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Wetlands Regulatory Assistance Program

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Abstract

This report presents a hydrogeomorphic (HGM) classification of the wetlands of New Mexico based on a broad division of natural regions within the state. Four Land Resource Regions (LRRs) that occur in New Mexico were used to develop the HGM classifications: Western Range and Irrigated Region, Rocky Mountain Range and Forest Region, Western Great Plains Range and Irrigated Region, and Central Great Plains Winter Wheat and Range Region. HGM wetland classes and regional wetland subclasses for New Mexico are presented. The report includes cross-reference tables for HGM subclasses and vegetation communities.

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Preface

This work was conducted by the Environmental Laboratory (EL), U.S. Army Engineer Research and Development Center (ERDC), for the Corps of Engineers Wetlands Regulatory Assistance Program (WRAP). Timothy C. Wilder, Chris V. Noble, and Jacob F. Berkowitz compiled this report and the WRAP Program Manager was Sally Yost, EL.

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At the time of publication, COL Kevin J. Wilson was Commander of ERDC. Dr. Jeffery P. Holland was Director.

Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
inches	0.0254	meters
miles (U.S. statute)	1,609.347	meters
square miles	2.589998 E+06	square meters

1 Introduction

The intent of this report is to present a hydrogeomorphic (HGM) classification of the wetlands of New Mexico based on a broad division of natural regions within the state. Further regional refinement is appropriate and is expected by the authors.

The HGM approach to wetland classification groups wetlands based on geomorphic setting, water source, and hydrodynamics (Brinson 1993). This perspective reflects functional similarities and differences among wetlands particularly with regard to the movement, storage, and processing of water and materials, as well as the habitats that wetlands provide for plants and animals. The HGM classification approach groups wetlands into classes, which may encompass a wide variety of community types that can appear very different, but function similarly (Table 1). The wetlands of New Mexico comprise six of the seven possible HGM classes: riverine, slope, depression, mineral soil flats, organic soil flats (peatlands), and lacustrine fringe. Only the marine-tidal fringe class is not present within the state.

Table 1. Potential regional wetland subclasses in relation to hydrogeomorphic classification criteria.

Classification Criteria			Potential Regional Wetland Subclasses	
Geomorphic Setting	Dominant Water Source	Dominant Hydrodynamics	Eastern USA	Western USA/Alaska
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina bays	California vernal pools
Fringe (tidal)	Ocean (marine)	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake or Reservoir	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Bayheads and Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Very large playas
Flat (organic soil)	Precipitation	Vertical	Peat bogs; portions of the Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands

Note: Adapted from Smith et al. (1995), and Rheinhardt et al. (1997).

Grouping entities sharing key characteristics is the essence of any classification, a primary purpose of which is to reduce the range of variation that must be considered. The first hierarchy of HGM classes is based on the three key characteristics of geomorphic setting, water source, and hydrodynamics (Brinson 1993). Wetlands exhibit tremendous variation worldwide within these broad HGM classes (Table 1). The riverine wetlands of the Yukon Flats in Alaska, for example, differ greatly from the forested floodplain riverine wetlands of the Amazon basin in Brazil. These wetlands lie in distinct regions having their own climate and geologic history, which in turn dictates hydrology, soils, and landform.

The fundamental differences among the natural regions of the earth's land surfaces are due mainly to their structure, the varieties of rock in their composition, and the regional and temporal variations of climate that govern the hydrologic, erosional, and sedimentation processes that have sculpted them (Hunt 1974). Plant and animal communities respond to a region's climate and to variations of soils and hydrology that naturally arise from structure and composition. For these reasons, the second hierarchy of HGM wetland classification is based on natural regions (Smith et al. 1995), which are used here as the basis for regional subclasses in New Mexico.

A number of systems that classify natural regions based on ecologic and physiographic factors have been published (Bailey 1995; Commission for Environmental Cooperation 1997; Griffith et al. 2006; U.S. Deparment of Agriculture (USDA) Natural Resource Conservation Service (NRCS) 2006). In this report, the NRCS publication, "Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin" (USDA NRCS 2006) is used to identify regions.

2 Natural Regions of New Mexico

New Mexico contains portions of four Land Resource Regions (LRR's) (Figure 1).

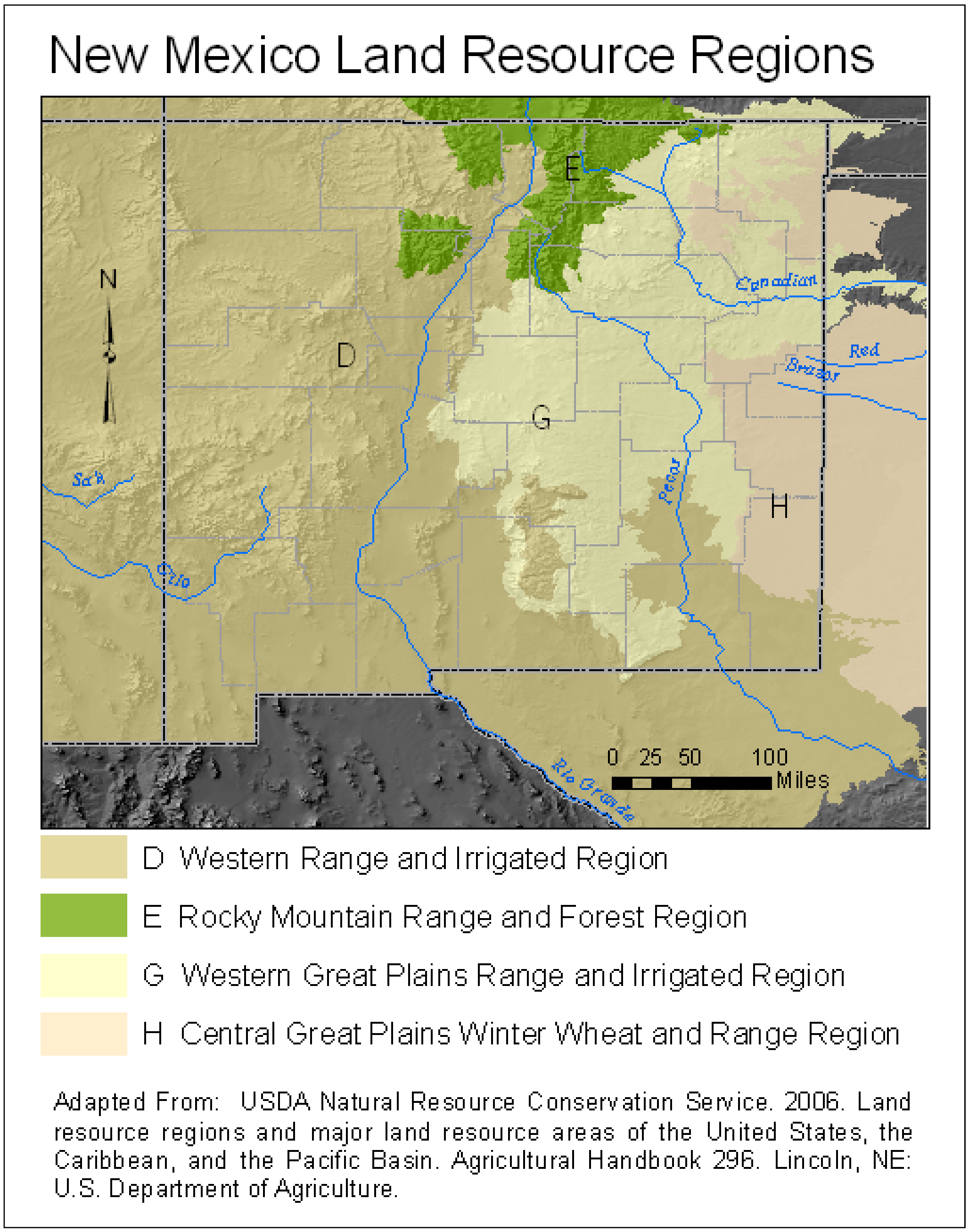

Figure 1. Land resource regions of New Mexico.

Table 2 shows how these LRRs correspond to the Commission for Environmental Cooperation's (1997) Level I Ecoregions and the major physiographic provinces identified by Hunt (1974). LRRs are divided into Major Land Resource Areas (MLRAs) and Ecoregions are likewise subdivided into additional levels. A table cross-referencing the MLRAs with the Level III Ecoregions and the USDA Forest Service ecoregions (Bailey 1995) is located in the appendix of the NRCS LRR publication (USDA NRCS 2006). A wetland classification by subregions finer in scale than those identified in Table 2 is beyond the scope of this report. Although the LRRs of Table 2 were used to organize this report's classification, the terminology of Hunt (1974) is used in their description. The boundaries of the provinces as Hunt defined them correspond well to the boundaries of the LRRs, and his terminology is in general usage.

Table 2. Land Resource Regions of New Mexico cross-referenced with ecoregions and physiogrpahic provinces.

USDA NRCS Land Resource Regions (LRRs) (USDA NRCS 2006)	Level I Ecoregions (Commission for Environmental Cooperation 1997)	Physiographic Provinces (Hunt 1974)
D Western Range and Irrigated Region	10.0 North American Desserts 13.0 Temperate Sierras	Colorado Plateau Basin and Range
E Rocky Mountain Range and Forest Region	6.0 Northwestern Forested Mountains	Southern Rocky Mountains
G Western Great Plains Range and Irrigated Region	9.0 Great Plains	Great Plains
H Central Great Plains Winter Wheat and Range Region		

LRR D Western Range and Irrigated Region

Colorado Plateau

The Colorado Plateau is an area of uplift covering about 130,000 square miles, generally 5,000 ft above mean sea level, with some plateaus and peaks reaching 11,000 ft (Hunt 1974). The region includes deeply incised, brightly colored canyons, high plateaus and mountains, broad areas of level terrain, and large areas buried under lava flows.

New Mexico contains about 22,000 square miles of the Colorado Plateau in two distinct regions. One of these regions, the Datil Section, is characterized by thick lavas of varying age, with some as young as early Holocene (Hunt 1974). The other, known as the Navajo Section, is typified by broad plains separated by cuestas and dissected by deep canyons (Hunt 1974). The Colorado Plateau in New Mexico is bounded on the south and east by the Rio Grande rift (Baldridge et al. 1994).

Annual precipitation in this area of New Mexico typically ranges between 8 and 20 in. About one-third to one-half of the precipitation falls during intense convective storms in July and August, with the remainder falling mainly in late fall and winter during low-intensity events (USDA NRCS 2006). The driest months are in the spring and average annual temperatures range from 36 to 66 °F. Generally, precipitation increases and temperature decreases with elevation and proximity to the Southern Rockies (USDA NRCS 2006).

Typical streams of the Colorado Plateau are ephemeral, although the San Juan in northern New Mexico is perennial, with the highest mean annual discharge in the state (USDA NRCS 2006). Floodplains have formed on ephemeral and high-order perennial streams of the region that possess large drainage areas. The floodplains of these streams are typically marked with shallow depressions associated with abandoned courses, scroll marks, and scour (Graf et al. 1987). Streams of the Colorado Plateau in New Mexico underwent erosion and incision in the late 1880's (Bryan 1928; Graf et al. 1987), probably due to land use practices and periodic shifts in climate (Huckleberry and Duff 2008). A period of aggradation and floodplain development followed beginning in the early 1940's. Some erosion of these floodplains has been evident since the early 1980's (Graf et al. 1987).

Many of the valleys and canyons of the Colorado Plateau are cuspate at their head. This distinct characteristic arises from sapping, a process in which discharge from a permanent groundwater source along a free face leads to the undermining and collapse of valley head and side walls (Graf et al. 1987). In addition to a free face at which groundwater may discharge, it requires a rechargeable aquifer over an impermeable boundary and a hydrologic gradient (Graf et al. 1987). The groundwater discharge at the head of many such canyons supports slope wetlands and is often the source of perennial streams. These areas saw increased use by Puebloan people in the 1300's when shifts in climate reduced the viability of their agriculture at lower elevations (Huckleberry and Duff 2008).

Basin and Range

The Basin and Range Province covers about 300,000 square miles of LRR D. Dohrenwend (1987) describes it as a "corrugated landscape" of alternating series of mountain ranges and broad, down-warping desert basins. The basins are partially filled with debris eroded from the adjacent mountain ranges. The mountain ranges, of which there are more than 400, consist of fault blocks lying generally on a north-south axis (Dohrenwend 1987). Most peaks are less than 10,000 ft in altitude and are approximately 3,000-5,000 ft above the floor of the adjacent basins. Some peaks exceed 13,000 ft (Hunt 1974).

Approximately 42,000 square miles of New Mexico are within two sections of the Basin and Range Province, the Mexican Highland Section and the Sacramento Mountains Section (Dohrenwend 1987; Hunt 1974). The major features of the Mexican Highland Section are well-defined mountains separated by wide valleys (Hunt 1974). The Sacramento Mountains Section occupies the southeastern part of LRR D in New Mexico to the west of the Great Plains Province. Principal features include mountain ranges (Gallinas, Jicarilla, Captain Mountains, and the Sacramento Range) and two large, topographically closed basins; the Estancia Basin in the north (occupying about 1,000 square miles) and the Tularosa Basin in the south (occupying about 3,000 square miles).

Annual precipitation in the Basin and Range of New Mexico ranges between 8 and 14 in. in the valleys and lower elevations, and from 15 to 30 in. in the mountains. Intense convective storms during the growing season bring most of the year's precipitation to the valleys and lower elevations of the Sacramento Mountains Section. In the Mexican Highlands Section, roughly half of the precipitation falls during summer storms from late spring to mid-autumn (USDA NRCS 2006). Average annual temperatures range from 50 to 71 °F in the southern areas, and from 36 to 44 °F in the mountainous areas (USDA NRCS 2006).

Perennial streams are scarce in the Basin and Range Province. Those present generally originate in mountainous areas. Smaller streams evaporate or infiltrate into alluvial fans at mountain bases or into the sediments of the basin after leaving the mountains. They are, however, an important means of aquifer recharge (Robson and Banta 1995).

In the mountains, groundwater often moves along faults or other discontinuities, and springs develop where these reach the surface (Hunt 1974), but the principal groundwater-bearing strata of the region are the basin fill formations between the mountain ranges. Basin aquifers are perched on top of impermeable rocks within the basin-fill sediments (Robson and Banta 1995). These may be confined locally if the basin is closed, or they may extend through several basins. Recharge to these basin aquifers may also occur when adjacent uplands contain volcanic formations sufficiently permeable to allow groundwater recharge directly (Robson and Banta 1995). Seeps and springs sometimes occur at the toe of alluvial fans where the gravel and coarse sands of a fan grade into the silts and clays of a basin. These and other areas in the desert where high groundwater promotes surface inundation, such as along headwater streams, support slope wetlands known locally as ciénegas (Minckley and Brunelle 2007).

Rio Grande Rift

A major feature of LRR D in New Mexico (and the North American continent) is the Rio Grande Rift (RGR) (Ingersoll et al. 1990). The RGR is part of a regional extension of Earth's lithosphere in the western United States, which began approximately 30 million years ago and includes the Basin and Range province (Ingersoll et al. 1990). The development of the RGR as distinct from the Basin and Range probably began during a second phase of extension approximately 10-16 million years ago (Keller and Baldridge 1999).

The RGR extends from near Leadville, Colorado through central New Mexico to Texas and Chihuahua, Mexico (Keller and Baldridge 1999; Olsen et al. 1987). The modern physiographic form of the RGR consists of interconnected, sediment-filled basins, underlain by half-grabens, lying along an axis that is generally coincident with the Rio Grande River (Keller and Baldridge 1999). The RGR in New Mexico occurs mainly within LRR D. It is narrowest in the northern portion of the state, bound on the west by the Colorado Plateau and on the east by the Sangre de Cristo mountains (Baldridge et al. 1994). The RGR widens south of Socorro, and is physiographically similar to the adjacent Basin and Range province to the west (Baldridge et al. 1991, Keller and Baldridge 1999; Olsen et al. 1987).

The RGR contains the most extensive wetland complexes in the state, the riverine wetlands (the riparian Bosque) of the Middle Rio Grande (Finch and Tainter 1995). Though these wetlands are highly modified from their natural state through centuries of irrigation, drainage, introduction of exotic species (Everitt 1998), and hydrologic modification through flood control reservoirs and channelization (Bhattacharjee et al. 2006), they remain critical to the region's economy and biodiversity (Finch and Tainter 1995). The RGR contains a an array of groundwater-driven systems, including hydrothermal springs of varying chemical composition (Goff et al. 1985, 1981; Rzonca and Schulze-Makuch 2003), numerous springs within the Rio Grande Gorge cutting through the Taos Plateau (Bauer and Johnson 2010, Kinzli et al. 2011), and saline groundwater discharge into the Rio Grande River system (Hogan et al. 2007).

LRR E Rocky Mountain Range and Forest Region

Southern Rocky Mountains

The Southern Rocky Mountains Province encompasses 45,920 square miles of LRR E. The province is centered in Colorado, which contains three-quarters of its area. About 7,100 square miles of the region is in New Mexico and consists of two mountain ranges flanking the northern portion of the Rio Grande Rift; on the east is the Sangre de Cristo Range and on the west are the Jemez Mountains, an extension of the San Juans.

Precipitation

Precipitation in the Southern Rocky Mountain Province is generally between 14 and 32 in. annually, though some areas may experience as little as 7 in. and some may receive more than 60 (USDA NRCS 2006). Precipitation is more evenly distributed throughout the year here than in the other provinces of New Mexico, though a bit more than half of it comes as snow with storms in winter. The mountain snowpack contributes to the maintenance of baseflow of streams as it melts over the summer. It is usually gone by August, though it may persist in a few, sheltered locations at high altitude (Robson and Banta 1995). Average annual temperatures range from 26 to 54 °F. Temperature and precipitation are strongly correlated with elevation; temperatures decrease and precipitation increases with elevation (USDA NRCS 2006).

Glaciers have probably been the greatest force modifying the Rocky Mountains (Madole et al. 1987). They sculpted the topography directly in the areas they covered, leaving behind cirques, moraines, hummocks, U-shaped valleys, and terraces of glacial till high above modern stream courses (Fawcett et al. 2002; Ray 1940). In the Southern Rocky Mountains of New Mexico, the glaciers were mainly confined to areas above 10,000 ft (Ray 1940), although their debris has been carried far below their furthest advance. Some has been carried into valleys of the Great Plains by large floods as the glaciers thawed during the waning of the glacial stages (Hunt 1974). The coarse sediments of the mountains, much of which originated from glacial activity, is today the most important control of fluvial processes of the intermountain basins (Madole et al. 1987).

Significance

The Southern Rockies are a small part of New Mexico geographically, but they are first in importance to the water economy of the state (Hunt 1974). They are the main source of water for the San Juan River on the west, the Canadian River to the east, and the Pecos and Rio Grande to the south (Robson and Banta 1995). These rivers are generally the only significant source of year-round surface water in the regions they cross, and without them, these areas could only support a sparse human population (Hunt 1974). The Middle Rio Grande, for example, was a center of Puebloan agriculture, and of the European settlement that followed, beginning with the Spanish (Finch and Tainter 1995) and is today the home of 40% of the state's population (Akasheh et al. 2008).

LRR G Western Great Plains and LRR H Central Great Plains

The Great Plains Province spans about 434,000 square miles (combining LRR G and LRR H) from Montana to Texas. New Mexico contains about 43,100 square miles of the province in three sections. The Raton Section in the northeastern portion of the state and the Pecos Valley Section in the center of the state occupy 34,300 square miles of LRR G. The High Plains Section occupies 8,800 square miles of LRR H.

Precipitation in the Great Plains of New Mexico ranges from 10 to 22 in. annually, but with wide fluctuations from year to year (USDA NRCA 2006). Most of the precipitation falls as rain during intense convective storms through the growing season. Winters generally bring light snowfall and rain. Average annual temperatures range from 46 to 58 °F, generally increasing from the northeast to the southwest.

Fundamentally, the Great Plains is a depositional environment of fluvial and eolian debris eroded from the adjacent uplift of the Rocky Mountains

(Osterkamp et al. 1987). In New Mexico, the surface morphology is distinctly different in the three sections of the province. The Raton Section is unique in the Great Plains in that it contains high mesas capped by lava flows, some standing 1,000 ft higher than the surrounding plains (Hunt 1974). The Pecos Valley Section arose from the dissolution of Permian-age evaporite beds by groundwater during the Miocene and early Pliocene Epochs, which contributed to the collapse and subsidence of overlying strata and the development of the Pecos River valley (Osterkamp et al. 1987). The subsequent incisement of the Canadian and Pecos River valleys captured the water and sediment supplies from the mountains to the west, denying them to the High Plains Section lying in New Mexico and Texas to the east (Hunt 1974, Osterkamp et al. 1987). The High Plains Section has, therefore, a poorly developed drainage network and remains a large, virtually featureless, nearly level undissected plateau of 31,000 square miles (Hunt 1974). What little drainage has developed occurs in narrow draws oriented to the southwest that are characterized by ephemeral streamflow (Osterkamp et al. 1987). Development of the geomorphic features of the High Plains of Texas and New Mexico, where fluvial erosion was limited, probably had a strong groundwater influence with substantial modification by eolian processes (Osterkamp et al. 1987). With almost no surface drainage network on the plateau, runoff collects in closed depressions, playas, and either evaporates or infiltrates to the aquifers (Osterkamp et al. 1987). Playas are virtually the only wetland type on the plateau, and are the characteristic feature of the High Plains Section. They are critically important to agriculture and their habitats contribute greatly to the region’s biodiversity (Haukos and Smith 1994).

3 Structure and Application of the New Mexico HGM Classification

Most classification systems for wetlands are based on the composition of plant communities, and secondarily on factors such as geology and geomorphic setting. Such vegetation-based systems are useful for many resource-management and inventory applications, and can be readily and consistently applied by natural resource professionals with a working knowledge of the common plant species of a region. However, vegetation-based classification systems also have certain disadvantages that HGM classification avoids. Because HGM focuses on abiotic factors, the classification of a unit of land does not change as the dominant vegetation changes with succession or management. Furthermore, certain plant species occur as dominants in a wide variety of geomorphic and hydrologic settings, so vegetation-based systems tend to lump together many sites that function very differently and develop differently over time. However, vegetation-based systems may be easier to apply when the principal source of water is not apparent. For example, it can be difficult to identify the predominant water source in a wetland where precipitation, occasional flooding from streams, and groundwater all play some role in maintaining wetland hydrology. Such situations commonly occur in New Mexico.

Approach

A highly detailed vegetation-based classification system is available for New Mexico: the *Handbook of Wetland Vegetation Communities of New Mexico, Volume I, Classification and Community Descriptions* (Muldavin et al. 2000). Muldavin et al. (2000) use a regional approach in their classification hierarchy, which was used in conjunction with the Land Resource Regions in Table 2 as the basis for an HGM/wetland plant community cross-reference for the entire state (Muldavin et al. (2000) Table A2). Although most vegetation-based classification systems focus on plant species composition, some are sufficiently detailed and descriptive of site conditions that landscape positions and hydrology can be inferred at a level appropriate to HGM classification. Cross-referencing such a detailed vegetation-based classification system with an HGM classification offers a significant advantage for recognizing HGM classes and subclasses in the field. The predominant vegetation is used to quickly identify the potential

HGM subclasses represented on a site, and then the detailed community type descriptions and additional field observations can be used to assign the site to the most appropriate HGM category.

Vegetation alliances in Table A2 were assigned to HGM classes (in some cases, multiple classes) based on descriptions given by Muldavin et al. (2000) and the wetland ecological systems descriptions by NatureServe (NatureServe 2009). Assignments relied primarily on the described land form and hydrology of community types, and used the descriptions of soils and associated vegetation to resolve ambiguity. For example, Muldavin et al. (2000) stated that communities of the Plains Cottonwood Alliance require frequent overbank flooding for establishment. One of the described communities, however, the Plains Cottonwood/Rubber Rabbitbush (*Populus deltoiddes-Chrysothamus nauseosus*) community, occurs on stream terraces that are rarely flooded (one to four times in a century) and also lacks hydric soils and groundwater. Since it lacks all wetland indicators except for the presence of *P. deltoides*, this community type was not used for classification purposes when this alliance was assigned to the HGM Riverine class. In other cases community types within an alliance are described as occurring in multiple landscape settings with varying soils and hydrology. In such instances, the alliance was assigned to more than one HGM class. The assignment of vegetation alliances in Table A1 and HGM subclasses in Table A2 is not intended to be comprehensive, but rather as a classification framework that can be refined.

It is important to note that the plant communities included in this classification system are considered to be wetlands because the site descriptions in the Handbook (Muldavin et al. 2000) and on the NatureServe website indicated that they typically or potentially occur in areas with wetland hydrology, hydric soils, and predominantly hydrophytic vegetation. However, including a particular plant community in this classification does not imply that it is necessarily a “jurisdictional wetland” under Section 404 of the Clean Water Act.

Considerations in applying and refining the classification

The descriptions of the natural regions of New Mexico within this report are general and are based mainly on literature dealing with the subject on a continental scale. Detailed regional treatment is beyond the scope of the report. However, the descriptions in the *Handbook of Wetland Vegetation Communities of New Mexico* (Muldavin et al. 2000) were sufficiently detailed to be useful for developing HGM wetland subclasses on this regional scale. The resulting subclasses presented here should be regarded as a starting point, and may need refinement to meet the needs of a particular purpose. Generally, HGM subclasses should be limited to situations where distinct functional or structural differences occur within a class. Subclasses should not be established simply to reflect successional changes in vegetation after a disturbance. In most cases, the best approach is to make only a limited number of a priori subclasses based on broad and obvious criteria, such as natural regions and landform origins. Subclasses can then be developed based on direct field observations across a broad range of settings.

A common difficulty encountered in HGM classification is that water sources are not always apparent or do not uniformly affect different parts of a wetland complex. For example, headwater streams often have a narrow floodplain adjacent to the channel, but overbank flooding is infrequent and does not have a significant influence on the character and function of an adjacent riparian wetland; instead, groundwater is the predominant water source. Such a site is most appropriately classified as a slope wetland. The influence of overbank flooding generally increases with the size of the watershed and at some point will dominate the character and function of downstream wetlands. These would appropriately be classified as riverine wetlands. Field indicators may be the only reliable means of assigning a classification to a particular site, including the presence or absence of particular plant species or flood debris, or the presence of fluvial features including layering of soils, sorting of silt, sand and gravel, abandoned channels, deposition, and scour.

Another common classification difficulty arises when wetlands occur as a complex, varying in water source or landform at a fine scale. For example, floodplain wetlands dominated by overbank flow are predominantly riverine in character and function, but often include depressional features. Small floodplain swales may pond precipitation and abandoned channels or may form ponds or oxbow lakes that have permanent deepwater areas fringed with emergent vegetation. In such instances, most HGM guidebooks do not treat them as individual wetlands, but classify the entire complex as riverine, and specifically acknowledge the common occurrence of depressional inclusions as a feature of the riverine subclass. Generally, splitting integrated wetland complexes into distinct units for classification and assessment is not useful and is contrary to their interconnected nature.

New Mexico HGM wetland classes and regional wetland subclasses

The subclasses presented in this report were developed from the wetland plant community descriptions of Muldavin et al. (2000). The first hierarchy of classification is New Mexico's natural regions (Table 2). The Physiographic Provinces of New Mexico (Hunt 1974) and the Land Resource Regions (Howe and Knopf 1991), and selected literature were used; the Colorado Plateau and the Basin and Range provinces of Hunt (1974) are located in LRR D, the Southern Rocky Mountains are in LRR E, and the Great Plains province occupies portions of LRRs G and H. Three natural regions were the result.

The next hierarchy used criterion specific to the major HGM classes. Gradient and lateral confinement (Carsey et al. 2003, Durkin et al. 1995) were used in defining two subclasses of riverine wetlands for each of the three regions. Salinity of water source was used for slope wetland subclasses and alkalinity of soils was used for depression wetland subclasses in each of the three regions (Minshall et al. 1989; Tomaso 1998). Finally, a montane regional subclass was identified for beaver impoundments due to their influence on fluvial processes (Butler and Malanson 1995). A dichotomous key to New Mexico HGM classes is presented in Figure 2. Keys to the regional subclasses (Figures 3, 7, and 12) are followed by photos of examples from within each region.

Key to the HGM wetland classes of New Mexico	
1. Wetland is associated with point bars or active floodplain of a stream and principal water source is the stream	Riverine
1. Wetland is not associated with point bars or active floodplain of a stream and principal water source is not the stream	2
2. Wetland is not in a topographic depression nor is it impounded	5
2. Wetland is in a topographic depression or it is impounded	3
3. Wetland is within a stream valley and is associated with a beaver impoundment or with a shallow man-made impoundment managed principally for wildlife (e.g. greentree reservoirs or moist soil units)	Riverine
3. Wetland is an impoundment or depression other than above	4
4. Wetland is associated with a water body that has permanent open water more than 2 m deep in most years	Fringe
4. Wetland is associated with a water body that is ephemeral, or less than 2 m deep in most years	Depression
5. Topography is flat, principal water source is precipitation	Flat
5. Topography is sloping to flat, principal water source is groundwater discharge or subsurface flow	Slope

Figure 2. Key to the HGM wetland classes of New Mexico.

Key to wetland subclasses of the Southern Rocky Mountains (LRR E) of New Mexico	
1. Wetland is associated with point bars or active floodplain of a stream and principal water source is the stream..	2
1. Wetland is not associated with point bars or active floodplain of a stream and principal water source is not the stream	4
2. Wetland is not associated with a beaver impoundment...	3
2. Wetland is associated with beaver impoundment	Montane Riverine Beaver Impoundment
3. Meandering of stream is controlled by colluvium, or stream is confined within a V-shaped valley or a canyon	Montane Confined Riverine
3. Meandering of stream is not controlled by colluvium, nor is stream confined within a V-shaped valley or a canyon. Gradient is low or moderate	Montane Meandering Riverine
4. Wetland is not in a topographic depression nor is it impounded..................................	5
4. Wetland is in a topographic depression or it is adjacent to an impoundment	6
5. Topography is flat and principal water source is precipitation	Montane Flat
5. Topography is flat to sloping and principal water source is groundwater	Montane Slope
6. Wetland is associated with a water body that is ephemeral, or less than 2 m deep in most years	7
6. Wetland water source is adjacent permanent open water > 2 m deep in most years...	Montane Lacustrine Fringe
7. Wetland is on mineral soil	Montane Mineral Soil Depression
7. Wetland is on organic soil	Montane Organic Soil Depression

Figure 3. Key to wetland subclasses of the Southern Rocky Mountains (LRR E) of New Mexico.

Figure 4. Montane Meandering Riverine Subclass. Cimarron River above Cimarron Canyon at approximately 8000 ft in elevation.

Figure 5. Montane Confined Riverine Subclass. Red River at an elevation of approximately 7600 ft, Sangre de Cristo Mountains.

Figure 6. Montane Slope Subclass. Bobcat Creek, at an elevation of about 9600 ft, Bobcat Pass, Sangre de Cristo Mountains.

Key to wetland subclasses of the Colorado Plateau, the Basin and Range , and the Rio Grande Rift (LRR D) of New Mexico	
1. Wetland is associated with point bars or active floodplain of a stream and principal water source is the stream...	2
1. Wetland is not associated with point bars or active floodplain of a stream or principal water source is not the stream	3
2. Meandering of stream is controlled by colluvium, or stream is confined within a V-shaped valley or a canyon	Intermountain Confined Riverine
2. Meandering of stream is not controlled by colluvium, nor is stream confined within a V-shaped valley or a canyon. Gradient is low or moderate	Intermountain Meandering Riverine
3. Wetland is not in a topographic depression nor is it impounded..........................	4
3. Wetland is in a topographic depression or it is adjacent to an impoundment	6
4. Topography is flat to sloping and principal water source is groundwater	5
4. Topography is flat and principal water source is precipitation	Intermountain Flat
5. Wetland water source is fresh	Intermountain Freshwater Slope
5. Wetland water source is saline	Intermountain Saline Slope
6. Wetland is associated with a water body that is ephemeral, or less than 2 m deep in most years	7
6. Wetland water source is adjacent permanent open water > 2 m deep in most years..	Intermountain Lacustrine Fringe
7. Wetland is on mineral soil	Intermountain Mineral Soil Depression
7. Wetland is on alkali/saline soil...	Intermountain Alkali Soil Depression

Figure 7. Key to wetland subclasses of the Colorado Plateau and the Basin and Range (LRR D) of New Mexico. (Mountainous areas of LRR D may be more appropriately considered with LRR E.)

Figure 8. Intermountain Meandering Riverine Subclass. Gila River near confluence of Little Creek, elevation is approximately 5700 ft.

Figure 9. Intermountain Confined Riverine Subclass. Rio Grande River, within the Rio Grande Gorge, near Questa, New Mexico. Intermountain Freshwater Slope subclass also occurs within the Rio Grande Gorge.

Figure 10. Intermountain Freshwater Slope Subclass. Seeps at base of a slope at the end of a ridge west of Williamsburg, NM at an elevation of approximately 4500 ft.

Figure 11. Intermountain Freshwater Slope Subclass. Water source is principally groundwater. Stream terrace along the Gila River at an elevation of approximately 5800 ft.

Key to wetland subclasses of the Great Plains (LRRs G & H) of New Mexico	
1. Wetland is associated with point bars or active floodplain of a stream and principal water source is the stream..........	2
1. Wetland is not associated with point bars or active floodplain of a stream or principal water source is not the stream	3
2. Meandering of stream is controlled by colluvium, or stream is confined within a V-shaped valley or a canyon	Great Plains Confined Riverine
2. Meandering of stream is not controlled by colluvium, nor is stream confined within a V-shaped valley or a canyon. Gradient is low or moderate	Great Plains Meandering Riverine
3. Wetland is not in a topographic depression nor is it impounded..........	4
3. Wetland is in a topographic depression or it is adjacent to an impoundment	6
4. Topography is flat to sloping and principal water source is groundwater	5
4. Topography is flat and principal water source is precipitation	Great Plains Flat
5. Wetland water source is fresh	Great Plains Freshwater Slope
5. Wetland water source is saline	Great Plains Saline Slope
6. Wetland is associated with a water body that is ephemeral, or less than 2 m deep in most years	7
6. Wetland water source is adjacent permanent open water > 2 m deep in most years..........	Great Plains Lacustrine Fringe
7. Wetland is on mineral soil	Great Plains Mineral Soil Depression
7. Wetland is on alkali/saline soil..........	Great Plains Alkali Soil Depression

Figure 12. Key to wetland subclasses of the Great Plains (LRRs G & H) of New Mexico.

Figure 13. Great Plains Freshwater Slope Subclass. Curtis Creek north of Maxwell, New Mexico. Elevation of approximately 6000 ft (note: if the dominant hydrology is overbank flow, this wetland would be in the Great Plains Meandering Riverine Subclass).

Figure 14. Great Plains Depression Subclass. Playa in Kiowa National Grassland. Elevation is approximately 6000 ft.

Figure 15. Great Plains Lacustrine Fringe Subclass. Water source is principally adjacent deep water. Maxwell National Wildlife Refuge, elevation of approximately 6000 ft.

Refinement of additional subclasses

Additional HGM regional subclasses beyond the scope of this report may be useful. These may include subclasses based on distinct differences such as elevation ranges (reported by Muldavin et al. (2000) and included in Table A2), whether a fringe wetland is associated with a man-made impoundment or natural waterbody, or whether an area was glaciated or not (Chadwick et al. 1997; Fawcett et al. 2002; Ray 1940). Other possible subclasses may be based on the chemistry of the source water, which can have a significant effect on vegetation (Cooper 1996).

The unique geology of the RGR, discussed briefly above, and the system-wide hydrologic modifications of wetland complexes within the RGR may be the strongest criteria for creating additional regional subclasses. Imposition of an unnatural hydrologic regime has such a profound effect on riverine wetland functions (Akasheh et al. 2008, Birken and Cooper 2006, Busch and Smith 1995, Durkin et al. 1995, Ellis 1995, Finch and Tainter 1995, Graf 2006, Howe and Knopf 1991) that comparison to a natural state is probably not valid, except when assessing the magnitude of departure from a natural state. Further, a subclass based on hydrologic modifications may be appropriate because of the size and significance of the riparian areas affected in New Mexico and also because such modifications are probably permanent. The varied human dependencies on the altered hydrologic regimes in place today would make efforts to return to natural hydrology extremely difficult and expensive. Figures 16 and 17 are photos from an area along the Middle Rio Grande, illustrating an Intermountain Meandering Riverine Subclass, but one that has a significantly altered hydrologic regime (Bhattacharjee et al. 2006).

Figure 16. Aerial view of the Bosque Del Apache National Wildlife Refuge. Main channel of the Rio Grande is in the lower right (southeast) part of the photo. Note the canal, levees, and water management units in the area west of the main river channel. This part of the floodplain no longer functions as a natural Intermountain Meandering Riverine Subclass wetland complex.

Figure 17. Photos from within the area of the Bosque Del Apache National Wildlife Refuge shown in Figure 16 (elevation is approximately 4500 ft).

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Appendix A: Cross-reference Tables for HGM Subclasses and Vegetation Communities

Table A1. Proposed HGM Subclasses cross-referenced with wetland vegetation communities.

HGM Subclass	Vegetation (Muldavin et al. 2000)
LRR G and H The Great Plains	
Great Plains Confined Riverine	Arizona Sycamore Alliance Bluestem Willow Alliance Common Spikerush Alliance Coyote Willow Alliance Narrowleaf Cottonwood Alliance Threesquare Bulrush Alliance
Great Plains Meandering Riverine	Baltic Rush Alliance Bluestem Willow Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Coyote Willow Alliance Emory Baccharis Alliance Reed Canarygrass Alliance Rio Grande or Plains Cottonwood Alliance Russian Olive Alliance Saltcedar Alliance Seepwillow Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance
Great Plains Flat	Arizona Walnut Alliance Russian Olive Alliance Saltcedar Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance Vine Mesquite Alliance
Great Plains Freshwater Slope	Arizona Walnut Alliance Baltic Rush Alliance Beaked Sedge Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Russian Olive Alliance Saltcedar Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance Vine Mesquite Alliance
Great Plains Saline Slope	Inland Saltgrass Alliance

HGM Subclass	Vegetation (Muldavin et al. 2000)
Great Plains Lacustrine Fringe	Beaked Sedge Alliance Baltic Rush Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Reed Canarygrass Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance
Great Plains Mineral Soil Depression	Saltcedar Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Reed Canarygrass Alliance Softstem Bulrush Alliance Spreading Yellowcress Alliance Threesquare Bulrush Alliance Vine Mesquite Alliance
Great Plains Alkali Soil Depression	Inland Saltgrass Alliance
LRR D Colorado Plateau and the Basin and Range	
Intermountain Confined Riverine	Bluestem Willow Alliance Common Spikerush Alliance Coyote Willow Alliance Narrowleaf Cottonwood Alliance Threesquare Bulrush Alliance
Intermountain Meandering Riverine	Arizona Alder Alliance Baltic Rush Alliance Bluestem Willow Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Coyote Willow Alliance Boxelder Alliance Emory Baccharis Alliance Fremont Cottonwood Alliance Goodding Willow Alliance Reed Canarygrass Alliance Rio Grande or Plains Cottonwood Alliance Russian Olive Alliance Saltcedar Alliance Seepwillow Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance
Intermountain Flat	Arizona Walnut Alliance Boxelder Alliance Russian Olive Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance

HGM Subclass	Vegetation (Muldavin et al. 2000)
Intermountain Freshwater Slope	Arizona Walnut Alliance Baltic Rush Alliance Beaked Sedge Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Fremont Cottonwood Alliance Netleaf Hackberry Alliance Russian Olive Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance
Intermountain Saline Slope	Inland Saltgrass Alliance
Intermountain Lacustrine Fringe	Baltic Rush Alliance Beaked Sedge Alliance Broadleaf Cattail Alliance Inland Saltgrass Alliance Reed Canarygrass Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance
Intermountain Mineral Soil Depression	Broadleaf Cattail Alliance Common Spikerush Alliance Inland Saltgrass Alliance Reed Canarygrass Alliance Saltcedar Alliance Softstem Bulrush Alliance Threesquare Bulrush Alliance
Intermountain Alkali Soil Depression	Inland Saltgrass Alliance
LRR E Southern Rocky Mountains (may also apply to mountainous areas of LRR D)	
Montane Riverine Beaver Impoundment	Baltic Rush Alliance Beaked Sedge Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Reed Canarygrass Alliance Threesquare Bulrush Alliance Water Sedge Alliance
Montane Confined Riverine	Blue Spruce Forested Wetland Alliance Bluestem Willow Alliance Common Spikerush Alliance Narrowleaf Cottonwood Alliance River Birch Alliance Thinleaf Alder Alliance Water Sedge Alliance

HGM Subclass	Vegetation (Muldavin et al. 2000)
Montane Meandering Riverine	Baltic Rush Alliance Beaked Sedge Alliance Bluestem Willow Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Coyote Willow Alliance Narrowleaf Cottonwood Alliance Reed Canarygrass Alliance River Birch Alliance Thinleaf Alder Alliance Threesquare Bulrush Alliance Water Sedge Alliance
Montane Flat	Blue Spruce Forested Wetland Alliance
Montane Slope	Baltic Rush Alliance Beaked Sedge Alliance Common Spikerush Alliance Diamondleaf Willow Alliance Threesquare Bulrush Alliance Wooly Sedge Alliance
Montane Lacustrine Fringe	Baltic Rush Alliance Broadleaf Cattail Alliance Common Spikerush Alliance Northern Mannagrass Alliance Reed Canarygrass Alliance Threesquare Bulrush Alliance Water Sedge Alliance Wooly Sedge Alliance
Montane Mineral Soil Depression	Broadleaf Cattail Alliance Common Spikerush Alliance Northern Mannagrass Alliance Reed Canarygrass Alliance
Montane Organic Soil Depression	Mud Sedge Alliance Water Sedge Alliance

Table A2. Wetland vegetation communities of New Mexico identified in Muldavin et al (2000) cross-referenced with HGM class and Land Resource Regions.

New Mexico Wetlands Vegetation Classification		HGM Classification = X Possible Alternative or Significant Inclusions =O							
Regional Group	Alliance (Number of Community Types)	Riverine	Slope	Depression	Fringe	Flat	Environment	Elevation, ft	LLR
Montane Rocky Mountain Needle-leaved Evergreen Forested Wetland	Blue Spruce Forested Wetland Alliance (2)	X	X				Mountain stream bars, riparian areas and terraces (flats).	7500-9100	E
Montane Interior Southwest Broad-leaved Deciduous Forested Wetland	Arizona Alder Forested Wetland Alliance (4)	X					cobble bars and side channels, frequent over-bank	5000-7250	D
Montane Rocky Mountain Broad-leaved Deciduous Forested Wetland	Boxelder Alliance (3)	X				X	Point bars and terraces	6500-7500	D
	Narrowleaf Cottonwood Alliance (9)	X				O	Point bars along unregulated, narrow, high-gradient perennial streams in the mountains and foothills	5650-8900	E,D,G
Lowland Interior Southwest Broad-leaved Deciduous Forested Wetland	Arizona Sycamore Alliance (3)	X				X	Point bars and terraces along lower montane canyons to broad lowland valleys	4300-5800	D
	Arizona Walnut Alliance (4)		X			X	Terraces and toe of slopes at the outer edge of floodplains	3500-7500	D,G

New Mexico Wetlands Vegetation Classification		HGM Classification = X Possible Alternative or Significant Inclusions =O							
Regional Group	Alliance (Number of Community Types)	Riverine	Slope	Depression	Fringe	Flat	Environment	Elevation, ft	LLR
	Fremont Cottonwood Alliance (8)	X	X			O	On point bars and terraces of low to moderate-gradient streams	3800-5800	D
	Goodding Willow Alliance (2)	X					Active floodplain of low-gradient streams	3250-3650	D
	Netleaf Hackberry Alliance (2)					X	High terraces in stream valleys, rarely flooded, hydrology is typically toe-slope seeps and springs	4500-6200	D
Lowland Plains/Great Basin Broad-leaved Deciduous Forested Wetland	Rio Grande or Plains Cottonwood Alliance (20)	X					Active floodplain and point bars of low-gradient streams	3550-6500	D,G,H
Lowland Exotic Broad-leaved Deciduous Forested Wetland	Russian Olive Alliance (4)	X				X	Altered Riverine hydrology	4775-5450	D,G
Alpine-Subalpine Rocky Mountain Scrub-Shrub Wetland	Diamondleaf Willow Alliance (1)		X			O	Alpine and subalpine slopes and broad, flat valleys	11,550	E
Montane Interior Southwest Broad-leaved Deciduous Scrub-Shrub Wetland	Bluestem Willow Alliance (6)	X					Active floodplain and new depositional surfaces	6100-7750	D,E,G

New Mexico Wetlands Vegetation Classification		HGM Classification = X Possible Alternative or Significant Inclusions =O							
Regional Group	Alliance (Number of Community Types)	Riverine	Slope	Depression	Fringe	Flat	Environment	Elevation, ft	LLR
Montane Rocky Mountain Broad-leaved Deciduous Scrub-Shrub Wetland	River Birch Alliance (1)	X					Moderate-gradient montane streams	7880	E
	Thinleaf Alder Alliance (4)	X					Active floodplain and depositional surfaces of moderate to steep-gradient montane streams	6300-8800	E
Lowland Western Broad-leaved Deciduous Scrub-Shrub Wetland	Coyote Willow Alliance (12)	X					Active floodplain, new depositional surfaces, sometimes abandoned channels and pools	3900-7000	D,E,G
Lowland Interior Southwest Broad-leaved Deciduous Scrub-Shrub Wetland	Emory Baccharis Alliance (4)	X					Active floodplains and depositional features of low-gradient, silt-laden streams	3550-4500	D,G
	Seepwillow Alliance (2)	X					Active depositional surfaces within and adjacent to the active channel of low-gradient streams	4500-4975	D
Lowland Exotic Needle-leaved Deciduous Scrub-Shrub Wetland	Saltcedar Alliance (8)	X		O	X	O	Low terraces and floodplains, particularly larger rivers that are regulated or otherwise modified. Also in playas and alkali flats.	3250-6100	D,G,H

New Mexico Wetlands Vegetation Classification		HGM Classification = X Possible Alternative or Significant Inclusions =O							
Regional Group	Alliance (Number of Community Types)	Riverine	Slope	Depression	Fringe	Flat	Environment	Elevation, ft	LLR
Alpine-Subalpine Rocky Mountain Persistent Emergent Wetland	Mud Sedge Alliance (1)			X			Occurs on floating mats of peat-high elevations of the Sangre de Cristo Mts	None given	E
Montane Western Persistent Emergent Wetland	Northern Mannagrass Alliance (1)			X	X		Margins of high-elevation, shallow catchment lakes; ponded year-long, dependant on snow-pack	>8,500	E
	Beaked Sedge Alliance (1)	X	X		X		Montane streams, spring-fed wet meadows, margins of beaver ponds	6000-9700	D,E,G
	Water Sedge Alliance (5)	X	O	X	X		Moist, sandy alluvial soils along cobble streams; margins of deepwater and peatlands	7000-11550	E
	Woolly Sedge Alliance (1)		X		X		Wet meadows and areas flat areas around deep water	8250	E
Lowland Western Persistent Emergent Wetland	Broadleaf Cattail Alliance (1)	X	O	X	X		Springs, margins of deepwater, backwater channels, generally requires ponding	3650-6720	D,E,G,H
	Softstem Bulrush Alliance (1)	X	X	X	X		Seeps and springs, sloughs, margins of deep-water, areas of prolonged ponding and saturated soils of floodplains	4850-6400	D,G,H

New Mexico Wetlands Vegetation Classification		HGM Classification = X Possible Alternative or Significant Inclusions =O							
Regional Group	Alliance (Number of Community Types)	Riverine	Slope	Depression	Fringe	Flat	Environment	Elevation, ft	LLR
	Threesquare Bulrush Alliance (5)	X	X	X	X		Active floodplain and depositional surfaces, abandoned channels that are permanently flooded, margins of deep water, spring-fed marshes	2925-7650 (majority at 5000-7000)	D,E,G,H
	Baltic Rush Alliance (5)	X	X		X		Floodplains and active depositional surfaces of moderate and low-gradient streams; fringes of ponds; wet meadows	4925-7840	D,E,G
	Common Spikerush Alliance (6)	X		X	X		On floodplains, margins of deepwater, spring-fed wet meadows and in playas	3600-6500	D,E,G,H
	Reed Canarygrass Alliance (2)	X		X	X		Sloughs, margins of deep-water, and ponded areas and saturated soils of floodplains	5500-7500	D,G,E
	Vine Mesquite Alliance (1)			X	X	X	Flats, swales, seeps, playas and playa lake margins	4925-5150	G,H
	Spreading Yellowcress Alliance (2)			X			Playas	5000-7000	G,H
	Inland Saltgrass Alliance (4)	X		X		X -alkali	Depositional surfaces and floodplains, terraces, alkali flats and closed basins	3450-4220	D,E,G,H

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14. ABSTRACT
This report presents a hydrogeomorphic (HGM) classification of the wetlands of New Mexico based on a broad division of natural regions within the state. Four Land Resource Regions (LRRs) that occur in New Mexico were used to develop the HGM classifications: Western Range and Irrigated Region, Rocky Mountain Range and Forest Region, Western Great Plains Range and Irrigated Region, and Central Great Plains Winter Wheat and Range Region. HGM wetland classes and regional wetland subclasses for New Mexico are presented. The report includes cross-reference tables for HGM subclasses and vegetation communities.

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16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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