited to the temporary storage of equipment and materials, the right to borrow or dispose of materials and all other rights necessary for the surface waste management facility's operation, termination and closure in accordance with the surface waste management facility permit and to conduct post closure operations.

8.0 19.15.36.19: EXCEPTIONS AND WAIVERS

(A) In a surface waste management facility permit application, the applicant may propose alternatives to requirements of 19.15.36 NMAC, and the division may approve such alternatives if it determines that the proposed alternatives will provide equivalent protection of fresh water, public health and the environment.

(B) The division may grant exceptions to, or waivers of, or approve alternatives to requirements of 19.15.36 NMAC in an emergency without notice or hearing. The operator requesting an exception or waiver, except in an emergency, shall apply for a surface waste management facility permit modification in accordance with Subsection C of 19.15.36.8 NMAC. If the requested modification is a major modification, the operator shall provide notice of the request in accordance with 19.15.36.9 NMAC.

As specified in 19.15.36.15(F)(5), if concentrations of constituents listed in Subsections A and B of 20.6.2.3103 NMAC detected in treatment zone closure samples after analysis by EPA SW-846 Methods 6010B or 6020 exceed the Landfarm background concentrations and/or laboratory PQLs, Western can propose risk assessment based closure standards based upon individual site conditions that protect fresh water, public health and the environment. As such, Western proposes an exception to use the New Mexico Environment Department (NMED) residential Soil Screening Levels (SSLs) for constituents listed in Subsections A and B of 20.6.2.3103 NMAC, as determined by EPA SW-846 Methods 6010B or 6020 (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, uranium, and zinc) that exceed the NMOCD approved background concentrations and/or laboratory PQLs, as allowed by 19.15.36.15.F(5) NMAC. The NMED *Risk Assessment Guidance for Investigations and Remediation, Volume I* (November 2022), also known as the Soil Screening Guidance (SSG), is based on various EPA risk assessment guidance documents and derives SSLs for various exposure pathways.

The following sections describe the basis for the proposed alternative closure standards for the Landfarm.

8.1 RISK ASSESSMENT METHODS

Generic NMED SSLs are based on default exposure parameters and factors that represent Reasonable Maximum Exposure (RME) conditions for both acute and long-term/chronic exposures. The SSLs also are based on the methods outlined in EPA's *Risk Assessment Guidance for Superfund* (1989), which have been adapted by the NMED based on current and future land use, pathways, and exposure scenarios appropriate for the source area (residential, commercial/industrial, and worker protection). Generic NMED SSLs are calculated using toxicity values typically provided in the EPA Integrated Risk Information System (IRIS) and corresponding to a Hazard Index of 1 for non-carcinogens, or a cancer risk of one in 100,000 for carcinogens. If NMED SSLs for a particular constituent were not provided, EPA regional screening levels were calculated using the online "Regional Screening Level Calculator" available on the EPA website. Generic exposure parameters and toxicity values are inherently conservative. Exceedances of the generic NMED SSLs do not necessarily indicate that conditions are unsafe or present an unacceptable risk; rather, exceedance of an SSL may trigger the need for further evaluation.

8.2 CONSTITUENTS OF POTENTIAL CONCERN

Based on the testing requirements for treatment zone closure presented in 19.15.36.15(F) NMAC, the constituents of potential concern (COPC) for the Landfarm are considered to be the following analytes:

- Benzene
- BTEX
- GRO plus DRO as a combined fraction
- TPH
- Chloride
- Constituents listed in Subsections A and B of 20.6.2.3103 NMAC, as determined by EPA SW-846 Methods 6010B or 6020 (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, uranium, and zinc); hereafter referred to as “metals”

Treatment zone closure performance standards presented in 19.15.36.15(F) will be applied to benzene, BTEX, GRO plus DRO as a combined fraction, TPH, and chloride and are not considered in this exception request.

8.3 CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) was developed for the Landfarm location. Potential future land use is not known at this time, therefore residential, industrial/occupational, and construction worker potential receptors were used to evaluate the most conservate SSL. COPCs, generally discussed here as inorganics (metals), and their associated SSLs are first based on the potential exposure pathways and receptors at a specific location. The table below presents potential exposure pathways and identifies the pathways that are complete for the Landfarm that should be further considered. An exposure pathway is considered complete if five elements are present:

1. A source (or potential source) exists (i.e., COPCs in Landfarm treatment zone soils)
2. There is a mechanism of contaminant release (i.e., placement of soils at the Landfarm to be treated and associated physical properties of the contaminants)
3. There is a receiving or contact medium (i.e., ingestion, contact, inhalation, migration)
4. A receptor population exists (i.e., future land use)
5. There is an exposure route

If a pathway is incomplete, a justification for that determination is provided below the table.

Exposure Pathway	Complete	Incomplete	Comments
Direct ingestion of soil	X		Ingestion from soil particles on hands
Dermal Contact	X		Dermal contact from handling soil
Inhalation of Fugitive Dusts	X		Inhalation of fugitive dusts through recreation or construction activities
Ingestion of potentially contaminated beef	X		Potential livestock grazing in area, addressed through use of residential screening levels for direct contact/ingestion
Dermal contact with tap water		X	Incomplete based on absence of domestic water wells and incomplete migration to groundwater pathway
Migration to groundwater		X	Incomplete based on depth to groundwater, nature of aquifers in the area, and nature of contaminant migration
Inhalation of Volatiles	Not Applicable		
Inhalation of volatiles from tap water	Not Applicable		
Inhalation of volatiles in indoor air	Not Applicable		

Dermal contact with tap water is incomplete based on lack of receptors (buildings, facilities, houses, and water wells) within 0.5 miles of the Site.

An incomplete pathway for migration-to-groundwater is based on depth to groundwater (i.e., distance contaminants would need to travel) and the lithologic setting of the Landfarm, as further described below Based on depth to water information presented in the New Mexico Office of the State Engineer (NMOSE) database for wells within 10 miles of the Landfarm, depth to water in the area is greater than 100 feet below ground surface (bgs) and has an average depth to water of 186 feet bgs. The closest permitted water well to the Landfarm is 5.6 miles away (SJ 03815 POD1) with a well depth of 730 feet bgs; however, no water was encountered during drilling and the boring was backfilled. The closest permitted well with depth to water information (SJ 00221) is located 6.6 miles from the Landfarm with a reported depth to water of 135 feet bgs.

Based on United States Geological Survey (USGS) geologic mapping, the Site is located within the Tertiary Nacimiento Formation. In the report titled *Hydrogeology and Water Resources of San Juan Basin, New Mexico* (Stone, Lyford, Frenzel, Mizell, & Padgett, 1983), the Nacimiento Formation is characterized by interbedded black carbonaceous mudstones and white, coarse-grained sandstones. This formation ranges in thickness from 418 to 2,232 feet. Stone and others (1983) state that the aquifers in the Nacimiento Formation are largely untested and display variable hydrologic properties dependent on location. Where sufficient yield is present, the primary use of water from this formation is for domestic and/or livestock supply.

Based on the lithologic logs for wells within 10 miles of the Landfarm, the lithologic setting at the Site is dry unconsolidated sediment and sandstone from the ground surface up to depths ranging from 40 to 95 feet bgs underlain by dry blue shale between depths of 40 and 240 feet bgs. The minimum thickness of the blue shale unit is 70 feet. Groundwater is present in a water-bearing sand/sandstone that underlies the blue shale unit. Based on this assessment, groundwater at the Landfarm is likely confined below the

blue shale unit at depths between 110 feet bgs and 240 feet bgs and is unlikely to be recharged from infiltrating surface water in the area based on vertical distance and the minimal porosity of the blue shale. As such, the migration to groundwater pathway is incomplete. A summary of permitted NMOSE wells within 10 miles of the Landfarm and their associated well logs are included in Appendix D. Additionally, Figure 3 presents the locations and depths to water (when available) for NMOSE wells near the Landfarm.

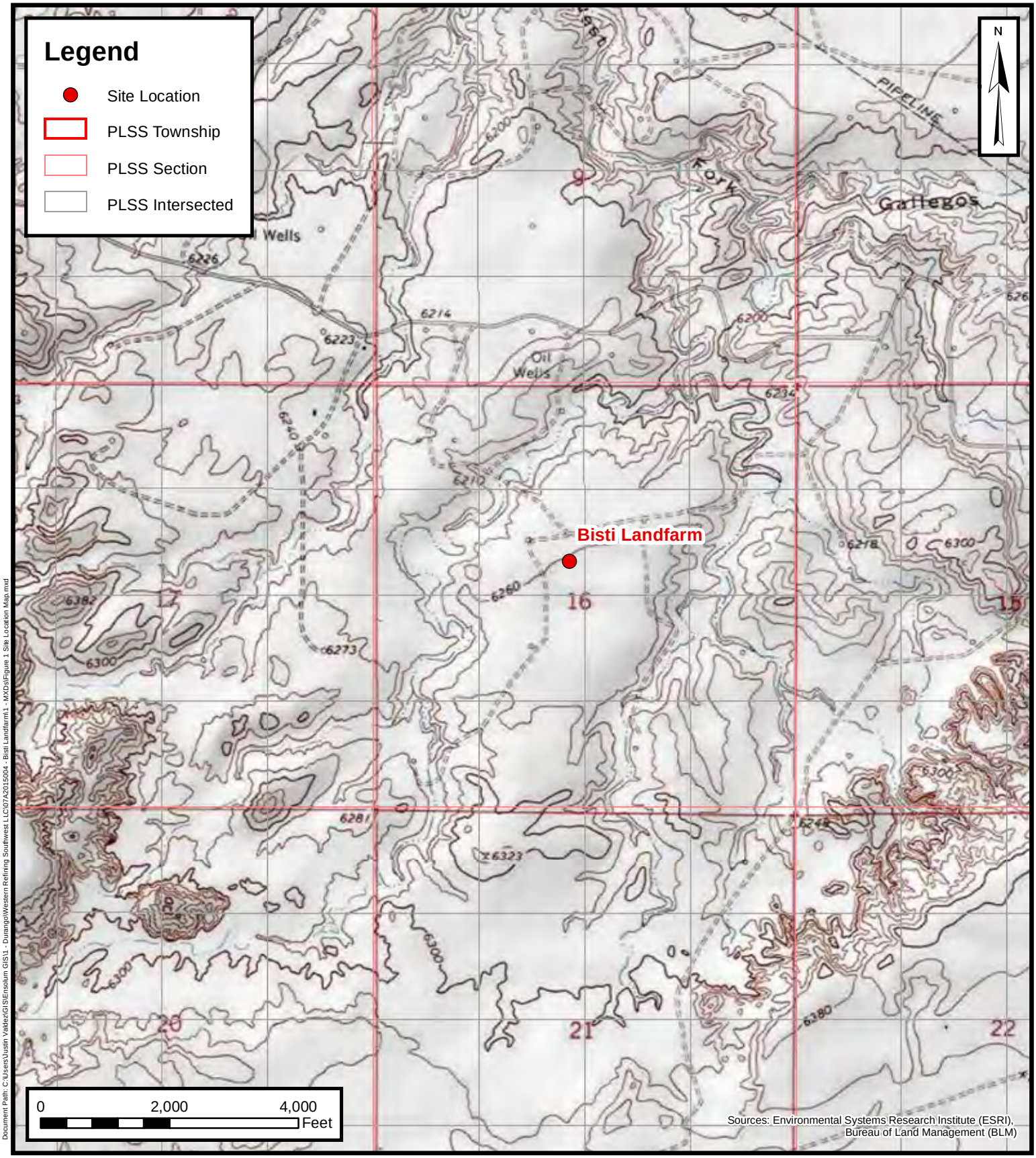
To strengthen the risk analysis for the Landfarm, it is worth noting that various conservative assumptions have been applied. All proposed screening levels have been determined based on the most conservative SSLs presented by the NMED/EPA for direct contact/ingestion and fugitive dust inhalation. The NMED SSG migration-to-groundwater model assumes that the potentially receiving aquifer is unconfined and unconsolidated with homogenous and isotropic hydrologic properties, which is not the case in this environmental setting. Based on the location of the facility, compliant with these siting requirements, in conjunction with the information provided above, the migration-to-groundwater pathway incomplete at the Landfarm.

Based on the exposure pathway evaluation above, soil screening levels determined in the NMED SSG for the following pathways should be used in lieu of direct comparison to background concentrations: direct ingestion of soil, dermal contact with soil, and inhalation of fugitive dust in a residential setting. The soil screening levels proposed as alternative treatment zone closure performance standards are presented in attached Table 1.

8.4 CONCLUSIONS AND REQUEST FOR AN EXCEPTION

Based on the above risk assessment following NMED and EPA guidance documents, this exception offers equal protection to fresh water, public health, and the environment by applying conservative NMED SSLs to metals constituents. As such, if treatment zone soils meet the closure criteria specified in 19.15.36.15(F)(1) through 19.15.36.15(F)(4), as well as the highlighted SSLs presented in attached Table 1 for arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, uranium, and zinc, Western plans to leave the treated soils in place in accordance with 19.15.36.15(G)(1).

FIGURES



Document Path: C:\Users\Justin Valdez\GIS\Ensolum GIS\1 - Durango\Western Refining Southwest LLC\07A2015004 - Bisti Landfarm\1 - MXDs\Figure 1 Site Location Map.mxd

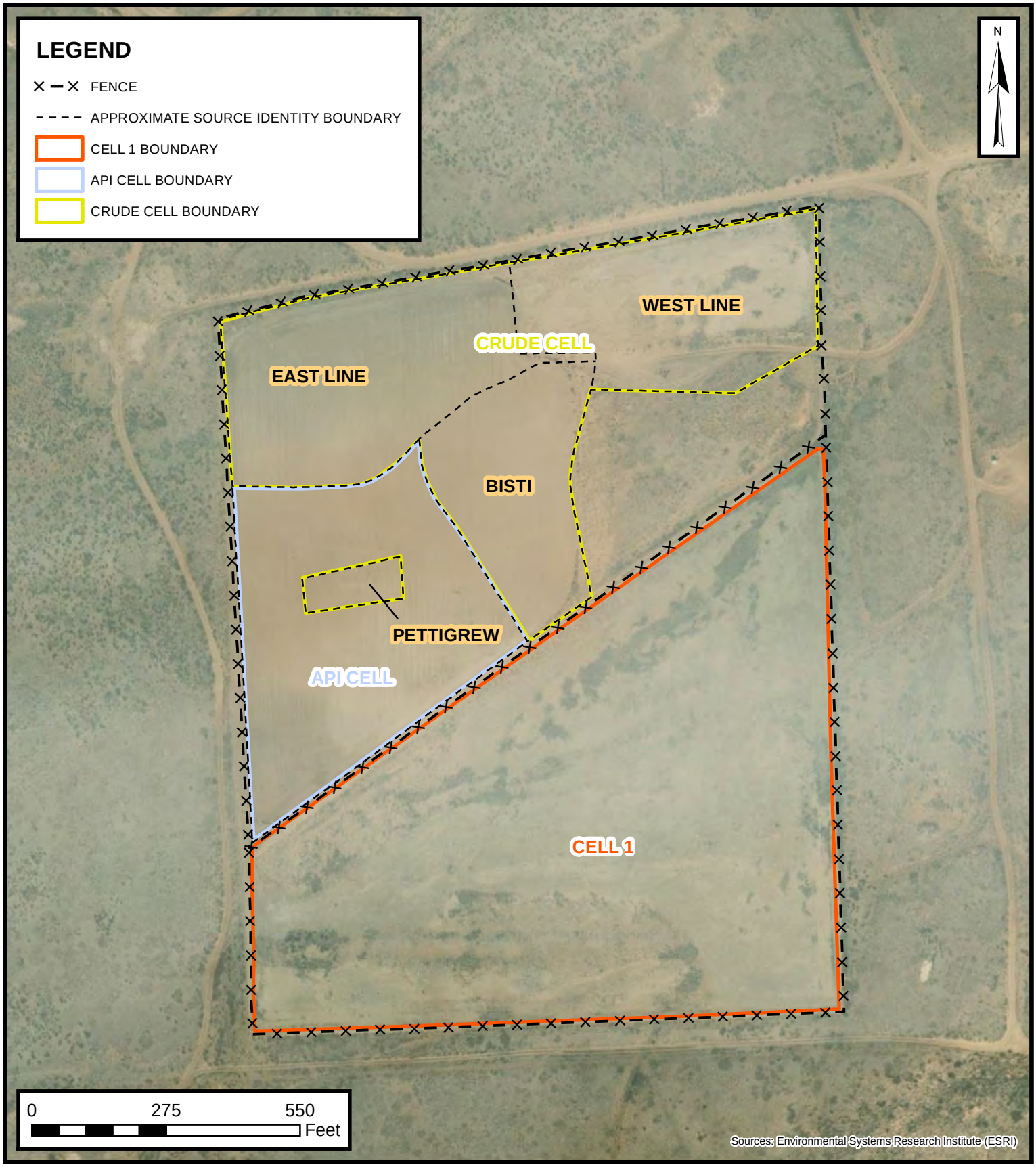
ENSOLUM
Environmental, Engineering and Hydrogeologic Consultants

Site Location Map

BISTI LANDFARM
SEC 16 T25N R12W
SAN JUAN COUNTY, NM

WESTERN REFINING SOUTHWEST, INC

FIGURE
1

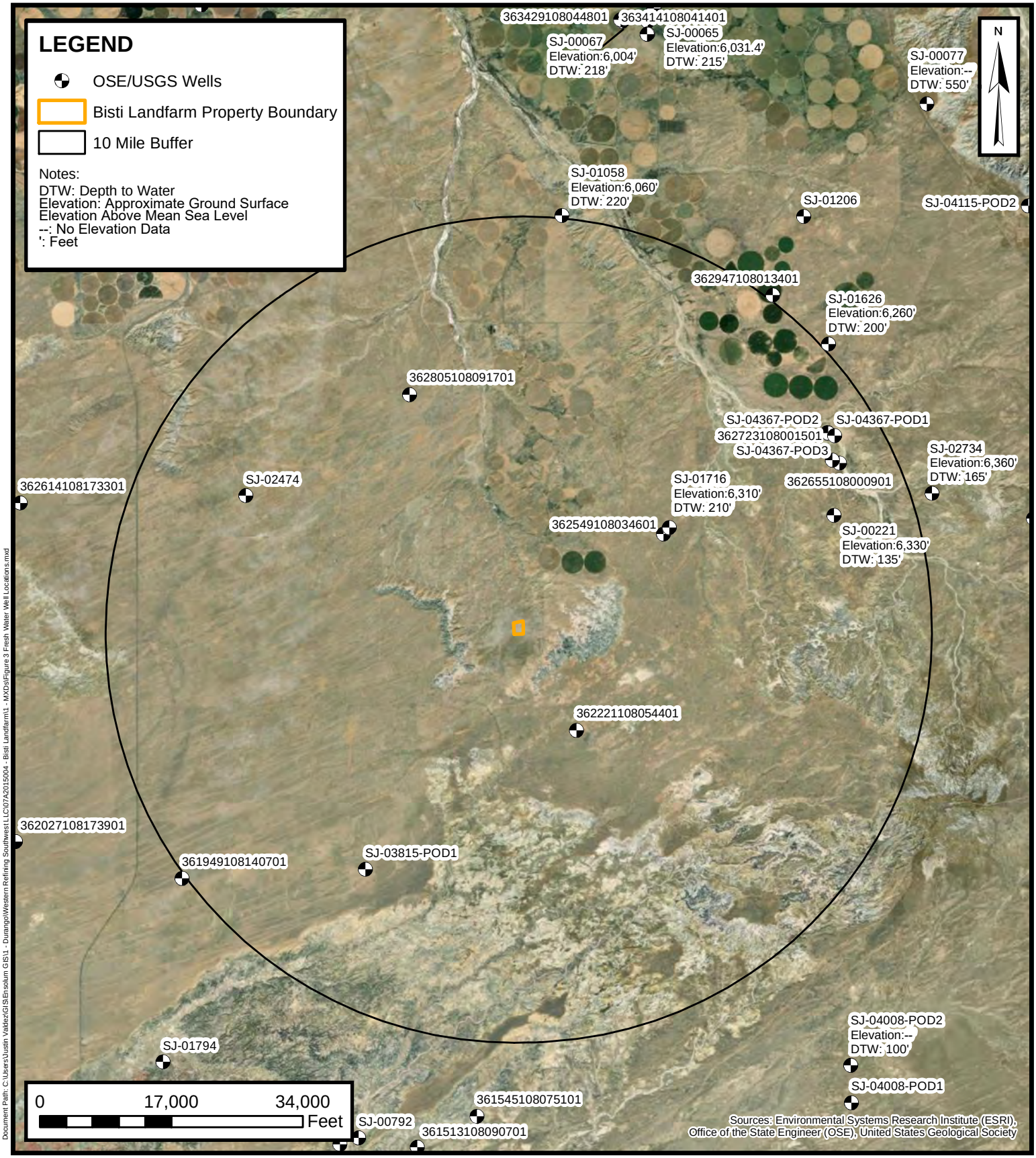


ENSOLUM
Environmental & Hydrogeologic Consultants

Site Map

BISTI LANDFARM
SEC 16 T25N R12W
SAN JUAN COUNTY, NM
WESTERN REFINING SOUTHWEST LLC

FIGURE
2



Document Path: C:\Users\Justin Valdez\GIS\Ensolum GIS\1 - Durango\Western Refining Southwest LLC\07A2015004 - Bisti Landfarm\1 - MXDs\Figure 3 Fresh Water Well Locations.mxd

ENSOLUM
Environmental, Engineering and Hydrogeologic Consultants

Well Locations

BISTI LANDFARM
SEC 16 T25N R12W
SAN JUAN COUNTY, NM
WESTERN REFINING SOUTHWEST LLC

FIGURE
3

TABLES

ENSOLUM

TABLE 1
TREATMENT ZONE CLOSURE PERFORMANCE STANDARDS
Western Refining Southwest LLC
San Juan County, New Mexico

Ensolum Project No. 07A2015005

ANALYTE	UNITS	NMOCD Treatment Zone Closure Performance Standards	NMED Soil Screening Level, Direct Contact/Ingestion, Residential Cancer (2)	NMED Soil Screening Level, Direct Contact/Ingestion, Residential Non-Cancer (2)	NMED Soil Screening Level, Direct Contact/Ingestion, Industrial/ Occupational Cancer (2)	NMED Soil Screening Level, Direct Contact/Ingestion, Industrial/ Occupational Non-Cancer (2)	NMED Soil Screening Level, Direct Contact/Ingestion, Construction Worker Cancer (2)	NMED Soil Screening Level, Direct Contact/Ingestion, Construction Worker Non-Cancer (2)	EPA Soil Screening Level, Inhalation of Volatiles and Fugitive Dusts (3)	Most Stringent Soil Screening Level
Petroleum Hydrocarbons by EPA Method 8015M										
GRO+DRO	mg/kg	500	---	---	---	---	---	---	---	---
TPH	mg/kg	2,500	---	---	---	---	---	---	---	---
Volatile Organic Compounds by EPA Method 8021B										
Benzene	mg/kg	0.20	---	---	---	---	---	---	---	---
BTEX	mg/kg	50	---	---	---	---	---	---	---	---
Anions by EPA Method 300.0										
Chloride	mg/kg	1,000	---	---	---	---	---	---	---	---
Metals by EPA Method 6010B and 6020										
Arsenic	mg/kg	2.8	7.07	13.0	35.9	208	216	41.2	8,880	7.07
Barium	mg/kg	180	NE	15,600	NE	25,500	NE	4,390	709,000	4,390
Cadmium	mg/kg	<1.3	85,900	70.5	417,000	1,110	3,610	72.1	14,200	70.5
Chromium	mg/kg	<5.0	96.6	45,200	505	314,000	468	134	14,200	96.6
Copper	mg/kg	3.2	NE	3,130	NE	51,900	NE	14,200	NE	3,130
Iron	mg/kg	7,200	NE	54,800	NE	908,000	NE	248,000	NE	54,800
Lead (4)	mg/kg	6.8	NE	400	NE	800	NE	800	NE	400
Manganese	mg/kg	150	NE	10,500	NE	160,000	NE	464	70,900	464
Mercury	mg/kg	<0.5	NE	23.8	NE	112	NE	20.7	10.9	20.7
Selenium	mg/kg	<2.5	NE	391	NE	6,490	NE	1,750	28,400,000	391
Silver	mg/kg	<1.3	NE	391	NE	6,490	NE	1,770	NE	391
Uranium	mg/kg	<4.9	NE	234	NE	3,880	NE	277	56,700	234
Zinc	mg/kg	14	NE	23,500	NE	389,000	NE	106,000	NE	23,500

Notes:

(1): background soil concentrations based on Table 4 values (soil considered to have potential for use as topsoil), USGS Paper 1134-C, Geochemical Variability of Natural Soils and Reclaimed Mine-Spoil Soils in the San Juan Basin, New Mexico.

(2) - soil screening levels are based on the "NMED Risk Assessment Guidance for Site Investigations and Remediation, Volume I - Soil Screening Guidance for Human Health Risk Assessments" (November 2022)

(3) - United Stated EPA regional screening level for inhalation of fugitive dust using the EPA online "Regional Screening Level Calculator"

(4) - lead soil screening level based on Section 5.2 of the EPA online resource "Regional Screening Levels (RSLs) - User's Guide" dated November 2022

BTEX: benzene, toluene, ethylbenzene, total xylenes

DRO: diesel range organics

GRO: gasoline range organics

mg/kg: milligrams per kilogram

NE: Not Established

NMED: New Mexico Environment Department

NMOCD: New Mexico Oil and Gas Conservation Division

PQL: practical quantitation limit

TPH: total petroleum hydrocarbons

<: indicates result is less than the stated laboratory method practical quantitation limit

Gray shading indicates the concentration to be used for treatment zone closure performance standard

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TABLE 2
COMPLIANCE MONITORING SAMPLING SCHEDULE
Bisti Landfarm
Western Refining Southwest LLC
San Juan County, New Mexico

Ensolum Project No. 07A2015005

Quarter	Rule	Zone	Collection Method	TPH (USEPA 8015)	BTEX (USEPA 8021)	Chlorides (USEPA 300.0)	Major Cations/ Anions	Heavy Metals	Subsection A and B by EPA Method 6010B/6020; Plus Mercury by EPA Method 7471
Q1	711	Vadose Zone (3 feet below native)	1 random discrete sample each source area (West Line, East Line, Bisti, Pettigrew, API), 5 total samples	X	X	---	X	X	---
	36	Vadose Zone (3 feet below native)	4 random discrete samples from each Cell, 8 total samples (API = 4 samples) (Crude = 4 samples)	X	X	X	---	---	---
	36	Treatment Zone (0-8 inches)	1 composite from each cell, 2 total samples (API = 4 aliquots) (Crude = 4 aliquots)	X	---	X	---	---	---
Q2	711	Vadose Zone (3 feet below native)	1 random discrete sample each source area (West Line, East Line, Bisti, Pettigrew, API), 5 total samples	X	X	---	---	---	---
Q3	711	Vadose Zone (3 feet below native)	1 random discrete sample each source area (West Line, East Line, Bisti, Pettigrew, API), 5 total samples	X	X	---	---	---	---
	36	Vadose Zone (3 feet below native)	4 random discrete samples from each Cell, 8 total samples (API = 4 samples) (Crude = 4 samples)	X	X	X	---	---	---
	36	Treatment Zone (0-8 inches)	1 composite from each cell, 2 total samples (API = 4 aliquots) (Crude = 4 aliquots)	X	---	X	---	---	---
Q4	711	Vadose Zone (3 feet below native)	1 random discrete sample each source area (West Line, East Line, Bisti, Pettigrew, API), 5 total samples	X	X	---	---	---	---
5-Year Sampling (last occurred in 2022)	36	Vadose Zone (3 feet below native)	4 random discrete samples from each Cell, 8 total samples (API = 4 samples) (Crude = 4 samples)	---	---	---	---	---	X

Notes:

BTEX: Benzene, Toluene, Ethylbenzene, and Xylenes

EPA: Environmental Protection Agency

TPH: Total Petroleum Hydrocarbons

Compliance Sampling Analyte Lists

5- Year Sampling, Subsection A & B by EPA Method 6010B/6020 Plus Mercury by EPA Method 7471, Rule 36 Metals	Annual Sampling, Rule 711 Heavy Metals	Major Cations/Anions - Rule 711 (USEPA Method)
Arsenic	Arsenic (6010B)	Alkalinity (ASA10-3)
Barium	Barium (6010B)	Bicarbonate (ASA10-3
Cadmium	Cadmium (6010B)	Carbonate (ASA10-3)
Chromium	Chromium (6010B)	Chloride (300.0)
Copper	Lead (6010B)	Calcium (6010B)
Iron	Selenium (6010B)	Magnesium (6010B)
Lead	Silver (6010B)	Potassium (6010B)
Manganese	Mercury (7471)	Sodium (6010B)
Mercury		Sulfate (300.0)
Selenium		
Silver		
Uranium		
Zinc		

APPENDIX A

CLOSURE INSPECTION CHECKLIST

LANDFARM NAME	
DATE	

Landfarm Closure Inspection Checklist			
ITEM / AREA	**Yes, No, NA**	**Cell Number**	**COMMENTS / ACTION TAKEN**
Berms Removed?			
Buildings, Fences, Roads, and Equipment Removed?			
Residual Contamination/Staining Removed and Sampled?			
Sampling Reports Submitted to NMOCD?			

NA – Not Applicable

Comment section should be used to provide details of unsatisfactory findings.

Additional Inspection Remarks:

Inspector Signature:_____ Manager Signature:_____

Name (Print):_____ Name (Print):_____

APPENDIX B

POST-CLOSURE REVEGETATION AND RECLAMATION PLAN

ENSOLUM

APPENDIX B
POST-CLOSURE REVEGETATION PLAN

February 17, 2023

Bisti Landfarm

Permit NM-02-0010

Western Refining Southwest LLC

C/O Ms. Kateri Luka

Table of Contents

Attachments:

Attachment 1: NRCS Soil Resource Report
Attachment 2: New Mexico Range Plants
Attachment 3: NMDOT Seed Mix

1.0 INTRODUCTION

Ensolum, LLC has prepared the following *Post-Closure Revegetation Plan* for the Bisti Landfarm (Landfarm) for Western Refining Southwest LLC (Western). This Revegetation Plan has been prepared in accordance with the requirements of 19.15.36.18 of the New Mexico Administrative Code (NMAC). This Revegetation Plan has been prepared to outline procedures for the revegetation of the Landfarm in order to establish 70 percent (%) vegetative cover (not including noxious weeds) through two successive growing seasons. Vegetative cover shall consist of native perennial vegetation consisting of at least three native plant species and at least one grass.

1.1 AREA DESCRIPTION

The Landfarm occupies approximately 28 acres of land in Section 16, Township 25 North, Range 12 West in San Juan County, New Mexico. It is located on a 640-acre parcel of land which is privately owned by Western. The Landfarm is located within the eastern portion of the Natural Resources Conservation Service (NRCS) Land Resource Region (LRR) Major Land Resource Area (MLRA) D35 – Colorado and Green River Plateaus. The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has mapped the Landfarm location within the Doak-Sheppard-Shiprock (DS) association, rolling soil zone. The Landfarm location is also within the San Juan/Chaco Tablelands and Mesas ecoregion identified by the United States Environmental Protection Agency (EPA) and several collaborating agencies. The NRCS description is included as Attachment 1. This setting is characterized by a mean annual precipitation of 6 to 10 inches, not prime farmland, with alluvium soil derived from sandstone and shale.

This area supports natural vegetation and is used primarily as grazing land. Primary vegetation consists of grasses, shrubs, and sagebrush. According to the New Mexico State University pamphlet “New Mexico Range Plants, Circular 374” (Attachment 2), the following native plants are found in the vicinity of the Landfarm:

Scientific name	Common Name
Artemisia tridentata	Big sagebrush
Atriplex canescens	Fourwing saltbrush
Ceratoides lanata	Winterfat
Agropyron smithii	Western wheatgrass
Bouteloua gracilis	Blue grama
Bouteloua curtipendula	Sideoats grama
Hilaria jamesii	Galleta

2.0 SITE REVEGETATION

Total area of disturbance at the Landfarm is approximately 28 acres. Revegetation of the Landfarm will increase the natural vegetative community of the Landfarm in order to maintain biologically active topsoil and control potential erosion. Successful revegetation of the Landfarm will be based on the establishment of 70 % or greater vegetative cover (not including noxious weeds) and maintenance through two successive growing seasons.

Revegetation of the Landfarm, including areas previously developed with roads within the Landfarm boundary (fenced area of the property) and treatment cell berms, will be accomplished using the seed mix and application rates listed in Attachment 3. This seed mix is provided by the New Mexico Department of Transportation (NMDOT) for revegetation of areas on plateaus and mesas in New Mexico. The seed mix and application rate are based on the NRCS MLRA described in Section 1.1 above. The seed mix is subject to change based on availability. Reseeding will be accomplished by rangeland drill. If mulch is used at the Landfarm, areas will be covered with hay or stray at a rate of 1.5 tons per acre. Of note, roads outside of the fenced area of the Landfarm, and not associated with Landfarm activities, are located on private surface and will not be revegetated.

3.0 NOXIOUS WEED CONTROL

The New Mexico Department of Agriculture (NMDA) has developed a noxious weed list for the state and identified methods of control. The NMDA has developed the following classes of noxious weeds.

- **Class A** species are currently not present in New Mexico or have limited distribution. Preventing new infestations of these species and eradicating existing infestations is the highest priority.
- **Class B** species are limited to portions of the State. In areas with severe infestations, management should be designed to contain the infestation and stop any further spread.
- **Class C** species are widespread in the State. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation.
- **Watch List** species are species of concern in the State. These species have the potential to become problematic. More data is needed to determine if these species should be listed.

When NMDA noxious weeds are encountered after revegetation of the Landfarm, their location, density, and estimated extent will be documented and will be treated to eliminate their potential spread.

When controlling noxious weeds, it is imperative to prevent damage to the existing desirable plant species during weed treatments. Weed control can be achieved through direct treatments, prevention through best management practices (BMPs), and monitoring of treatment efficacy. A field inventory of noxious weeds will be performed prior to reseeding of the Landfarm to assess baseline conditions. ground-breaking disturbances to document existing noxious weeds to understand baseline conditions on site. Class List A and B noxious weed species should be identified, photographed, and located using a sub-meter global positioning system (GPS) unit. During the revegetation monitoring period, noxious weeds should be regularly inventoried to document infestations and develop treatment strategies.

3.1 NOXIOUS WEED TREATMENT AND CONTROL

Noxious weeds are commonly treated and controlled through application of herbicides, mechanical removal, and grazing. These and other alternative methods will be considered on a case-by-case basis at the Landfarm depending on weed species, area of weed cover, and time of year.

3.1.1 Herbicides

Several noxious weed species are able to be controlled through commercially available herbicides. It is recommended that Western retain professionals that are state licensed/certified to select and apply herbicides to prevent human harm and avoid damage to desirable species being used for revegetation.

3.1.2 Mechanical Removal

Small and isolated weed infestations can often be controlled with hand tools by cutting and/or digging. Mechanical removal can also be used in combination with herbicides to control larger and/or denser infestations. Severing the weed roots is generally the most effective method for removal. Of note, certain species, such as Canada thistle (*Cirsium arvense*) and Russian knapweed (*Acroptilon repens*), may increase rather than decrease if mechanical removal is the only method used.

3.1.3 Grazing

Grazing can be an effective weed control method. However, grazing is not recommended prior to the establishment of 70 % cover through two successive growing seasons.

3.2 NOXIOUS WEED TREATMENT STRATEGIES

In order to effectively manage and reduce noxious weeds, treatment methods should be applied depending on whether the species are annual, biennial, or perennial. Biennial and perennial weeds are common in the vicinity of the Landfarm.

3.2.1 Control of Annual and Biennials

1. Hand grubbing (pulling), hoeing, tillage, solarization, cultivation in rosette stage and before flowering or seed maturity.
2. Chop roots at least 2 inches below soil level.
3. Post emergent herbicide treatment in the rosette or bolting stage before flowering.
4. Pre-emergent herbicide treatment is effective on most annual weeds. Apply in the early spring before spring annual weeds emerge and in the late summer for winter annuals. Pre-emergent treatments can be effective for up to 3 months. Watering into the soil may be necessary to get the herbicide into the germination zone. Follow label instructions carefully.
5. Mow biennials after bolting stage and before seed set; be aware that mowing annuals may not prevent the plants from flowering and setting seed.

3.2.2 Control of Perennials

1. It is important to know what perennial weed you have before deciding on a control tactic. Perennials vary widely in their response to mechanical control.
2. Allow plants to expend as much energy from root system as possible; do not treat when first emerging in spring but allow them to grow to bud to bloom stage.
3. Herbicide treatment at bud to bloom stage or in the fall. Spraying in the fall will kill the following year's shoots, which are formed in the fall. If the weed patch has been there a long time, another season of seed production is not as important as getting the herbicide into the root system.
4. Mowing is not recommended for all perennials because some of them will flower at the mowed height; however, seed production may be reduced. Herbicides alone may be more effective than mowing followed by herbicide treatment. A combination of repeated mowing to prevent flowering followed by herbicide treatment in the fall is effective for some perennial weeds such as Canada thistle. The effect of mowing is species dependent.
5. Tillage may or may not be effective. Most perennial roots can sprout from pieces only ½ inch to 1 inch long. Repeated tillage over the course of a summer may destroy soil structure and be more detrimental than an herbicide treatment. Clean machinery thoroughly before leaving the weed patch.

ATTACHMENT 1

NRCS SOIL RESOURCE REPORT

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for San Juan County, New Mexico, Eastern Part

June 28, 2022

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

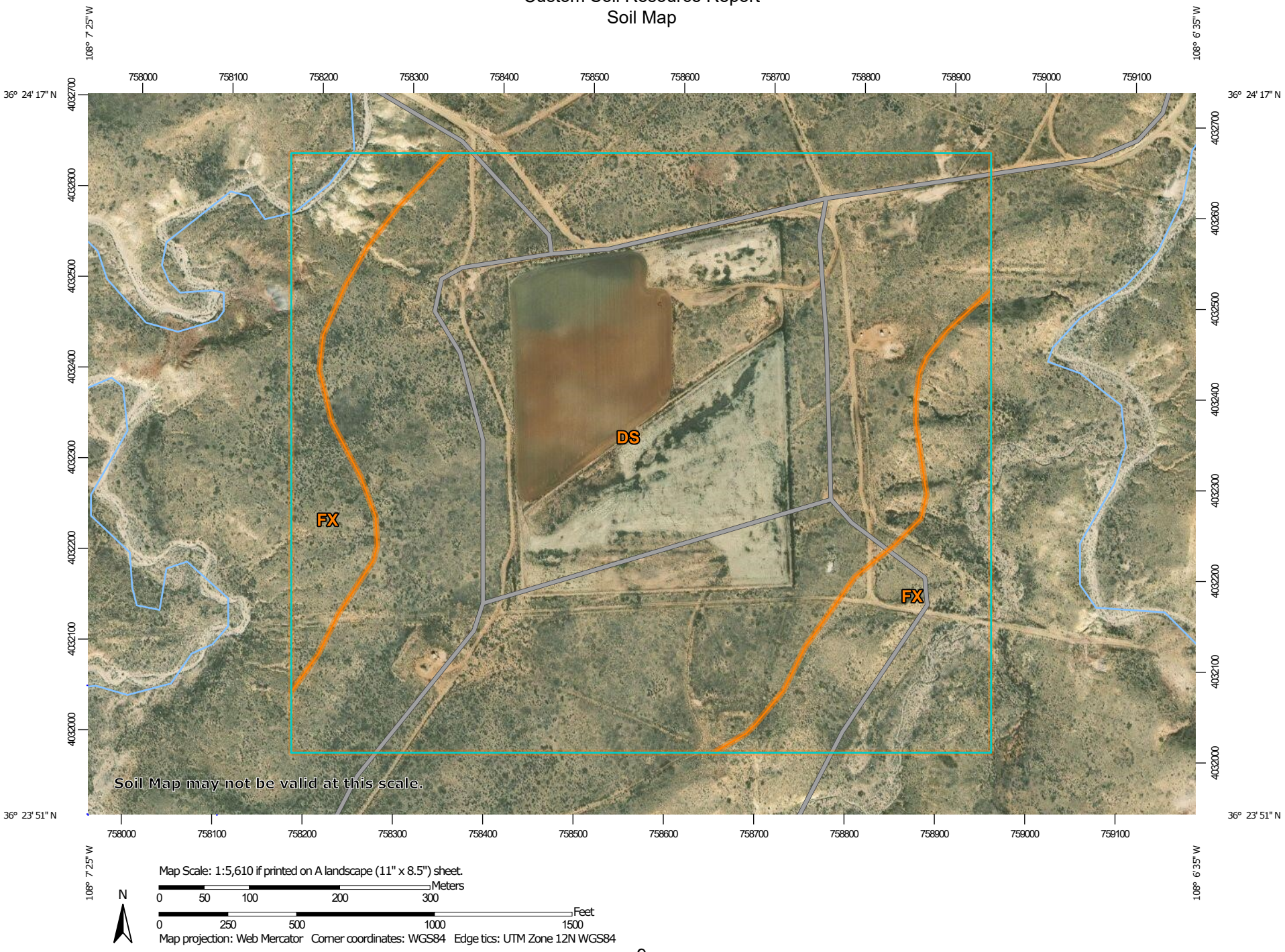
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:63,400.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Juan County, New Mexico, Eastern Part
Survey Area Data: Version 17, Sep 12, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 11, 2016—Oct 10, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
DS	Doak-Sheppard-Shiprock association, rolling	100.4	79.1%
FX	Fruitland-Persayo-Sheppard complex, hilly	26.6	20.9%
Totals for Area of Interest		**127.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however,

onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

San Juan County, New Mexico, Eastern Part

DS—Doak-Sheppard-Shiprock association, rolling

Map Unit Setting

National map unit symbol: 1wwf
Elevation: 5,600 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Doak and similar soils: 40 percent
Sheppard and similar soils: 30 percent
Shiprock and similar soils: 20 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Doak

Setting

Landform: Stream terraces, mesas, fan remnants
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Alluvium derived from sandstone and shale

Typical profile

A - 0 to 3 inches: loam
Btk - 3 to 41 inches: clay loam
Ck - 41 to 60 inches: loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: High (about 10.1 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: R035XB001NM - Loamy
Hydric soil rating: No

Description of Sheppard

Setting

Landform: Stream terraces, mesas, fan remnants, dunes
Landform position (three-dimensional): Side slope, tread, talf
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Eolian deposits over mixed alluvium

Typical profile

A - 0 to 3 inches: loamy fine sand
C - 3 to 60 inches: loamy fine sand

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R035XB007NM - Deep Sand
Hydric soil rating: No

Description of Shiprock

Setting

Landform: Stream terraces, mesas, fan remnants
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Eolian deposits over alluvium derived from sandstone

Typical profile

A - 0 to 3 inches: fine sandy loam
CBk - 3 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Calcium carbonate, maximum content: 2 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: Moderate (about 6.6 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R035XB002NM - Sandy
Hydric soil rating: No

Minor Components

Avalon

Percent of map unit: 5 percent
Ecological site: R035XB003NM - Limy
Hydric soil rating: No

Mayqueen

Percent of map unit: 2 percent
Ecological site: R035XB007NM - Deep Sand
Hydric soil rating: No

Monierco

Percent of map unit: 2 percent
Ecological site: R035XB006NM - Shallow
Hydric soil rating: No

Uffens

Percent of map unit: 1 percent
Ecological site: R035XB005NM - Salt Flats
Hydric soil rating: No

FX—Fruitland-Persayo-Sheppard complex, hilly

Map Unit Setting

National map unit symbol: 1wwr
Elevation: 4,800 to 6,400 feet
Mean annual precipitation: 6 to 10 inches
Mean annual air temperature: 51 to 55 degrees F
Frost-free period: 140 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Fruitland and similar soils: 40 percent
Persayo and similar soils: 30 percent
Sheppard and similar soils: 25 percent

Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fruitland

Setting

Landform: Stream terraces, alluvial fans
Landform position (three-dimensional): Riser, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Slope alluvium derived from sandstone and shale

Typical profile

A - 0 to 4 inches: sandy loam
C - 4 to 60 inches: fine sandy loam

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: Moderate (about 7.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R035XB002NM - Sandy
Hydric soil rating: No

Description of Persayo

Setting

Landform: Hills, breaks, ridges
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Crest, nose slope, side slope, head slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Residuum weathered from shale

Typical profile

A - 0 to 18 inches: clay loam
Cr - 18 to 20 inches: bedrock

Properties and qualities

Slope: 5 to 30 percent
Depth to restrictive feature: 5 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Very high

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: Very low (about 2.9 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: R035XA130NM - Shale Hills 10-14"p.z.
Hydric soil rating: No

Description of Sheppard

Setting
Landform: Dunes
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Eolian deposits over mixed alluvium

Typical profile
A - 0 to 4 inches: loamy fine sand
C - 4 to 60 inches: loamy fine sand

Properties and qualities
Slope: 5 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.2 inches)

Interpretive groups
Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R035XB007NM - Deep Sand
Hydric soil rating: No

Minor Components

Farb
Percent of map unit: 5 percent
Ecological site: R035XB006NM - Shallow
Hydric soil rating: No

Custom Soil Resource Report

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "National Soil Survey Handbook."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology)

from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left

behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^{1}/_{3}$- or $^{1}/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth’s crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can

occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and

promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1
Moderate: 13-30:1
Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0
Coarse sand: 1.0 to 0.5
Medium sand: 0.5 to 0.25
Fine sand: 0.25 to 0.10
Very fine sand: 0.10 to 0.05
Silt: 0.05 to 0.002
Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated
Prismatic: Vertically elongated and having flat tops
Columnar: Vertically elongated and having rounded tops
Angular blocky: Having faces that intersect at sharp angles (planes)
Subangular blocky: Having subrounded and planar faces (no sharp angles)
Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand
Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field

generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.

ATTACHMENT 2

NEW MEXICO RANGE PLANTS

New Mexico Range Plants

Circular 374

Revised by Christopher D. Allison and Nick Ashcroft[1]

Cooperative Extension Service • College of Agricultural, Consumer and Environmental Sciences

New Mexico contains almost 78 million acres, more than 90 percent of which is in native vegetation grazed by domestic livestock and wildlife. The kinds of plants that grow on a range, along with their quality and quantity, determine its value. A successful rancher knows the plants on his or her range.

There are more than 3,000 species of plants in New Mexico. The 85 discussed here are most important to the livestock industry. Most of these are native plants.

RANGELAND AREAS OF NEW MEXICO

Figure 1 represents the major rangeland areas in New Mexico. The northern desert, western plateau, and high valley areas are enough alike to be described together, as are the central and high plains areas and the southern desert and basin.

Southern Desert and Basin

The southern desert and basin occupies much of southern New Mexico at elevations between 3,000 and 5,000 feet. This area follows the Rio Grande north into the southern part of Sandoval County.

Some of the most common plants are creosote bush (*Larrea tridentata* [DC.] Coville), mesquite (*Prosopis glandulosa* Torr.), cacti (*Opuntia* spp.), black grama (*Bouteloua eriopoda* Torr.), tobosa (*Hilaria mutica* [Buckl.] Benth.), and dropseeds (*Sporobolus* spp.). Much of the southern desert area now occupied by creosote bush and mesquite once produced mostly black grama and other valuable grasses (Figure 2). The combination of overgrazing and drought over the past 100 years has worked to the advantage of undesirable shrubs.

Precipitation is less than 12 inches annually and variable. Most of it comes during July, August, and September. Forage production is usually low and uncertain, so that range management is quite difficult.

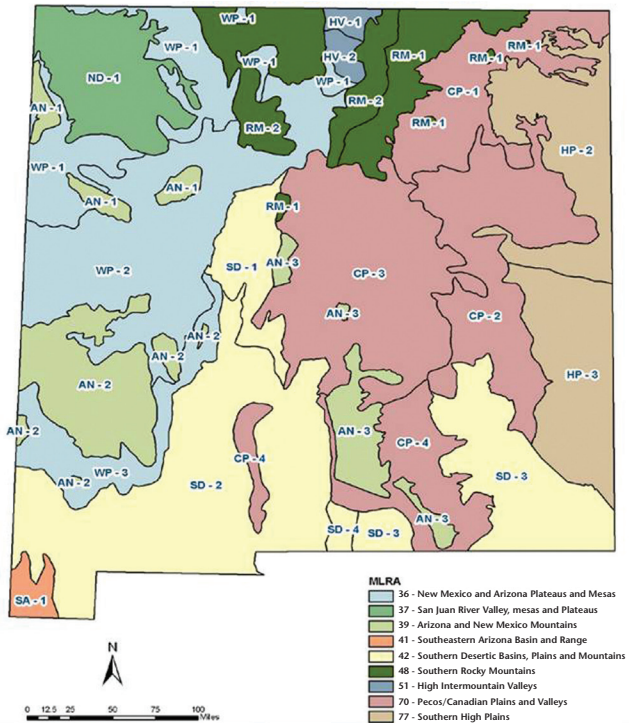


Figure 1. **New Mexico rangeland areas.**
Source: USDA-NRCS. Used with permission.

Northern Desert, Western Plateau, and High Valley

The northern desert, western plateau, and high valley region of northwestern New Mexico receives about 10 to 14 inches of precipitation annually. The average elevation is around 5,500 to 6,000 feet.

In the northern desert, big sagebrush (*Artemisia tridentata* Nutt.), fourwing saltbush (*Atriplex canescens* [Pursh] Nutt.), and winterfat (*Ceratoides lanata* [Pursh] J.T. Howell) are the most important shrubs (Figure 3).

[1]Respectively, Range Management Specialist and Department Head; and Range Management Specialist, both of the Department of Extension Animal Sciences and Natural Resources, New Mexico State University.

Photo courtesy of Nicholas Ashcroft.

Figure 2. **Creosote bush and mesquite dominate much of the range in the southern desert region.**

Big sagebrush is most common where soils are alkali-free, and it spreads in areas of grazing abuse. Fourwing saltbush and winterfat are desirable browse plants. Western wheatgrass (*Agropyron smithii* Rydb.) and blue grama (*Bouteloua gracilis* [H.B.K.] Lag.) are common understory forage grasses.

At the higher elevations of the western plateau, piñon pine (*Pinus edulis* Engelm.) and several species of juniper (*Juniperus* spp.) occupy mostly rocky ridges and shallow soils (Figure 4). These plants have also moved into some of the better grassland soils. In the open areas, sideoats grama (*Bouteloua curtipendula* [Michx.] Torr.), blue grama, and galleta (*Hilaria jamesii* [Torr.] Benth.) are important understory forage plants. The lower elevations are dominated by blue grama.

Central and High Plains

Much of the eastern half of the state lies in these two rangeland resource areas. The elevation averages between 4,500 and 5,000 feet over most of the region. The mean annual precipitation is between 14 and 18 inches, with about 70 percent coming between April and September.

Most of the central and high plains is short-grass country, dominated primarily by blue grama (Figure 5). Sideoats grama, hairy grama (*Bouteloua hirsuta* Lag.), and galleta are also prominent in some areas, especially on coarser soils and gravelly slopes. Big bluestem (*Andropogon gerardii* Vitm.) sometimes dominates heavier soils that receive additional run-in water, and sand bluestem (*A. hallii* Hack.) is found on sandy soils. Little bluestem (*Schizachyrium scoparium* [Michx.] Nash) is common on coarse soils and rocky slopes.

Buffalograss (*Buchloe dactyloides* [Nutt.] Englem.) occupies heavy soils, especially in the extreme northeast part of the state. In the southern parts, vine-mesquite (*Panicum obtusum* H.B.K.) is important on the heavy, adobe soils. The alkali soils of meadows, valleys, and flood plains are dominated by alkali sacaton (*Sporobolus airoides* Torr.).

Short-grass ranges that are grazed moderately are highly productive.

Mountains

The high mountain areas of the state provide grazing in the subalpine meadows and openings of the forests (Figure 6). The meadows occur in parklike openings mostly above 9,000 feet and have an annual precipitation from 30 to 35 inches. Fescues (*Festuca* spp.) are common grasses in the subalpine meadows, as well as sedges (*Carex* spp.) and rushes (*Juncus* spp.).

The ponderosa pine (*Pinus* ponderosa Lawson) forests grow at elevations from 6,500 to 11,500 feet, with an annual precipitation from 20 to 30 inches. In the dense forests, there is very little herbaceous understory, but where the forest canopy is relatively open, herbaceous forage plants are common. Most important are Arizona fescue (*Festuca arizonica* Vasey.) and mountain muhly (*Muhlenbergia montana* [Nutt.] Hitchc.). Blue grama is also prominent but less productive, especially on overgrazed mountain ranges (Figure 7).

Photo courtesy of Nicholas Ashcroft.

Figure 3. **Livestock graze crested wheatgrass that was seeded following big sagebrush control on a northern desert range.**

Photo courtesy of Nicholas Ashcroft.

Figure 4. **Piñon and juniper species occupy shallow soils at higher elevations in the western plateau.**

Photo courtesy of Nicholas Ashcroft.

Figure 5. **The central and high plains give an aspect of a sea of grass.**

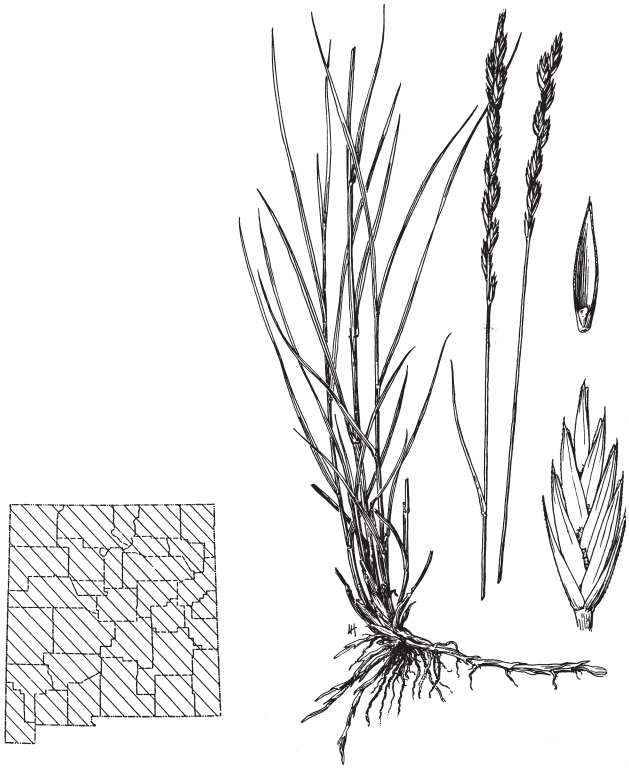
Photo courtesy of Nicholas Ashcroft.

Figure 6. **Openings in the forest provide much of the grazing in the mountain areas.**

Photo courtesy of Nicholas Ashcroft.

Figure 7. **Cholla, juniper, and blue grama are typical of many transitional areas between the central plains and mountainous areas.**

GRASSES



WESTERN WHEATGRASS
Agropyron smithii Rydb.

Description
Moderately coarse. One to 2 1/2 feet tall. Spreads by long, slender rhizomes. Blue-green when growing. Leaves are erect and have conspicuous ridges on the upper surface.

Cool-season, perennial, sod grass.

Occurrence
Widespread throughout the state from 3,000 to 10,000 feet. Most abundant on bottomland and mountain grassland sites. Grows best on rather heavy soils with runoff water. Tolerant of moderately alkaline soils.

Forage Value and Management
Western wheatgrass provides early green forage before warm-season grasses begin growth. It is palatable to all livestock. The grass produces moderately large amounts of forage and cures well on the ground. Sheep like the seedheads. The grass withstands light grazing in the spring. Heavier grazing reduces its vigor and forage production.

SLENDER WHEATGRASS
Agropyron trachycaulum (Link) Malte.

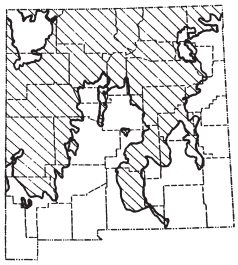
Description
Rather coarse. Moderately leafy. One to 3 feet tall. Bluish with violet seedheads. The leaves, somewhat rough to the touch, are 2 to 10 inches long and flat or slightly inrolled at the edges. Seedheads, 2 to 8 inches long, are slightly flattened spikes.

Cool-season, perennial, bunch grass.

Occurrence
Mountain areas in open forests and mountain meadows at elevations from 6,000 to 10,000 feet.

Forage Value and Management
Slender wheatgrass, one of the most palatable and nutritious wheatgrasses, is relished by all livestock. Sheep do not graze the coarse mature plants readily but like the seedheads.

The grass begins to grow early in the spring and continues through the summer if moisture is available. Under moderate grazing, the plant will maintain itself.



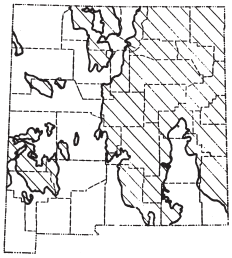
REDTOP
Agrostis gigantea Roth

Description
Coarse. One to 3 feet tall. Strong rhizomes. Numerous flat leaves about 1/4 inch wide and mostly basal. The leaf is harsh to the touch with a prominent ligule. The seedhead is a purplish-red loose panicle, pyramid-shaped, 4 to 12 inches long.

Introduced from Europe as a cultivated species. Cool-season, perennial, sod grass.

Occurrence
Mostly in mountain meadows and subalpine grasslands where openings in the tree canopy occur. Also in wet meadows in the western plateau and central plains. Ranges in elevation from 5,000 to 10,000 feet, but most common at 7,500 feet.

Forage Value and Management
Redtop is palatable to cattle and horses, and sheep will graze it if necessary. When moisture is adequate, the plants remain green all summer and can be grazed throughout the season. Redtop grows vigorously and forms good sod. Because of this, on its preferred sites, the plant withstands heavy use and serves well as a soil binder for reclaiming gullies and holding slopes and banks. It is well adapted to wet acid soils.



BIG BLUESTEM*
Andropogon gerardii Vitm.

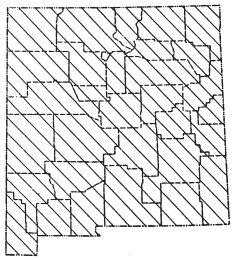
Description
Large, 3 to 4 feet tall, sometimes 6 feet under favorable conditions. Short, thick rhizomes. Growing leaf blades are bluish green, usually tinged with red or purple, cure to reddish purple. Leaf blades 4 to 18 inches long with rough margins and fine hairs near the base. Seedheads have 2 to 6 branches (usually 3, resembling a turkey foot) and are covered by bent, twisted awns 1/2 to 1 inch long.

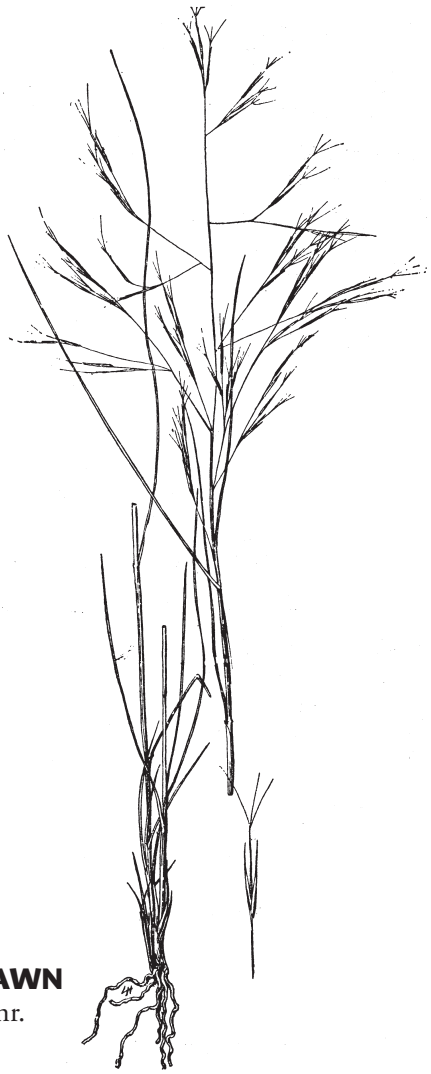
Warm-season, perennial, sod or bunch grass.

Occurrence
Restricted to sites with good moisture in the high plains, central plains, and mountain areas from 3,500 to 9,000 feet in elevation.

Forage Value and Management
Big bluestem, highly palatable to all livestock during the spring and early summer, becomes coarse later in the growing season. It cures well when cut for hay. Stands decrease under heavy grazing, and therefore indicate range conditions since the grass is most abundant on good to excellent rangeland.

*Sand bluestem, *Andropogon hallii* Hack., not shown, is a perennial sod grass that looks much like big bluestem, except that the awns on the seedheads are shorter and it has aggressive underground stems. It grows within the high plains, central plains, and southern desert on sandy sites from 3,000 to 7,000 feet. Sand bluestem forage value and management are similar to big bluestem.





POVERTY THREEAWN

Aristida divaricata Henr.

Description

Tall, 1 to 3 feet high. Dark green, curing to straw. Leaves up to 6 inches long, inrolled, and spirally twisted when dry. Seedheads open with spreading branches. Each seed is tipped with three spreading awns.

Warm-season, perennial, bunch grass.

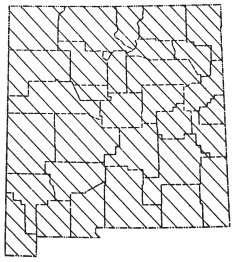
Occurrence

Occurs throughout the state. Typical of poor, rather sterile soils at elevations of 3,100 to 7,000 feet.

Forage Value and Management

The palatability of this grass before the seed matures is rated low to moderate for all livestock. After the troublesome seeds have matured, its forage value is negligible. Poverty threeawn produces the most forage after spring rains.

Rangelands supporting abundant poverty threeawn may afford spring grazing not obtained from other grasses. Since this grass tends to increase under heavy use, grazing management is based on the more productive associated grasses.



RED THREEAWN

Aristida longiseta Steud.

Description

Densely tufted. Six to 20 inches tall. In heavy clumps. Green, curing to tan. Old leaves from previous years cause the growing plants to appear grayish-green. Leaves, less than 6 inches long, inrolled, and harsh on the upper surface. Seed stalks usually short and branched. Seeds, tipped with three awns, 2 to 3 inches long, and red when immature.

Warm-season, perennial, bunch grass.

Occurrence

Throughout the state at elevations of 3,100 to 7,000 feet. Most abundant in the southern desert, high plains, and central plains. Typical of dry sandy or gravelly plains and uplands.

Forage Value and Management

The palatability of this species when green is low to moderate for all livestock. The grass has little value when dry. Although growth begins in the late spring, little forage is produced until the summer rains.

Red threeawn increases under heavy grazing because it is less palatable than associated grasses. The grass may indicate an overgrazed range, but it may also indicate a dry, well-drained soil.

Deep soils supporting extensive stands of red threeawn can be improved through light, winter, or deferred grazing. Before reseeding can be successful, red threeawn must be removed.

PINE DROPSEED
Blepharoneuron tricholepis (Torr.) Nash

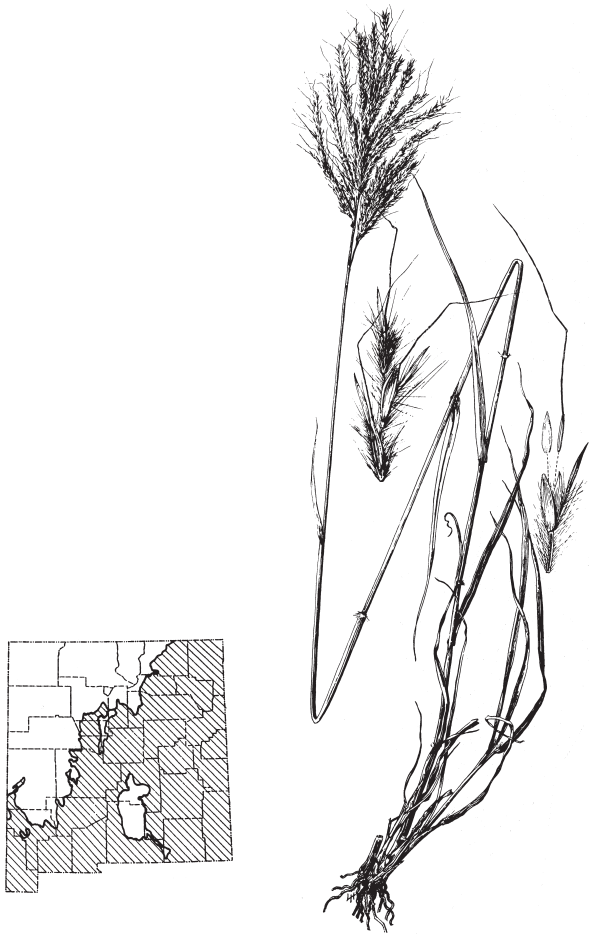
Description
Fine-stemmed. Erect. One and a half to 2 1/2 feet tall. Deep, fibrous root system. Bright green to light grey-green. Leaves abundant, narrow, and usually short. Seedheads 3 to 9 inches long, slender, grayish, and somewhat open.

Warm-season, perennial, bunch grass.

Occurrence
Mountain areas at 6,500 to 10,000 feet.

Forage Value and Management
Young, tender pine dropseed is highly palatable to all livestock. After maturity, the stems are grazed only slightly.

The plant should be grazed during the summer. In the grass composition of mountain rangeland, it indicates good range condition.



CANE BLUESTEM*
Bothriochloa barbinodis (Lag.) Herter

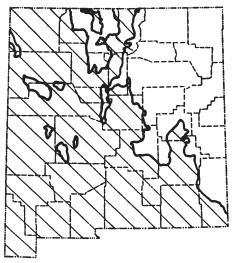
Description
Coarse. Two to 4 feet tall. Blue-green, drying to reddish-brown with lighter leaf midribs. Tufts of bright silvery hair form fan-shaped seedheads on the ends of long seed stalks. Stem nodes, encircled with hairs.

Warm-season, perennial, bunch grass.

Occurrence
Common within the southern desert region on west sites. Found on bottomland sites in the central plains, high plains, and western plateau. Occurs at 3,000 to 7,000 feet.

Forage Value and Management
Actively growing cane bluestem provides fair to good forage for cattle and sheep. Dry plants are low in nutrients as they leach readily. The grass is a good indicator of range condition because it rapidly decreases under improper use.

*Sliver bluestem, *Bothriochloa saccharoides* (Swartz.) Rydb., is much like cane bluestem. The information given for cane bluestem also applies to silver bluestem.



SIXWEEKS GRAMA*

Bouteloua barbata Lag.

Description

Relatively short-lived. Three to 15 inches tall. Stems spread along the ground before turning upward. Light green, curing to straw. Very few leaves. Seedheads comb-like spikes borne on the sides of the seed stalks, usually 4 to 7 seedheads per stalk.

Warm-season, annual, bunch grass.

Occurrence

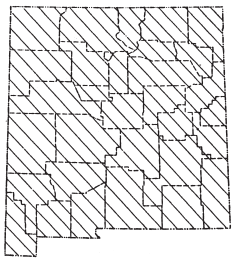
Scattered throughout the western and southern portions of the state. Typical on coarse-soiled breaks, slopes, and washes. Grows below 7,000 feet.

Forage Value and Management

The forage value of sixweeks grama is low. The green period is short, little forage is produced, and the plants are easily uprooted when grazed because the root system is weak. The plant is practically worthless after maturity.

Ranges with abundant annual grasses, such as six-weeks grama, become productive a few weeks after the summer rains. These areas will remain productive for about two months and can be heavily stocked during this period, as they will deteriorate rapidly.

*Needle grama, *Bouteloua aristidoides* (H.B.K.) Griseb., occurs in association with sixweeks grama, especially in southern New Mexico. It has the same forage value and management characteristics as sixweeks grama.



SIDEOATS GRAMA

Bouteloua curtipendula (Michx.) Torr.

Description

Largest grama, 15 to 30 inches tall. Leaves mostly basal, coarse, usually bluish-green in the spring and straw in the fall. The seedheads have 10 to 30 small spikes attached to one side of the seed stalk.

Warm-season, perennial, bunch grass.

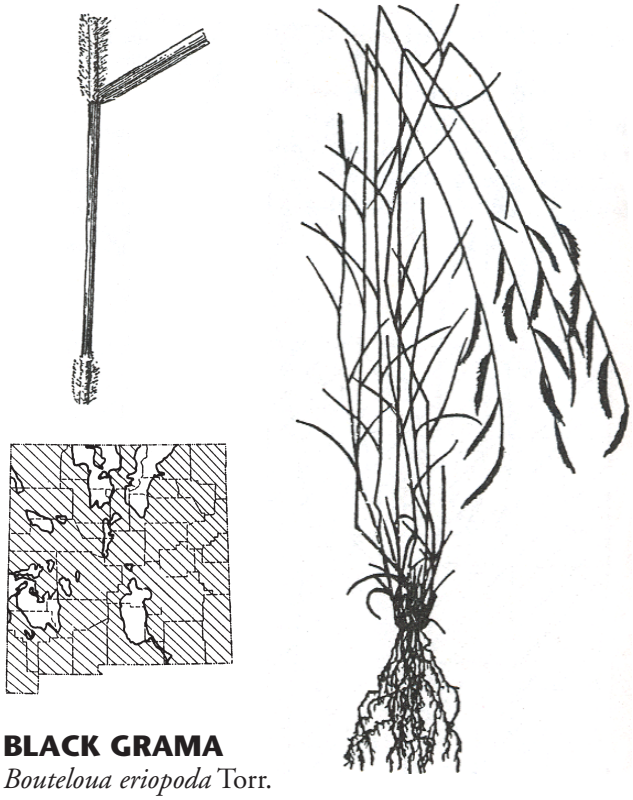
Occurrence

Widely distributed. Common on most sites throughout the state from 3,000 to 9,000 feet. Grows best on alluvial soils but is also typical of dry slopes, ridges, and rocky hillsides.

Forage Value and Management

Sideoats grama is palatable and productive. It grows earlier in the spring and later in the fall than blue grama. Sideoats grama maintains a fairly high feeding value throughout the year.

Due to its high palatability, the species is soon killed by overgrazing. Many ranges that formerly had large quantities of this grass now produce little.



BLACK GRAMA

Bouteloua eriopoda Torr.

Description

Tangled, with crooked, woolly stems. One to 2 feet tall. Grayish green, curing to gray. Stem bases covered with fine white fuzz. Stem joints enlarged and frequently take root. Leaves narrow, less than 1/8 inch wide, and 1 to 5 inches long, inrolled, and wavy. Usually 4 to 5 comb-like spikes on the sides of the seed stalks. The spikes are narrow and persistent.

Warm-season, perennial, sod grass.

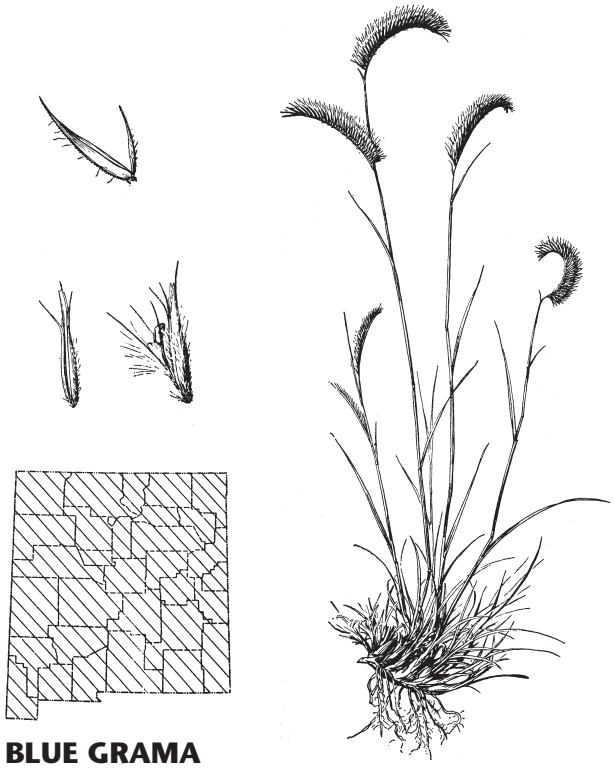
Occurrence

Throughout the southern desert and common on sandy and shallow sites of most other areas below 7,000 feet.

Forage Value and Management

Black grama is one of New Mexico's most valuable and nutritious grasses. It is highly palatable and a good forage producer, and it remains palatable and nutritious throughout the year. Because it cures well and the stems remain green near the ground, black grama is well adapted to fall, winter, spring grazing. Heavy summer grazing often prevents reproduction by tillers and stolons.

Black grama often indicates range condition and utilization. The lack of stolons, uniform cropping below a 2-inch height, and almost no flower stalks indicate over-use. When black grama is used properly, associated plants will also grow well.



BLUE GRAMA

Bouteloua gracilis (H.B.K.) Lag.

Description

Low-growing, 6 to 12 inches tall, with seed stalks occasionally reaching 4 feet. Grayish-green curing to gray or straw yellow. Leaves basal, fine, 2 to 5 inches long, with hairs at the junction of the leaf blade and stem. Seeds most commonly in two comb-like, purplish spikes on each seed stalk.

Warm-season, perennial, sod or bunch grass.

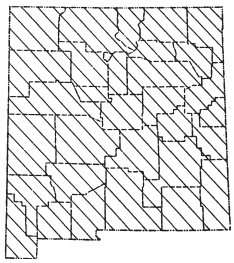
Occurrence

All areas and on most sites. Most prevalent on sands, loams, shallow sites, bottomlands, and mountain grasslands, mostly between 3,000 and 8,000 feet.

Forage Value and Management

Blue grama is highly palatable to all livestock. The species cures well and may retain as much as 50 percent of its nutritive value when dormant.

Under favorable conditions, blue grama produces abundant forage. However, under heavy grazing it tends to increase. Nearly pure stands may grow in woodlands where grazing has been severe. These stands provide poor soil protection and produce little herbage. Under these conditions, it is an inferior forage plant. At higher elevations, blue grama dominance indicates a deteriorated range, but on short-grass range, it indicates a satisfactory condition.



HAIRY GRAMA

Bouteloua hirsuta Lag.

Description

One to 2 feet tall. Closely resembles blue grama. Bluish-green while growing, cures to gray or straw color. Leaves, fine and narrow with tiny pimple-like projections containing hairs along the margins. Hairs often found along the midrib. Comb-like flower heads, usually two, remain on leafless flower stalks throughout winter. A beak-like naked projection extends about 1/4 inch beyond flower head.

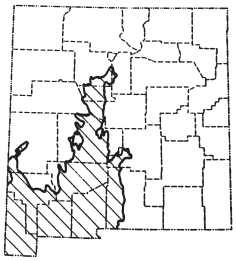
Warm-season, perennial, sod or bunch grass.

Occurrence

Throughout the state on most sites, particularly on sandy or gravelly sites at elevations of 3,000 to 10,000 feet.

Forage Value and Management

Hairy grama is quite nutritious and moderately to highly palatable. It withstands grazing well. Because of its curing quality, hairy grama is well suited for fall, winter, and spring grazing.



SLENDER GRAMA

Bouteloua repens (H.B.K.) Scribn. & Marr.

Description

Fine-stemmed, 12 to 18 inches tall. Bright green, curing to yellow or gray. Leaves narrow and basal, curly with maturity. Three to 7 tuft-like spikes usually hang along one side of the flower stalk.

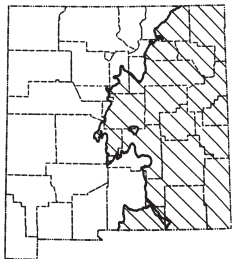
Warm-season, perennial, bunch grass.

Occurrence

Gravelly, stony, and malpais sites in the southwestern portions of the southern desert and western plateau, from 3,500 to 7,000 feet.

Forage Value and Management

Slender grama is highly palatable when green, moderately palatable when dry. The grass withstands grazing well, although it is relatively short-lived and not highly drought resistant.



BUFFALOGRASS

Buchloe dactyloides (Nutt.) Engelm.

Description

Low-growing. Two to 12 inches tall. Creeping surface runners take root at the leafy joints. Gray-green, curing to yellowish brown. Male and female plants grow separately. Seeds are borne by the female plant in burs clustered among the curly leaves. Male plants have two or three flaglike seedheads.

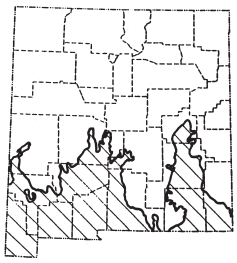
Warm-season, perennial, sod grass.

Occurrence

Most common on loamy and clayey sites in the high plains, central plains, and the southwestern tip of the southern desert, from 3,000 to 7,000 feet.

Forage Value and Management

Palatability is high for all livestock. The plant does not produce large amounts of forage. It withstands grazing well but is killed when overgrazed. The plant cures well on the ground providing good winter and early spring forage.



BERMUDAGRASS

Cynodon dactylon (L.) Pers.

Description

Creeping turf-type, 6 to 12 inches tall. Blue-green, curing to light straw. Leaves short, flat, and often opposite one another. A prominent fringe of white hair lies at the base of each leaf. Seedheads have 3 to 8 branches in a whorled cluster. The grass spreads rapidly by surface runners and underground stems.

Introduced. Warm-season, perennial, sod grass.

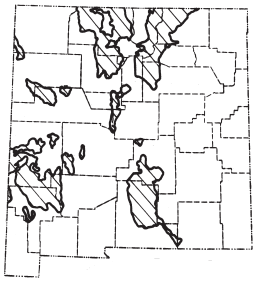
Occurrence

Widely used thoroughout the southern portion of the state as a lawn and pasture grass. Often found along streams and ditches where it has escaped cultivation.

Forage Value and Management

Moderately to highly palatable for all livestock, bermudagrass grows through the spring, summer, and fall where moisture is adequate.

Bermudagrass should be grazed fairly heavily because mature growth becomes tough and wiry. Irrigated pastures should not be grazed while wet or muddy. The grass responds well to nitrogen fertilization. Animals gain best when bermudagrass is grown with some pasture legume.



TUFTED HAIRGRASS

Deschampsia caespitosa (L.) Beauv.

Description

Erect, 2 to 4 feet tall. Bright green leaves, purplish flower head. Leaves basal, flat, folded, or occasionally inrolled, coarse, and stiff. The flower head, usually open, may be drooping, and is 4 to 12 inches long.

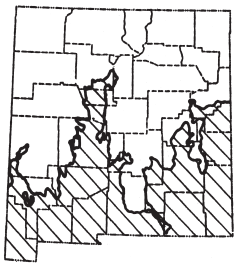
Cool-season, perennial, bunch grass.

Occurrence

Moist open sites in meadows and ponderosa pine forests within mountain areas above 7,000 feet. May occur in pure stands.

Forage Value and Management

When tufted hairgrass is growing rapidly, livestock relish it. Otherwise, it is usually moderately palatable. The grass occasionally becomes so coarse that cattle and sheep graze it only lightly. The plant withstands fairly close grazing.



ARIZONA COTTONTOP

Digitaria californica (Benth.) Henr.

Description

Slender, erect, with hard, round stems. One to 4 feet tall. Tufted, with woolly, enlarged bases. Dark bluish-green, curing to a gray or straw. Leaves, 3 to 5 inches long, loosely attached to smooth, purple stem. Long seedheads with silky, cotton-like hairs covering the spikelets. Seeds drop at maturity leaving the seedhead looking like broomstraw.

Warm-season, perennial, bunch grass.

Occurrence

Throughout the southern desert and the southern portion of the western plateau, scantily in the southern portion of the high plains and central plains. Elevations from 3,000 to 6,500 feet.

Forage Value and Management

Arizona cottontop responds quickly to summer rains and grows rapidly. It provides highly palatable green forage.

Palatability decreases as the grass matures. The plant cures well. Because of its palatability, the grass is often overgrazed. It will come back rapidly if not grazed during the summer.

DESERT SALTGRASS

Distichlis spicata (L.) Green var. *stricta* (Torr.) Beetle

Description

Low-growing, harsh, with scaly, creeping rootstocks. Blue-green to gray-green, curing to golden-brown. Leaves are wiry, usually inrolled, and sharp. Seed stalks up to 15 inches tall.

Warm-season, perennial, sod grass.

Occurrence

Common on salt flats and salty bottomlands and meadows over most of the state except mountains. Seldom found above 6,500 feet in elevation.

Forage Value and Management

Palatability is usually low to moderate for all livestock. Although somewhat harsh, desert saltgrass remains green when other grasses are dry.

Desert saltgrass is usually best grazed during the spring and fall droughts because it generally grows in damp areas and is green when upland grasses are dry.

BOTTLEBRUSH SQUIRRELTAIL

Elymus longifolius (J.G. Smith) Gould
Sitanion hystrix (Nutt.) J.G. Smith

Description

Erect, up to 24 inches tall. Bright green, curing to grayish tan. Tufted, slender stems. Narrow leaves, occasionally inrolled, and often harsh on the upper surface. Seedhead long, narrow, spiked, often partly enclosed in the upper sheath, bearing bristly, crinkled awns.

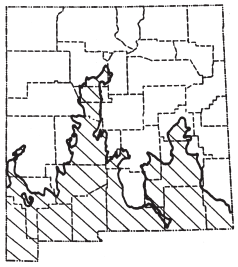
Cool-season, perennial, bunch grass.

Occurrence

Scattered throughout the state, particularly in the southern desert. Reaches greatest abundance on disturbed soil. Grows at elevations from 3,000 to 10,000 feet.

Forage Value and Management

Palatability is moderate for cattle and horses and low for sheep, in the spring and early summer before the heads develop. The plant may produce green forage in the fall if rains come, and seedheads have fallen.



PLAINS LOVEGRASS

Eragrostis intermedia Hitchc.

Description

Fairly coarse. Sixteen to 36 inches tall. Loose, spreading growth habit. Light green, curing to light straw yellow. Leaves long and slender with the blades rolled toward the upper side. Seedheads broad and open with numerous branchlets, 8 to 16 inches long and 6 to 12 inches wide.

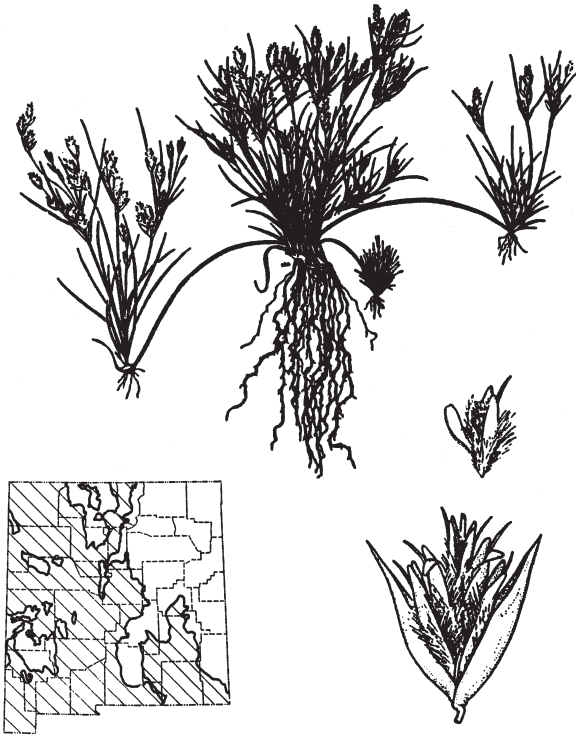
Warm-season, perennial bunchgrass.

Occurrence

Common in the southern desert and the southwestern plateau. Typical of coarse, gravelly soils. Grows between 3,800 and 8,500 feet in elevation.

Forage Value and Management

Because of its palatability and early greening when moisture is available, plains lovegrass is often overgrazed in the spring. An abundant stand of this grass can be maintained by not grazing it until mid-summer every third or fourth year.



FLUFFGRASS

Erioneuron pulchellum (H.B.K.) Tateoka.

Description

Low, tufted. Three to 6 inches. May produce runners. Bluish-green, curing to a grayish-white. Densely hairy, thin, wiry leaves 1 to 2 inches long, in distinct groups at the stem base and just beneath the seedheads. Seeds form in clumps of leaves at the end of the stem. Seedheads produce thick silvery hair and retain a pair of papery bracts when seeds fall.

Warm-season, perennial, bunch grass.

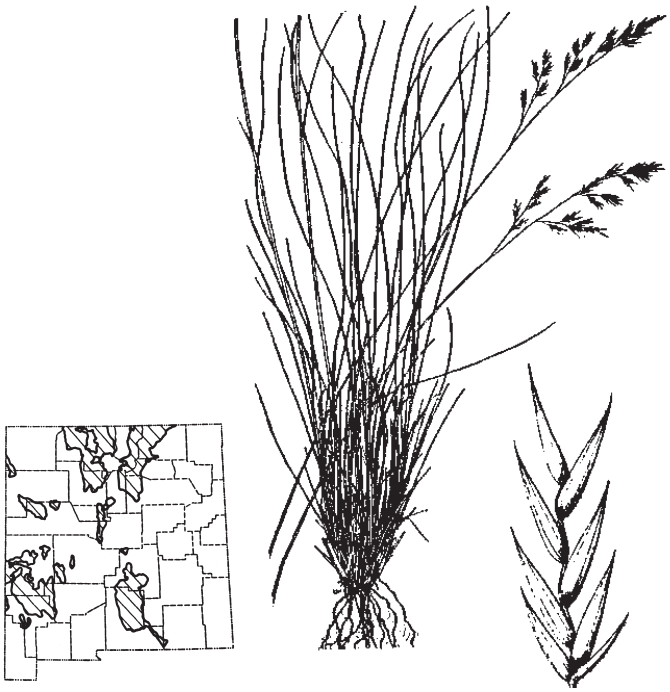
Occurrence

Most abundant on sandy and gravelly soils in the southern desert, western plateau, northern desert, and portions of the high and central plains. Usually associated with sites of low productivity. Found below 5,800 feet elevation.

Forage Value and Management

Fluffgrass is usually grazed only on ranges suffering from feed shortages because the grass is probably less palatable than any other New Mexico range grass.

Grazing of fluffgrass indicates that too little forage is available. Therefore, stocking rates should be reduced to protect the livestock and the range.



ARIZONA FESCUE
Festuca arizonica Vasey.

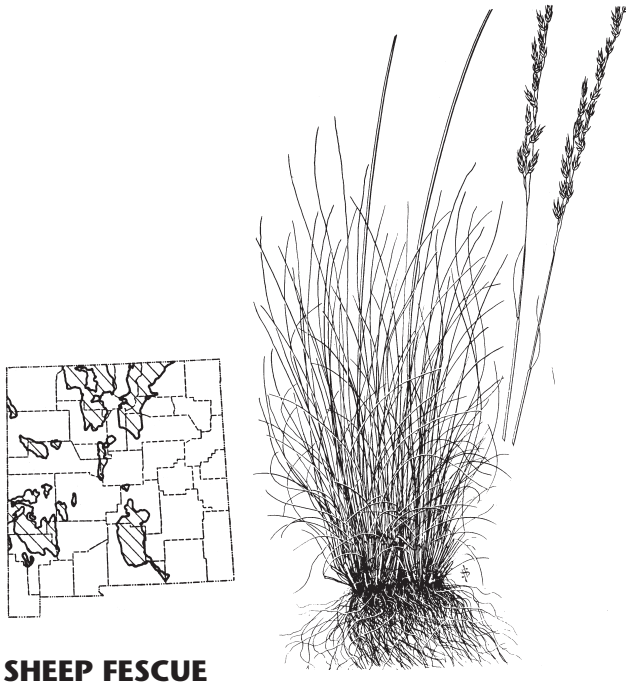
Description
Densely clustered stems. Seed stalks 1 to 3 feet tall. Gray-green to blue-green. Leaves slender, 6 to 20 inches long, stiff, and wiry with inrolled edges. Seedheads narrow, 3 to 6 inches long, with alternate, rough, erect branches.

Cool-season, perennial, bunch grass.

Occurrence
Throughout the mountain grasslands on most sites from 6,000 to 10,000 feet. Commonly associated with mountain muhly.

Forage Value and Management
Arizona fescue is palatable to cattle and horses, and moderately palatable to sheep. The grass produces large amounts of forage, and remains at least partly green from spring through fall.

Arizona fescue withstands moderate grazing well, but decreases rapidly under heavy use. It is, therefore, a good indicator or proper grazing management. Because of its heavy root system, the plant withstands drought well and is an excellent soil binder.



SHEEP FESCUE
Festuca ovina L.

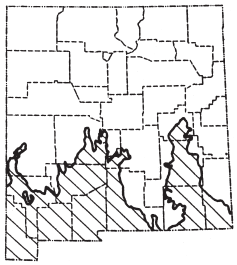
Description
Vigorously growing, strongly rooted, 4 to 16 inches and occasionally 24 inches tall. Light to gray-green. The numerous leaves are basal, fine, inrolled, and tend to persist after death to form a compact clump 2 to 5 inches high. The seedheads are 2 to 4 inches long, usually open, and appear one-sided.

Cool-season, perennial, bunch grass.

Occurrence
Subalpine meadows of mountain areas, sparse in timber stands above 8,000 feet.

Forage Value and Management
Palatability of sheep fescue is high for all livestock, and where it grows, it usually produces the bulk of the forage. Livestock particularly relish the highly nutritious seedheads.

The plant stands up well under moderate grazing. It should not be grazed in the spring until the seedheads begin to show. When cattle graze this species, the stocking should permit summer-long use. Subalpine meadows in good condition contain an abundance of this grass.



TANGLEHEAD

Heteropogon contortus (L.) Beauv.

Description

Coarse, tufted, 1 to 3 1/2 feet tall. Bright green when growing, orange-brown when cured. Leaves broad, creased down the middle, clasp the flattened stem at the base. Seeds sharply pointed at bases with long, coarse awns that twist together, black at maturity.

Warm-season, perennial, bunch grass.

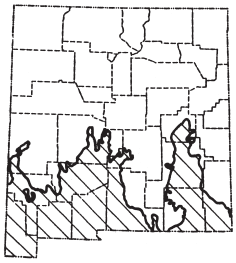
Occurrence

Southern desert. Most abundant on coarse gravelly and stoney soils at elevations between 3,800 and 8,500 feet.

Forage Value and Management

As this species grows, it is moderately palatable to cattle and horses, and sheep will eat it. As it matures, tanglehead becomes coarse and unpalatable.

Ranges with abundant tanglehead should be used during the spring when the grass is most palatable. Ranges where tanglehead is sparse should be grazed on the basis of all the forage. Then tanglehead will be lightly grazed because of its low palatability.



CURLYMESQUITE

Hilaria belangeri (Steud.) Nash.

Description

Small, fine-leaved, up to 1 foot tall. Bright bluish-green, curing to near white. Leaves flat, numerous, basal, and curl tightly as they cure. Seedheads are at the end of slender stalks. Seeds are chaffy, and leave a conspicuous zigzag stalk when they fall. Runners are long, slender, and aggressive. Both runner and stem joints hairy.

Warm-season, perennial, sod grass.

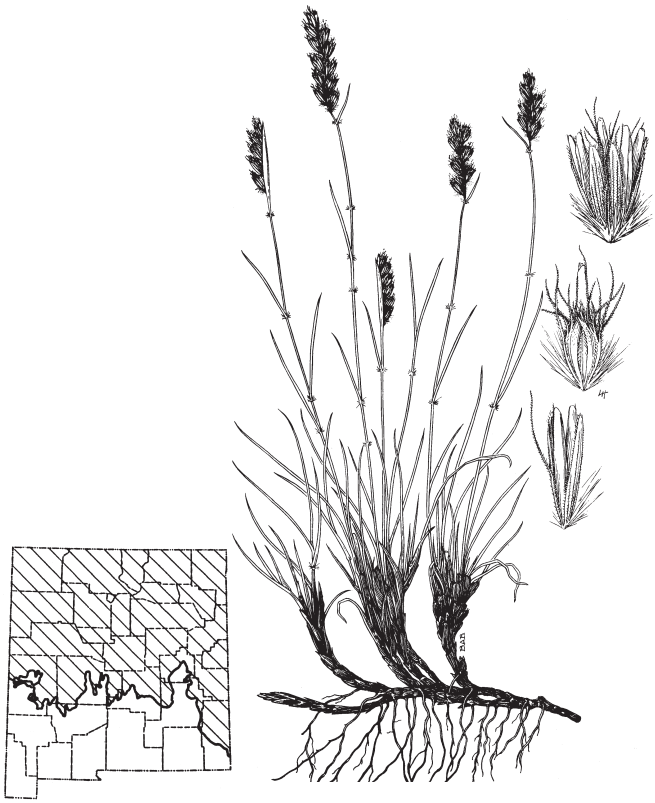
Occurrence

Most abundant in the southern and southwestern desert area. Most common on rocky, gravelly soils between 3,800 and 8,500 feet.

Forage Value and Management

Curlymesquite is highly palatable to all livestock. Although most nutritive when green, the grass cures well and remains palatable when dry.

The grass withstands heavy grazing, spreads rapidly by runners and seed, and is one of the last grasses to disappear on overgrazed ranges. It increases under grazing, and pure stands often indicate longtime heavy use. Because of its size, curlymesquite produces less forage than a mixed stand. Ranges with abundant curly-mesquite should be managed to increase or at least maintain the more productive associated grasses. Where curlymesquite is increasing, stocking should be lightened or grazing deferred occasionally during the growing season.



GALLETA
Hilaria jamesii (Torr.) Benth.

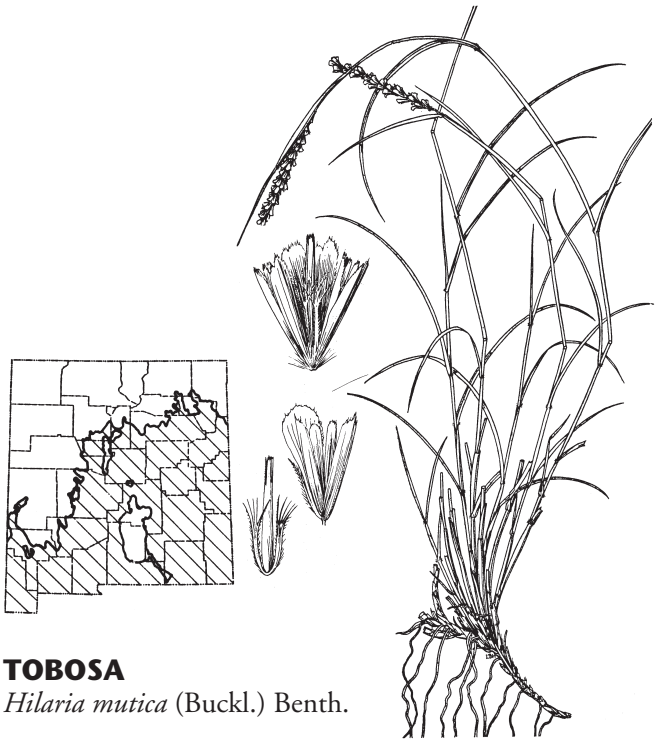
Description
Coarse, bunchy, usually 1 to 2 feet tall. Tough, woody rootstalks sometimes 6 feet long. Dull blue-green, curing to light straw yellow. Stems erect with conspicuous hairs at the joint. Leaves mostly basal, stiff, straight, with the edges usually inrolled. Seeds hairy, chaffy, drop at maturity, leaving a zigzag stalk.

Warm-season, perennial, sod grass.

Occurrence
Most common in the northern two-thirds of the state. Important on the high plains in northwestern New Mexico, where it often forms pure stands. May grow on all sites from 3,500 to 7,500 feet in elevation.

Forage Value and Management
During the summer, galleta affords moderately good forage for cattle and horses, and moderate forage for sheep. When dry, it is not palatable.

The grass should be grazed during the growing season. Galleta withstands heavy grazing well, but needs rest occasionally when grazed closely year after year. In seedings, this species is an excellent erosion control plant.



TOBOSA
Hilaria mutica (Buckl.) Benth.

Description
Smooth-stemmed. One to 2 feet tall. Grows from coarse, scaly rootstock. Dull bluish-green, curing to gray. Leaves up to 6 inches long, stiff, harsh, and hairless. Seedheads erect, chaffy, broad, and white. The seeds drop, leaving a zigzag stem.

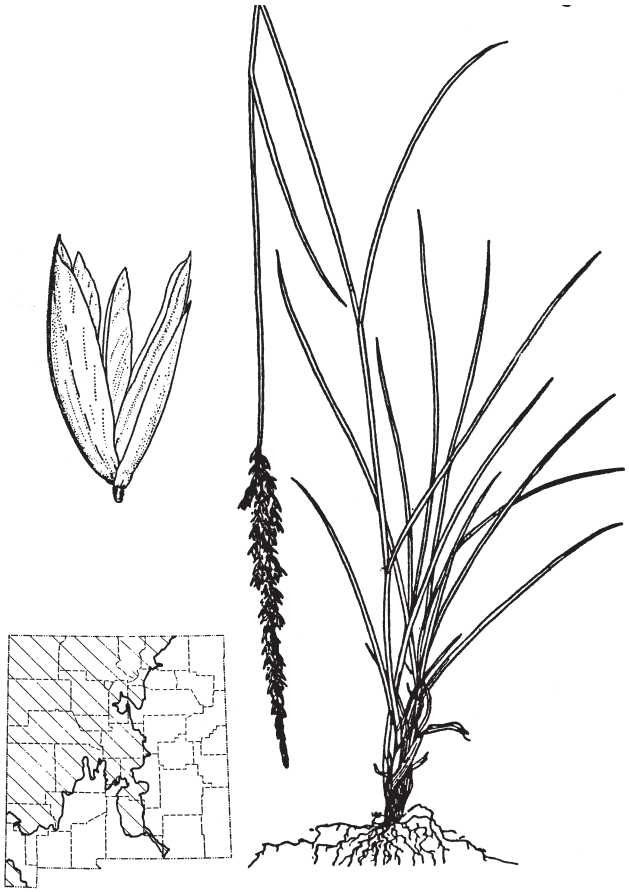
Warm-season, perennial bunchgrass.

Occurrence
Throughout the southern desert, the southern portions of the western plateau, and the central and high plains at elevations of 3,000 to 6,500 feet. Grows best on areas subject to flooding. Often forms pure stands in swales that receive runoff water.

Forage Value and Management
While green and growing, tobosa is highly palatable to cattle and horses, and sheep will eat it. The species provides little winter feed.

Tobosa is fairly resistant to grazing. Its feed value is highest during the summer. Tobosa areas are often rotated with black grama areas for the winter. This keeps the black grama in top condition and does not injure the tobosa.

Removing old growth makes tobosa more palatable. This is often done by heavy grazing, burning, or mowing hay from it. Heavy grazing may injure the stand, however, and burning every third or fourth year is satisfactory only if the burned areas are allowed to regrow before being grazed.



JUNEGRASS
Koeleria pyramidata (Lam.) Beauv.

Description
Slender, tufted, 1 to 2 1/2 feet tall. Bright green. Leaves, mostly basal, narrow, flat, sharply pointed, and rough on the upper surface. Seed stalks long. Seedheads narrow, dense, and tapered at both ends.

Cool-season, perennial, bunch grass.

Occurrence
Scattered throughout the northwestern portion of the state and mountain areas. Most abundant on coarse sandy or rocky soils at elevations from 5,500 to 10,000 feet.

Forage Value and Management
The palatability of Junegrass is high for all livestock. The plant greens and matures early in the spring.

Because it greens early, Junegrass is often overgrazed. Care should be taken to avoid overuse if the grass is important on a range.

GREEN SPRANGLETOP
Leptochloa dubia (H.B.K.) Nees.

Description
Coarse, erect, wiry-stemmed. Two to 3 feet tall. Bluish to dark green. Sheath often purple. Leaves either flat or folded at the midrib, and usually 1/8 to 1/4 inch wide. Seedheads branched from central stem, 15 slender, well-separated, drooping branches.

Warm-season, perennial, bunch grass.

Occurrence
Throughout the southern desert and the southern portion of the western plateau and central plains. Generally on upland sites with coarse rocky or gravelly soils from 3,500 to 6,500 feet in elevation.

Forage Value and Management
Green sprangletop is usually palatable for all livestock. It grows most often with other grasses. The grass decreases quickly under heavy grazing, but is generally not considered an important forage species.

WOLFTAIL (TEXAS TIMOTHY)

Lycurus phleoides H.B.K.

Description

Densely tufted. One to 1 1/2 feet tall. Foliage somewhat like blue grama or hairy grama, with which it grows. Grayish-green, curing to grayish-straw. Leaves mostly basal, fine, and usually with white margins. Stems usually bent at the joints. Seedheads narrow, spike-like, 1 to 3 inches long.

Warm-season, perennial, bunch grass.

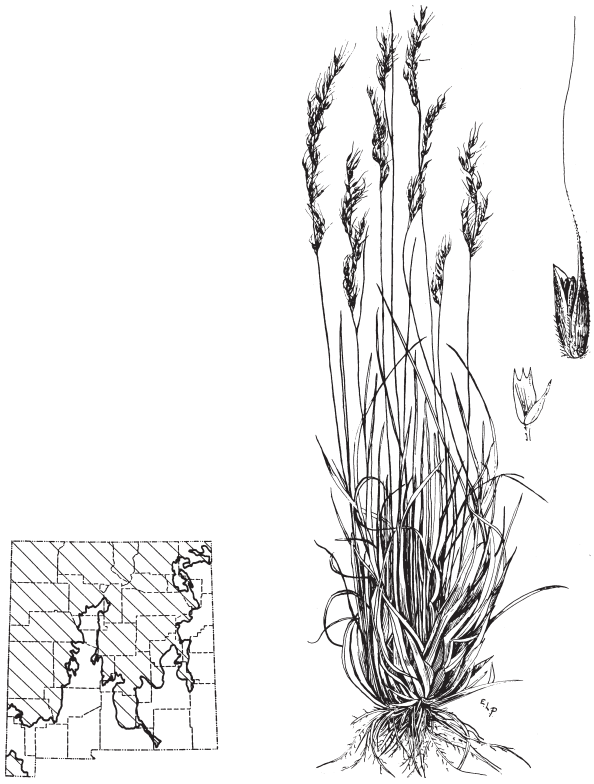
Occurrence

Scattered throughout the state on most sites. Most abundant on gravelly and stoney sites, below 8,500 feet in elevation.

Forage Value and Management

Wolftail is moderately to highly palatable for all livestock. Although the plants green up some in early spring, they grow most after summer rains begin.

Wolftail is best used during the summer and spring. Unless grazing is moderate so that good seed crops are set, wolftail disappears rapidly under grazing.



MOUNTAIN MUHLY

Muhlenbergia montana (Nutt.) Hitchc.

Description

Densely bunched. One to 2 feet tall. Light green, appearing purplish when seeds mature. Leaves mostly basal, rigid, and often inrolled and partially twisted. Seedheads narrow, loose, and somewhat one-sided. Flowers after summer rains.

Warm-season, perennial, bunch grass.

Occurrence

Northern, western, and mountain areas, on coarse cinder or stoney sites and in mountain meadows and grassland at 5,500 to 9,000 feet.

Forage Value and Management

Mountain muhly is palatable to all livestock, especially during the spring when the grass is green and succulent. Mountain muhly produces fairly large amounts of forage.

Mountain muhly, along with Arizona fescue, is most abundant in the ponderosa pine areas between meadows. Because meadow grasses are usually more palatable than mountain muhly, the meadows become overgrazed unless they are fenced. With fencing, ranchers can use both the mountain muhly and the meadow grasses, thus increasing the stocking and, at the same time, maintaining the grass.

BUSH MUHLY

Muhlenbergia porteri Scribn.

Description

Wiry and weak-stemmed. One to 3 feet tall. Stems leafy for entire length, many branched, bent at the joints. A tangled leafy mass when ungrazed. Purplish-green, curing to buff. Some stems remain green throughout the year. Leaves short and fine. Seedheads fine, loose, many branched, purplish to white.

Warm-season, perennial, bunch grass.

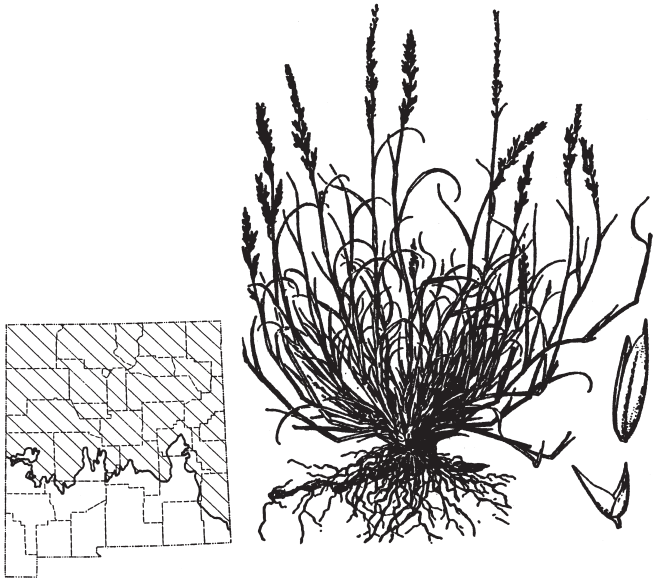
Occurrence

Throughout the southern desert and the southern portions of the western plateau, central plains, and high plains on most sites below 7,000 feet. Formerly common, but now found largely as individual plants under brush piles or shrubs.

Forage Value and Management

Bush muhly is highly palatable to all livestock. If moisture is available, the grass will remain green through most of the year.

Bush muhly disappears rapidly when overgrazed on depleted ranges. Deferred grazing during July and August allows a full crop of seed to develop.



MAT MUHLY

Muhlenbergia richardsonis (Trin.) Rydb.

Description

Grows in dense carpetlike patches. Up to 2 feet tall. Dull green while growing. Leaves usually inrolled and narrow with loose sheaths. Stems erect, wiry, and commonly bent at the joints. Seedheads narrow and contracted, 1/2 to 4 inches long, with few flowers.

Warm-season, perennial, sod grass.

Occurrence

Most common in the northern two-thirds of the state. Typical on sandy, gravelly, and bottomland sites, and often on alkaline soils. Found at elevations of 5,000 to 7,400 feet.

Forage Value and Management

Green mat muhly is palatable to cattle and horses and moderately palatable to sheep. The plant cures fairly well and is readily eaten by all livestock, although palatability is lowest when dry.

Mat muhly increases under grazing. Because of its sod-forming habit, the grass withstands heavy use well. It is usually found in scattered patches and is rarely abundant enough to be of any managerial importance.

RING MUHLY

Muhlenbergia torreyi (Kunth.) Hitchc.

Description

Tufted, dense. Up to 2 feet tall. As each tuft enlarges, the center (6 to 18 inches in diameter) dies. Leaves light green, mostly basal, strongly curved, densely matted, and up to 4 inches tall. Seedheads open and spreading, brownish-purple, with numerous seeds on fine, wavy branchlets. The purplish seeds are tipped with a fine awn.

Warm-season, perennial, sod grass.

Occurrence

Throughout the state on coarse soils from 3,100 to 7,000 feet. Reaches its greatest abundance in the northern half of the state.

Forage Value and Management

Palatability is low to moderate for all livestock when the grass is green. Ring muhly is abundant on overgrazed ranges and thus is a good indicator of range condition. Since the species produces only a small volume of forage and its useful season is short, ring muhly ranges should be managed to restore better grasses.

SPIKE MUHLY

Muhlenbergia wrightii Vasey.

Description

Often in individual bunches, 2 to 2 1/2 feet in diameter. Light green with gray to blackish seedheads and purplish leaf sheaths near the stem joints. Narrow, long leaves taper to sharp points. Seedheads, seldom over 1 foot tall, look somewhat like timothy, but often separate into distinct segments, especially the lower half.

Warm-season, perennial, bunch grass.

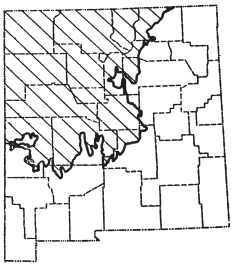
Occurrence

Northern and western portions of the state in mountains. Most abundant on rocky soils and in mountain meadows. Grows at elevations from 3,800 to 9,000 feet.

Forage Value and Management

Spike muhly rates high in palatability for all livestock.

Abundant spike muhly on rangeland in good condition needs only moderate grazing for maintenance. Depleted ranges may need summer deferment.



INDIAN RICEGRASS

Oryzopsis hymenoides (Roem. & Schult.) Ricker

Description

Leafy, tufted. One to 2 feet tall. Rigid, erect stems. Dark green while growing, cures to a light straw color. Numerous long, slender, and inrolled leaves. Loose, widely spreading seedheads with main branches divided into two wavy branchlets, each supporting an oval, hairy, black seed at the end.

Warm-season, perennial, bunch grass.

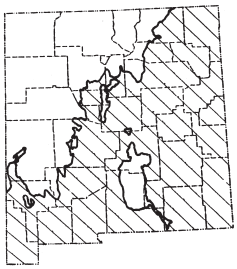
Occurrence

Sandy and rocky sites in the southern desert, most sites in the northern desert and western plateau, sands and clays in the central plains, and shaly sites in the mountains. At elevations from 4,000 to 9,000 feet.

Forage Value and Management

Exceptional curing ability makes this grass palatable even in winter. The high protein content of seeds, which stay on the plant, is largely responsible for its winter feed value.

The grass should be grazed only lightly during the spring to allow maximum development of the seedheads. Areas supporting large stands are best grazed in winter.



HALL'S PANICGRASS

Panicum hallii Vasey.

Description

Tufted. Up to 3 feet tall. Light green to bluish-green while growing and straw-colored at maturity. Thin, mostly basal leaves are curled, with the appearance of wood shavings when dry. Open, erect seedheads. Seeds appear to be small nutlets.

Warm-season, perennial, bunch grass.

Occurrence

Scattered throughout the state except the northwestern and mountain areas. Common on coarse soils and bottomlands. Grows at elevations from 3,000 to 6,500 feet.

Forage Value and Management

Growing, Hall's panicgrass is highly palatable for all livestock. It retains this quality after curing because some leaves remain green most of the year.

Palatability causes the grass to decrease quickly under grazing even when associated grasses are properly utilized. Therefore, this species can be maintained only on areas reseeded as pure stands.

VINE MESQUITE

Panicum obtusum H.B.K.

Description

Viney. One to 2 feet tall. Long, tough stolons with swollen, woolly joints. Light blue-green, curing to reddish-straw, then finally to grayish-tan. Leaves somewhat inrolled and up to 8 inches long. Seedheads in 2 to 6 branchlets, partially enclosed in the upper leaf sheath, and tightly pressed to the main stem. Large, blunt seeds.

Warm-season, perennial, sod grass.

Occurrence

In the southern desert and southern portion of the western plateau, especially on sites with extra moisture. Also grows on loamy, clayey, and bottomland sites in the high and central plains, and scattered on bottomland sites in the northern portion of the western plateau and northern desert. Grows at elevations from 3,100 to 7,200 feet.

Forage Value and Management

Vine mesquite is usually fairly unpalatable, although livestock readily eat the fruiting heads. Because the grass forms sod vigorously, it is valuable for erosion control. The grass provides the best grazing in the summer since it is coarse at maturity. Light grazing permits the plant to spread rapidly. Since it is usually found on sites subject to erosion, vine mesquite should not be heavily grazed.

MUTTON BLUEGRASS

Poa fendleriana (Steud.) Vasey.

Description

Also called muttongrass. Medium-sized. One to 2 feet tall. Bunches up to a foot or more in diameter. Leaves basal, pale, bluish-green, stiff, usually folded or with inrolled edges. Seedheads 1 to 4 inches long, erect, and densely flowered. Male and female parts commonly on separate plants.

Cool-season, perennial, bunch grass.

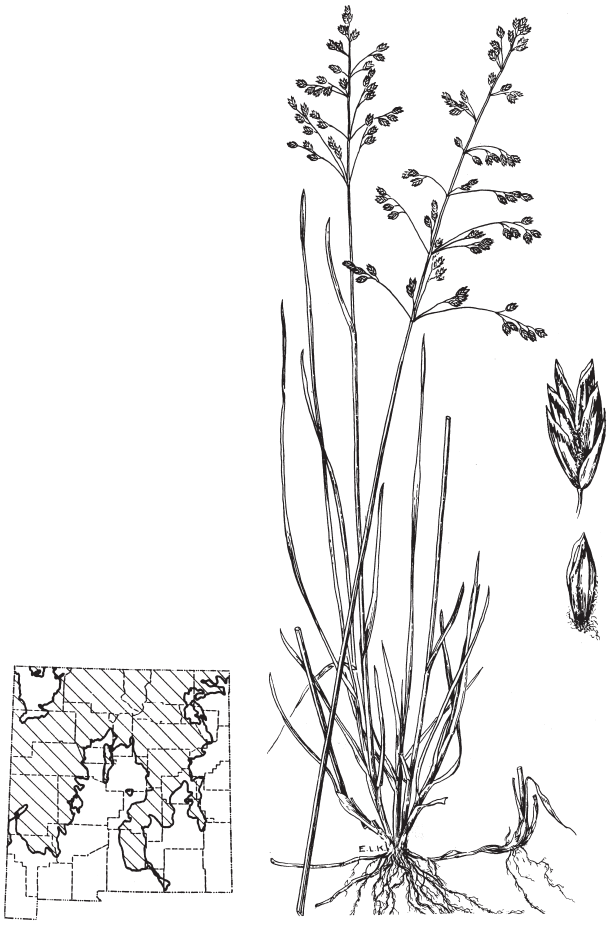
Occurrence

Common on well-drained soils in woodlands and forests within the mountain areas at 6,500 to 10,000 feet.

Forage Value and Management

Mutton bluegrass, highly palatable to all livestock, is particularly valuable as summer sheep feed. It begins to grow in late winter or early spring and provides abundant forage earlier than most other forage plants. The plant cures well and provides fair fall forage, although the palatability declines.

Because of its value, rangeland with abundant mutton bluegrass should be managed to maintain or improve the stand. Depleted areas, if rested during July and August in alternate years, can set seed and increase vigor.



KENTUCKY BLUEGRASS
Poa pratensis L.

Description
Low-growing. Numerous seed stalks, 1 to 3 feet tall, in tufts. Dark, shiny, green. Leaves 2 to 7 inches long, with boat-shaped tips. Seedheads pyramid-shaped, 1 to 4 inches long, and open. Base of individual flowers looks cobwebby.

Introduced, cool-season, perennial, sod grass.

Occurrence
Mountain grasslands and wet meadows in portions of the central plains and western plateau at elevations of 6,500 to 10,000 feet.

Forage Value and Management
Green Kentucky bluegrass is extremely palatable to all livestock. Growth begins early in the spring and provides good forage early.

This grass withstands continued heavy use better than most grasses. Under irrigation, nitrogen fertilization is required for maximum production. Because it spreads rapidly to form a dense cover, Kentucky bluegrass is valued as a soil stabilizer.

LITTLE BLUESTEM*
Schizachyrium scoparium (Michx.) Nash

Description
Tufted and leafy. One to 4 feet tall, erect and slender. Bluish-green during growth and dark reddish-brown when cured. Stems flattened at the base. Several flower heads, each with a long stalk, on each stem. Seedheads slender and fuzzy.

Warm-season, perennial, bunch grass.

Occurrence
Rarely dominant on any site, but grows throughout the state from 3,000 to 9,000 feet.

Forage Value and Management
The palatability of this grass during growth is low to moderate. The cured grass is rarely grazed. The species grows best when grazed during the growing season. Under heavy grazing, the plant decreases and is usually replaced by the gramas.

*Texas bluestem, *Schizachyrium cirratum* (Hack.) Woot. and Standi., is similar in appearance and environmental needs to little bluestem. The plant is smaller, 1 to 2 feet tall, and cures to a reddish- or purplish-brown.

BURROGRASS

Scleropogon brevifolius Phil.

Description

Creeping, with long, coarse, prostrate stems that often root at joints in moist soil. Light green, becoming silvery at maturity because of the numerous seedheads. Mostly basal, short, coarse leaves. Male and female seedheads on separate plants. Female seedheads have long, silvery, thread-like, twisted awns. Male seedheads are many flowered and awnless.

Warm-season, perennial, sod grass.

Occurrence

Commonly found on most sites in the southern desert. Common associate of tobosa grass on adobe clay soils of swales. Scattered throughout portions of the western plateau and central plains. Grows at elevations of 3,000 to 6,500 feet.

Forage Value and Management

Long, wiry awns and stiff, coarse leaves make burrograss unpalatable. Because this species increases under heavy grazing, its abundance on ranges indicates deterioration, and livestock numbers should be reduced, or grazing should be deferred and rotation established. Small infestations can be corrected by establishing water and salt away from the infested areas, or by fencing and reseeding the areas to more desirable grasses.

PLAINS BRISTLEGRASS

Setaria leucopila (Scribn. & Merr.) K. Schum.

Description

Densely tufted. Bright green, curing to orange-brown. One to 4 feet tall. Stems often bend abruptly at the nodes. Leaves up to 1/2 inch wide, somewhat roughened on the upper surface, and curly after curing. Narrow, spikelike seedheads with stiff hairs extending from between the seeds.

Warm-season, perennial, bunch grass.

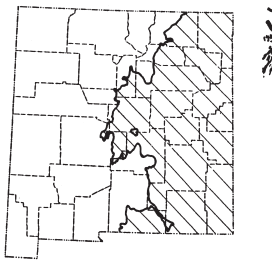
Occurrence

On most sites throughout the southern desert, portions of the western plateau, and on alkaline sites in parts of the central plains, at elevations of 3,000 to 7,000 feet.

Forage Value and Management

Plains bristlegrass is moderately to highly palatable to all livestock, particularly the tender basal leaves. Under grazing, the plant decreases rapidly. It is often found growing in the open shade of small trees and brush where it is relatively protected from livestock.

Where plains bristlegrass is abundant, careful management will maintain it. Where other perennial grasses dominate, they should be considered first in management plans because plains bristlegrass cannot withstand grazing when other species are properly utilized.



INDIANGRASS

Sorghastrum nutans (L.) Nash.

Description

Tall. Four to 8 feet. Bluish-green, curing to dull straw. Leaves fairly wide, with a conspicuous claw-shaped ligule where the blade attaches to the sheath. Large, plume-like, golden seedheads.

Warm-season, perennial, bunch grass.

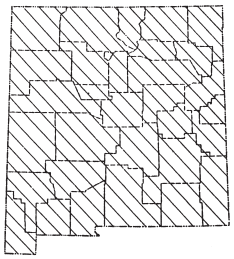
Occurrence

Scattered throughout the eastern portion of the state. Most common on sandy and bottomland sites between 3,700 and 7,000 feet.

Forage Value and Management

Indiangrass is highly palatable while growing, but not after curing. The grass produces large amounts of forage.

Indiangrass decreases under heavy grazing. If continually grazed shorter than 5 to 8 inches, it is replaced by less productive plants. This grass is well adapted for irrigated permanent pasture since it produces large quantities of seed and forage, and is well suited for combining or hay production.



ALKALI SACATON

Sporobolus airoides Torr.

Description

Coarse, tough, long-lived. Up to 3 1/2 feet. Dense clumps up to 12 inches in diameter. Pale green with a slight grayish cast while growing. Abundant leaves, sometimes 18 inches long, inrolled at the points. Loose pyramidal seedheads with widely spreading branches.

Warm-season, perennial, bunch grass.

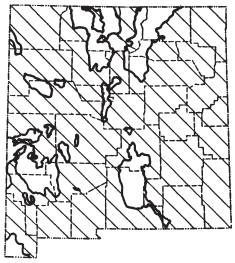
Occurrence

Found throughout the state at elevations of 3,100 to 7,500 feet, typical on alkaline soils of bottomlands and flats, and on sandy plateaus and washes.

Forage Value and Management

Growing alkali sacaton is fairly palatable to cattle and horses and slightly less palatable to sheep. When the grass is dry it is poor forage.

Dense stands provide spring and summer grazing. If alkali sacaton is fully grazed in scattered stands, however, the other perennial grasses with which it grows will be overgrazed because they are more palatable. Therefore, this grass should be somewhat under-used.



SAND DROPSEED

Sporobolus cryptandrus (Torr.) Gray.

Description

Erect, tufted, 1 1/2 to 4 feet tall. Stems leafy, with a ring of stiff, short white hairs at the junction of the stem and leaf. Bluish-green, curing to a light straw yellow. Leaves up to 12 inches long, at right angles to the stem, often frayed by the wind. Gray to purplish seedhead often enclosed in the uppermost leaf sheath. Portion not enclosed is spreading and open but narrow.

Warm-season, perennial, bunch grass.

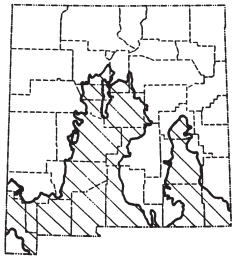
Occurrence

Throughout the state except in mountain areas. Most common in the southern desert and western plateau. Often on sand and gravelly sites, at 3,000 to 7,200 feet.

Forage Value and Management

Green sand dropseed is usually palatable to cattle and horses, and moderately so to sheep. The grass cures well and furnishes winter feed although it is less palatable when dry.

Sand dropseed increases under grazing. It provides better summer grazing than winter because of its low winter palatability.



MESA DROPSEED

Sporobolus flexuosus (Thurb.) Rydb.

Description

Tufted. Up to 2 feet. Smooth leaf sheaths with a conspicuous tuft of hairs where leaf and stem join. Bluish-green, curing to light straw yellow. Open or spreading seedheads, not often enclosed in a sheath, usually appear to be nodding.

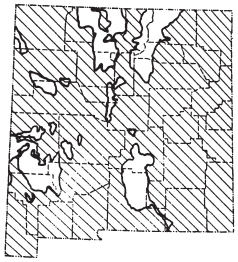
Warm-season, perennial, bunch grass.

Occurrence

Common in the southern desert and southern portion of the central plains. Typical on sandy and gravelly sites at elevations of 3,000 to 6,800 feet.

Forage Value and Management

Green mesa dropseed is moderately palatable to cattle, but the persistence of old growth usually interferes with its utilization. The sparse scattered stands are usually of little consequence in management.



GIANT SACATON

Sporobolus wrightii Monro.

Description

Large, coarse-stemmed, 3 to 6 feet tall. Clumps sometimes 3 feet in diameter. Pale grayish-green. Flat or partially inrolled leaves, up to one foot long. Open seedheads 1 to 2 feet long with many branchlets.

Warm-season, perennial, bunch grass.

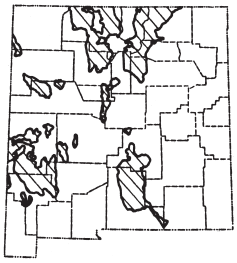
Occurrence

Found throughout the state except in mountain areas. Common on bottomlands and alluvial flats subject to flooding. Grows at elevations from 3,100 to 7,000 feet.

Forage Value and Management

Young, succulent sacaton is highly palatable, but the grass becomes coarse and tough at maturity.

Flats containing large amounts of sacaton are best grazed heavily in early spring. As grasses of other range areas begin to grow, livestock should be moved off the sacaton until fall. Coarse, unpalatable material is easily removed by burning every three or four years in early spring, just before growth beings.



COLUMBIA NEEDLEGRASS

Stipa columbiana Macoun.

Description

Erect, fine-stemmed. One to 3 feet tall, with purplish nodes. Slender leaves, flat when growing, but inrolled at maturity, with a conspicuous ligule. Narrow, loose seedheads up to 8 inches long, and often purple in color. Bent awn twisted twice, usually 3/4 to 1 1/2 inches long.

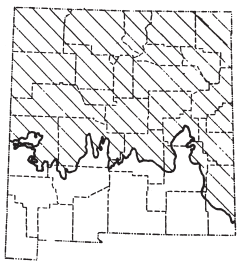
Cool-season, perennial, bunch grass.

Occurrence

Meadows and valleys within the mountain areas at elevations from 6,500 to 8,500 feet.

Forage Value and Management

Columbia needlegrass is highly palatable to cattle and horses, and moderately so to sheep. It usually remains green throughout the growing season. The grass tends to increase when more palatable blue grasses and wheatgrasses have been overgrazed.



NEEDLE-AND-THREAD

Stipa comata Trin. & Rupr.

Description

Erect, tufted. One to 4 feet. Relatively few stems. Leaves often inrolled and pointed with a conspicuous ligule. Loosely spreading seedheads often partly enclosed in the upper sheath. Seeds tipped by long, prominent, twisted awns, shed soon after maturity.

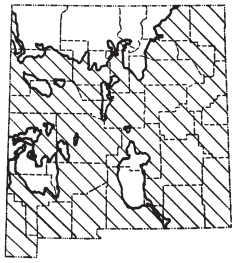
Cool-season, perennial, bunch grass.

Occurrence

Scattered throughout the northern half of the state. Most common on sandy, gravelly, and foothill sites at elevations from 3,700 to 9,000 feet.

Forage Value and Management

The grass produces early spring forage and is highly palatable to all livestock before the seeds mature and after the seeds are shed. Mature seeds cause mechanical injury if grazed. On ranges where needle-and-thread is abundant, continued heavy spring grazing may reduce the stand.



NEW MEXICO FEATHERGRASS

Stipa neomexicana (Thurb.) Scribn.

Description

A tufted needle grass. Sixteen to 36 inches high. Blue-green leaf sheath, covered with tiny hairs. Rolled leaf blade up to 12 inches long. A long feathery awn on the seed distinguishes this grass from needle-and-thread.

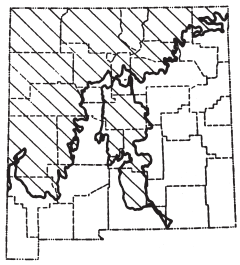
Cool-season, perennial, bunch grass.

Occurrence

Most common on sandy, gravelly, and rocky sites in all areas of the state except the northern desert, the northern portion of the western plateau, and the mountains. Occurs at elevations from 3,100 to 7,200 feet.

Forage Value and Management

New Mexican feathergrass provides moderate to good forage for all livestock. The sharp-pointed seeds, like needle-and-thread seeds, may injure the mouths of animals. The grass tends to decrease under grazing, especially on drier ranges. This grass withstands heavy use in the spring and fall and usually reproduces well if the plants are allowed to mature seed during summer.



SLEEPYGRASS

Stipa robusta Scribn.

Description

Coarse, leafy, thick-bunched. Three to 6 feet tall. Bright green. Broad leaves, up to 2 feet long, hairy where the blade joins the stem. Densely flowered, pale green seedheads. Seeds covered with short, soft, white hairs terminated by a twice-bent awn about 1 1/2 inches long.

Cool-season, perennial, bunch grass.

Occurrence

Throughout the northern and mountain areas of the state at elevations of 5,600 to 9,000 feet. Typical of coarse gravelly soils.

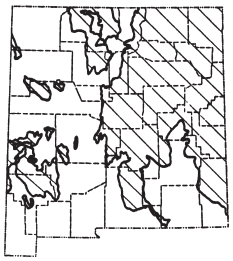
Forage Value and Management

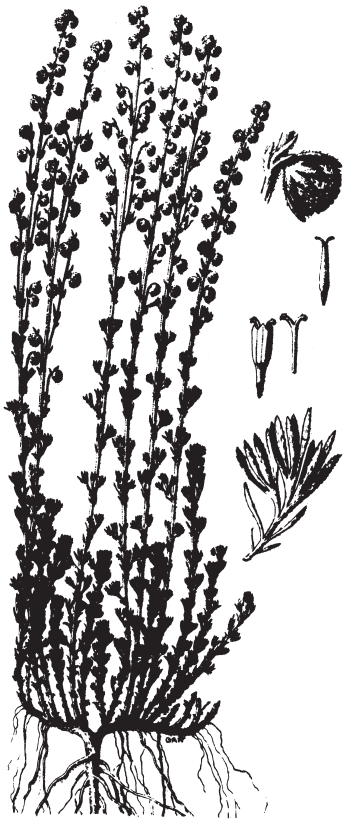
Even when sleepygrass is green, it is not very palatable. Livestock graze it only when more palatable forage is absent.

Although the grass is said to have a narcotic or sleep-inducing effect on livestock, particularly horses, it does not cause death.

Sleepygrass increases under heavy grazing, and spreads quickly from its abundant seed supply. However, the grass is not aggressive when in competition with more preferred grasses under controlled grazing.

FORBS





FRINGED SAGEBRUSH (ESTAFIATA)

Artemisia frigida Willd.

Description

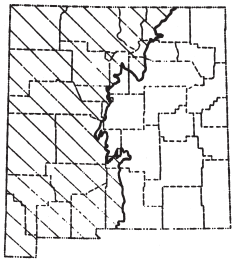
Silvery-gray half-shrub with semi-herbaceous annual stems and a low, perennial, woody base. Four to 24 inches high. Small, silvery-hairy leaves, fringed, emit a sagelike odor when crushed. Numerous small, nodding, globe-shaped flower heads

Occurrence

The high plains and central plains of northeastern New Mexico and the piñon-juniper zone of the mountain areas. Most common in full sunlight on dry gravelly, sandy, or loam soils, from 3,000 to 7,200 feet.

Forage Value and Management

This plant provides good to very good forage for sheep and goats and fair to good forage for cattle, especially in the late fall, winter, and early spring. It resists heavy grazing fairly well and will increase at the expense of desirable grasses, but may be killed by overgrazing. Moderate grazing will maintain a proper mixture of grass and fringed sagebrush.



HORSETAIL MILKWEED (WHORLED MILKWEED)

Asclepias subverticillata (Gray) Vail

Description

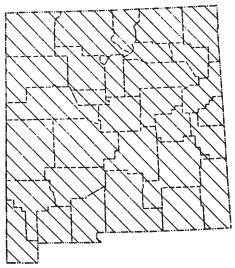
Perennial, poisonous. Extensive horizontally spreading rootstocks can form new stems. Leaves narrow, 2 to 4 inches long, pale green, hairless, and in whorls of three to six at stem joints. Stems erect, usually one or two but sometimes five together. Both leaves and stems exude a milky sap when wounded. Small, greenish-white flowers form umbrella-shaped clusters.

Occurrence

Most common in the northwest part of the state, especially on bottomland soils. Appears to be increasing in the southern desert area. Elevations of 4,500 to 8,000 feet.

Forage Value and Management

This plant ranks among those most deadly to range livestock, especially sheep. Its palatability is quite low, but poisoning has been reported from ranges with plenty of desirable grass. Several species of milkweed, scattered throughout the state, are generally poisonous, but horsetail milkweed is the most common and causes the greatest losses.



LOCO

Astragalus spp.*

Description

The group of poisonous plants known as locos or locoweed includes many species that differ widely in appearance. Most are perennials, although one important New Mexico species, Wooton loco (*A. wootoni* Sheldon), is an annual or biennial. Woolly loco (*A. mollissimus* Torr.) is also a common species in New Mexico. The locos are essentially stemless, with leaves made up of several leaflets which are usually silky hairy. Flowers look like those of the garden pea and vary from white through violet to purple. The dry fruit pod rattles with seeds. For more information, see Cooperative Extension Circular 557: *A Guide to the Common Locoweeds and Milkvetches of New Mexico.*

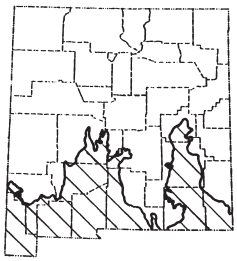
Occurrence

On most sites in the southern and northern desert, western plateau, and grassy parts of the higher mountains. Often increases on disturbed sites, but many also grow where grass cover is fairly dense. Found at elevations from 3,100 to 8,000 feet.

Forage Value and Management

Some locos are highly poisonous, and small amounts will kill an animal in a short time. Others can be consumed in fairly large amounts over a long period before ill effects are noticeable. Most loco poisoning occurs in early spring as these plants become green before forage plants. Locos are generally not very palatable, but animals, especially horses, appear to develop a taste for them.

*Lamberts crazyweed, *Oxytropis lambertii* Pursh., is very similar to the locos; however, it occurs primarily in the higher mountain areas.



ALFILERIA (FILAREE)

Erodium cicutarium (L.) L'Her.

Description

An annual, heavily branched from the base, with finely divided, hairy leaves, which at first form a basal rosette but also appear on the stems when they develop. Leafy stems, 3 to 12 inches tall. Pinkish to purplish flowers, in umbrella-shaped clusters. Seeds are tipped with long tails that coil spirally at maturity.

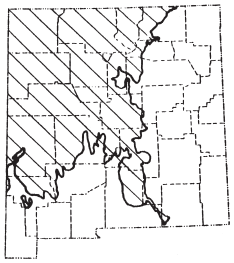
A native of Europe, the plant was introduced to North America from the Mediterranean region.

Occurrence

The southern desert, especially the southwestern portion of the state. Grows well on sandy soils. Occurs mostly below 5,000 feet.

Forage Value and Management

This plant furnishes choice, highly palatable spring forage for all classes of livestock, as well as deer. In areas with some winter moisture it flourishes in early spring and is one of the first plants to appear. Its growth period is short, and it dries quickly after soil moisture is depleted. It tends to hug the ground under heavy grazing and thus protects itself by being less accessible.



PINGUE (COLORADO RUBBERWEED)

Hymenoxys richardsonii (Hook.) Cockerell

Description

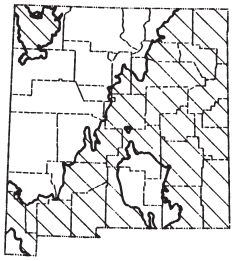
Perennial. Thick taproots usually divide into several root crowns, each producing a branched, leafy stem 4 to 15 inches tall. Base is quite woolly at ground level. Leaves have 3 to 5 very narrow lobes, gland-dotted. Basal leaves with tufts of woolly hairs in the axils. Many yellow flower heads, about 1/2 inch across, in flat-topped clusters.

Occurrence

Most common in the northwestern portion of the state. Frequent in high mountain grassland, mostly at 4,500 to 7,500 feet, sometimes at 10,000 feet.

Forage Value and Management

Under normal conditions, pingue is not palatable for any livestock, although under extreme shortage of desirable forage it is grazed by sheep and goats, and to some extent by cattle. The plant is especially poisonous to sheep. In the areas where it occurs, pingue rapidly invades overgrazed ranges. The best control is grazing management that favors more palatable forage plants. They will gradually crowd out the pingue.



WOOLLY INDIANWHEAT (PLANTAIN)

Plantago patagonica Jacq.

Description

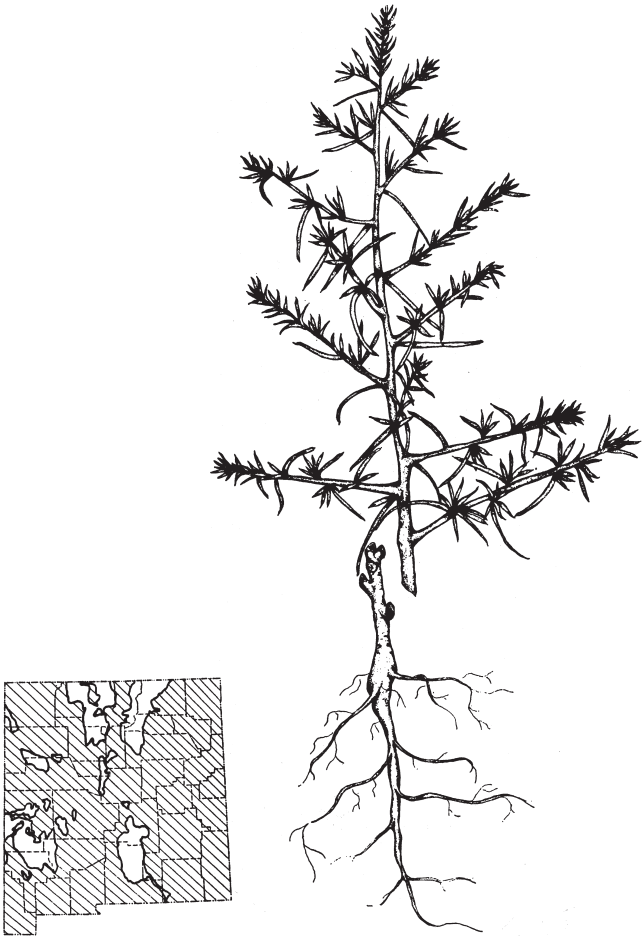
Small, silvery, annual. Two to 15 (mostly 6) inches tall. Dense, woolly, cylindrical flower head, 1 to 3 inches long. Basal, narrow leaves, covered with soft hairs.

Occurrence

Fairly common in the southern desert and central and high plains areas. Grows on a wide variety of sites from heavy clay to sand, but seems to prefer loamy soils. Occurs mostly below 5,500 feet.

Forage Value and Management

Woolly indianwheat is fair to good forage for sheep and cattle on most ranges, but especially on desert lambing grounds. The seedheads are the most palatable part of the plant. Because the species is an annual, its abundance depends upon the amount of precipitation and the character and density of the perennial plant cover. Its production, therefore, is variable and should not be depended upon.



RUSSIAN THISTLE (TUMBLEWEED)

Salsola kali L.

Description

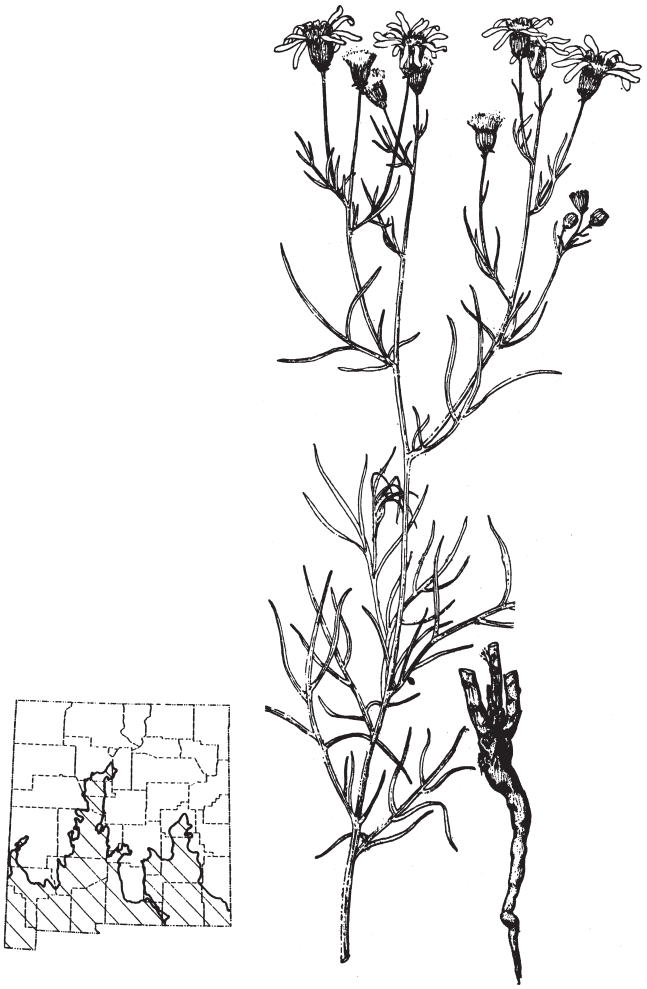
Native of Eurasia. Prolific, annual. Introduced to North America from Europe. Grows rapidly to form a dense bushlike plant. One to 4 feet high. Very tender and juicy when young. Small, narrow, green leaves give a grasslike appearance. After flowering, the plant begins to dry and becomes quite harsh and brittle. Ridged stems often with reddish veins.

Occurrence

Fairly widespread over the state mostly at elevations below 6,000 feet. Grows best on sandy soils but also occurs on heavier types. A pest in cultivated areas.

Forage Value and Management

In early spring, Russian thistle rates as fair forage for all livestock, but it is worthless after maturity. It is quite drought-resistant. In emergencies it has been chopped and fed as fodder or silage. If fed alone, the plant has a very laxative effect on cattle.



THREADLEAF GROUNDSEL

Senecio longilobus Benth.

Description

Gray-white half-shrub. Conspicuous bright yellow flowers. One to 3 feet tall. Dense white hairs cover the foliage. Leaves deeply divided into long linear segments.

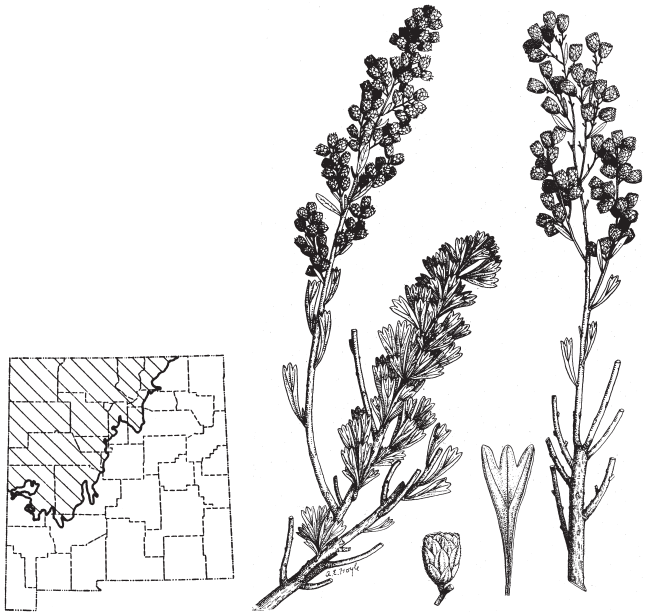
Occurrence

Most common in the southern desert, particularly on sandy and bottomland sites. Frequent along roadsides, sacrifice areas around stock tanks, and waste places. At elevations of 3,000 to 7,000 feet.

Forage Value and Management

Threadleaf groundsel has little or no forage value. It is considered poisonous, but because of its very low palatability it is probably not a source of danger on the range except during prolonged drought or on badly overgrazed areas.

TREES AND SHRUBS



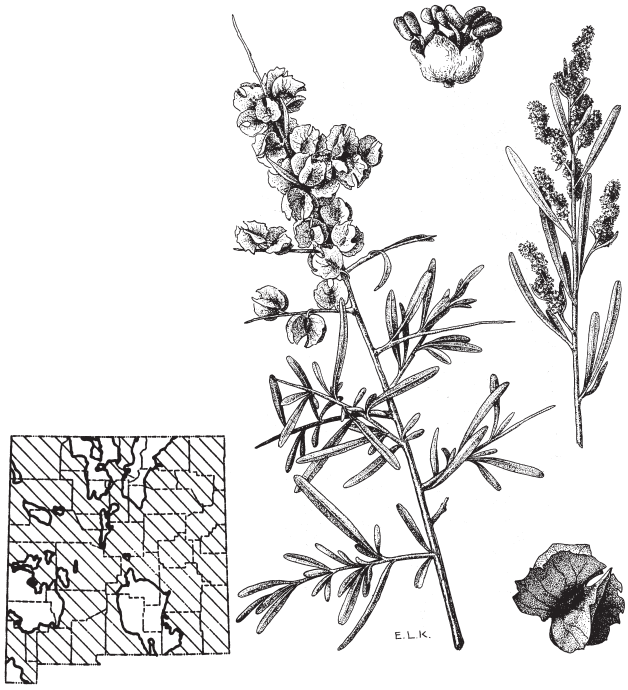
BIG SAGEBRUSH*
Artemisia tridentata Nutt.

Description
Grayish, aromatic leaves, spatula-shaped, three-lobed. Varies greatly in size according to habitat. May reach 7 feet under favorable conditions. Good growth indicates deep, fertile, non-saline soil. Areas dominated by robust plants are often good sites for range seeding.

Occurrence
Found primarily in the northern desert and western plateau regions at elevations of 5,000 to 7,200 feet.

Forage Value and Management
Big sagebrush, although not very palatable, is grazed some. Sheep eat it on winter range, especially when snow covers the better plants. As a general rule this shrub will increase with heavy grazing.

*Sand sagebrush, *Artemisia filifolia* Torr., looks much like big sagebrush but is smaller (usually not over 3 feet tall), has very slender leaves, and is mostly restricted to the sandy solis of the state from 3,000 to 7,500 feet in elevation.



FOURWING SALTBUSH
*Atriplex canescens (*Pursh) Nutt.

Description
Also called chamiza. Grayish-white to pale green shrub, often with a scurfy coating on the foliage. Branches from ground level to occasional heights of 6 feet. Male and female flowers borne on separate plants. Seed has four conspicuous wings. Green throughout the winter.

Occurrence
Adapted to very diverse soil and climatic conditions. Most common on bottomland sites. Occurs in every region of the state except the mountain areas. Quite drought-resistant. Inhabits dry, saline, or alkaline soils. Found on most sites of the southern and northern deserts and western plateau.

Forage Value and Management
This is one of the most preferred shrubs of the Southwest. Leaves, stems, flowers, and seeds are grazed by all livestock except horses. Livestock so relish the seeds that they reduce reproduction of the plant. Prolonged use of more than 60 percent of the current growth will weaken and eventually kill the plant. This plant has been used in reseeding deteriorated range areas.

SHADSCALE

Atriplex confertifolia (Torr. & Frem.) Wats.

Description

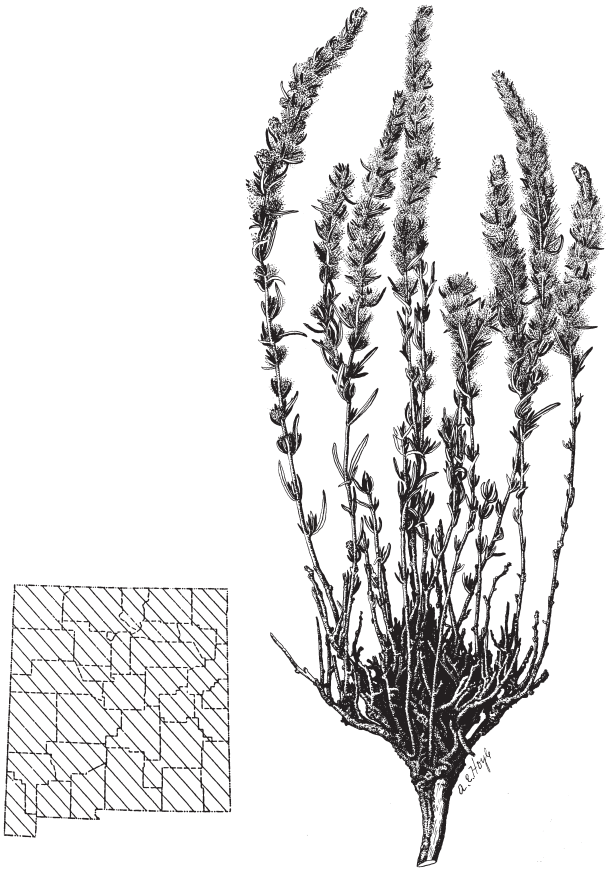
Compact, spiny shrub. Dense clumps usually 1 to 2 feet high. Sharply spine-tipped branches, scurfy when young, smooth and straw-colored when old. Oval, gray, scurfy leaves 1/2 to 3/4 inch long. Almost round fruit, shaped like a wedge.

Occurrence

Most common in the northern desert and western plateau. Frequently inhabits alkali soils and dry valleys, extending up slopes and dry washes into foothill areas. At elevations of 4,000 to 7,000 feet.

Forage Value and Management

Shadscale is palatable to all livestock, but it is particularly valuable as fall, winter, and spring browse on sheep ranges. The shrub is often less palatable than the grasses with which it occurs. Overgrazing on much of the winter range, however, has increased its use. Stands of this plant are easily maintained with moderate grazing.



WINTERFAT

Ceratoides lanata (Pursh) J.T. Howell

Description

Bushy-branched, semi-shrub. One to 3 feet tall. Many erect stems, woody at the base and herbaceous above, grow from the crown. Dense, woolly hairs, white at first, pale rust towards maturity, cover the twigs, leaves, and branches. Narrow leaves, about 1 inch long, with edges rolled under.

Occurrence

Widely distributed over the state but grows best in the southern and northern desert and western plateau areas. Found on most ranges at 3,000 to 7,500 feet in elevation and occasionally as high as 9,000 feet in mountain grasslands.

Forage Value and Management

As the name implies, winterfat is a valuable winter forage and furnishes much palatable and nutritious feed for cattle and sheep, as well as deer and elk. Chemical analysis shows it to be high in crude protein. Persistent overgrazing has greatly reduced this plant on many ranges and completely destroyed it on others. It responds well to regulated grazing, which allows the plant to reproduce and maintain its vigor.

TRUE MOUNTAIN MAHOGANY*

Cercocarpus montanus Raf.

Description

Bushy shrub. Two to 10 feet high. Broadly oval leaves up to 2 inches long and 1 inch wide. Mostly evergreen. Leaves usually wedge-shaped at the base, edges triangularly toothed on the upper two-thirds, thickly veined, and hairy on the underside. Fruits have a feathery tail up to 4 inches long.

Occurrence

Most abundant at higher elevations in the piñon pine and juniper woodland and ponderosa pine zones of the mountains. Occurs on breaks and gravelly, stoney, and cinder sites at 4,500 to 9,500 feet in elevation.

Forage Value and Management

True mountain mahogany rates as good to very good browse for all livestock. This is one of the most valuable winter feeds for deer. The plant withstands grazing well.

*Hairy mountain mahogany, *Cercocarpus breviflorus* Gray, is similar in forage value and distribution but has smaller leaves (about one inch long or less) with smooth edges.

RUBBER RABBITBRUSH

Chrysothamnus nauseosus (Pall,) Britton

Description

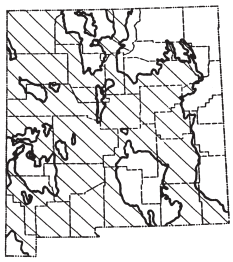
Deep-rooted, much-branched shrub. Twenty to 40 inches tall. Small, yellow flower heads clustered at the ends of stems. Narrow-linear leaves, 1 to 3 inches long, less than 1/8 inch wide, gray-green. Stems often white and felty with a grayish cast. Contains a high-grade rubber called chrysil, especially in the lower woody portions.

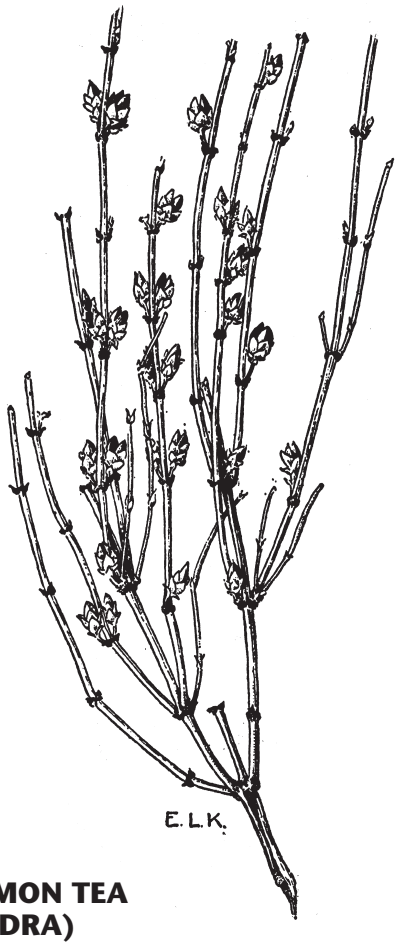
Occurrence

Throughout the northwestern part of the state, on breaks and gravelly, rocky, and bottomland sites in the southern desert. Also at high altitudes in the mountain areas, from 5,500 to 8,000 feet.

Forage Value and Management

Under normal conditions this plant has little or no forage value. All classes of stock graze the flowertops lightly and occasionally eat small amounts of leaves and young stems from September to November. Heavy grazing usually indicates an overstocked range.





LONGLEAF MORMON TEA (JOINT FIR, EPHEDRA)

Ephedra trifurca Torr. *

Description

Scraggly shrub. Three to 5 feet tall. Slender branches, ranging from dark green to yellow-green, are tipped with a weak spine. Leaves 1/4 to 1/2 inch long, brownish, three at each stem joint. Grooved or ridged twigs are opposite or clustered at stem joints. The plant was used as a medicine as well as a beverage by Indians, Spanish, and early settlers.

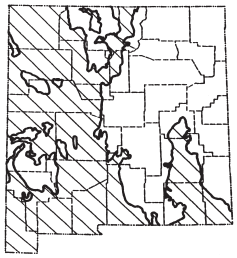
Occurrence

Most common on open sandy sites in the southern desert and sandy sites and breaks in the northwestern parts of the state. Also found on gyp sites in central portion. Grows at elevations of 3,000 to 7,500 feet.

Forage Value and Management

Mormon tea ranks quite low in forage value, although it is frequently browsed in such emergency periods as extended drought.

*Torrey Mormon tea, *Ephedra torreyana* Wats., is a common associated species that is very similar in distribution and value. The scale leaves of Torrey Mormon tea are usually shorter, less than 1/6 inch long.



APACHE PLUME

Fallugia paradoxa (D. Don) Endl.

Description

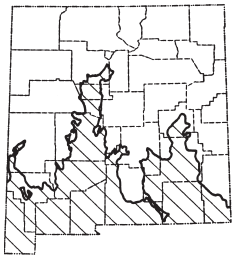
Many-branched, often evergreen shrub. Usually 2 to 3 feet tall but occasionally 6 to 7 feet under very favorable conditions. Large, white showy flowers resemble a wild rose. Soft-hairy seeds have many feathery tails, sometimes 2 inches long. These turn reddish with age. Clustered leaves are divided into 3 to 7 linear lobes.

Occurrence

Most common in the southern desert and western plateau under a wide range of conditions, from rocky or gravelly slopes to alluvial plains. Grows best in deep, moist bottomland, such as open canyon bottoms, and on the sides of arroyos. Altitudes from 4,800 to 7,500 feet.

Forage Value and Management

In general, Apache plume is considered good forage for all livestock, especially as winter browse for deer. It withstands close grazing well and recuperates quickly when given a rest.

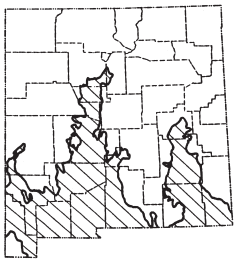


TARBUSH
Flourensia cernua DC.

Description
Many-branched shrub. Three to 6 feet tall. Small, thick, alternate leaves. Exudes a resinous substance. Yellowish, bell-shaped flowers have a nodding or drooping appearance.

Occurrence
Mesas and slopes of the dry southern portions of the state, often on limestone soils. Also common on some bottomland sites and the fringe areas of tobosa grass swales. At elevations of 3,000 to 6,500 feet.

Forage Value and Management
Tarbush is unpalatable to all livestock. It increases as overgrazing reduces forage plants, until it is now the dominant plant on most of the adapted sites.



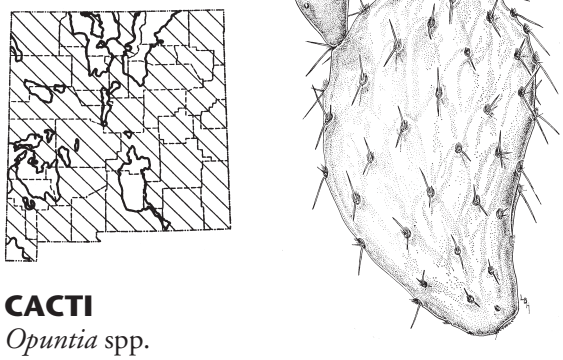
CREOSOTE BUSH
Larrea tridentata (DC.) Coville

Description
Many-branched shrub. Leaves small, shiny, evergreen. Most characteristic of the southern desert of New Mexico. Three to 6 feet tall. Yellow flowers. Hairy, bluish fruit. Stems gray with black bands. Strong creosote-like odor, especially when burned or after a rain.

Occurrence
The southern desert at elevations of 3,000 to 7,000 feet. Often forms pure stands of uniformly spaced plants on the sandy or gravelly soils of mesas and hill-sides. Extremely well adapted to severe climatic and soil conditions.

Forage Value and Management
Creosote bush is important chiefly because of its abundance. It is worthless as forage. Usually very little palatable vegetation grows in a creosote bush stand.

The creosote bush area of the Southwest has increased tremendously since the introduction of domestic livestock. The combination of over-grazing and cessation of fires seems to be responsible for the increase.



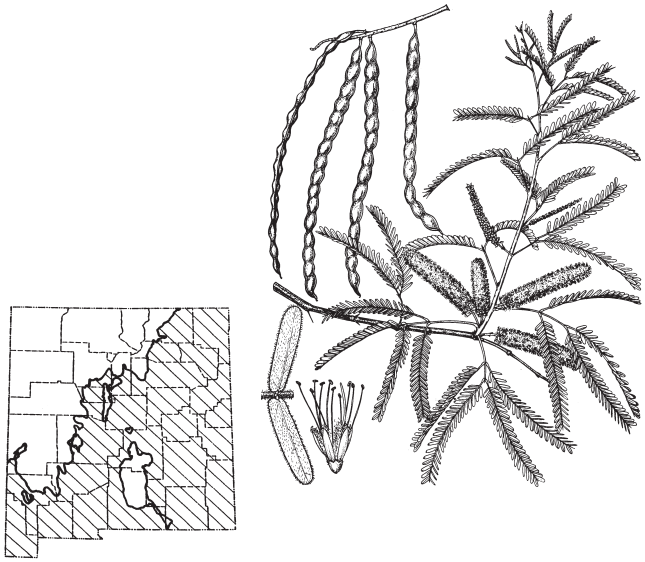
CACTI
Opuntia spp.

Description
One to 10 feet tall. Generally classed as shrubs. Characterized by joint stems which may be round as in cholla cactus or flattened as in the prickly pear. Leaves small, fleshy, inconspicuous, with many bristles at the bases. Stems covered with barbed spines. Flowers bright, yellow, orange, red, or purple. Fruit usually reddish or purplish, fleshy, often spiny, with many hard seeds.

Occurrence
Widely distributed and very abundant on some ranges. Found on most sites and soils throughout the state, except in the high mountain areas. Least common on gyp and seldom on salty areas. Grow at elevations of 3,000 to 7,500 feet.

Forage Value and Management
Cacti are used as emergency feed for cattle and sheep during prolonged drought. During emergencies, the spines are singed off to make accessible the fleshy joints, which are palatable to cattle and sheep. Under normal conditions, cacti are grazed only slightly but serve as important food for rabbits and rodents.

Both the prickly pear and cholla cacti increase under heavy grazing. They are often grubbed out to reduce heavy infestations, which decrease grass production.



MESQUITE
Prosopis glandulosa Torr.

Description
Thorny shrub or tree. Usually 2 to 10 but sometimes 50 feet tall. Deciduous. Dark green leaves, divided into many small leaflets. Cream-colored flowers develop into pods 4 to 8 inches long. Drought resistant. Roots sometimes grow to a depth of 60 feet.

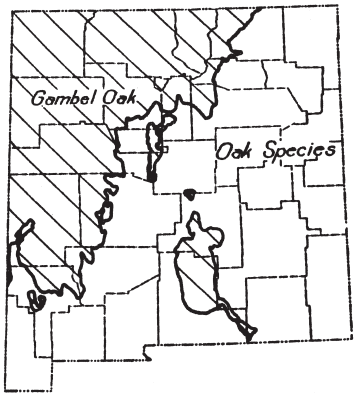
Occurrence
Most common in the southern desert. Found in bottomland areas of the high plains and central plateau. Grows at elevations of 3,000 to 8,500 feet.

Forage Value and Management
Much of the state now occupied by mesquite was formerly grassland. Prolonged abusive grazing has killed the grass, and mesquite has taken its place. The plant is aggressive, adapted to a wide range of habitats, and extremely hardy.

The leaves are grazed only when there is no other forage, but the beans are sought out and eaten avidly, presumably because of their high sugar and protein content. No doubt dissemination of undigested seeds by livestock has spread mesquite.

This plant can be controlled with certain chemicals now on the market.

Shinnery oak brush



Gambel oak brush

OAK BRUSH

Quercus spp.

Description

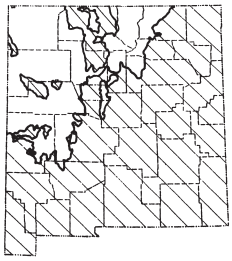
Shrubs or small trees. Leaves dark green, persistent, generally deeply lobed. Acorns usually less than 1 inch long. Bark of main branches rough or flaky.

Occurrence

Shinnery oak (*Quercus havardii* Rydb.) occurs on sandy soils at elevations generally below 4,000 feet, mostly in the southeastern part of the state. Gambel oak (*Q. gambelii* Nutt.) commonly grows in piñon-juniper and ponderosa pine areas at elevations of 4,800 to 9,000 feet.

Forage Value and Management

The leaves of oak brush provide valuable forage for sheep and goats. Cattle browse oak leaves some. An exclusive oak leaf diet, however, results in sickness and sometimes death among cattle and lambs. The acorns constitute an important food for various wild game such as deer, elk, and turkey, as well as smaller mammals.



SKUNKBRUSH SUMAC

Rhus trilobata Nutt.

Description

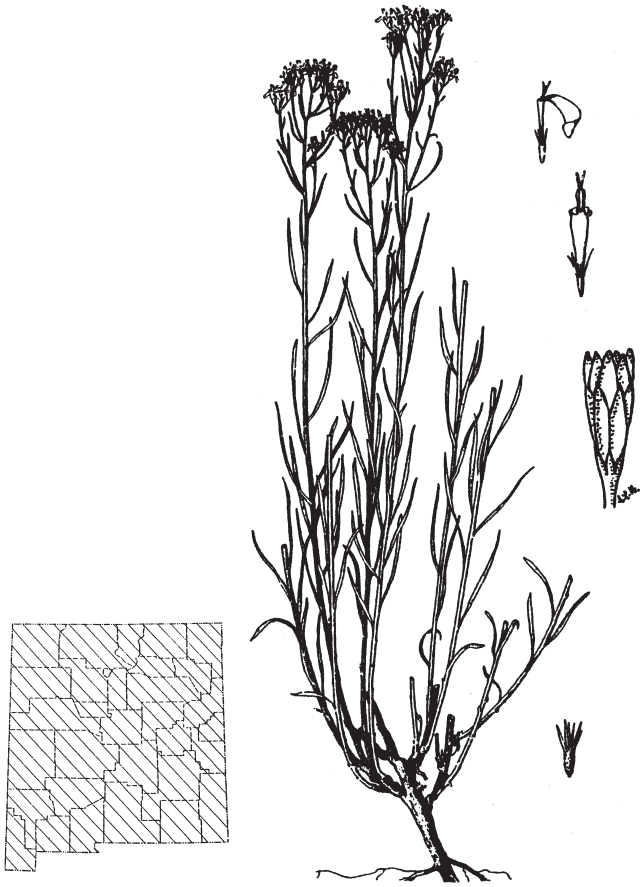
Many-branched shrub. Two to 7 feet tall. Conspicuously 3-lobed leaves have a disagreeable odor when crushed. Bright red berrylike fruits, acid to taste, were often eaten by Indians.

Occurrence

Widely distributed over the state except for the northwestern high desert regions. Most commonly inhabits rocky, gravelly, or sandy sites and frequently bottomland areas from 3,100 to 9,000 feet.

Forage Value and Management

The palatability of skunkbrush is distinctly low, but both cattle and sheep will graze it when lacking more palatable herbaceous vegetation. Palatability is rated much higher for goats.



BROOM SNAKEWEED

Xanthocephalum sarothrae (Pursh) Skinners.

Description

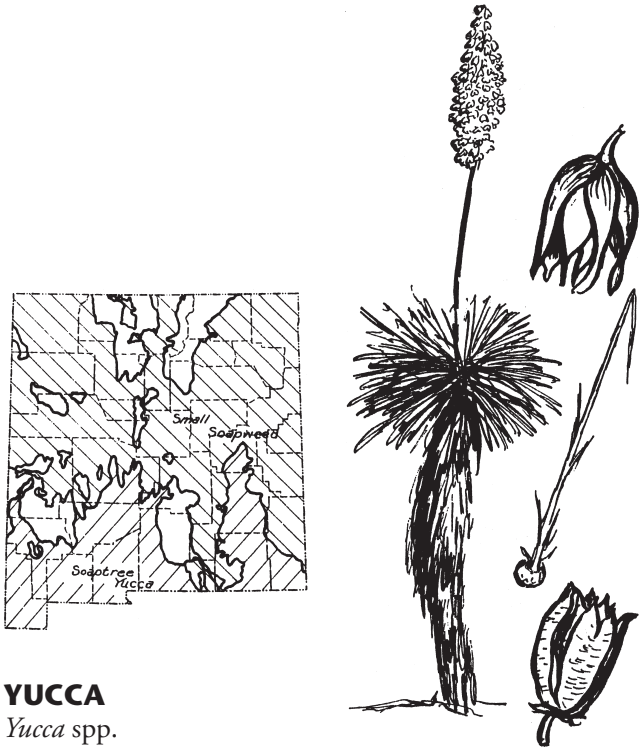
Also called snakeweed, broomweed, and turpentineweed. Semi-shrub. One to 2 feet tall. Woody base. Stems numerous, lower portions somewhat woody, but mostly herbaceous, unbranched except for flower-bearing branchlets near top. Bright green, very narrow leaves 1/2 to 1 1/2 inches long. Small, yellow flowers in flat-topped clusters on stem ends.

Occurrence

In most areas of the state. Grows best on dry plains and slopes of the southern and northern deserts and the western plateau. Ranges in altitude from 3,000 to 8,000 feet, occasionally above 9,000 feet in mountain grasslands.

Forage Value and Management

This plant is nearly worthless as forage for cattle, but sheep graze the young succulent foliage when more palatable plants are scarce. Broom snakeweed aggressively invades livestock ranges where the better forage grasses have been depleted or destroyed by overgrazing. Consumption of large quantities of this plant is reported to cause abortion in range cows.



YUCCA

Yucca spp.

Description

Shrubs. Bases and stems heavy. Leaves slender, daggerlike, spine-tipped. Large flowers with creamy white petals bloom in large clusters on stalks rising from the center of the plant. Striking plants, most frequently associated with the desert in art and literature.

Occurrence

Yucca elata Engelm., or soaptree yucca, is most common in the southern desert. Often associated with black grama or former black grama range. Grows on stalks 3 to 20 feet tall (occasionally 30). *Y. glauca* Nutt., small soapweed, is found primarily in the high plains and central plateau. It is usually less than 4 feet tall and does not grow on stalks.

Forage Value and Management

The main grazing value of the yuccas is the highly palatable, succulent flowers produced in May and June. During prolonged drought, the plants serve as valuable emergency maintenance feed when chopped or shredded and fed with protein supplement.

SCIENTIFIC NAME INDEX

GRASSES

FORBS

TREES AND SHRUBS

COMMON NAME INDEX

GRASSES

FORBS

TREES AND SHRUBS

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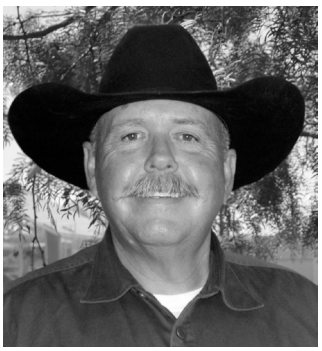
ACKNOWLEDGMENTS

Appreciation is expressed to the Agricultural Experiment Station, University of Arizona, Texas Agricultural Experiment Station, Texas A&M University, and the Herbarium of the U.S. Forest Service for furnishing the drawings of various plants.

Plant names follow Correll and Johnston's *Manual of the Vascular Plants of Texas* and Gould's *Grasses of Texas*. The Soil Conservation Service's *Range Site Technical Descriptions and Range Condition Guide for New Mexico* was used in determining distribution, sites and elevation ranges for the plant species.

Original authors: *Charles W. Gay, Jr., Extension range management specialist; and Don D. Dwyer, professor of range management. Subsequent revisions by Robert E. Steger, Extension range management specialist; Stephan Hatch, assistant professor of range management; and Jerry Schickedanz, coordinator, Range Improvement Task Force and former Dean and Chief Administrative Officer of the College of Agricultural, Consumer and Environmental Sciences.*



Christopher D. Allison *is Department Head of the Department of Extension Animal Sciences and Natural Resources at NMSU. Chris earned his Ph.D. in range science from Texas A&M University. He is a range management specialist with interest and expertise in range animal nutrition, grazing management, and plant toxicology.*

Revised November 2011 **Las Cruces, NM**

ATTACHMENT 3

NMDOT SEED MIX

2017 Zone 1 Seed List: NM Plateaus and Mesas

Common Name	Botanical Name	Lbs of PLS*/Acre
Annual quick-cover grasses		
Oats	*Avena sativa*	0.50
Sterile triticale	*Triticum aestivum X Secale cereale'Quickguard'*	0.50
Cool-season grasses		
Bottlebrush squirreltail	*Elymus elymoides*	1.75
Indian ricegrass	*Achnatherum hymenoides* var. *Paloma***	0.75
Western wheatgrass	*Agropyron smithii*	1.75
Warm-season grasses		
Alkali sacaton	*Sporobolus airoides*	0.20
Blue grama	*Bouteloua gracilis* var. *Alma***	0.50
Galleta	*Pleuraphis jamesii* var. *Viva***	1.00
Little bluestem	*Schizachyrium scoparium*	0.50
Sand dropseed	*Sporobolus cryptandrus*	0.08
Sideoats grama	*Bouteloua curtipendula* var. *Vaughn***	0.75
Wildflowers		
Blanket flower	*Gaillardia pulchella*	0.20
Broadbeard penstemon	*Penstemon angustifolius*	0.20
Hairy golden aster	*Heterotheca villosa*	0.20
Lewis flax	*Linum lewisii*	0.20
Narrowleaf paintbrush	*Castilleja linariifolia*	0.02
Nelson globemallow	*Sphaeralcea parvifolia*	0.30
Prairie aster	*Machaeranthera tanacetifolia*	0.20
White prairie Clover	*Dalea candida*	0.20
Wild four o'clock	*Mirabilis multiflora*	0.30

Woody Shrubs

Antelope bitterbrush	*Purshia tridentata*	1.00
Four-wing saltbush	*Atriplex canescens*	0.40
Winterfat	*Krascheninnikovia lanata*	0.20
Sand sage	*Artemisia filifolia*	0.05

***PURE LIVE SEED/ACRE TOTAL**	**11.75**

**** Local, wild-sourced genotypes preferred. Provide specified registered variety only if wild-sourced seed is unavailable.**

APPENDIX C

POST-CLOSURE INSPECTION CHECKLIST

LANDFARM NAME	
DATE	
WEATHER	
PRECIPITATION (LAST 24 HOURS)	

Landfarm Post-Closure Inspection Checklist				
Inspection Item	**Met**	**Not Met**	**NA**	**COMMENTS / ACTION TAKEN**
Compacted Areas (i.e., roadways) Ripped/Disked				
Seeded: □ Drill Seeded □ Broadcast □ Other:				
Erosion and Runoff Controlled: Methods:				
Mulch: Type:				
Free of Noxious or Invasive Weeds: Species Present: Treatment Needed Yes □ No □ Treatment Performed Yes □ No □ Type:				
Revegetation Success: Density/Cover Measurement and %: Species Types and %:				
Overal Site Stability (wind/water erosion, subsidence, vegetation)				
Remediation and Closure Under 19.15.29 and/or 19.15.30 NMAC Complete?				
Other: (describe)				

NA – Not Applicable

Comment section should be used to provide details of unsatisfactory findings.

Additional Inspection Remarks:

Inspector Signature:_____

Name (Print):_____

Final Reclamation Approvable (year 3): Yes □ No □

Manager Signature:_____

Name (Print):_____

APPENDIX D

NMOSE SUMMARY OF NEARBY WELLS AND WELL LOGS

Well POD Number	Water Use	Well Permit Status	Well Status	Owner Last Name	Owner First Name	Surface Elevation at Well (feet amsl)	Depth of Well (feet)	Depth to Water (feet)	Distance from Bisti Landfarm (miles)	UTM Easting	UTM Northing	Well Installation Date
SJ-01716	Livestock and Wildlife	Permitted	Unknown	BLM	Null	6,310	403	210	3.320	215373.0	4025538.0	6/20/1963
SJ 03815 POD1	Domestic	Permitted	Active	WERITO	ANDREW A.	6,150	730	Null	5.602	215372.9	4025538.6	9/30/2008
SJ 00221	Domestic	Permitted	Active	BROWN	CHARLEY Y.	6,330	198	135	6.617	230613.0	4036253.0	5/6/1977
SJ 01058	Domestic	Permitted	Active	WILFORD	PETE	6,060	254	220	8.178	222289.0	4046001.0	9/27/1979
SJ 01626	Domestic	Permitted	Active	BROWN	CHARLIE Y.	6,260	255	200	8.297	230607.0	4041673.0	10/3/1982
SJ 02734	Drinking Water/Sanitary	Permitted	Active	CARSON LIVING WATERS	Null	6,360	275	165	8.590	233750.0	4036858.0	2/14/1997

Notes:

amsl: above mean sea level

---: surface elevation not stated

Bisti Landfarm surface elevation approximately 6,260 feet amsl

Revised June 1972

STATE ENGINEER OFFICE

77 MAY 18 AM 11 03

WELL RECORD

STATE ENGINEER OFFIC
SANTA FE, N.M. 87501

Section 1. GENERAL INFORMATION

(A) Owner of well Charlie Y. Brown Owner's Well No. _____
Street or Post Office Address Box 221
City and State Bloomfield, New Mexico.

Well was drilled under Permit No. SJ 221 and is located in the:

a. ____ ¼ ____ ¼ ____ ¼ NE ¼ of Section 4 Township 25W Range 11W N.M.P.M.

b. Tract No. _____ of Map No. _____ of the _____

c. Lot No. _____ of Block No. _____ of the _____
~~Subdivision~~, recorded in San Juan County.

d. X= _____ feet, Y= _____ feet, N.M. Coordinate System _____ Zone in the _____ Grant.

(B) Drilling Contractor ~~William J. Hood~~ License No. WD 717

Address Rt.3, Box 234, Flora Vista, New Mexico

Drilling Began 5/3/77 Completed 5/7/77 Type tools Cable Size of hole 6-5/8 in.

Elevation of land surface or _____ at well is 5500 ft. Total depth of well 198 ft.

Completed well is ☐ shallow ☒ artesian. Depth to water upon completion of well 135 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
168	198	30	Blue Water Sand	10

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
6 5/8	.188		0	52	52	None		
5.3	S - 200	Plastic	52	198	146		158	198

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement

Section 5. PLUGGING RECORD

Plugging Contractor _____
Address _____
Plugging Method _____
Date Well Plugged _____
Plugging approved by:
_____
State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received 5/18/77

Quad _____ FWL _____ FSL _____

File No. SJ-221 Use Dom Location No. 25N.11W.4 200

San Juan Co.

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	52	52	Sandy Over - Burden
52	168	116	Blue Shale
168	198	30	Blue Water-Bearing Sand

Section 7. REMARKS AND ADDITIONAL INFORMATION

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

W. J. Hood
Driller

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the appropriate district office of the State Engineer. All sections, exc[illegible] Section 5, shall be answered as completely a[illegible] accurately as possible when any well is drilled, repaired or deepened. When this [illegible]s used as a plugging record, only Section 1([illegible] Section 5 need be completed.

TRN 226440

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

'79 OCT 16 PM 1 11

STATE ENGINEER OFFICE
SANTA FE, N.M. 87501

Section 1. GENERAL INFORMATION

(A) Owner of well Wilford Pete Owner's Well No. _____
Street or Post Office Address Box 234
City and State Bloomfield, New Mex.

Well was drilled under Permit No. SJ-1058 and is located in the:

a. ___ ¼ ___ ¼ SW ¼ NW ¼ of Section 3 Township 26N Range 12W N.M.P.M.

b. Tract No. _____ of Map No. _____ of the _____

c. Lot No. _____ of Block No. _____ of the _____
Subdivision, recorded in San Juan County.

d. X= _____ feet, Y= _____ feet, N.M. Coordinate System _____ Zone in the _____ Grant.

(B) Drilling Contractor W.J. Hood License No. WD-717

Address Flora Vista, New Mex.

Drilling Began 9/18/79 Completed 9/28/79 Type tools Cable Size of hole 7 in.

Elevation of land surface or _____ at well is 5550 ft. Total depth of well 254 ft.

Completed well is ☒ shallow ☐ artesian. Depth to water upon completion of well 220 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
240	254	14	Blue Water Bearing Sand	5
		Gravel packed		

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
5 in.	Class 200 P.V.C.		0	254	254		234	254

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement

Section 5. PLUGGING RECORD

Plugging Contractor _____
Address _____
Plugging Method _____
Date Well Plugged _____
Plugging approved by:
_____
State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received 10/16/79

Quad _____ FWL _____ FSL _____

File No. SJ-1058 Use Dom. &Stk. Location No. 26N.12W.3 130

jts

San Juan County

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	10	10	Over Burden
10	40	30	Sand Stone
40	110	70	Blue Soft Shale
110	155	45	Blue Sandy Shale
155	180	25	Hard Wax Shale
180	240	60	Sandy Shale
240	254	14	Blue Water Bearing Sand

Section 7. REMARKS AND ADDITIONAL INFORMATION

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

W. J. Hood
Driller

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the appropriate district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1(a) and Section 5 need be completed.

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

227943

Section 1. GENERAL INFORMATION

(A) Owner of well Charlie Y. Brown Owner's Well No. _____
Street or Post Office Address PO Box 221
City and State Bloomfield,N.M. 87413

Well was drilled under Permit No. SJ 1626 and is located in the:

a. ____ ¼ ____ ¼ SW ¼ SE ¼ of Section 16 Township 26N Range 11W N.M.P.M.

b. Tract No. _____ of Map No. _____ of the _____

c. Lot No. _____ of Block No. _____ of the _____
Subdivision, recorded in _____ County.

d. X= _____ feet, Y= _____ feet, N.M. Coordinate System _____ Zone in the _____ Grant.

(B) Drilling Contractor Terry G Hood License No. WD 717

Address Rt 3 Box 234 A Flora Vista,N.M.

Drilling Began 9/24/82 Completed 10/4/82 Type tools CableTool Size of hole 5 in.

Elevation of land surface or _____ at well is 5800 ft. Total depth of well 255 ft.

Completed well is ☒ shallow ☐ artesian. Depth to water upon completion of well 200 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
200	255	55	Blue Water Bearing Sand	5

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
5	PVC		0	255	255		195	255

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement

OCT 7 PM 12 24

Section 5. PLUGGING RECORD

Plugging Contractor _____
Address _____
Plugging Method _____
Date Well Plugged _____
Plugging approved by:
_____
State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received 10/07/82

Quad _____ FWL _____ FSL _____

File No. SJ-1626 Use Dom. Location No. 26N.11W.16 340

jts

San Juan County

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	75	75	OverBurden Sand & Yellow SandStone
75	200	125	Blue Sandy Shale
200	255	55	Blue Water Bearing Sand

Section 7. REMARKS AND ADDITIONAL INFORMATION

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Toy Ward
Driller

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the appropriate district office of the State Engineer. All sections, ex Section 5, shall be answered as completel ccurately as possible when any well is drilled, repaired or deepened. When this is used as a plugging record, only Section 1 d Section 5 need be completed.

Revised December 1975

IMPORTANT — READ INSTRUCTIONS ON BACK BEFORE FILLING OUT THIS FORM.

232041

Declaration of Owner of Underground Water Right

HC-107368

SAN JUAN UNDERGROUND WATER BASIN
BASIN NAME

Declaration No. SJ-1716 Date received April 29, 1983

STATEMENT

1. Name of Declarant U. S. Dept. of Interior, Bureau of Land Management
   Mailing Address P. O. Box 568, Farmington, New Mexico 87499-0568
   County of San Juan, State of New Mexico
2. Source of water supply Nacimiento Formation
   (artesian or shallow water aquifer)
3. Describe well location under one of the following subheadings:
   a. ____ ¼ NE ¼ SW ¼ of Sec. 1 Twp. 25 N. Rge. 12 W. N.M.P.M., in San Juan County.
   b. Tract No. ____ of Map No. ____ of the ____.
   c. X = ____ feet, Y = ____ feet, N. M. Coordinate System ____ Zone in the ____ Grant.
   On land owned by Bureau of Land Management (see address above)
4. Description of well: date drilled 6/20/63-2/5/64 driller W. R. West Drilling Co. depth 403 feet. outside diameter of casing 6 5/8 inches; original capacity 40 gal. per min.; present capacity 40 gal. per min.; pumping lift 375 feet; static water level 210 feet ~~above~~ (below) land surface; make and type of pump 1 7/8 inch cylinder (plunger on sucker rod) make, type, horsepower, etc., of power plant 14 foot diameter aermotor mounted on steel tower. Fractional or percentage interest claimed in well 100% (all)
5. Quantity of water appropriated and beneficially used ____ (acre feet per acre) 15 (acre feet per annum) for livestock and wildlife purposes.
6. Acreage actually irrigated N/A acres, located and described as follows (describe only lands actually irrigated):

Subdivision	Sec.	Twp.	Range	Acres Irrigated	Owner

(Note: location of well and acreage actually irrigated must be shown on plat on reverse side.)

7. Water was first applied to beneficial use 2 (month) 5 (day) 1964 (year) and since that time has been used fully and continuously on all of the above described lands or for the above described purposes except as follows: N/A
8. Additional statements or explanations Carson No. 1 Well (see Log of Well and Project Completion Report)

I, Farmington Resource Area Manager being first duly sworn upon my oath, depose and say that the above is a full and complete statement prepared in accordance with the instructions on the reverse side of this form and submitted in evidence of ownership of a valid underground water right, that I have carefully read each and all of the items contained therein and that the same are true to the best of my knowledge and belief.

Jim Sims, declarant.

by: ____

Subscribed and sworn to before me this 25 day of April, A.D. 1983

My commission expires April 13, 1987 Shirley C. Davenport Notary Public

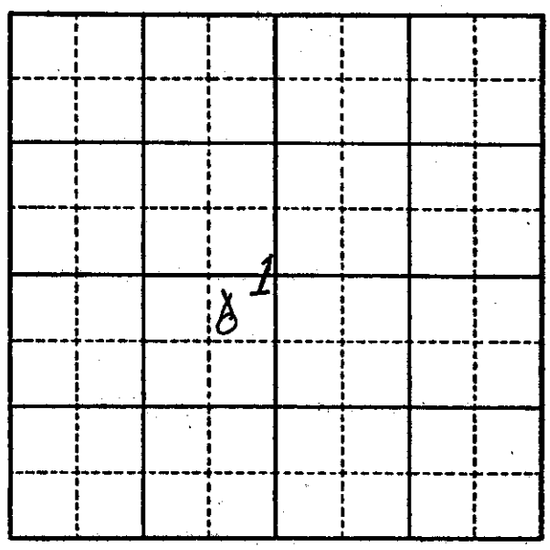
FILED
UNDER NEW MEXICO LAW A DECLARATION IS ONLY A STATEMENT OF DECLARANT'S CLAIM.
ACCEPTANCE FOR FILING DOES NOT CONSTITUTE APPROVAL OR REJECTION OF THE CLAIM.

STATE ENGINEER OFFICE ALBUQUERQUE, N. MEX. 83 APR 29 AM 10:35

Log in location file

Locate well and areas actually irrigated as accurately as possible on following plat:

Section (s) 1, Township 25 N., Range 12 W. N. M. P. M.



INSTRUCTIONS

Declaration shall be executed (preferably typewritten) in triplicate and must be accompanied by a $1.00 filing fee. Each of triplicate copies must be properly signed and attested.

A separate declaration must be filed for each well in use.

All blanks shall be filled out fully. Required information which cannot be sworn to by declarant shall be supplied by affidavit of person or persons familiar with the facts and shall be submitted herewith.

Secs. 1-3. Complete all blanks.

Sec. 4. Fill out all blanks applicable as fully as possible.

Sec. 5. Irrigation use shall be stated in acre feet of water per acre per year applied on the land. If used for domestic, municipal. or other purposes, state total quantity in acre feet used annually.

Sec. 6. Describe only the acreage actually irrigated. When necessary to clearly define irrigated acreages, describe to nearest 2½ acre subdivision. If located on unsurveyed lands. describe by legal supdivision "as projected" from the nearest government survey corners, or describe by metes and bounds and tie survey to some permanent, easily-located natural object.

Sec. 7. Explain and give dates as nearly as possible of any years when all or part of acreage claimed was not irrigated.

Sec. 8. If well irrigates or supplies supplemental water to any other land than that described above, or if land is also irrigated from any other source, explain under this section. Give any other data necessary to fully describe water right.

If additional space is necessary, use a separate sheet or sheets and attach securely hereto.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
FARMINGTON RESOURCE AREA
P.O. BOX 568
FARMINGTON, NEW MEXICO 87499-0568

IN REPLY REFER TO
7421

APR 28 1983

New Mexico State Engineer
District I Office
2340 Menaul, NE, Suite 206
Albuquerque, New Mexico 87107-1884

Dear Sir:

Enclosed, please find Declaration of Owner of Underground Water Right for sixteen of our wells for livestock and wildlife watering purposes. Sixteen dollars are enclosed for filing fees.

If you have any questions, please call Dana Shuford of our staff (505-325-3581).

Sincerely yours,

acting Area Manager

Enclosures

83APR29 A10:34
STATE ENGINEER OFFICE
DISTRICT I
ALBUQUERQUE, N. MEX.

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Carson Living Waters Assembly of God

Section 1. GENERAL INFORMATION

(A) Owner of well CARSON LIVING WATERS Owner's Well No. _____
Street or Post Office Address PO 2436
City and State BLOOMFIELD NM 87413

Well was drilled under Permit No. SJ-2734 and is located in the:

a. ____ ¼ NE ¼ SW ¼ SE ¼ of Section 35 Township 26N Range 11W N.M.P.M.

b. Tract No. _____ of Map No. _____ of the _____

c. Lot No. _____ of Block No. _____ of the _____
Subdivision, recorded in _____ County.

d. X= _____ feet, Y= _____ feet, N.M. Coordinate System _____ Zone in the _____ Grant.

(B) Drilling Contractor TERRY HOBO License No. WD-717

Address AZTEC NM 87410

Drilling Began 2-13-97 Completed 2-15-97 Type tools _____ Size of hole 4½ in.

Elevation of land surface or _____ at well is _____ ft. Total depth of well 275 ft.

Completed well is ☑ shallow ☐ artesian. Depth to water upon completion of well 165 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
165	275	110	BLUE SANDSTONE	8

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
4½	PVC		0	275	275		165	275

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement

Section 5. PLUGGING RECORD

Plugging Contractor _____
Address _____
Plugging Method _____
Date Well Plugged _____
Plugging approved by:

_____
State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received 2-20-97

Quad _____ FWL _____ FSL _____

File No. SJ-2734 Use Commercial Location No. 26N.11W.35.432

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	~~165~~ 50	50	GREY SANDY SHALE
50	95	45	GREY SAND STONE
95	165	70	BLUE SANDY SHALE
165	275	110	BLUE SAND STONE

Section 7. REMARKS AND ADDITIONAL INFORMATION

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Driller

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the appropriate district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well Andrew Werito Owner's Well No. _____

Street or Post Office Address 2600 Rio vista Way

City and State Farmington NM 87402

Well was drilled under Permit No. SJ 3815 and is located in the:

a. _____ ¼ ~~se~~ ¼ ~~ne~~ ¼ _____ ¼ of Section 12 Township 24N Range 13W N.M.P.M.

b. Tract No. _____ of Map No. _____ of the _____

c. Lot No. _____ of Block No. _____ of the _____

Subdivision, recorded in San Juan County.

d. X= 2623653 feet, Y= 1940639 feet, N.M. Coordinate System West Zone in the _____ Grant.

(B) Drilling Contractor Terry Hood License No. Wd717

Address Aztec NM

Drilling Began 9/20/08 Completed 10/1/08 Type tools _____ Size of hole 6 in.

Elevation of land surface or _____ at well is _____ ft. Total depth of well 730 ft.

Completed well is ☐ shallow ☐ artesian. Depth to water upon completion of well NA ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
				0

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet Top	Depth in Feet Bottom	Length (feet)	Type of Shoe	Perforations From	Perforations To
					0		NA	

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
5	20	7		7	Tremie

STATE ENGINEER OFFICE RECEIVED 2008 OCT -1 PM 3:08

STATE ENGINEER OFFICE AZTEC, NEW MEXICO 2008 OCT -1 PM 4:50

Section 5. PLUGGING RECORD

Plugging Contractor _____

Address _____

Plugging Method _____

Date Well Plugged _____

Plugging approved by:

_____

State Engineer Representative

No.	Depth in Feet Top	Depth in Feet Bottom	Cubic Feet of Cement
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received October 1, 2008

Quad _____ FWL _____ FSL _____

File No. SJ-3815 Use Stock Location No. 24N.13W.12.240

Trn# 397223

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	730	730	Sandy Brown to Blue Shale Streaks

Section 7. REMARKS AND ADDITIONAL INFORMATION

GPS 36 21 34
108 06 14

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Driller

INSTRUCTIONS: This form should be executed in triplicate, ~~preferably~~ typewritten, and submitted to the appropriate district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1(a) and Section 5 need be completed.

From: Jones, Brad, EMNRD
To: Luka, Kateri A.; Stuart Hyde
Subject: NM2-10 Western Refining Company LP - February 17, 2023, Closure and Post-Closure Plan and exception request conditional approval
Date: Monday, April 8, 2024 3:38:00 PM
Attachments: 2024 0408 NM2-10 Western Refining Company LP CPC Plan and Exception Request approval signed.pdf

Kateri and Stuart,

Please see the attached. OCD has completed the review of the February 17, 2023, Closure and Post-Closure Plan and exception request. If you have any questions regarding this matter, please do not hesitate to contact me.

Sincerely,

Brad A. Jones

Brad A. Jones Environmental Scientist Specialist - Advanced
Environmental Bureau
EMNRD - Oil Conservation Division
1220 S. Saint Francis Drive | Santa Fe, New Mexico 87505
(505) 469-7486 | brad.a.jones@emnrd.nm.gov
www.emnrd.nm.gov

State of New Mexico
Energy, Minerals and Natural Resources Department

Michelle Lujan Grisham
Governor

Dylan M. Fuge
Deputy Secretary

Dylan Fuge, Division Director (Acting)
Oil Conservation Division

BY ELECTRONIC MAIL

April 8, 2024

Ms. Kateri Luka
Western Refining Company LP
111 County Road 4990
Bloomfield, New Mexico 87413
kaluka@marathonpetroleum.com

RE: Closure and Post-Closure Plan and Exception Request
Western Refining Company LP (OGRID # 264727), Permit NM2-010

Dear Ms. Luka:

The Oil Conservation Division (OCD) has completed a review of Western Refining Company LP's (Western) Closure and Post-Closure Plan and exception request, dated February 17, 2023, for existing centralized surface waste management facility Permit NM2-10. The OCD hereby grants Western approval of the Closure and Post-Closure Plan and exception request with the following understandings and conditions:

1. Western shall comply with all applicable requirements of the Oil and Gas Act (Chapter 70, Article 2 NMSA 1978), existing permit NM2-010, the transitional provisions of 19.15.36.20 NMAC, and all conditions specified in this approval;

2. In the event closure samples exceed OCD approved facility background threshold values/PQLs, the OCD approves Western's exception request to utilize the most stringent soil screening levels for the treatment zone closure performance standards as identified in Table 1 (excluding Mercury) for the constituents required by 19.15.36.15.F(5) NMAC;

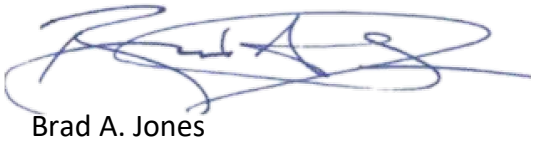
3. Western must utilize the EPA Soil Screening Level (Inhalation of Volatiles and Fugitive Dusts) of 10.9 mg/kg for Mercury, instead of the proposed NMED Soil Screening Level of 20.7 mg/kg; and

4. Western shall obtain written approval from the OCD prior to implementing any changes to the February 17, 2023, Closure and Post-Closure Plan and exception request.

Please be advised that approval of this request does not relieve Western of liability should operations result in pollution of surface water, ground water, or the environment. Nor does approval relieve Western of its responsibility to comply with any other applicable governmental authority's rules and regulations.

If there are any questions regarding this matter, please do not hesitate to contact me at (505) 469-7486 or brad.a.jones@emnrd.nm.gov.

Respectfully,



Brad A. Jones
Environmental Specialist - Advanced

cc: Stuart Hyde, Ensolum, LLC, shyde@ensolum.com

District I
1625 N. French Dr., Hobbs, NM 88240
Phone:(575) 393-6161 Fax:(575) 393-0720
District II
811 S. First St., Artesia, NM 88210
Phone:(575) 748-1283 Fax:(575) 748-9720
District III
1000 Rio Brazos Rd., Aztec, NM 87410
Phone:(505) 334-6178 Fax:(505) 334-6170
District IV
1220 S. St Francis Dr., Santa Fe, NM 87505
Phone:(505) 476-3470 Fax:(505) 476-3462

State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
1220 S. St Francis Dr.
Santa Fe, NM 87505

CONDITIONS

Action 187708

CONDITIONS

Operator: Western Refining Southwest LLC 539 South Main Street Findlay, OH 45840	OGRID: 267595
	Action Number: 187708
	Action Type: [C-137] Non-Fee SWMF Submittal (SWMF NON-FEE SUBMITTAL)

CONDITIONS

Created By	Condition	Condition Date
bjones	OCD emailed the conditional approval letter for the closure and post-closure plan and the exception request to Kateri Luka (Western), and Stuart Hyde (Ensolum) on April 8, 2024. The approval email is attached to this request as OCD's Response. If you have any questions, please contact me.	4/8/2024