THE HISTORICAL MONTE VISTA ECOSYSTEM

GEOLOGY AND GEOMORPHOLOGY

The SLV is the largest of a series of high-altitude, intermontane basins located in the Southern Rocky Mountains (Jodry and Stanford 1996). The SLV is part of the much larger Rio Grande Rift Zone that extends from southern New Mexico north through the SLV to its northern terminus near Leadville, Colorado (Chapin 1971, Bachman and Mehnart 1978). The SLV Basin is a compound graben depression that was down-faulted along the base of the Sangre de Cristo Mountains, which resulted from extensive block faulting during the Laramide Orogeny. The western side of the SLV, close to Monte Vista NWR, is bounded by the San Juan Mountains, which was created by extensive Tertiary volcanism about 22 to 28 million years before the present (BP) (McCalpin 1996). The Oligocene volcanic rocks of the San Juan Mountains slope gradually to the SLV floor where they are interbedded with alluvial-fill deposits (BLM 1991).

From the Pliocene to middle Pleistocene time, a large, high altitude lake, Lake Alamosa, occupied most of the SLV (Machette et al. 2007). This ancient lake accumulated sediments that are designated as the Alamosa Formation (Siebenthal 1906, 1910). Lake Alamosa existed for about three million years before it overtopped a low wall of Oligocene volcanic rocks in the San Luis Hills and carved a deep gorge that flowed south into the Rio Grande, entering at what is now the mouth of the Red River. Monte Vista NWR apparently was never within the ancient Lake Alamosa basin proper, but was near its western edge (Fig. 3). Santa Fe Pliocene and Miocene formations underlie the Alamosa Formation, which is in turn underlain by Echo Park alluvium and then Precambrian rocks (Fig. 4).

The Rio Grande enters the SLV near Del Norte, Colorado and flows to the southeast just northeast of Monte Vista NWR. The entry of the Rio Grande into the SLV created a large, low elevation, alluvial fan that extends south of Monte Vista, Colorado (Fig. 2). This fan is characterized as Quaternary-age younger alluvium with surficial deposits (Fig. 5) that overlie older Pleistocene Alamosa Formation coalescing alluvial fans and moderately well-sorted fluvial deposits near the valley margins that adjoin the San Juan Mountains (Fig. 3). Drainages including Rock, Spring, and Cat Creeks that originate from the San Juan Mountains historically flowed across Monte Vista NWR and deposited erosional sediments throughout their narrow floodplains (Fig. 6). A small alluvial fan created by the entry of Rock Creek onto the larger Rio Grande alluvial fan covers the western boundary of the Monte Vista NWR (Fig. 2). Another alluvial fan along the Alamosa River is present immediately to the south of Monte Vista NWR (MWH et al. 2005).

SOILS

About 30 distinct soil types are present on Monte Vista (Fig. 7). The distribution of soil series on Monte Vista NWR reflects the three major landforms of the region: the San Juan Mountain foothills, the large Rio Grande alluvial fan, and Spring, Rock, and Cat Creeks and associated floodplains. Soils generally are dominated by loamy sands, which cover much of the former salt desert shrub areas present on the Rio Grande alluvial fan (U.S. Department of Agriculture Soil Conservation Service) (SCS 1980). Some heavy loam and clay loam soils are present on Monte Vista NWR and indicate the presence of former wetland areas (SCS 1980). Cobbled and gravelly loams are present along relict stream courses and terrace edges.

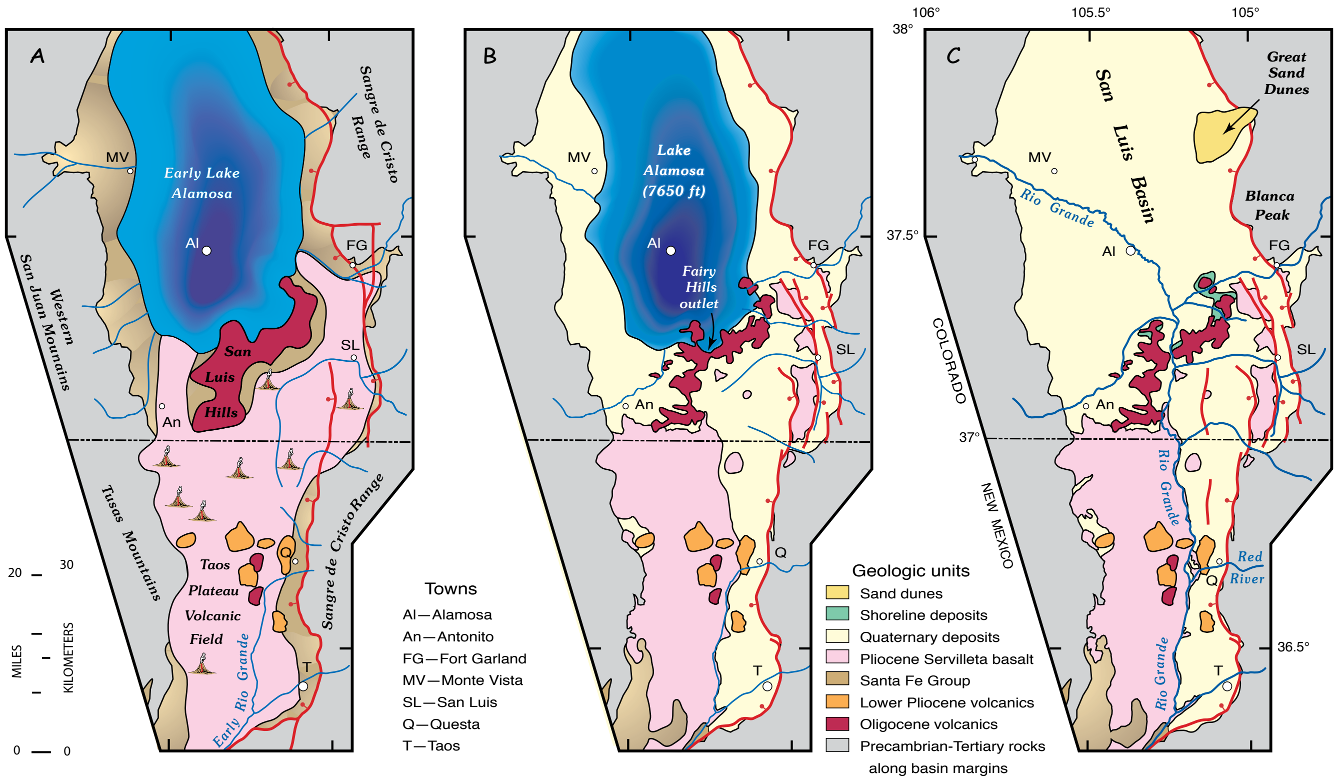

Figure 3. Simplified geological map of the San Luis Basin showing generalized geology and drainage patterns for the time intervals, A) 3.5-5 million years before the present (BP), B) 440,000 years BP, and C) current (from Machette et al. 2007).

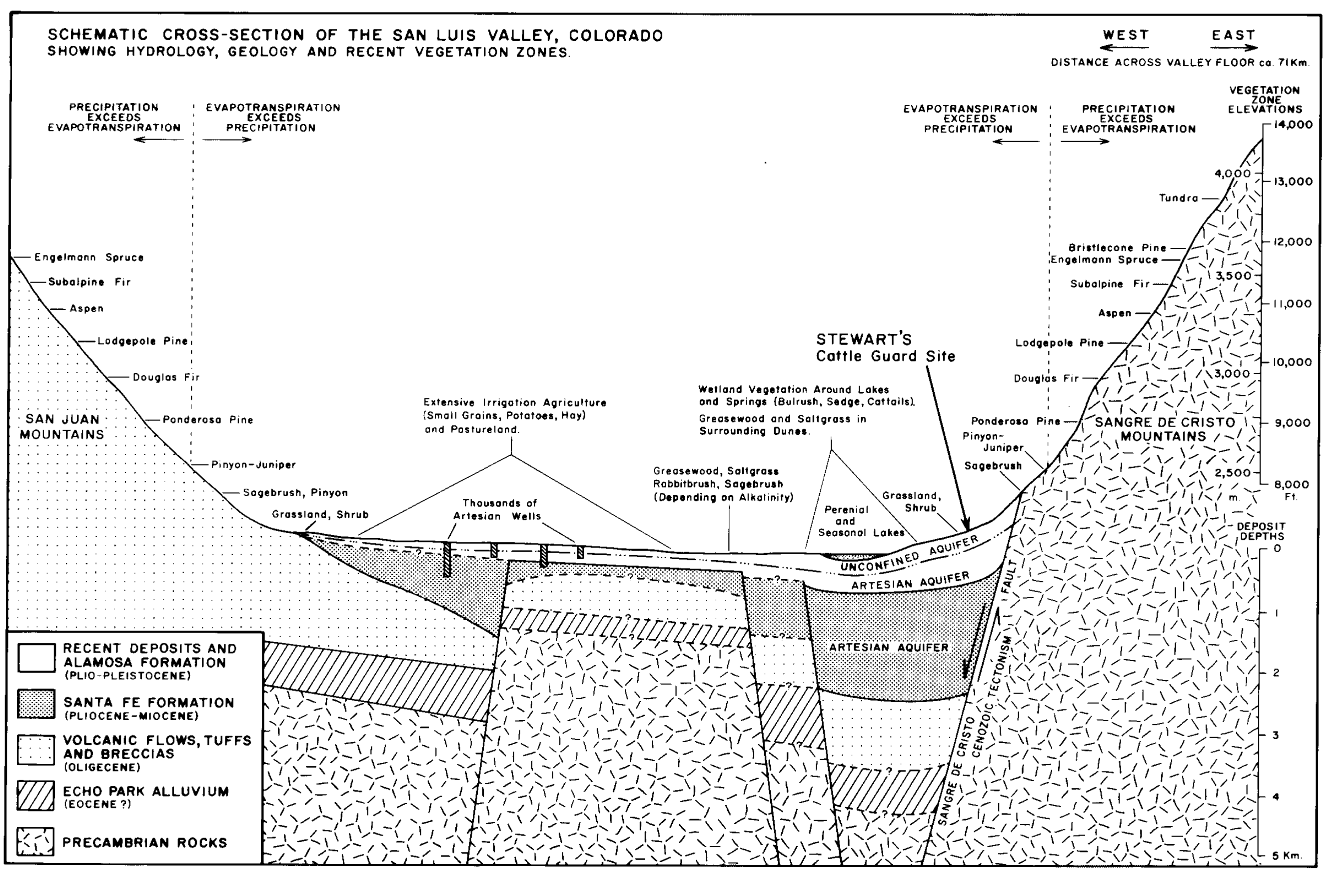

Figure 4. Schematic cross-section of the San Luis Valley (from Jodry and Stanford 1996).

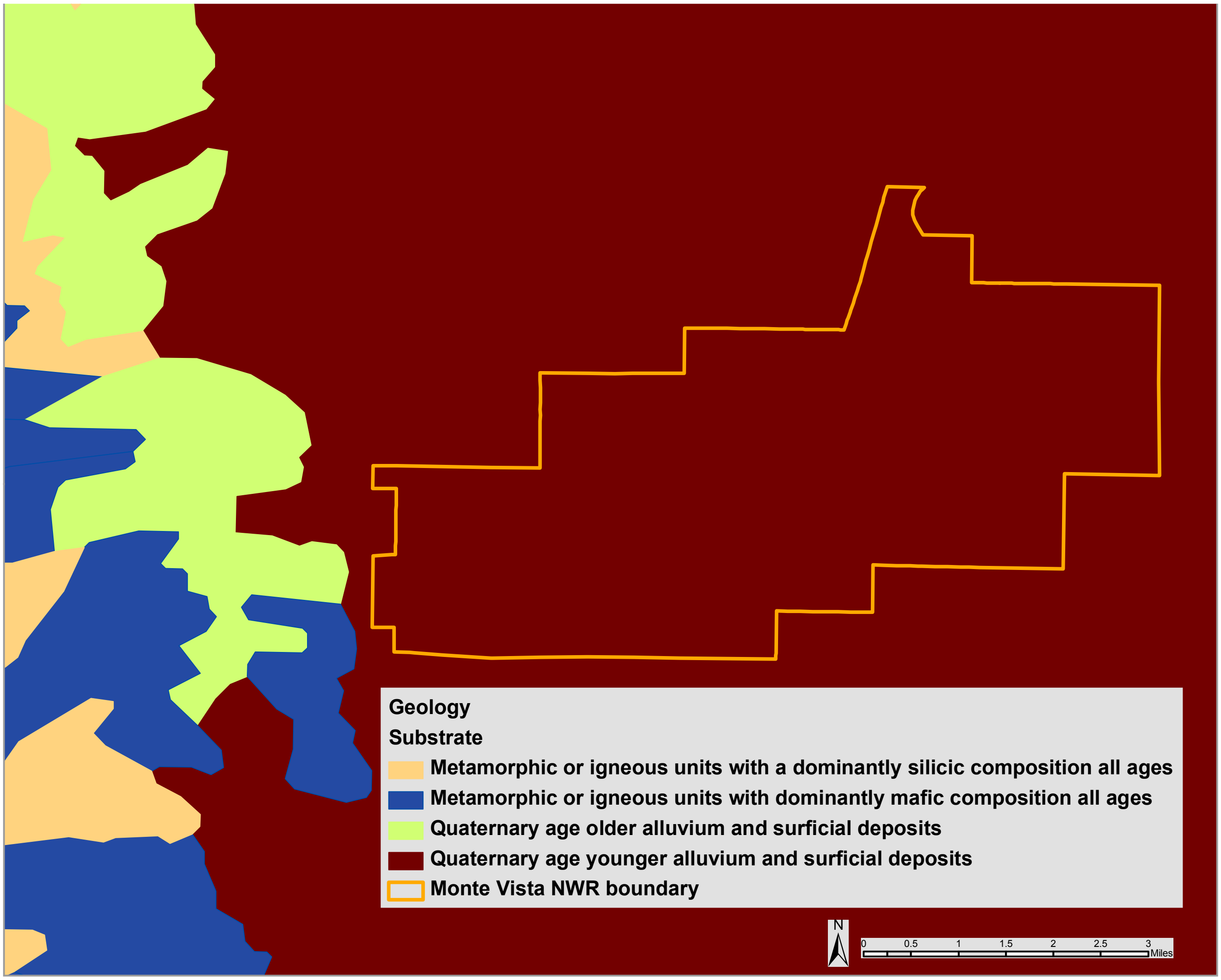

Figure 5. Surficial geology of the Monte Vista National Wildlife Refuge region (from USDA, Natural Resource Conservation Service, DataGateway site).

The San Juan Mountain foothills on the far west side of the refuge contain Luhon-Garita-Travelers Association soils (SCS 1980). These soils are well drained with coarse texture soils formed in mixed erosional alluvium and weathered basalt residuum. The Rio Grande alluvial fan is dominated by Hooper-Arena-San Luis Association soils; these soil types cover more area than other types on the refuge and are relatively flat (Table 1, SCS 1980). Hooper-Arena-San Luis soils were formed in mixed alluvium, often are alkaline, and contain loams about 20-60 inches deep that are underlain by sand and gravel layers. Alamosa loam, Gunbarrel loamy sand, San Arcacio sandy loam, Space City loamy sand, and Villa Grove sandy clay loam soils all have saline features. Torrifluvent-Torsido-Alamosa Association soils are intermingled on the refuge and formed in mixed alluvium. These soils occur in the historical floodplains of the small creeks on the refuge where surface water accumulated and deposited moderately-coarse to moderately-fine texture materials. These relict floodplain soils typically occur in depths of 10 to 60 inches over sand and gravel. Vastine clay loam soils reflect the presence of former wetlands that apparently had regular flooding based on redoxic features of the soil strata (SCS 1980). Vastine soils cover about 5.7% of Monte Vista NWR and are primarily mapped downstream of the confluence of the former Rock and Spring Creek channels; these soils provide a relative indication of the extent and distribution of more frequently inundated wetland locations on refuge lands. Acasco (4.0%), Torsido (3.5%), Mishak (1.5%), Alamosa (0.4%), and Typic fluvaquents (0.1%) soils total about 9.5% of Monte Vista NWR and indicate

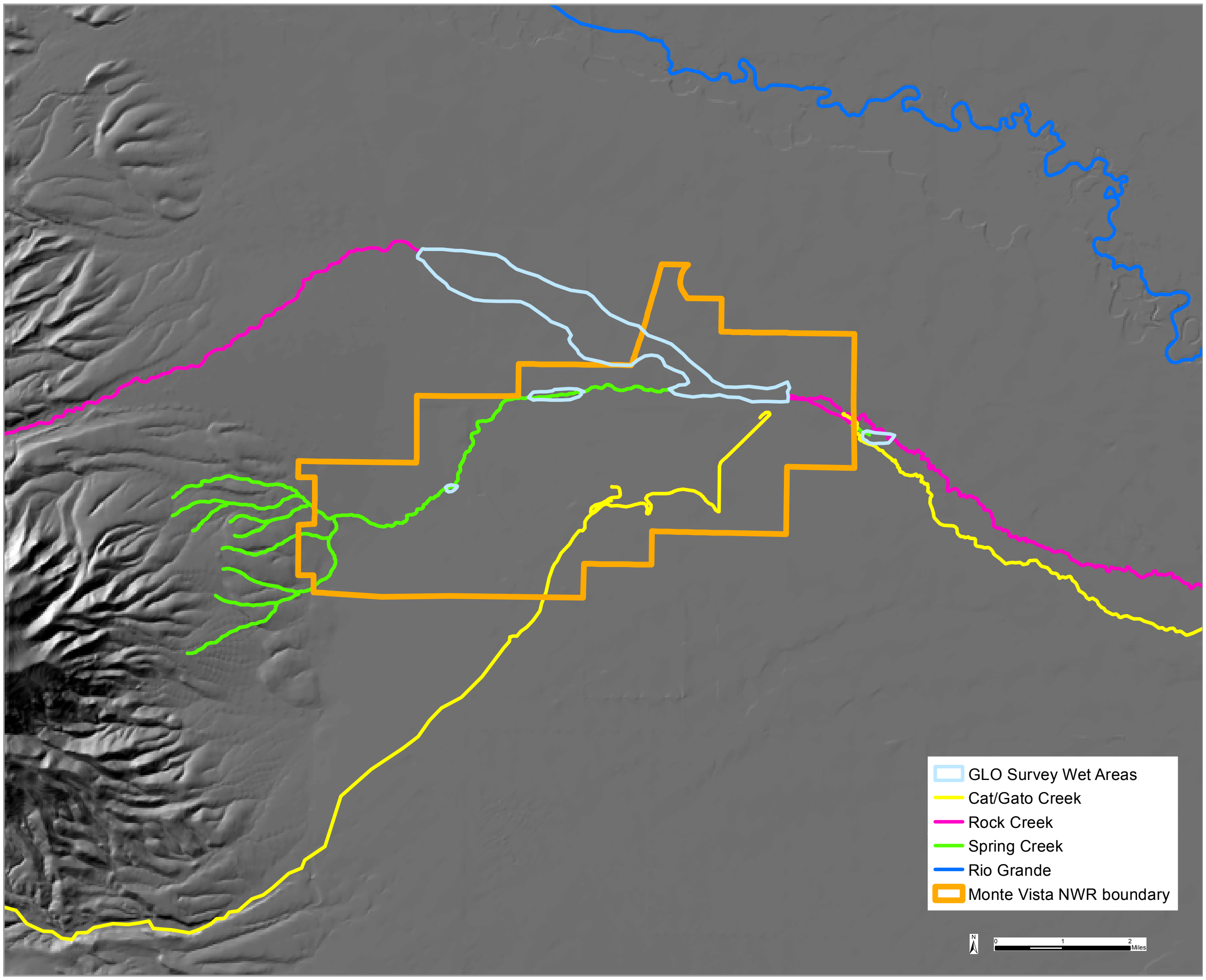

Figure 6. Location of major creeks flowing into and through Monte Vista National Wildlife Refuge.

locations of periodically flooded "wetland meadow" sites on the edges and adjacent to recent and former floodplains and overflow sites along Rock, Spring, and Cat Creeks (Table 1). Collectively, areas that at some point received flooding and were historical wetlands are indicated by soils mapped to about 15% of the current refuge area.

TOPOGRAPHY

The SLV is a large high elevation mountain valley averaging about 7,500 feet above mean sea level (amsl). Light Detection and Ranging (LiDAR) elevation surveys for the SLV region were flown in fall 2011 and data recently have been processed to produce 1 m resolution digital elevation model (DEM) maps for the refuge area (Fig. 8). Elevations on the refuge slope from 7,732 feet on the west boundary to 7,586 feet on the east boundary (Fig. 8). The LiDAR-DEM maps clearly identify the San Juan Mountain foothill area on the refuge (shown in red to yellow shading) that sharply transitions onto the large alluvial fan surface that covers the remainder of the refuge. The former creek and channel areas of Spring, Rock, and Cat Creeks also are distinguishable as are more subtle topographic features such as relict scour and deposition surfaces related to their historic fluvial dynamics (Fig. 9). Land depressions, indicated by marked changes in topography within the larger alluvial fan, suggest possible wetland depressions that historically occurred along the creek drainage corridors, especially in the confluence area of Spring and Rock creeks. The General Land Office (GLO) maps prepared from 1875 to 1880 also show

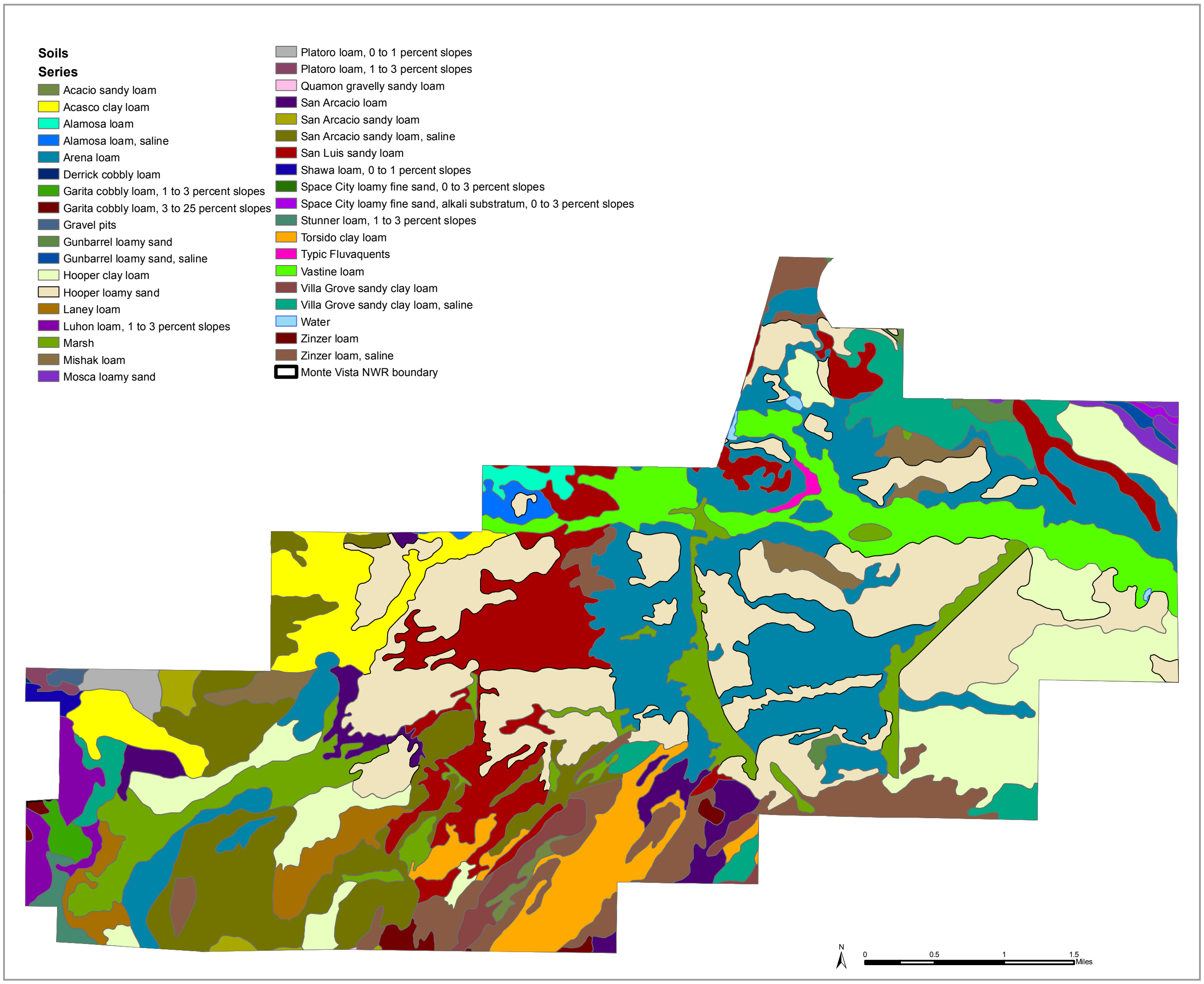

Figure 7. Soils on Monte Vista National Wildlife Refuge (from USDA SSURGO) datasets).

these wetland areas primarily along Rock Creek in the north-central part of the refuge (Fig. 10).

CLIMATE AND HYDROLOGY

The climate of the SLV is arid, with cold winters and moderate summers (Table 2). The Monte Vista area is in the pronounced rain shadow of the San Juan Mountains and receives about seven inches of precipitation per year (Table 3). About 60% of this precipitation occurs as rain in July and August. The source of summer moisture is the Gulfs of Mexico and California and is derived from monsoonal flow from the desert southwest. This monsoonal air moves north through Arizona and New Mexico into the SLV where no mountains obstruct the flow. Wide seasonal and annual variation in precipitation can occur in the SLV. Long-term precipitation data from Del Norte, Colorado west of Monte Vista NWR indicates annually dynamic patterns with frequent switches between dry (< 6 inches) and wet (> 12 inches) years (Fig. 11). Very dry periods in the long-term precipitation pattern for the period of record occurred in the early-1950s, the late-1970s, and the mid-2000s (Thomas 1963, Fig. 11). Generally, the long-term trend for total water year precipitation is increasing over time (Striffler 2012). Snow cover usually is sparse in the SLV and sometimes is completely lacking during much of the winter (BLM 1991). Mean annual temperature is 42° Fahrenheit at Del Norte. Temperatures of -20 to -30° Fahrenheit can be expected each year. The annual frost-free growing season averages about 90-100 days usually from late May through early September (SCS 1980), however wide annual variation occurs and July and August typically are the only consistent

Table 1. Soil types by acreage and percent (calculated from USDA SSURGO data).

Map Unit Name	Code	Acres	%
Hooper loamy sand	Ho	2,764.81	18.7%
Arena loam	Ar	2,296.01	15.6%
Hooper clay loam	Hp	1,375.78	9.3%
San Arcacio sandy loam, saline	Sc	1,225.74	8.3%
San Luis sandy loam	Sd	1,186.76	8.0%
Marsh	Ma	845.65	5.7%
Vastine loam	Va	839.25	5.7%
Zinzer loam, saline	Zr	762.62	5.2%
Acasco clay loam	Ac	587.28	4.0%
Torsido clay loam	To	517.34	3.5%
Villa Grove sandy clay loam, saline	Vh	490.81	3.3%
San Arcacio loam	Sa	319.07	2.2%
Laney loam	La	245.57	1.7%
Mishak loam	Mh	220.35	1.5%
Luhon loam, 1 to 3 percent slopes	LuB	176.00	1.2%
Villa Grove sandy clay loam, saline	Vg	155.34	1.1%
Platoro loam, 0 to 1 percent slopes	PaA	77.79	0.5%
San Arcacio sandy loam	Sb	67.75	0.5%
Mosca loamy sand	Ms	66.36	0.4%
Alamosa loam	Am	63.70	0.4%
Alamosa loam, saline	Ao	63.03	0.4%
Zinzer loam	Zn	59.07	0.4%
Gunbarrel loamy sand	Gs	56.05	0.4%
Stunner loam, 1 to 3 percent slopes	SrB	55.46	0.4%
Garita cobbly loam, 1 to 3 percent slopes	GaB	52.98	0.4%
Acacio sandy loam	Aa	34.90	0.2%
Shawa loam, 0 to 1 percent slopes	SmA	28.25	0.2%
Platoro loam, 1 to 3 percent slopes	PaB	22.05	0.1%
Typic Fluvaquents	Tt	20.87	0.1%
Gunbarrel loamy sand, saline	Gu	20.76	0.1%
Gravel pits	Gp	17.59	0.1%
Water	W	12.46	0.1%
Space City loamy fine sand, alkali substratum, 0 to 3 percent slopes	SpB	12.44	0.1%
Garita cobbly loam, 3 to 25 percent slopes	GaE	11.50	0.1%
Derrick cobbly loam	De	0.77	0.0%
Quamon gravelly sandy loam	Qa	0.54	0.0%
Space City loamy fine sand, 0 to 3 percent slopes	Snb	0.24	0.0%
Total		14,752.94	

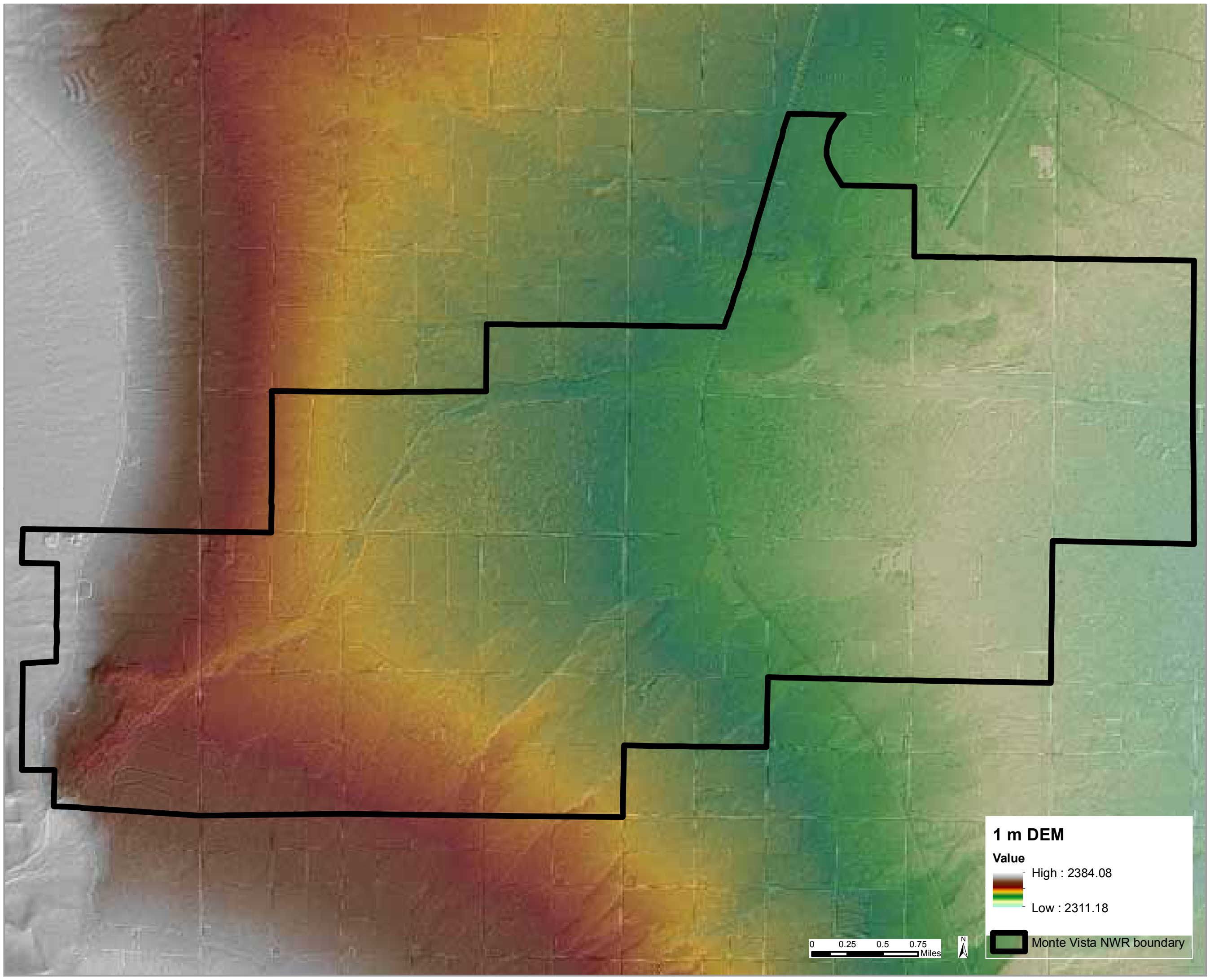

Figure 8. One meter DEM LiDAR elevations for Monte Vista National Wildlife Refuge.

completely frost-free months. Evapotranspiration (ET) rates at Monte Vista NWR typically are 45-50 inches per year (Leonard and Watts 1989, Ellis et al. 1993). A precipitation deficit (where potential ET exceeds precipitation) occurs every month of the year with the largest deficits occurring in June (Leonard and Watts 1989). Prevailing winds usually are from the south-southwest and light, although wind speeds of 40+ miles per hour can commonly occur in spring and early summer.

Historically, Monte Vista NWR received annual inputs of surface water primarily from limited onsite precipitation during summer and surface water drainage from Rock, Spring, and Cat Creeks (Striffler 2012). Rock Creek historically was fed primarily by snowmelt and rain runoff from the San Juan Mountains; it also received some groundwater discharge from local groundwater seeps and "springs." Sub-surface drainage likely contributed to the baseflow of the creek, but historical information on the seasonal and annual discharge dynamics of Rock Creek is limited. The original Rock and Spring Creek channels have been highly modified and currently carries water diverted from the Monte Vista Canal and irrigation return flow from hay fields irrigated from the Rio Grande Piedra Valley Ditch. Spring Creek, as its name implies, historically was primarily fed by a relatively large groundwater spring discharge "head" located in the southwest corner of Management Unit 19 (Figs. 6,12). Spring Creek also had small headwater drainages in the eastern San Juan Mountain foothills that coalesced at the Spring Creek discharge head point. This spring formerly produced groundwater discharges of up to 18 cubic feet/second (cfs) and water flowed east about 5.8 miles through the refuge and even-

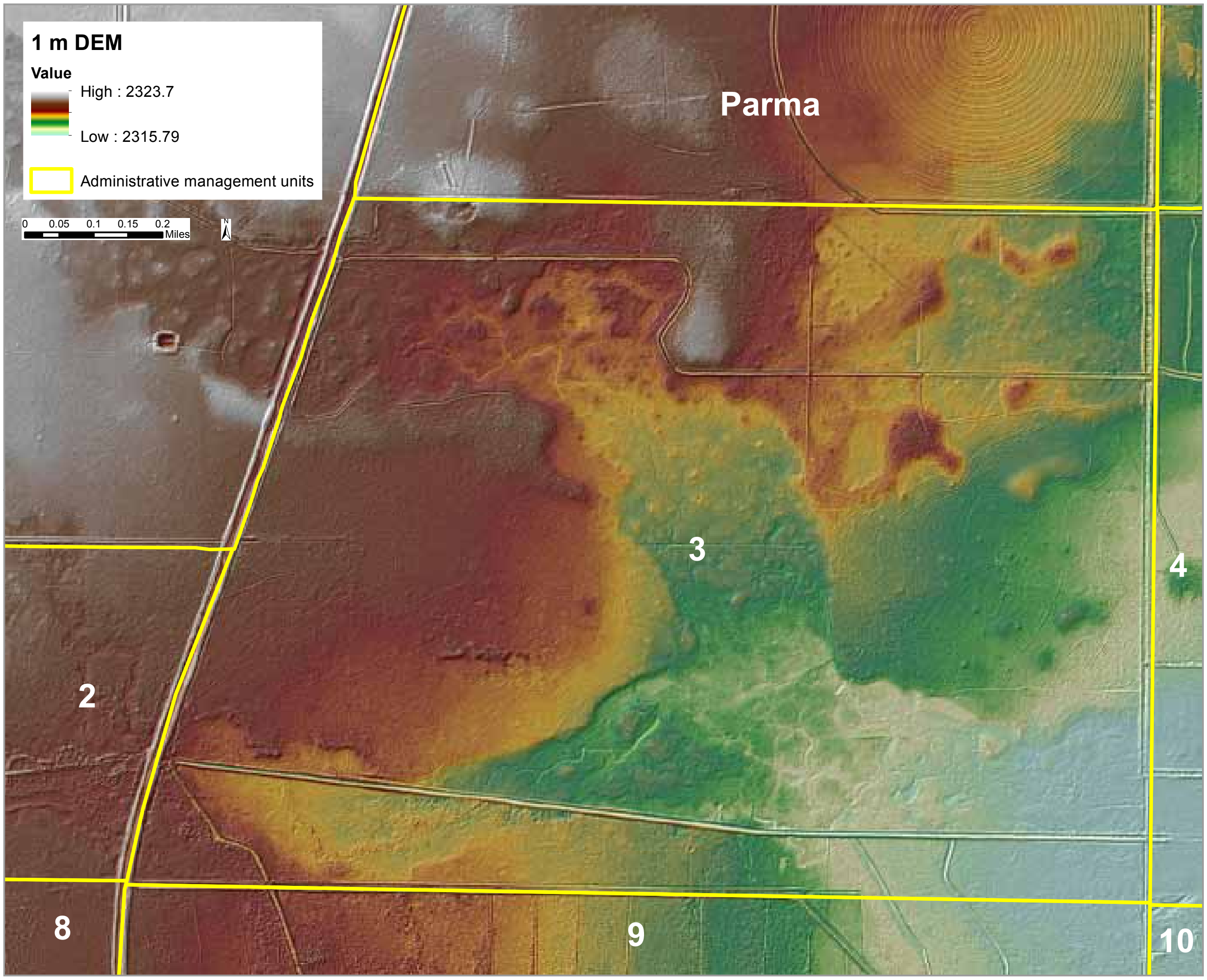

Figure 9. One meter DEM LiDAR elevations of Unit 3 in Monte Vista NWR.

tually joined Rock Creek along the eastern boundary of Unit 4 (Striffler 2012).

Early-1900s maps of the SLV (Siebenthal 1906, Clason 1910) indicate the presence of a small creek that originated in the San Juan Mountains south of Spring Creek that flowed northeast and ended in sections 9 and 10 of the southeast part of Monte Vista NWR (Fig. 6). The precise point where this creek ceased flowing is unknown. Apparently a ditch was dug in the late-1800s or early-1900s to irrigate meadow areas off of the creek; this ditch was subsequently ruled out of compliance and water rights were moved upstream by Terrace Reservoir. This ditch system off of the creek no longer exists, but its historic presence suggests some extension of creek flow or effect beyond the current Empire Canal. Siebenthal's map named this creek "Gato Creek", while Clason named the creek "Cat Creek." "Gato" is Spanish for the word "cat" and it is assumed the two differently named creeks are the same. Information on construction of a military wagon road from Alamosa to Pagosa Springs stated: "From Alamosa due west across the San Luis Valley, a natural road leads to Cat Creek, or El Rito de Gato, eighteen miles: and up the canyon of this creek and over a low divide, …" (Denver Daily Tribune 1878). From this account, it appears that "Cat" or "Gato" were both used as the name for this drainage. More recent USGS quadrangle map shows a "Cat Creek" as a parallel creek south of Rock Creek that joins Rock Creek in section 18 just southwest of the town of Alamosa. Neither Gato nor Cat Creek is identified on Monte Vista NWR in the 1800s GLO map (Fig. 10), but is noted as exiting the foothills southwest of the refuge. Regardless of name, the Gato/Cat Creek drainage apparently did flow into the south end of the current Monte Vista NWR, at least in the late-

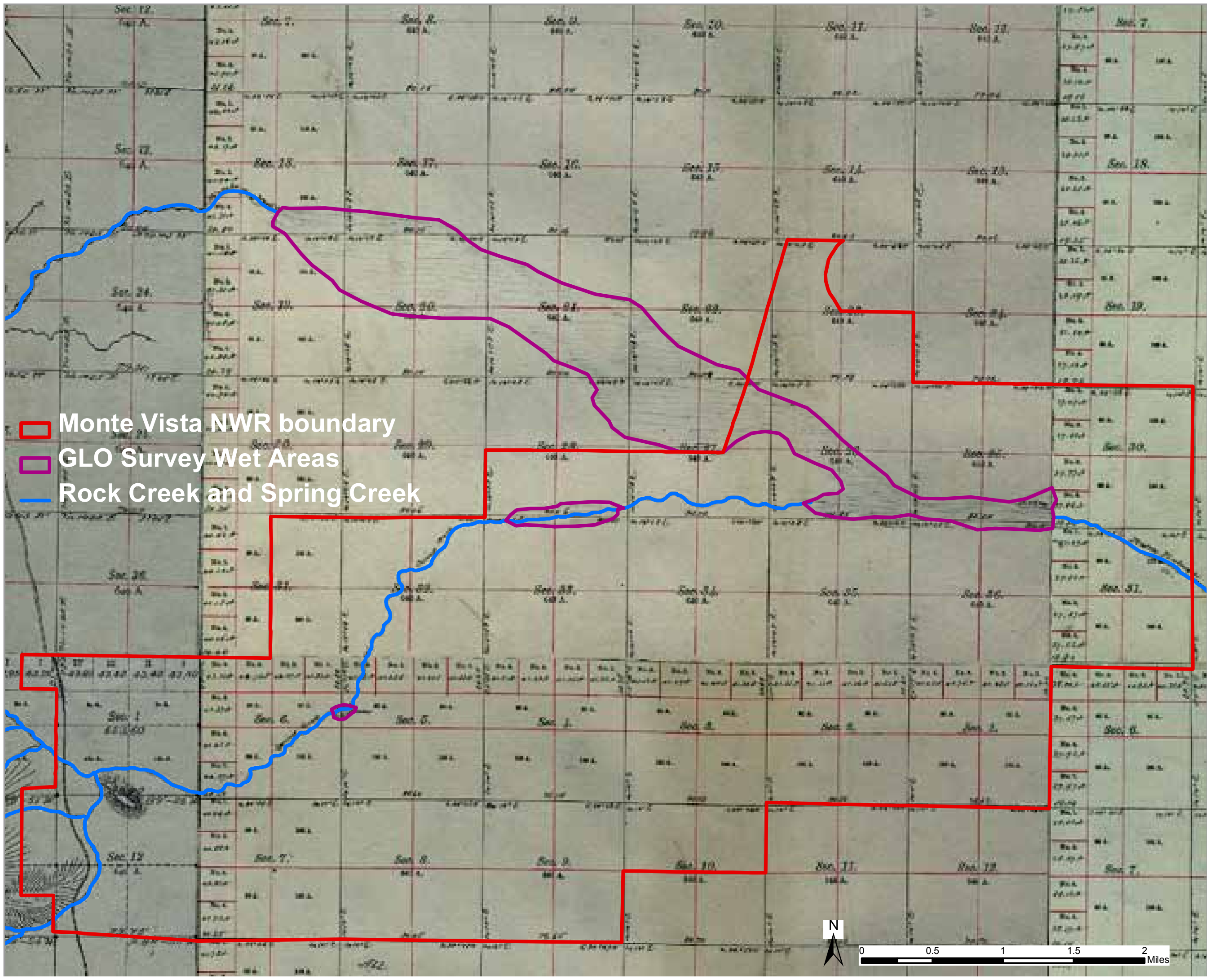

Figure 10. General Land Office map of the Monte Vista National Wildlife Refuge region.

1800s to early-1900s. The former existence of a creek at this location on Monte Vista NWR is corroborated in part by the presence of Acasco and Torsido clay loam "wetland type" soils in this area (SCS 1980, Fig. 7). Given the sporadic documentation of this creek in various reports, maps, surveys, and aerial photographs, it seems reasonable to assume that Cat Creek was an intermittent stream that contained surface water flow during peak seasonal runoff periods and during wetter years. This "intermittent" hypothesis might account for the disappearance of the creek in the southern portion of the refuge and its re-emergence south of Rock Creek to the east. Further, its absence from the GLO and other documents in the Monte Vista NWR area may reflect drought or dry seasons when the GLO survey occurred.

The modern floodplain of the Rio Grande does not extend into Monte Vista NWR, but historical high river flows may have occasionally slowed the drainage from the Spring-Rock Creek system and caused a small amount of backwater flooding up these creeks (Follansbee et al. 1915). However, no reference was located that indicates wide-spread flooding occurred historically on Monte Vista NWR lands from either overbank creek flows or backwater flooding from the Rio Grande (Striffler 2012). Unfortunately, no long-term gauge data are available for either Spring or Rock Creek. The existing gauge data on Rock Creek covers a 20 year period from 1935 to 1955 and indicates that peak flows typically occur in May, which contributes to the peak in Rio Grande flows in June (USGS monthly stream gauge data). Long-term precipitation data from the broader SLV region suggests an alternating wet-dry regional precipitation and river flow pattern. We assume that annual long-term variation in creek flows followed

Table 2. Temperature data from 1971-2000 at Alamosa Bergman Field, CO (from National Climatic Data Center, www.ncdc.noaa.gov).

Temperature (˚F)																					
Mean (1)				Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	33.1	-3.7	14.7	62	1971	20	25.6	1999	-41	1963	13	.6	1984	1551	0	.0	.0	2.0	13.7	31.0	18.5
Feb	40.2	4.7	22.5	66	1986	25	33.3	1995	-30+	1989	7	9.4	1979	1189	0	.0	.0	6.2	5.9	28.2	9.1
Mar	49.6	15.8	32.7	73+	1989	10	37.3	1999	-20	1964	4	26.1	1984	985	0	.0	.0	16.4	.8	30.6	1.0
Apr	58.7	22.8	40.8	80	1989	20	47.0	1992	-6	1973	8	35.5	1983	719	0	.0	.0	24.7	.1	27.0	.1
May	68.3	32.4	50.4	89	2000	29	55.2	1996	11	1967	1	46.2	1983	451	0	.0	.0	30.2	.0	13.7	.0
Jun	78.4	40.4	59.4	95	1994	26	62.4	1981	24	1990	2	56.0	1983	169	7	.0	.5	30.0	.0	1.8	.0
Jul	81.7	46.4	64.1	96	1989	5	66.7	1980	30	1997	2	62.1	1995	47	27	.0	.8	31.0	.0	@	.0
Aug	78.9	45.2	62.1	90	1977	7	64.7	1995	29	1964	21	58.3	1974	91	10	.0	@	31.0	.0	.1	.0
Sep	72.5	36.5	54.5	87+	1990	13	57.9+	1998	15+	1999	29	51.5	1985	302	0	.0	.0	29.9	.0	7.2	.0
Oct	61.7	23.9	42.8	81	1979	7	45.9	1992	-9	1991	31	39.1	1976	675	0	.0	.0	27.5	.3	27.0	.1
Nov	45.7	11.1	28.4	71+	1980	10	34.1	1998	-30	1952	27	17.8	1972	1082	0	.0	.0	12.2	3.9	29.5	4.3
Dec	34.8	-.7	17.1	61	1958	8	27.4	1980	-42+	1978	8	4.9	1991	1475	0	.0	.0	2.2	11.5	31.0	15.6
Ann	58.6	22.9	40.8	96	Jul 1989	5	66.7	Jul 1980	-42+	Dec 1978	8	.6	Jan 1984	8736	44	.0	1.3	243.3	36.2	227.1	48.7

trends in annual precipitation amounts (see Fig. 11 and discussion in McGowan and Plazak 1996).

The thick basin-fill deposits of interbedded clay, silt, gravel, and volcanic rock form two main aquifers (confined and unconfined) in the SLV (Burroughs 1981, Wilkins 1998, Hanna and Harmon 1989). The two aquifers are separated by a confining layer of discontinuous clay beds and volcanic rocks (Fig. 13, Emery et al. 1973). The unconfined alluvial aquifer underlies Monte Vista NWR to a depth of about 40+ feet. On the west side of the SLV the majority of the unconfined aquifer is comprised of Lower Alamosa and the Los Pinos geological strata formations. Hydraulic conductivity of the unconfined aquifer can range from 35 to 235 feet/day, with the highest values near the western edge of the SLV (Hanna and Harmon 1989). Natural recharge to the unconfined aquifer occurs from infiltration of local precipitation along the margins of the SLV, infiltration of surface water from natural stream channels (i.e., Rock and Spring Creeks), inflow of groundwater from the adjacent San Juan Mountains, and upward leakage of groundwater through the confining bed (Powell 1958, McGowan and Plazak 1996). Recharge of the unconfined aquifer is strongly affected by annual changes in runoff from the surrounding mountains, which is a function of annual snowpack and melting dynamics. Discharge from the unconfined aquifer includes ET, groundwater discharge to streams and creeks, and some groundwater flow to the south.

The confined aquifer occurs below the unconfined alluvial aquifer and consists of an active and passive zone (Fig. 13). At the periphery of the SLV, the unconfined and active confined aquifers are directly connected hydraulically. Recharge to the active confined aquifer takes place, in part, through the unconfined aquifer at these locations. The active confined aquifer is up to 4,000 feet below the land surface. Recharge to the confined aquifer occurs along the margins of the SLV from infiltration of precipitation, infiltration of surface water, and inflow of groundwater from the adjacent San Juan Mountains. Discharge from the confined aquifer occurs as groundwater flow to the south and upward leakage through the confining bed. A generalized schematic of hydrologic flow in the San Luis Valley (including current modifications and management) is provided in Fig. 14.

PLANT AND ANIMAL COMMUNITIES

Historically, an upland grassland or "under-shrub-grassland" xeric community dominated the San Juan Mountain foothills on the far west side of the refuge. A salt desert shrub community dominated the large Rio Grande alluvial fan that extended east from the San Juan Mountains to the Rio Grande floodplain and SLV floor (Hayden 1873; Hanson 1929; Ramaley 1929, 1942; Har-

Table 3. Precipitation data from 1971-2000 at Alamosa Bergman Field, CO (from National Climatic Data Center, www.ncdc.noaa.gov).

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med- ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	.25	.23	.33+	1974	1	.75	1979	.00+	1998	3.8	.9	.0	.0	.00	.03	.08	.12	.16	.21	.26	.32	.40	.53	.66
Feb	.21	.21	.88	1963	10	.77	1997	.00	1999	3.8	.7	.0	.0	.01	.03	.06	.09	.12	.16	.21	.26	.34	.46	.59
Mar	.46	.38	1.15	1992	4	1.62	1992	.03	1971	5.4	1.5	.1	@	.05	.09	.15	.22	.29	.36	.45	.56	.71	.96	1.20
Apr	.54	.42	1.22	1952	20	1.72	1990	.00	1972	5.1	1.6	.2	@	.02	.07	.15	.22	.31	.40	.52	.66	.85	1.17	1.49
May	.70	.70	.86	1967	26	1.85	1973	.01+	1998	6.1	2.3	.3	.0	.03	.06	.14	.23	.34	.47	.63	.84	1.13	1.63	2.14
Jun	.59	.58	1.02	1969	16	1.26	1995	.00	1980	5.4	1.9	.1	.0	.05	.11	.20	.29	.38	.48	.59	.73	.92	1.22	1.51
Jul	.94	.77	1.56	1971	18	2.59	1971	.02	1994	8.5	2.6	.2	@	.10	.17	.30	.43	.57	.73	.92	1.15	1.47	2.00	2.52
Aug	1.19	.98	1.31	1993	27	5.40	1993	.21	1980	10.1	3.6	.4	.1	.25	.36	.54	.70	.85	1.02	1.22	1.45	1.75	2.23	2.69
Sep	.89	.81	1.77	1959	30	1.85	1982	.19	1978	6.4	2.8	.3	.0	.21	.30	.43	.54	.66	.78	.92	1.08	1.29	1.63	1.95
Oct	.67	.52	.89	1969	11	2.16	1972	.00+	1995	4.8	2.1	.3	.0	.00	.07	.18	.29	.40	.52	.66	.83	1.07	1.46	1.83
Nov	.48	.44	.71	1981	7	1.23	1991	.00+	1999	4.4	1.5	.1	.0	.00	.04	.12	.20	.28	.37	.47	.60	.77	1.06	1.34
Dec	.33	.19	.91	1964	3	.99	1983	.00+	1996	4.0	1.1	.1	.0	.00	.02	.06	.11	.17	.23	.31	.41	.54	.78	1.01
Ann	7.25	7.18	1.77	Sep 1959	30	5.40	Aug 1993	.00+	Nov 1999	67.8	22.6	2.1	.1	4.80	5.27	5.86	6.32	6.73	7.13	7.55	8.01	8.58	9.40	10.12

Snow (inches)

Snow Totals															Mean Number of Days (1)								
Means/Medians (1)					Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	4.6	3.3	2	1	6.4	1974	1	17.8	1974	10+	1992	31	10	1992	4.1	1.4	.4	.2	.0	16.2	8.6	6.0	.9
Feb	2.7	2.5	1	1	3.5	1971	3	7.0	1987	10+	1992	20	9	1992	3.6	1.1	.1	.0	.0	9.0	4.6	3.1	.4
Mar	5.9	4.1	#	1	12.0	1992	4	29.2	1973	11	1992	5	3	1992	4.9	2.0	.4	.2	.1	3.6	1.2	.6	@
Apr	3.7	3.2	#	0	9.0	1990	30	9.2	1990	5+	1987	13	#	2000	2.7	1.0	.4	.2	.0	.9	.2	.1	.0
May	2.1	.1	#	0	8.4	1973	6	13.5	1978	4	1978	5	#	2000	1.3	.7	.2	.1	.0	.3	@	.0	.0
Jun	.0	.0	#	0	.2	1983	13	.2	1983	#	1990	9	#	1999	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	#	0	.0	0	0	.0	0	#+	1990	26	#	1997	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.1	.0	0	0	1.2	1971	18	1.2	1971	#	1973	26	0	0	.1	.1	.0	.0	.0	.0	.0	.0	.0
Oct	3.0	.5	#	0	13.1	1991	30	15.1	1991	12	1991	31	1	1991	1.3	.7	.3	.2	.1	.8	.2	.1	@
Nov	4.7	3.7	1	0	8.0	1985	14	19.8	1972	12	1972	1	4	1972	3.6	1.4	.5	.1	.0	5.4	2.6	.9	@
Dec	5.1	4.9	1	1	9.6	1978	6	12.1	1978	10+	1991	27	6	1991	4.3	1.6	.5	.2	.0	12.6	6.8	2.6	.2
Ann	31.9	22.3	N/A	N/A	13.1	Oct 1991	30	29.2	Mar 1973	12+	Oct 1991	31	10	Jan 1992	25.9	10.0	2.8	1.2	.2	48.8	24.2	13.4	1.5

rington 1954). Relatively narrow creek channels and their floodplains bisected the alluvial fan and contained narrow bands of wetland habitat. The GLO maps and survey notes indicate that most wetlands occurred along Rock Creek and at the junction of Spring and Rock Creeks in the northern part of Monte Vista NWR (Fig. 10). As previously mentioned, Cat Creek flowed intermittently into the south part of the refuge (Fig. 6) where it apparently dissipated and created a wet meadow/seasonal wetland area.

Vegetation in the SLV historically was highly influenced by the relatively low, but intense, amounts of late summer rainfall that usually occurred as thundershowers (Ramaley 1929, 1942). Most annual plants in the SLV germinate and grow, and most perennial plants flower, during the late summer (Carsey et al. 2003). Generally, little new plant growth occurs in the SLV before June because freezing weather continues through most of May and light frosts are likely to occur into early June. The surface soils in the SLV, outside of creek-riparian areas, usually are

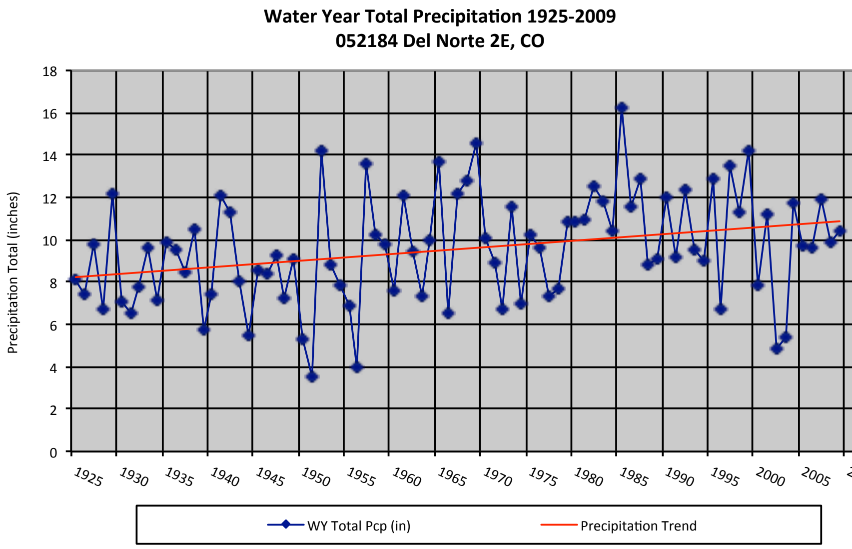

Figure 11. Total water year precipitation (inches) for Del Norte, CO, 1925-2009 (from Striffler 2012).

dry until early summer because little precipitation occurs in winter and early spring. Even if soils are not dry in spring the cold temperatures prevent plant germination until June.

The extensive salt desert shrub community at Monte Vista NWR and throughout the floor of the SLV was present on mixed alluvium soils and contained primarily greasewood (*Sarcobatus vermiculatus*), rubber rabbitbrush (*Ericameria nauseosa*), shadscale (*Atriplex canescens*), alkali sacaton (*Sporobolus airoides*), and saltgrass (*Distichlis spicata*) (Ramaley 1942). Scattered sagebrush (*Artemsia tridentata*) was present in transition areas between salt desert shrub and foothill "undershrub" grassland habitats. Soils in salt desert shrub areas typically are poorly drained and historically groundwater tables were relatively close to the surface (Cronquist et al. 1977). Even slight differences in elevation of a few inches can alter drainage and can cause ephemeral or seasonal surface water "ponding", which creates significant variation in soil salinity and consequently heterogeneity in plant species occurrence. For example, excess alkali occurs when water tables are close to the ground surface, especially in shallow depressional "pool" areas; these small depression sites typically contain saltgrass, chairmaker's rush (*Scirpus pungens)*, foxtail barley (*Hordeum jubatum)*, alkali muhly (*Mulhenbergia asperifolia*), and several other sedge and rush species (Ramaley 1942). Where alkali is extremely high, "chico slick spots" that consist of barren salt flats are typical within scattered greasewood clumps. Generally more saline subhabitats within the salt desert shrub area can be determined by salinity of soils (SCS 1980, Fig. 7). Tussocks of alkali sacaton occur between shrubs, but ground cover generally is sparse with substantial amounts of bare ground present. In a few areas, short wind-formed ridges are present in salt desert shrub communities and they typically support rabbitbrush where greater aeration of roots can occur. Many herbaceous species are present in the salt desert shrub habitats, including scattered grasses, sedges, rushes, and legumes with individual species presence reflecting soil aeration, seasonal ponding of water in small depressions, and depth to groundwater (e.g., Ramaley 1942).

The outer margin of salt desert shrub habitats changes from a greasewood dominated plant assemblage to an "undershrub-grama grass" community in valley-margin foothill areas (Ramaley 1942). These sites, which also have been called "limy bench" or "mountain outwash" areas (SCS 1980) are dominated by blue grama (*Bouteloua gracilis*), winterfat (*Eurotia lanata*), rabbitbrush, Indian ricegrass (*Acnatherum hymenoides*), and snakeweed (*Gutierrezia sarothrae*). Yucca (*Yucca glauca)* sometimes is present in these foothill areas as is buckwheat (*Eriogonum* spp.). Processes such as soil creep and overland flow associated with the formation of alluvial fans where the Rio Grande and small creeks exited the San Juan Mountains into the SLV distributed sediments differentially across the fan (SCS 1980, Burroughs 1981). This transfer of material influences soil structure, chemistry, infiltration, and percolation on the fans and adjacent foothill slopes. Shrubland community composition and structure varies based on these changes and also helps further change soil characteristics existing immediately below an individual shrub and the adjacent bare soil (Bedford and Small 2007). Soils in upland foothill sites are characterized by Luhon-Garita-Travelers association coarse-texture types and the groundwater table is much deeper than in the SLV floor areas (SCS 1980). Snakeweed and rabbitbrush usually are present on higher, drier sites, whereas sagebrush occupied areas with finer-texture soils and in shallow depressions (Ramaley 1942).

Mountain sage (*Artemisia frigida*) can occur in alluvial washes and ground disturbed by rodents or grazing animals.

The relatively narrow historical creek corridors at Monte Vista NWR include active and relict channels and associated small floodplains of Rock, Spring, and Cat Creeks. Remnant floodplain and abandoned creek channel depressions are present in some locations and contain wetlands with diverse sedges, rushes, alkali muhly, and some small pockets of cattail and softstem bulrush (Ramaley 1929, 1942; Carsey et al. 2003, Figs. 6, 10). GLO survey maps were prepared for the "flat" portions of the refuge in 1875 and the foothill areas were mapped by 1880. These GLO maps indicate that wetland areas on and near Monte Vista NWR were limited to relatively narrow corridors along the creeks, especially the northern Rock Creek drainage, along Spring Creek, and the Cat Creek channel (Figs. 6,10). Wetlands and sloughs in the SLV and at Monte Vista NWR, historically were seasonally flooded in late spring and early summer from snowmelt, spring rainfall, creek overflows, and groundwater discharge, with some wetlands holding water into July (Ramaley 1929, 1942; Rees 1939, Cooper and Severn 1992). Wetland sites have fine-grained Torrifluvent-Torsido-Alamosa soil associations that are relatively impermeable and lose little water from seepage; most surface water loss occurs from the high ET rates during summer (SCS 1980). The Vastine soil type is the most common wetland associated soil on Monte Vista NWR (Table 1, Fig. 7). Little evidence exists that deeper, more permanently flooded, wetland depressions historically occurred at Monte Vista NWR. However, occasional prolonged surface flooding may have occurred in a few areas along Rock and Spring Creeks during wetter years. Hydrostatic pressure (absence of water flow through soil pores and the pressure on those pores) increases in the fall,

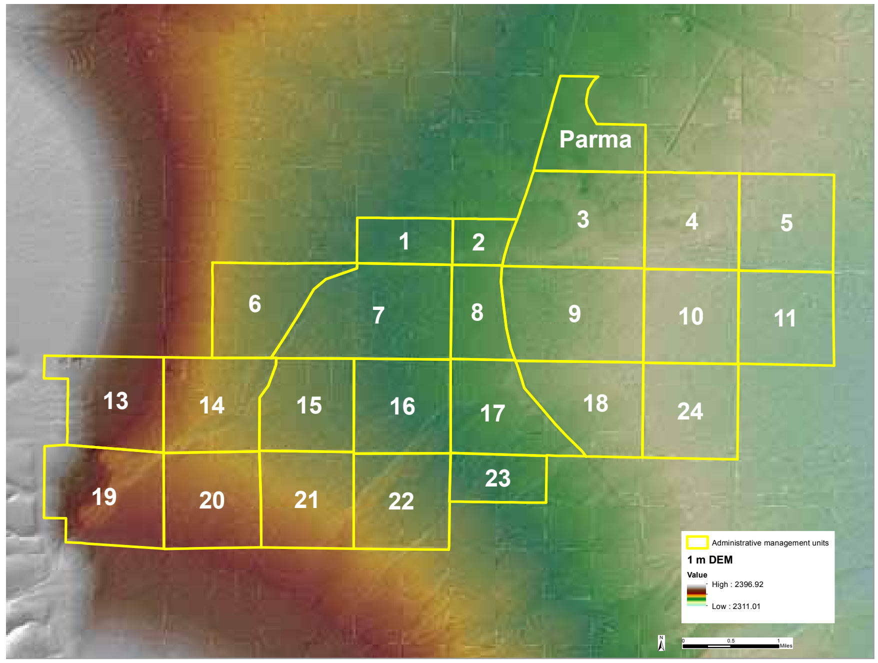

Figure 12. Administrative management units on Monte Vista National Wildlife Refuge.

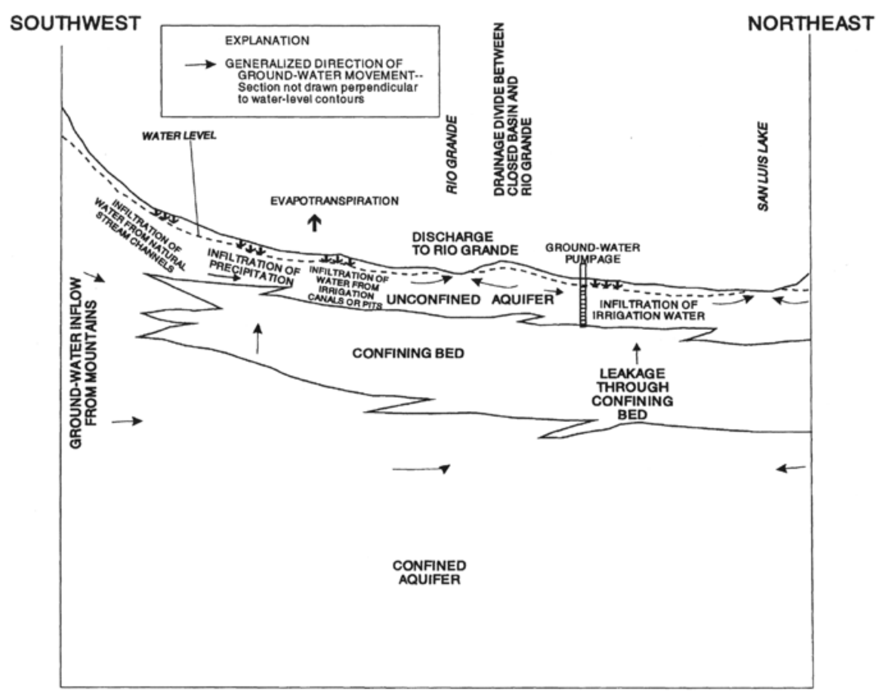

Figure 13. Schematic cross-section of groundwater movement in relation to the unconfined and confined aquifers in the San Luis Valley (modified from Hanna and Harmon 1989).

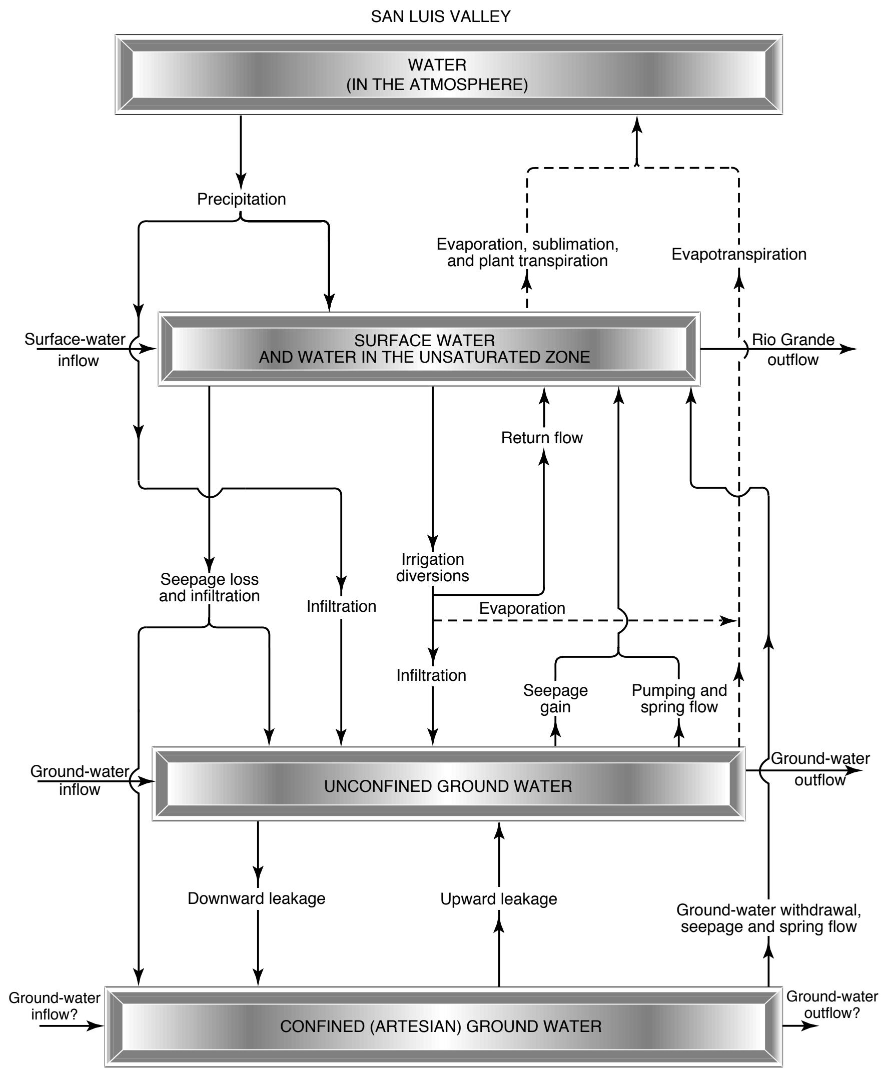

Figure 14. Generalized hydrological flow diagram of the San Luis Valley (modified from U.S. Bureau of Reclamation 1995 and Wilkins 1998).

which may have increased flows in some groundwater springs and created modest sheetflow that then froze creating sheet ice that may or may not have remained frozen until the following spring. The Spring Creek area may have historically supplied late fall water and potentially early spring water as the sheet ice melted (described in early refuge annual narratives).

Generally, it is believed that wetland habitats historically present in the SLV, and at Monte Vista NWR, probably contained concentric bands of vegetation (Ramaley 1942, Windell et al. 1986, Cooper and Severn 1992, Fig. 15) depending on size, depth, and frequency of inundation of the respective depressions. Natural wetland "ponds" in the SLV have: 1) a central deeper area with more prolonged flooding that includes some open water along with aquatic plants such as pondweeds (*Potamogeton* spp.) and tall and medium stature persistent emergent (PEM) plants such as cattail and softstem bulrush; 2) a "marsh" zone with abundant short stature emergent herbaceous plants that include perennial species such as sedges, spikerush, and rushes along with annual species such as dock (*Rumex* spp.), smartweed (*Polygonum* spp.), panic grass (*Panicum dichotimiflorum*), and millet (*Echnichloa* spp.); and 3) wet meadow zones (sometimes partitioned into "inner" and "outer" meadow communities) with many wet-type grasses, such as slimstem reedgrass (*Calamagrostis stricta*), sedges, and other herbaceous plants.

The edges of the historical Rock, Spring, and Cat Creek channels likely included a marginal wet meadow zone that contained diverse sedges, including many spikerushes, bulrush, *Carex* species, and *Juncus* species. Natural wet meadows also occurred just beyond the streambank zones. It is unknown if riparian trees such as willows or cottonwood historically occurred along Spring and Rock Creeks, but the relatively small seasonal discharge in these creeks, coupled with the arid conditions, likely limited trees to scattered clumps of sandbar willow perhaps in the area along the north Rock Creek drainage mapped by GLO surveys. Old literature on settlements in the Monte Vista NWR area does not mention any trees (e.g., Brown 1928).

A diverse assemblage of animal species historically was present in the various habitat types at Monte Vista NWR (Table 4). The majority of species were those adapted to salt desert shrub and creek-floodplain habitats (e.g., Laubhan and Gammonley 2000, D'Errico 2006) and included numerous upland birds, mammals, and reptiles. Wet meadow and wetland communities supported many waterbird, mammal, and amphibian/reptile species, especially during wet years when more flooding of meadows and wetland depressions occurred. The alternating wet vs. dry precipitation cycles in the SLV caused the availability of wetland habitat to be highly variable among years. Most waterbirds probably used the historic wetlands present on Monte Vista NWR mainly during migration, especially in spring; these included many species of waterfowl, shorebirds, and wading birds such as dabbling ducks, common snipe (*Gallinego gallinego*), American avocet (*Recurvirostra americana*), long-billed dowitcher (*Limnodromus scolopaceus*), various sandpipers (*Caldris* spp.), white-faced ibis (*Plegadis chihi*), pied-billed grebe (*Podilymbus podiceps*), sora (*Porzana carolina*), marsh wren (*Cistothorus palustris*), and yellow-headed blackbird (*Xanthocephalus xanthocephalus*). Grassland and upland shrub bird species such as Brewer's sparrow (*Spizella breweri*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes mantanus*), and western meadowlark (*Sturnella neglecta*) probably utilized many of the grassland and shrub habitats in the refuge area. Mammals such as the desert cottontail (*Sylvilagus auduboni*), white tailed jackrabbit (*Lepus townsendii*), long tailed weasel (*Mustela frenata*), mule deer (*Odocoileus menionus*), and elk (*Cervus canadensis*) were common (as noted in Jacob Fowler's journal edited by Coues 1965). Amphibians and reptiles such as the western terrestrial garter snake (*Thamnophis elegans*), northern leopard frog (*Rana pipiens*), and various toads frequented wetland areas.

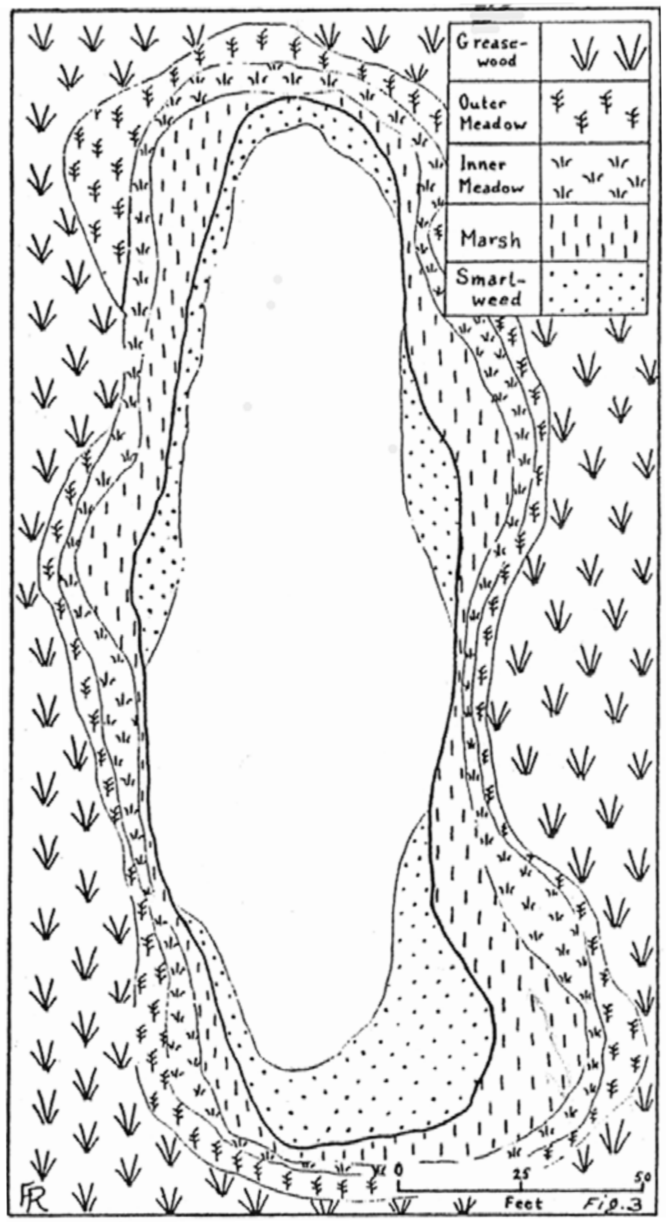

Figure 15. Vegetation associations around a typical semipermanently flooded wetland in the San Luis Valley (from Ramaley 1942).

HISTORICAL DISTRIBUTION AND EXTENT OF PLANT COMMUNITIES

An HGM matrix of the relationships between major plant communities and a combination of geomorphic surface, soil, topography, and hydrology attributes was developed (Table 5) to map potential distribution of historic communities on Monte Vista NWR (Fig. 16). Information used to develop this matrix included general plant communities described and mapped in the late 1800s by the GLO surveys, plant species associations described in published literature, older maps (Fig. 17), aerial photographs (Fig. 18), and state-of-the-art understanding of plant species relationships (i.e., botanical correlation) to geomorphology, soil, topography and elevation, hydrological regimes, and ecosystem disturbances (e.g., Carsey 2003, Robbins 1910, Summers and Smith 1927, Ramaley 1929, 1942, Hanson 1929, Harrington 1954, SCS 1980). These plant-abiotic correlations are the basis of plant biogeography and physiography (e.g., Barbour and Billings 1991, Bailey 1996). Obviously, the accuracy of predictions regarding type and distribution of communities depends on the quality and availability of geospatial data and plant-abiotic correlations (e.g., Allred and Mitchell 1955, Buck 1964) for the site and period of interest. For example, the precise delineation of historical small depressions within salt desert shrub areas that may have supported more meadow-type wetland vegetation is limited because the major topographic alterations that have occurred on and around the refuge from construction of the many roads, levees and dikes, ditches, canals, and water-control structures have destroyed former topographic features.

Table 4. Habitat types and utilization by select avian species on the Alamosa/Monte Vista NWR Complex.

Semiperm.(1'+)	Seasonal(<1')	Tall emergent	Short emergent	Saltgrass	Annuals	DNC	Riparian	Upland	Ag. Lands	Riverine
				Killdeer (ns.fo)						Killdeer (fo)
								Mountain plover(ns.fo)?		
	Black-necked stilt (ns.fo)			Black-necked stilt (ns.fo)						Black-necked stilt (fo)
	American avocet (ns.fo)		American avocet(fo)	American avocet (ns.fo)						American avocet(fo)
	Greater yellowlegs (fo)									Greater yellowlegs (fo)
	Lesser yellowlegs(fo)									Lesser yellowlegs(fo)
Solitary sandpiper (fo)	Spotted sandpiper(fo)									
	Long-billed curlew(lo,fo)		Long-billed curlew (fo)							
	Marbled godwit (fo)									
	Semi-palmated sandpiper (fo)									
	Western sandpiper(fo)									
	Least sandpiper(fo)									
	Baird's sandpiper(fo)									
	Pectoral Sandpiper(fo)									
	Stilt sandpiper(fo)									
	Long-billed dowitcher(fo)									
			Common snipe(ns,fo)							Common snipe(fo)
	Wilson's phalarope (fo)		Western phalarope (ns,fo)	Western phalarope (fo)						
	Red-necked phalarope (fo)									
Forster's tern (fo)	Forster's tern (fo)									
Least tern(fo)										
Black tern(fo)	Black tern(fo)	Black tern(fo)								
			Great Horned owl (fo)			Great Horned owl (fo)	Great Horned owl (ns)			
								Burrowing owl (ns,fo)		
			Short-eared owl(ns,fo)			Short-eared owl(ns,fo)				
							Willow flycatcher(ns,fo)			
		Marsh wren(ns,fo)								
								Sage thrasher (ns,fo)		
								Loggerhead shrike (ns,fo)		
							Yellow warbler (ns,fs)			

Table 4, Cont'd.

Semiperm.(1'+)	Seasonal(<1')	Tall emergent	Short emergent	Saltgrass	Annuals	DNC	Riparian	Upland	Ag. Lands	Riverine
							Yellow-breasted chat (ns,fo)?			
							Blue grosbeak (ns,fo)?			
							Indigo bunting (ns,fo)			
								Brewer's sparrow (ns,fo)		
			Vesper sparrow (ns,fo)	Vesper sparrow (ns,fo)						
			Savannah sparrow (ns,for)	Savannah sparrow (ns,fo)						
			Western meadowlark (ns,fo)							
		Yellowheaded blackbird (ns,fo)								
		Brewer's blackbird (ns,fo)								
							Bullock's oriole (ns,fo)			
Eared grebe (ns,fo)										
Pie-billed grebe (ns,fo)										
Western grebe (fo)										
American White pelican (fo)										
		Am.Bittern (ns)	Am.Bittern (fo)							
	Snowy egret (fo)	Snowy egret (ns)								Snowy egret (n
	Cattle egret (ns)	Cattle egret (fo)								
	Black-crowned night. heron (ns)									Black-crowned night heron (fo)
	White-faced ibis (fo)	White-faced ibis(ns)	White-faced ibis(fo)	White-faced ibis(fo)						
Canada geese(mo)		Canada geese(ns)	Canada geese(ns)						Canada geese (fo)	Canada geese (ro)
	Mallard(fo)	Mallard(br,ns)	Mallard(ns,fo)	Mallard(fo)	Mallard(fo)	Mallard(ns)		Mallard(ns)	Mallard(fo)	Mallard(ro)
Gadwall(fo)		Gadwall(br)	Gadwall(ns)		Gadwall(fo)	Gadwall(ns)		Gadwall(ns)		Gadwall(ro)
		Pintail(br)	Pintail(ns)	Pintail(fo)	Pintail(fo)	Pintail(ns)			Pintail(fo)	Pintail(ro)
			Green-wing teal(ns,br)		Green-wing teal(fo)				Green-wing teal(fo)	Green-wing teal(ro)
	Blue-wing cinnamon teal(fo)		Blue-wing cinnamon teal(ns,br)	Blue-wing cinnamon teal(fo)	Blue-wing cinnamon teal(fo)					Blue-wing cinnamon teal(ro)
	Shoveler(fo)		Shoveler(ns,br)		Shoveler(fo)					
Redhead(fo)		Redhead(ns)	Redhead(fo)							Redhead(ro)
Ruddy(fo)		Ruddy(ns)								
										Common merganser (fo)

Cont'd. next page

Table 4, Cont'd.

Semiperm.(1'+)	Seasonal(<1')	Tall emergent	Short emergent	Saltgrass	Annuals	DNC	Riparian	Upland	Ag. Lands	Riverine
Bufflehead(fo)										
Ringneck(fo)										
Canvasback(fo)										
							Osprey(ro)			Osprey(fo)
Bald Eagle(fo)	Bald Eagle(fo)						Bald Eagle(ro)			Bald Eagle(fo)
			Northern harrier(ns,fo)			Northern harrier(ns,fo)				
			Swainson's hawk(fo)			Swainson's hawk(fo)	Swainson's hawk(ns,ro)			
			Red-tail hawk(fo)			Red-tail hawk(fo)	Red-tail hawk(ns,ro)			
			Rough-leg hawk(fo)			Rough-leg hawk(fo)	Rough-leg hawk(ro)			
								Ferruginous hawk(fo)		
							Golden Eagle (ro)	Golden Eagle (fo)		
			Prairie falcon(fo)			Prairie falcon(fo)		Prairie falcon(fo)		
Peregrine falcon(fo)	Peregrine falcon(fo)									
						Ring-necked pheasant(ns)			R.N.pheasant(fo)	
			Sora (ns,fo)							
		Virginia rail(ns,fo)	Virginia rail(ns,fo)							
American coot (fo)		American coot (ns)								
	Sandhill crane(ro)		Sandhill crane(lo,fo)		Sandhill crane(fo)				Sandhill crane(fo)	
	Whooping crane(ro)		Whooping crane(lo,fo)		Whooping crane(fo)				Whooping crane(fo)	
	Snowy plover(fo)			Snowy plover (ns,fo)?						
	Semipalmated plover(fo)									

Activity Code: ns=nesting, fo=foraging, mo=molting, ro=roosting, br=brood rearing, lo=loafing

The major factors influencing the type and distribution of historical vegetation communities at Monte Vista NWR are:

1. The geomorphic and topographic surfaces of the San Juan Mountain foothills; alluvial fans; and the historic channels of Spring, Rock, and Cat Creeks and their associated floodplains (Figs. 2,3,6,8).
2. Soil type and salinity (Fig. 7).
3. On-site hydrology that is affected by seasonally and annually variable inputs of water and whether the site is subirrigated by high groundwater tables.

These ecosystem attributes were used to construct the HGM matrix (Table 5) and subsequent map of potential historical vegetation community distribution (Fig. 16). The first step in this process was to determine the distribution of major vegetation/community types from GLO surveys (Fig. 10), early botanical accounts (e.g., Ramaley 1929), and older maps and aerial photographs (Figs. 17,18). This information defines the locations of upland foothills, the historic Rock, Spring, and Cat Creek channels, salt desert shrub, and the distribution of larger wetland areas along Rock and Spring Creeks. These major landscape and vegetation features were overlaid on contemporary geomorphology, soil, and topography maps to determine correspondence. While older maps and accounts have limitations and may not be completely georeferenced, they do provide the opportunity to specifically define some areas, such as the historical Rock and Spring Creek channels, the general area of larger wetlands along Rock Creek in the northern part of the refuge, and the San Juan foothills with Luhon-Garita-Travelers association soils (SCS 1980). Once the major creek, wetland, and foothill areas were identified, the balance of Monte Vista NWR was divided into potential historical communities/habitat types based on soil types. Information in the 1980 soil survey for Rio Grande County is especially useful to distinguish major communities associated with specific soil types and series (SCS 1980). We acknowledge that soil mapping in the 1980 soil survey may reflect some changes in soil chemistry and hydrologic characteristics that occurred since

Table 5. Hydrogeomorphic (HGM) matrix of historic distribution of vegetation communities/habitat types on Monte Vista National Wildlife Refuge. Relationships were determined from old aerial photographs (Fig. 16), plat and GLO maps (Figs. 6,9,15) geomorphology maps (Fig. 5), soil maps (Fig. 7) and survey publications (SCS 1980), various historical botanical accounts of the region (Hayden 1873, Hanson 1929, Ramaley 1929, 1942, Carsey et al. 2003) and land cover maps prepared by the U.S. Fish and Wildlife Service.

Habitat type	Geomorphic surface	Soil type	Flood frequency[a]
Undershrub-grassland	San Juan Mountain foothill slopes	Luhon,Garita	OSL
Salt desert shrub	Alluvial fan, Floodplain	Hooper,Arena, San Luis, etc.	OSL, MSWF
Semipermanent wetland	Creek corridors	Vastine	OBF
Seasonal wet Meadow	Floodplain margins	Alamosa, Acasco, Mishak, Torsido, Typic Fluvaquents	OBF, SWF

[a] OSL – on-site local precipitation, MSWF – minor surface sheetwater flow, OBF – overbank flows of Spring and Rock Creek, SWF – surface sheetwater flow.

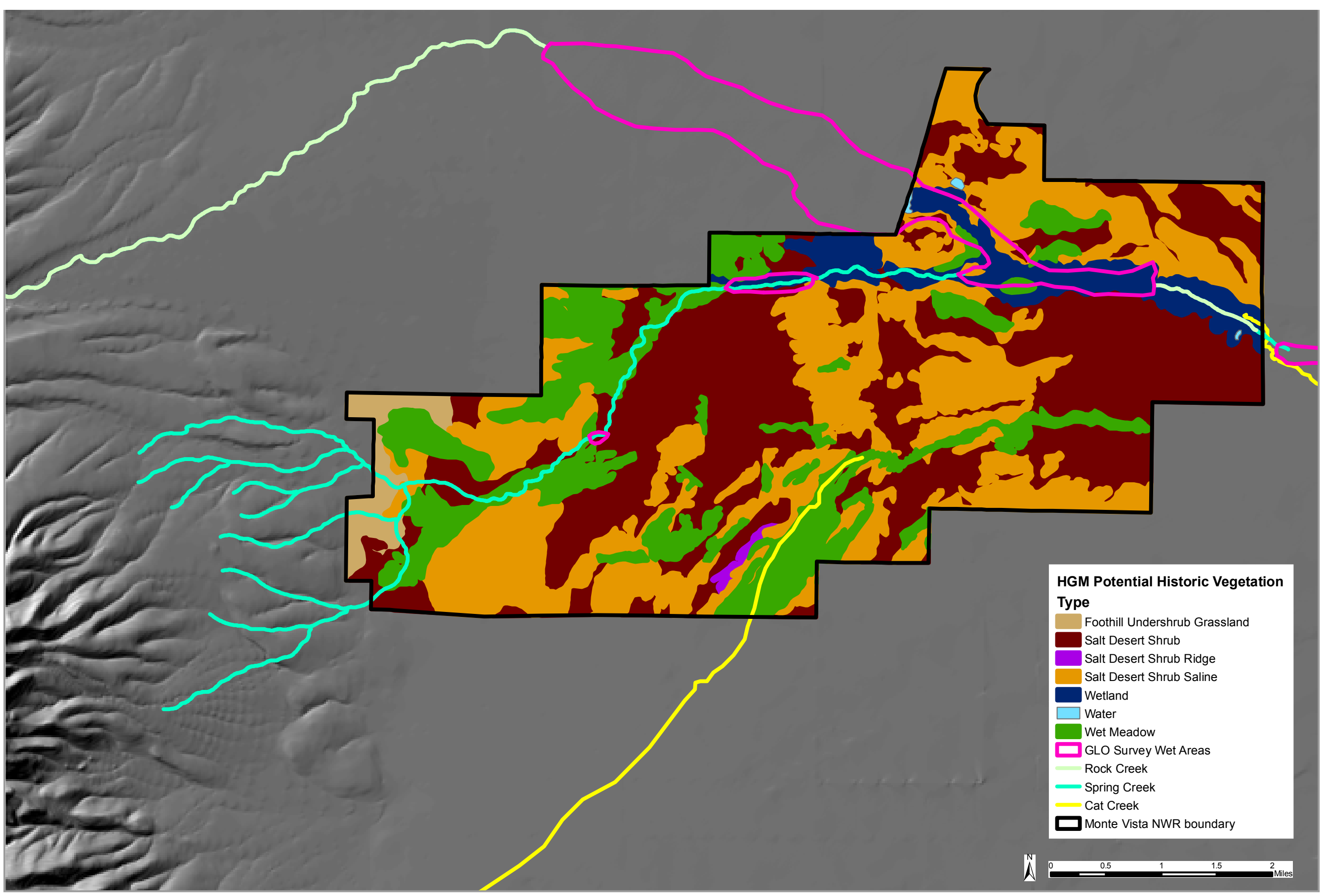

Figure 16. Potential historical vegetation community distribution on Monte Vista National Wildlife Refuge (mapped using HGM attribute relationships in Table 5).

Figure 17. Wheeler Geologic Map of the San Luis Valley depicting land coverages. Yellow= Agricultural (irrigated); Pink= Arid and barren; Light green= Grazing; and Dark green= Timber. From U.S. Geological Surveys West of the 100th Meridian Land Classification Map of Southwestern Colorado: Expeditions of 1873, 74, 75, and 76. Atlas Sheet No. 61.

the late-1800s because of the extensive alterations in surface and groundwater inputs, creation of roads, levees, ditches, canals, water diversions, and land leveling. However, basic soil texture and strata should not be different than in earlier times unless excavation and movement of soil material occurred.

The salt desert shrub community covered much of the large alluvial fan surface on Monte Vista NWR. These sites had sandy loam soil characteristics that had short duration saturation and supported more upland species such as greasewood and alkali sacaton. Consequently, the historical distribution of this community type can be generically mapped by overlapping these features. The salt desert shrub habitat at Monte Vista NWR undoubtedly had considerable diversity in specific plant distribution related to site-specific soils, hydrology and topography. The presence of this shrub heterogeneity is supported by remnant vegetation diversity that suggests lateral heterogeneity and older botanical accounts that suggest interspersion of highly saline "chico" flats and ephemeral wetland basins in this community type (Ramalay 1929, 1942). Consequently salt desert shrub communities likely were historically separated into highly saline vs. low saline assemblages based on soil salinity (Fig. 7). As mentioned above, the uncertainty about soil salinity changes at Monte Vista NWR that occurred in response to major valley-wide and site-specific land and water uses make modeling of this historical vegetation/habitat diversity difficult. Nonetheless, some of the attributes of salt desert shrub habitat diversity are known and are articulated in the HGM matrix

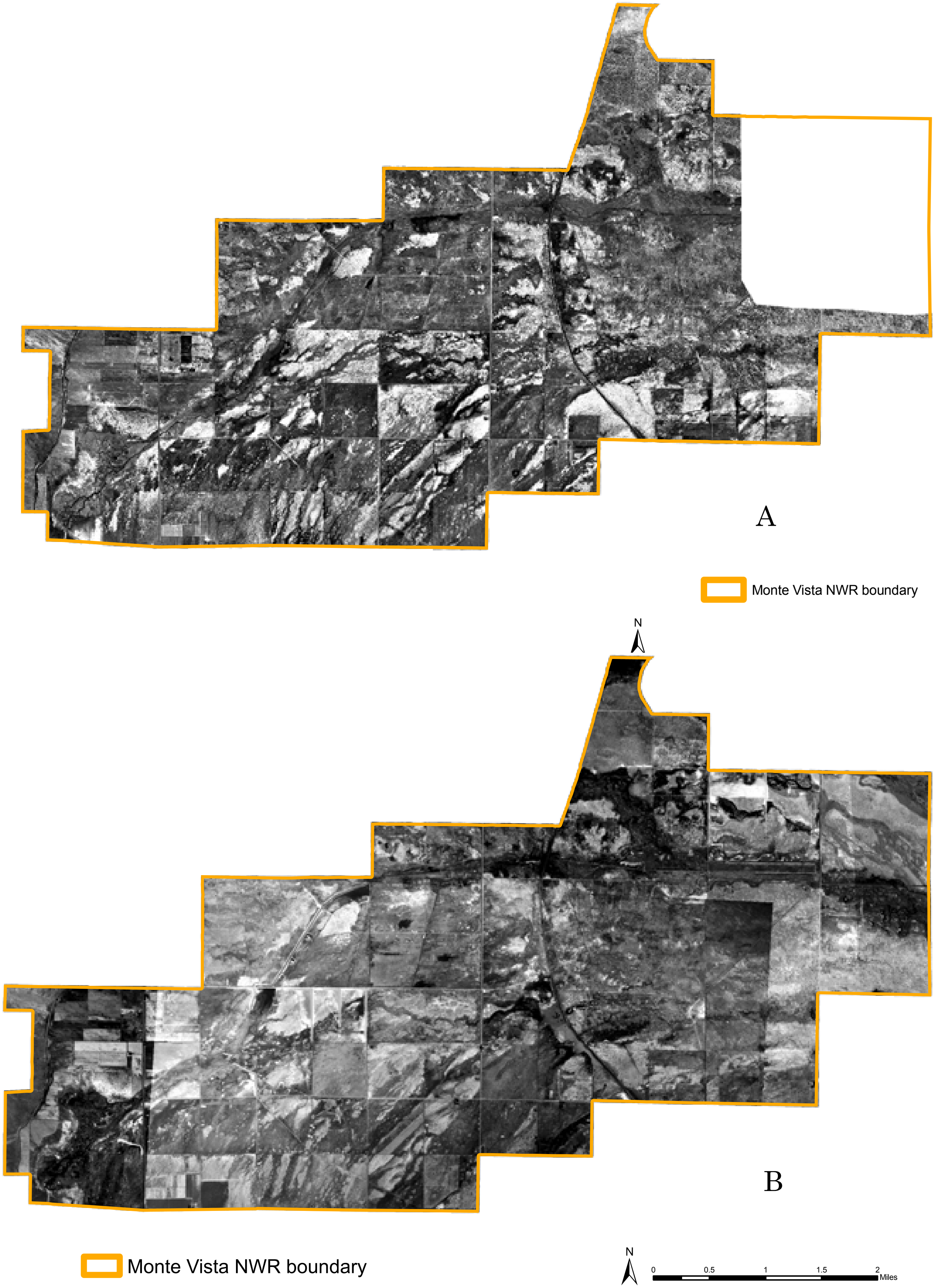

Figure 18. Aerial photographs of Monte Vista National Wildlife Refuge, a) 1941 and b) 1960.

(Table 5) so that some guidance can be provided to future restoration activities.

The GLO maps and survey notes (Fig. 10) suggest that wetlands historically present on Monte Vista NWR were mostly confined to areas near creeks and that wet meadow communities occurred in slightly higher adjacent areas in the floodplain surfaces. Based on the strong seasonal inputs of water from the relatively small Rock, Spring, and Cat Creeks, it seems likely that most of the wetlands were seasonally flooded. However, some of the wetland areas identified on the GLO maps may have been deeper and had semi-permanent flooding regimes at least during wet years. Most of the identified historical more frequently flooded wetland areas on Monte Vista NWR occurred in Vastine soils; these were at and near the confluence of Rock and Spring Creeks. Vastine soils are typically located in floodplain areas dominated by clay-loam textures that have moderate permeability and a water holding capacity conducive to vegetation species associated with wetlands such as sedges and rushes (SCS 1980). In contrast, wet meadow habitats have a variety of clay and loam soils including Alamosa, Acasco, Mishak, Torsido, and Typic Fluvaqeunts series (Table 5). The distribution of wet meadow areas on Monte Vista closely tracks the Spring and Cat Creek corridors (Figs. 6, 16). The GLO surveys did not document small depressional temporary or ephemeral wetlands associated with shrublands. Undoubtedly, some of these small depressions historically were present and they were temporally flooded or had saturated soils from onsite precipitation or some groundwater discharge depending on the season and presence of a confining soil strata layer (Rocchio 2005).

Southern Ute
Chief Buckskin Charlie
1895