A preliminary riparian/wetland vegetation community classification of the Upper and Middle Rio Grande watersheds in New Mexico

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Abstract.-The riparian/wetland vegetation communities of the upper and middle Rio Grande watersheds in New Mexico were surveyed in 1992 through 1994. The communities are hierarchically classified in terms of species composition and vegetation structure. The resulting Community Types are related to soil conditions, hydrological regime, and temporal dynamics. The classification is part of a comprehensive effort to develop a systematic understanding across the state of the diversity of riparian/wetland communities and how they are influenced by specific hydrologic, edaphic and climatic environments. An overview of the classification is presented with an emphasis on the middle Rio Grande watershed. The floristic composition, structure, environmental relationships, and successional trends of example communities are briefly described. Also discussed is the classification process which leads to the initial inventory and mapping of resources, and the identification of high quality sites.

INTRODUCTION

In New Mexico and elsewhere in the Southwest riparian areas are the conspicuous narrow belts of vegetation along ephemeral, intermittent, and perennial streams that occupy less than one percent of the western landscape (Knopf et al. 1988). Despite their limited extent, these areas support some of the greatest diversity of plant and animal communities in the region (Pase and Layser 1977, Hink and Ohmart 1984, Siegel and Brock 1990, Howe and Knopf 1991, Crawford et al. 1993, Durkin et al. 1995). The geographic extent of native riparian / wetland ecosystems is declining rapidly along many of the major river systems in the Southwest (Carothers 1977, Fenner et al. 1985, Howe and Knopf 1991, Crawford et al. 1993, Stromberg et al. 1993, Busch and Scott 1995, Durkin et al. 1995, Roelle and Hagenbuck 1995). It is thus considered to be a highly threatened ecosystem. In response to this decline in resource value the state of New Mexico, through the Environment Department, has initiated the development of a Wetlands Protection Plan for this ecosystem following the guidelines of the National Wetlands Policy Forum. The primary goals of this plan are inventory and assessment of wetland resources, the identification of wetlands protection mechanisms and the development of strategies for implementation of the plan.

To meet the first goal of inventory and assessment, a classification of riparian/wetland vegetation communities of the state was initiated to aid in inventory and assessment. We present the

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hierarchical structure of this classification and list the vegetation communities we have identified for the upper and middle Rio Grande watershed. We also provide selected examples of typical communities showing their position in the landscape in relation to one another, their associated soils, as well as the hydrological regime and vegetation dynamics. We then discuss how the classification process has been useful in identifying and assessing the processes, dynamics and quality of riparian ecosystems.

STUDY AREA

The study area includes the "upper" and "middle" watersheds of the Rio Grande in New Mexico (Fig. 1). The upper Rio Grande stretches from the Colorado border to Cochiti Dam. The major tributary is the Chama River, along with several smaller ones such as Embudo Creek, Red River, and the Nambe River. The middle Rio Grande stretches from Cochiti Lake south to Elephant Butte Reservoir. Its major tributaries include the Rio Puerco, Rio San Jose and Rio Salado. Important smaller streams include the Jemez River, Santa Fe River and Galisteo Creek to the north, and the Alamosa, Palomas and Las Animas Creeks to the south.

Precipitation patterns vary, but the primary pattern is that of predominantly late-summer rains (60-80%) derived from the Gulfs of Mexico and California. However, with respect to runoff, while summer storms contribute significantly to late-summer and fall discharges, peak runoff usually occurs in late spring (May-June) in response to snowmelt in the surrounding mountains.

Streamflows of the Rio Grande in New Mexico vary not only as a function of local climatic factors and environment, but also as a result of stream diversions and impoundments. Regulated streamflow on the Rio Grande begins near the headwaters at the Rio Grande Reservoir in southern Colorado, but the impact on flows in New Mexico is minor. Irrigation drawdown in the San Luis Valley in Colorado can have impacts on mid- and late-summer flows. Despite these upper watershed inpoundments and diversions, the Rio Grande from the Colorado border south for 50 miles through the Rio Grande Gorge is still considered

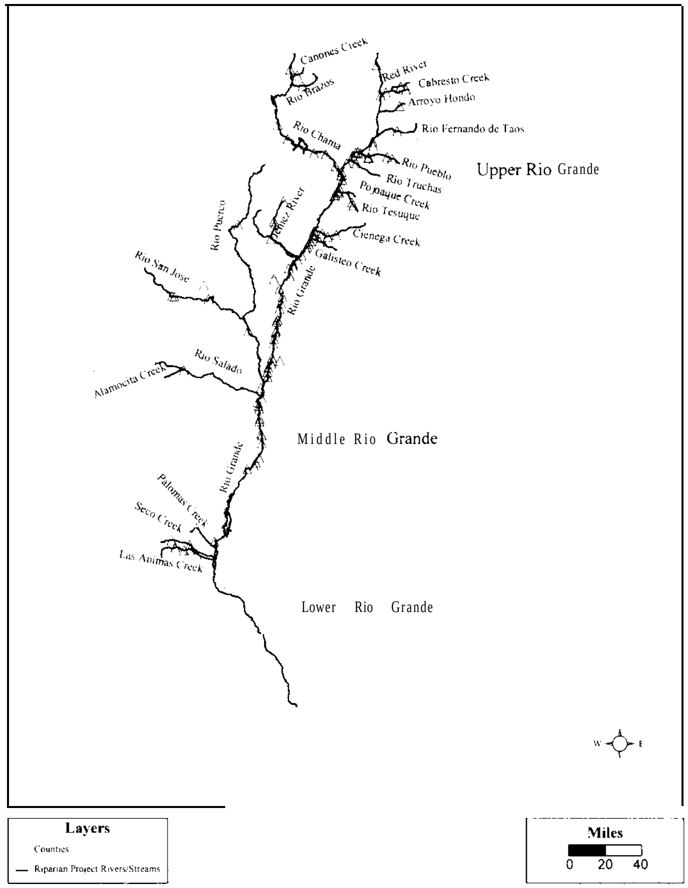

Figure 1. Distribution of riparian/wetland sites assessed and the tributary reaches sampled in the Rio Grande watershed, New Mexico.

free flowing, and is protected by the Wild and Scenic Rivers Act of 1968 (Bullard and Wells 1992). South of the Gorge, the Rio Grande opens up into a wide floodplain at Velarde, and down through Española. Here, significant irrigation diversions occur, and channel controls have been implemented for flood and erosion control, and water delivery.

In the upper Rio Grande several tributary basins have also been altered. The Rio Chama has three major water impoundments (Abiquiu, Heron and El Vado) and, via transmountain tunnels, receives water from the San Juan River as well. Other smaller tributaries, for example Embudo Creek, are contained by small levees bordering the channel, and have water diverted into small irrigation systems (acequias).

The middle Rio Grande runs through the middle basin from Cochiti Lake to Elephant Butte Reservoir (roughly 150 miles). It is intensely managed and altered hydrologically. Nearly every major tributary, with the exception of the Rio Puerco and Rio Salado, contains a reservoir or diversion dam for flood and sediment control, or irrigation. Water delivery demands and flows are regulated at Cochiti Dam. The channel is periodically dredged and straightened, and banks are rip-rapped to prevent erosion. Additionally, river bars are mowed of their vegetation to maximize water delivery along a 600-foot-wide corridor maintained by a network of flood-control fencing (jetty jacks), and levees. Flows are also diverted into ditches and conveyance channels that drain an area of nearly a quarter million square miles (Hink and Ohmart 1984). Despite these major alterations, the Rio Grande, in certain localities, still overflows its banks within the levees (Crawford et al. 1993).

The middle Rio Grande currently supports one of the most extensive and continuous forested wetlands or "bosques" in the Southwest. The bosque is dominated by Rio Grande cottonwood, along with scattered shrub and herbaceous emergent wetlands of willows and sedges (Hink and Ohmart 1984). Exotics such as Russian olive and salt cedar have become problems, and because of hydrological manipulations the long-term status of these forested wetlands is uncertain (Howe and Knopf 1991, Crawford et al. 1993). The upper Rio Grande and the tributary reaches are considerably less modified and tend to support montane forested wetlands dominated by narrowleaf cottonwoods, and various shrub and herbaceous wetlands. Exotics are less of a problem, and overall site conditions are better.

METHODS

Site selection and field sampling

Vegetation sampling was designed to characterize the communities throughout the study area and to evaluate their relationship to the hydrological regime and soils. Using aerial photography and reconnaissance flights along each of the major reaches of the Rio Grande and its tributaries identified above, potential sites for field sampling were categorized by gross vegetation structure, species composition, size and condition. National Wetlands Inventory maps were consulted to confirm gross vegetation type (NWI 1984). Sites dominated by both native and exotic vegetation such as saltcedar or Russian olive were considered. Final sampling site selection was determined by ground reconnaissance. The final sample set was structured to maximize geographic distribution, floristic variation and stand quality. Sites that were drastically altered by human activities such as cultivation, dumping of refuse, livestock holding sites, logging, and mining were not included in the sampling. Site selection was also dependent on finding a relatively homogeneous stand of vegetation 0.1 hectare in size (1,000 meters^2) or larger.

To evaluate potential flows at a site, cross-sections of the channel and the adjacent floodplain were surveyed using either a ground-based level and rod, or by using aerial photographs to photogrammetrically determine elevation and distance along a cross-section(see Durkin et al. 1995 and BOR 1995 for details). Along each cross-section the elevations of current water surface, high-water marks, locations of flood debris and root crown heights for significant riparian species, as well as bank heights of the main channel, and channel substrate character were recorded. Stream gradients along the reach were also measured with a level and rod, and discharges on the day of sampling were measured with an electronic flow meter.

Each cross-section contained one or more vegetation plots and associated soil pits in stands of homogeneous vegetation that represented the typical vegetation community. Within each stand, a 400 m^2 square or rectangular plot was established and canopy cover of all species present estimated. Trees were tallied in two-inch diameter stem-size classes. Height of the canopy was measured, and one or more dominant trees was cored to determine age. Other variables estimated or measured at each site included: elevation, aspect (stream bearing), valley floor width, ground cover, landscape position, hydrologic and geomorphic features, adjacent upland communities, indications of wildlife or domestic livestock utilization, and other disturbances (i.e., flooding, fire, windthrow, logging, etc.). Soil sampling and profile descriptions followed guidelines established by the Soil Conservation Service (SCS 1991). For each horizon, bulk samples for pH and salinity determinations were also taken.

Analysis

Hydraulic analysis was performed on each cross-section resulting in estimated flows at designated stage heights. The analysis of simpler and smaller streams was done with XSPRO (Grant et al. 1992). Modeled flows were calibrated from discharge measurements for the date of sampling, or from nearby U.S.G.S. gauges. Complex modeling of the larger Rio Grande was accomplished in cooperation with the Bureau of Reclamation and their STARS program which estimates flood stage height and discharge by comparing the hydraulic gradients of two or more cross-sections (backwater calculation). Water surface stages are interactively computed for all cross-sections until they correspond (BOR 1995).

Return intervals for flows at various stages on the cross-sections was determined using the recurrence probabilities calculated at stream gauges by Waltemeyer (1986). For the cross-sections located on smaller tributary basins without stream gauging stations, recurrence intervals were calculated using Waltemeyer's (1986) linear regression equations based on drainage basin size and elevation.

As a corollary to recurrence interval, the ratio of the cross-sectional area of the floodplain to the cross-sectional area of the channel at bankfull height was calculated. Each vegetation plot located on a cross-section has a recurrence interval associated with it along with cross-sectional ratios and actual cubic feet per second (cfs) discharges necessary to flood the site.

Soils were classified to the family level of Soil Taxonomy (Soil Survey Staff 1992). Soils were also ranked in terms of wetness based on Great Group and Family characteristics. Percentages of plant available water based on soil texture were estimated for the moisture control section of the soil profile (Donahue et al. 1983). Depths to gleying and redox features were also determined.

The vegetation community classification was developed using agglomerative cluster analysis. Euclidean distance and Ward's Method was used as an initial organizational tool to define the riparian/wetland community types. The program SYNTAX IV (Podani 1990) was used to generate a dendrogram of hierarchical groupings of plots with similar vegetation associates. Plots were then sorted using synthesis stand tables into final vegetation community types following procedures outlined in Mueller-Dombois and Ellenberg (1974). Hydrological, soil and other site characteristics were then correlated to community types.

RESULTS

The classification system

The classification system is organized in a multilevel hierarchical and open-ended system based primarily on the existing natural vegetation. The system draws upon Cowardin's (1979) classification of wetlands and deepwater habitats of the United States; Brown, Lowe and Pase's (1979) classification of biotic communities of the Southwest; and UNESCO's physiognomic-ecological classification of plant formations of the earth (Mueller-Dombois and Ellenberg 1974, Driscoll et al. 1984, Bourgeron and Engelking 1994). The UNESCO system is currently used by Natural Heritage Programs throughout the United States as a basis for regional, national and international comparisons. The classification of Cowardin et al. (1979) was adopted by the U.S. Fish and Wildlife Service for use in its National Wetland Inventory

Initially, all riparian/wetland communities are considered part of the Palustrine System as defined by Cowardin et al. (1979). There are seven hierarchical levels to the classification structure:

1. **Class —** The major physiognomic type based on dominant growth form and cover; similar to Class of Cowardin et al. (1979) and UNESCO (Driscoll et al. 1984);
2. **Zone —** Moisture and temperature-defined sub-classes; similar to Brown, Lowe and Pase's (1979) Climatic Zone and Subclass and Group in part, of UNESCO;
3. **Regional Biome —** Biogeographically related Series Groups; similar to Brown, Lowe and Pase's (1979) Biome;
4. **Series Group —** The dominant plant communities within the same biome, zone, and class related by equivalent sets of morphological, environmental or floristically related series; commonly equivalent to the Cowardin et al.

(1979) Sub-class and UNESCO Formation (Driscoll et al. 1984);

5. Series — Sets of Community Types related by at least a single common dominant; equivalent to the primary Dominance Types of Cowardin et al. (1979) and patterned after the Series of Daubenmire (1968), and the Alliance of Braun-Blanquet (1965) and Bourgeron and Engelking (1994);
6. Community Type — Fundamental repeated assemblages of species; synonymous with plant association of Braun-Blanquet (1965) and Bourgeron and Engelking (1994); somewhat equivalent to secondary Dominance Types of Cowardin et al. (1979);
7. Phase — Floristic variants of Community Types; synonymous with sub-association of Braun-Blanquet (1965); the term Typic refers to the modal species composition of the Community Type.

Upper and Middle Rio Grande Basin riparian/wetland communities

A preliminary classification of riparian/wetland vegetation communities of the upper and middle Rio Grande Basin is presented in Table 1. It is based on data from 52 cross-sections, and 109 vegetation plots and soil pits distributed throughout the basin (Figure 1). Communities are divided into three main Classes — forested, scrub-shrub and persistent emergent herbaceous riparian/wetlands. Within each Class there can be either Cold Temperate or Warm Temperate Zones (Level II), followed by Regional Biomes such as Rocky Mountain Montane, Rio Grande/Great Plains or Southwest (Level III). Level IV's are commonly defined as either needle-leaved evergreen series groups, or broad-leaved deciduous series groups. At the lowest levels of the classification, we identified 20 Series and 58 community types within those series.

Table 1. A preliminary riparian/wetland vegetation community classification of New Mexico for the upper and middle Rio Grande watershed. The classification is hierarchically arranged within the Palustrine System into Class (level I), Zone (level II), Regional Biome (level III), Series Group (level IV), Series (level V) and Community Type (CT; level VI). Organization of the classification system follows Cowardin's (1979) classification system with modifications based on NMNHP's statewide classification (see text). The Series Group, level (IV), is parenthetically cross referenced to the UNESCO classification system (Driscoll et al. 1984). Community Types are identified by their common name, scientific nomenclature, and six- or seven-letter acronym.

PALUSTRINE SYSTEM—RIPARIAN/WETLAND VEGETATION

I. FORESTED WETLANDS CLASS - FORESTS AND WOODLANDS

II. COLD TEMPERATE FORESTED RIPARIAN/WETLANDS

III. ROCKY MOUNTAIN MONTANE FORESTS

IV. NEEDLE-LEAVED EVERGREEN SERIES GROUP (closed forests, cold temperate, evergreen)

V. BLUE SPRUCE *(PICEA PUNGENS)* SERIES

1. Blue Spruce-Thinleaf Alder CT *(Picea pungens—Alnus incana;* PICPUN-ALNINCT)

IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (closed forests, cold temperate, deciduous with evergreens)

V. THINLEAF ALDER *(ALNUS INCANA)* SERIES

1. Thinleaf Alder/Bluestem Willow CT (*Alnus incana/Salix irrorata;* ALNINCT/SALIRR)

V. NARROWLEAF COTTONWOOD *(POPULUS ANGUSTIFOLIA)* SERIES

1. Narrowleaf Cottonwood—Thinleaf Alder CT *(Populus angustifolia—Alnus incana;* POPANG-ALNINCT)
2. Narrowleaf Cottonwood-Arizona Alder CT *(Populus angustifolia—Alnus oblongifolia*; POPANG-ALNOBL)
3. Narrowleaf Cottonwood-Rocky Mountain Juniper CT *(Populus angustifolia—Juniperus scopulorum*; POPANG-JUNSCO)
4. Narrowleaf Cottonwood/New Mexico Olive CT *(Populus angustifolia/Forestiera pubescens* CT; POPANG/FORPUBP)
5. Narrowleaf Cottonwood/Coyote Willow CT *(Populus angustifolia/Salix exigua*; POPANG/SALEXI)
6. Narrowleaf Cottonwood/Bluestem Willow CT *(Populus angustifolia/Salix irrorata;* POPANG/SALIRR)
7. Narrowleaf Cottonwood/Kentucky Bluegrass CT *(Populus angustifolia/Poa pratensis;* POPANG/POAPRA)

(Cont'd.)

Table 1. Continued

III. SOUTHWEST MONTANE FORESTS

IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (closed forests, cold temperate. deciduous with evergreens)

V. ARIZONA ALDER (*ALNUS OBLONGIFOLIA*) SERIES

1. Arizona Alder—Goodding's Willow CT (*Alnus oblongifolia—Salix gooddingii;* ALNOBL-SALGOO)
2. Arizona Alder/Seepwillow CT (*Alnus oblongifolia/Baccharis salicifolia*; ALNOBL/BACSAL)

III. RIO GRANDE/GREAT PLAINS FORESTS

IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (woodlands, cold temperate. deciduous with microphyllous shrublands or thickets)

V. RIO GRANDE COTTONWOOD (*POPULUS DELTOIDES*) SERIES

1. Rio Grande Cottonwood--Russian Olive CT (*Populus deltoides—Elaeagnus angustifolia*; POPDELW-ELAANG)
2. Rio Grande Cottonwood—Oneseed Juniper CT (*Populus deltoides—Juniperus monosperma;* POPDELW-JUNMON)
3. Rio Grande Cottonwood-Saltcedar CT (*Populus deltoides—Tamarix chinensis;* POPDELW-TAMCHI)
4. Rio Grande Cottonwood/New Mexico Olive CT (*Populus deltoides/Forestiera pubescens*; POPDELW/FORPUBP)
5. Rio Grande Cottonwood/Coyote Willow CT (*Populus deltoides/Salix exigua;* POPDELW/SALEXI)
6. Rio Grande Cottonwood/Water Sedge CT (*Populus deltoides/Carex aquatilis*; POPDELW/CARAQU)
7. Rio Grande Cottonwood/Smooth Horsetail CT (*Populus deltoides/Equisetum laevigatum*; POPDELW/EQULAE)
8. Rio Grande Cottonwood/Kentucky Bluegrass CT (*Populus deltoides/Poa pratensis;* POPDELW/POAPRA)
9. Rio Grande Cottonwood/Sparse CT (*Populus deltoides/*Sparse; POPDELW/SPARSE)

V. RUSSIAN OLIVE (*ELAEAGNUS ANGUSTIFOLIA*) SERIES

1. Russian Olive-Saltcedar CT (*Elaeagnus angustifolia—Tamarix chinensis*; ELAANG-TAMCHI)

IV. NEEDLE-LEAVED DECIDUOUS SERIES GROUP (cold deciduous microphyllous thickets)

V. SALTCEDAR (*TAMARIX CHINENSIS*) SERIES

1. Saltcedar/Coyote Willow CT (*Tamarix chinensis/Salix exigua:* TAMCHI/SALEXI)
2. Saltcedar/Sparse CT (*Tamarix chinensis/*Sparse: TAMCHI/SPARSE)

II. WARM TEMPERATE FORESTED RIPARIAN/WETLANDS

III. SOUTHWEST LOWLAND FORESTS

IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (closed forests, warm temperate. deciduous with evergreens, or microphyllous shrublands or thickets)

V. NETLEAF HACKBERRY (*CELTIS LAEVIGATA*) SERIES

1. Netleaf Hackberry/Skunkbush Sumac CT (*Celtis laevigata/Rhus trilobata*; CELLAER/RHUTRIT)

V. ARIZONA WALNUT (*JUGLANS MAJOR*) SERIES

1. Arizona Walnut/Sideoats Grama CT (*Juglans major/Bouteloua curtipendula*; JUGMAJ/BOUCUR)

V. ARIZONA SYCAMORE (*PLATANUS WRIGHTII*) SERIES

1. Arizona Sycamore-Arizona Alder CT (*Platanus wrightii—Alnus oblongifolia*; PLAWRI-ALNOBL)
2. Arizona Sycamore/Seepwillow CT (*Platanus wrightii/Baccharis salicifolia*; PLAWRI/BACSAL)
3. Arizona Sycamore/Sideoats Grama CT (*Platanus wrightii/Bouteloua curtipendula*; PLAWRI/BOUCUR)
4. Arizona Sycamore/Sparse CT (*Platanus wrightii/*Sparse; PLAWRI/SPARSE)

V. FREMONT'S COTTONWOOD (*POPULUS FREMONTII*) SERIES

1. Fremont's Cottonwood-Velvet Ash CT (*Populus fremontii-Fraxinus velutina*; POPFRE-FRAVEL)
2. Fremont's Cottonwood—Goodding's Willow CT (*Populus fremontii—Salix gooddingii;* POPFRE-SALGOO)
3. Fremont's Cottonwood/Yerba Mansa CT (*Populus fremontii/Anemopsis californica*; POPFRE/ANECAL)

I. SCRUB-SHRUB WETLANDS CLASS ▪ SHRUBLANDS

II. COLD TEMPERATE SCRUB-SHRUB RIPARIAN/WETLANDS

III. ROCKY MOUNTIAN MONTANE SHRUBLANDS

IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (scrub, cold temperate, deciduous shrublands or thickets)

(Cont'd.)

Table 1. Continued

V. BLUESTEM WILLOW *(SALIX IRRORATA)* SERIES
1. Bluestem Willow-Coyote Willow CT *(Salix irrorata—Salix exigua*; SALIRR-SALEXI)
2. Bluestem Willow/Sparse CT *(Salix irrorata*/Sparse; SALIRR/SPARSE)

III. RIO GRANDE/GREAT PLAINS SHRUBLANDS
IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (scrub, cold temperate, deciduous shrublands or thickets)

V. COYOTE WILLOW *(SALIX EXIGUA)* SERIES
1. Coyote Willow-Rubber Rabbitbrush CT *(Salix exigua—Chrysothamnus nauseosus;* SALEXI-CHRNAU)
2. Coyote Willow/Redtop CT *(Salix exigua/Agrostis gigantea;* SALEXI/AGRGIG)
3. Coyote Willow/Water Sedge CT *(Salix exigua/Carex aquatilis*; SALEXI/CARAQU)
4. Coyote Willow/Woolly Sedge CT *(Salix exigua/Carex lanuginosa*; SALEXI/CARLAN)
5. Coyote Willow/Saltgrass CT *(Salix exigua/Distichlis spicata;* SALEXI/DISSPI)
6. Coyote Willow/Common Spikerush CT *(Salix exigua/Eleocharis palustris;* SALEXI/ELEPAL)
7. Coyote Willow/False Quackgrass CT *(Salix exigua/Elymus x pseudorepens:* SALEXI/ELYPSE)
8. Coyote Willow/Smooth Horsetail CT *(Salix exigua/Equisetum laevigatum;* SALEXI/EQULAE)
9. Coyote Willow/Baltic Rush CT *(Salix exigua/Juncus balticus*; SALEXI/JUNBAL)
10. Coyote Willow/American Bulrush CT *(Salix exigua/Scirpus americanus;* SALEXI/SCIAME)

II. WARM TEMPERATE SCRUB-SHRUB RIPARIAN/WETLANDS
III. SOUTHWEST LOWLAND SHRUBLANDS
IV. BROAD-LEAVED DECIDUOUS SERIES GROUP (scrub, cold temperate, deciduous shrublands or thickets)

V. SEEPWILLOW *(BACCHARIS SALICIFOLIA)* SERIES
1. Seepwillow/Prairie Wedgescale CT *(Baccharis salicifolia/Sphenopholis obtusata:* BACSAL/SPHOBT)

V. COYOTE WILLOW *(SALIX EXIGUA)* SERIES
1. Coyote Willow-Seepwillow CT *(Salix exigua—Baccharis salicifolia*; SALEXI-BACSAL)
2. Coyote Willow/Yerba Mansa CT *(Salix exigua*/Anemopsis californica; SALEXI/ANECAL)
3. Coyote Willow/Sparse CT *(Salix exigua*/Sparse; SALEXI/SPARSE)

I. PERSISTENT-EMERGENT WETLANDS CLASS - HERBACEOUS RIPARIAN/WETLANDS
II. COLD TEMPERATE PERSISTENT-EMERGENT RIPARIAN/WETLANDS
III, ROCKY MOUNTAIN MONTANE HERBACEOUS RIPARIAN/WETLANDS
IV. PERSISTENT SERIES GROUP (terrestrial herbaceous communities, sedge swamps or temperate reed swamps on river banks)

V. BALTIC RUSH *(JUNCUS BALTICUS)* SERIES
1. Baltic Rush-Nebraska Sedge CT *(Juncus balticus—Carex nebrascensis;* JUNBAL—CARNEB)
2. Baltic Rush-Common Spikerush CT *(Juncus balticus—Eleocharis palustris;* JUNBAL-ELEPAL)
3. Baltic Rush/Smooth Horsetail CT *(Juncus balticus/Equisetum laevigatum;* JUNBAL/EQULAE)

V. AMERICAN BULRUSH *(SCIRPUS AMERICANUS)* SERIES
1. American Bulrush—Common Spikerush CT *(Scirpus americanus—Eleocharis palustris;* SCIAME-ELEPAL)
2. American Bulrush/Smooth Horsetail CT *(Scirpus americanus/Equisetum laevigatum;* SCIAME/EQULAE)

III. SOUTHWEST LOWLAND HERBACEOUS RIPARIAN/WETLANDS
IV. PERSISTENT SERIES GROUP (terrestrial herbaceous communities, sedge swamps or temperate reed swamps on river banks)

V. WATER SEDGE (*CAREX AQUATILIS*) SERIES
1. Water Sedge/Smooth Horsetail CT *(Carex aquatilis/Equisetum laevigatum:* CARAQU/EQULAE)

V. COMMON SPIKERUSH (*ELEOCHARIS PALUSTRIS*) SERIES
1. Common Spikerush-Rice Cutgrass CT *(Eleocharis palustris—Leersia oryzoides;* ELEPAL-LEEORY)
2. Common Spikerush/Smooth Horsetail CT *(Eleocharis palustris/Equisetum laevigatum;* ELEPAL/EQULAE)

V. BROADLEAF CATTAIL *(TYPHA LATIFOLIA)* SERIES
1. Broadleaf Cattail/American Bulrush CT *(Typha latifolia/Scirpus americanus;* TYPLAT/SCIAME)
2. Broadleaf Cattail/Rice Cutgrass CT *(Typha latifolia/Leersia oryzoides;* TYPLAT/LEEORY)

To elucidate the usefulness of the classification, examples of four representative cross-sections from various parts of the study area are given below. The cross-sections are described in terms of community types, their composition and where those communities lie in the landscape, as well as their soil and hydrological conditions, and implications in terms of community dynamics and sustainability. Three of the examples are from river reaches that are only minimally modified, and a fourth (Corrales Bosque) is from a reach that is highly modified.

Rio Grande/Great Plains riparian/wetlands

The cross-sectional diagram in Figure 2 depicts a typical landscape on the Jemez River, supporting an example of riparian/wetland communities of the Rio Grande/Great Plains. In this reach the hydrological regime is relatively intact with only minor irrigation diversions. The gravelly channel is moderately entrenched and slightly confined by the valley, but definite depositional bars and terraces occur. Depositional bars adjacent to the channel support young stands of the Coyote Willow /Smooth Horsetail community. These sites are currently flooded annually and are potentially good sites for cottonwood regeneration. Hence, the community type can be intermixed with young cottonwood seedlings and saplings. The understory is dominated by grasses and sedges/rushes that are tolerant of water-saturated soils (Aquic or Oxyaquic Ustifluvents), such as Canada wildrye, creeping bentgrass and American spikerush. With recurring flooding, the sites often collect more flood deposits and are built up into higher bars and terraces. Over time the bars build up to the point that they are no longer frequently flooded; cottonwood regeneration stops and the cottonwood forest develops and matures. In this case, the highest terraces, at about eight feet above the channel, and support a mature Rio Grande Cottonwood/New Mexico Olive community. This is probably the most mature type of forest community that can occur here. The sites are only occasionally flooded (5-25 year flood-return intervals), and are relatively stable. Large scouring floods

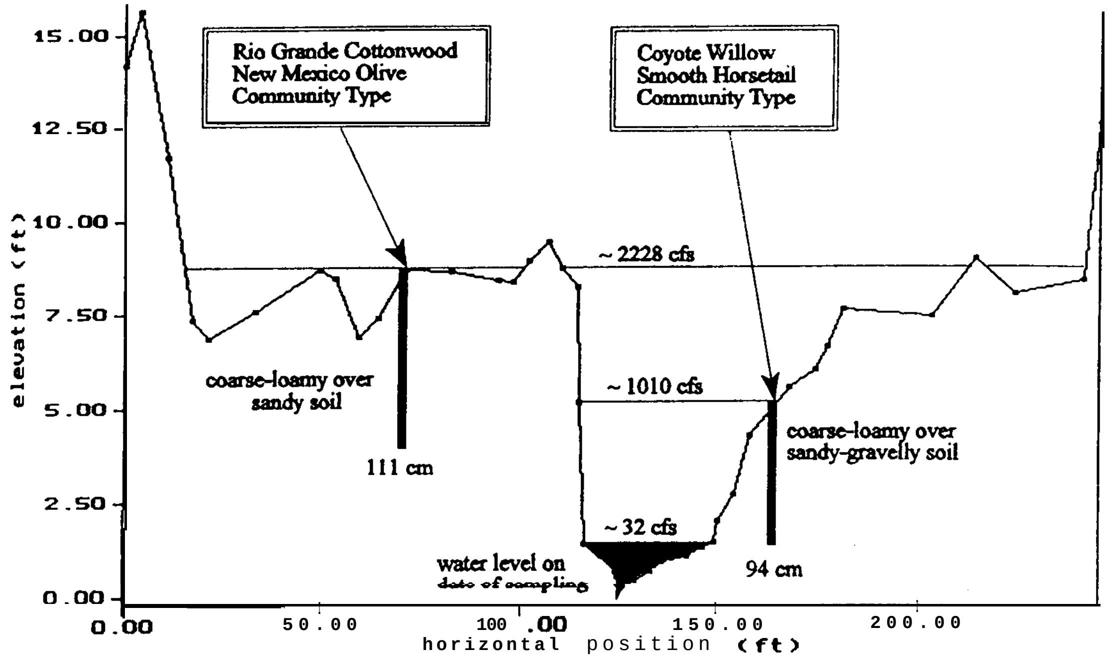

Figure 2. Cross-sectional profile of the Jemez River at the Cañon Site depicting the location of Rio Grande/Great Plains riparian/wetland communities, the predominant soil textures of each type and depths of soil pits (black bar). Also **shown is the water level on the day of sampling and the estimated flows required to flood the different communities. For example, an estimated flow of 2228 cubic feet per second (cfs) would recur at 5 year intervals for the Rio Grande Cottonwood/New Mexico Olive Community Type while an estimated flow of 1010 cfs would recur every other year for the Coyote Willow/Smooth Horsetail Community Type.**

could still potentially remove the old forest, and restart the cycle. Otherwise, the forest community will probably be sustained on this site until the trees die, either from old age, or if the water table is altered (either naturally, by changing channel configuration, or artificially).

In Figure 3 the cross-sectional diagram also depicts Rio Grande/Great Plains communities along the middle Rio Grande, but on the main stem at Corrales. Here the hydrological regime is highly modified. Flows are regulated at Cochiti Dam and there are numerous upstream irrigation diversions. The floodplain is bounded by levees and conveyance channels, and stabilized with jetty jacks creating a 600-foot-wide channel that is essentially "locked" in place. The bed of the channel is predominantly sandy with mixtures of gravels and silt. At low flows, low-lying depositional bars become exposed and are good sites for cottonwood regeneration. These sites, however, are continually flooded on an annual basis and the cottonwood seedlings are removed, rarely becoming sapling-sized trees, or reaching maturity. Mature stands of Rio Grande Cottonwood/New Mexico Olive communities border the river on high terraces. Unlike the communities on the Jemez cross-section, these stands are even-aged and are often intermixed with exotic trees, commonly Russian olive, salt cedar, and Siberian elm. The communities require more than 10,000 cfs to flood. Restarting the cycle with these flows, however, is beyond the maximum prescribed release that is currently allowed from Cochiti. Hence, the native forest communities will likely be replaced by the exotic trees that do not require flooding for development and maintenance.

Southwest riparian/wetlands

Figure 4 depicts a riparian zone that is different overall from Rio Grande/Great Plains. This landscape is from the southern end of the study area along Palomas Creek. This reach supports Southwest riparian/wetland communities that are closely related to communities of the Gila River basin to the west, and others rivers of Arizona and northern Mexico. The gravelly/cobbly channel is

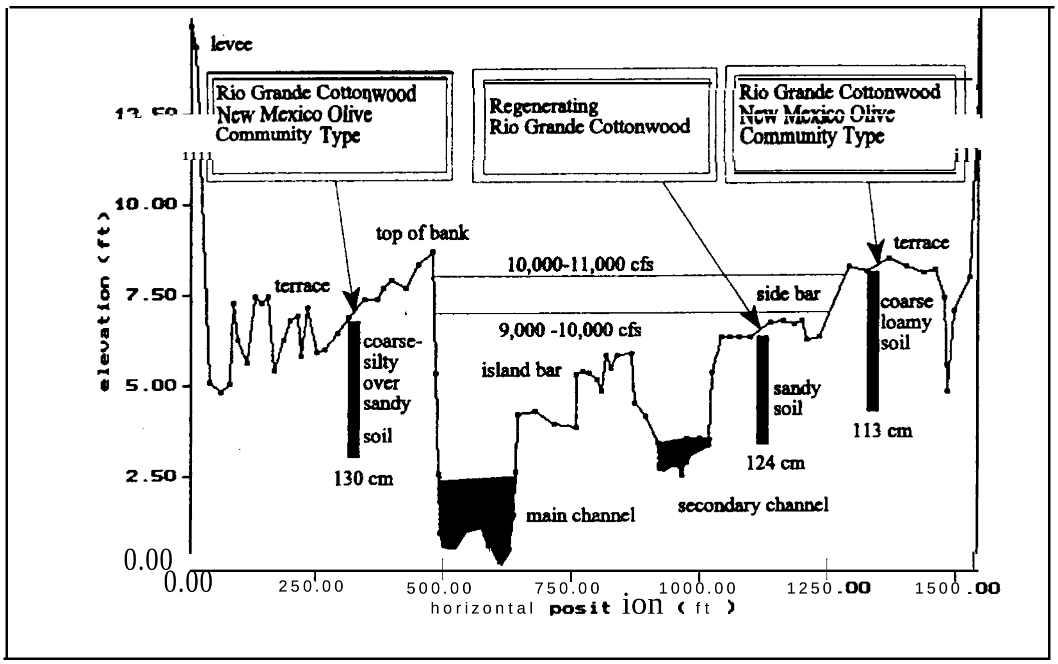

Figure 3. Cross-sectional profile of the middle Rio Grande at the Corrales Bosque Site depicting location of Rio Grande/ Great Plains riparian/wetland communities, the predominant soil textures of each type and depths of soil pits (black bar). Along this regulated segment of the river, flows of 10,000-l 1,000 cubic feet per second (cfs) would nearly reach the highest terraces supporting Rio Grande cottonwood/New Mexico olive communities every 25-100 years, whereas the same flows under unregulated conditions would recur at 2-3 year intervals. The lowest side bars which support sapling-sized cottonwoods would currently require flows of 9,000-10,000 cfs to re-flood these sites and recur at 10-25 year return intervals, while the same unregulated peak flows would recur at approximately 1-2 year return intervals.

moderately entrenched and moderately confined by the valley. It meanders across a narrow floodplain, and overflows the lowest banks at one- to two-year intervals. Within two feet of the active channel herbaceous persistent-emergent vegetation is common beneath an understory of young seepwillow (the Seepwillow/Prairie Wedgescale community type). Reproduction of cottonwoods, willows, and alders occurs in this zone where the soils are frequently saturated. Further away from the channel and slightly higher above it, the Arizona Alder/Seepwillow Community Type develops on drier, coarse sandy-gravelly soils (Aeric Fluvaquents). These soils have either aggraded as a result of continued deposits of sediments during flooding events, or the channel has moved laterally away-from the site, or the channel has become slightly incised. Common understory species include sapling-sized Arizona walnut, Goodding's willow, and boxelder, as well as the vine Arizona grape. These sites are only occasionally flooded at 5-25 year intervals and are relatively stable. Beyond two overflow channels and only slightly higher on a terrace, a third community co-dominated by Fremont's cottonwood and Goodding's willow further diversifies the site on slightly different and more developed soils (Oxyaquic Torrifluvents). Hydric indicators are located deeper within the soil profile suggesting that the site is rarely inundated (greater than 25 year return intervals). Sub-canopy trees including Arizona walnut, boxelder and velvet ash may also be present, while understory grasses such as deergrass and alkali muhly may also be well represented. This is a stable forest community that will either be replaced by the sub-canopy trees in the community, or the forest will be reset by large scouring floods.

Rocky Mountain montane

In the upper reaches of the watersheds at higher elevations the Rio Grande/Great Plains and Southwest riparian/wetlands are replaced by Rocky Mountain montane community types. In Figure 5,

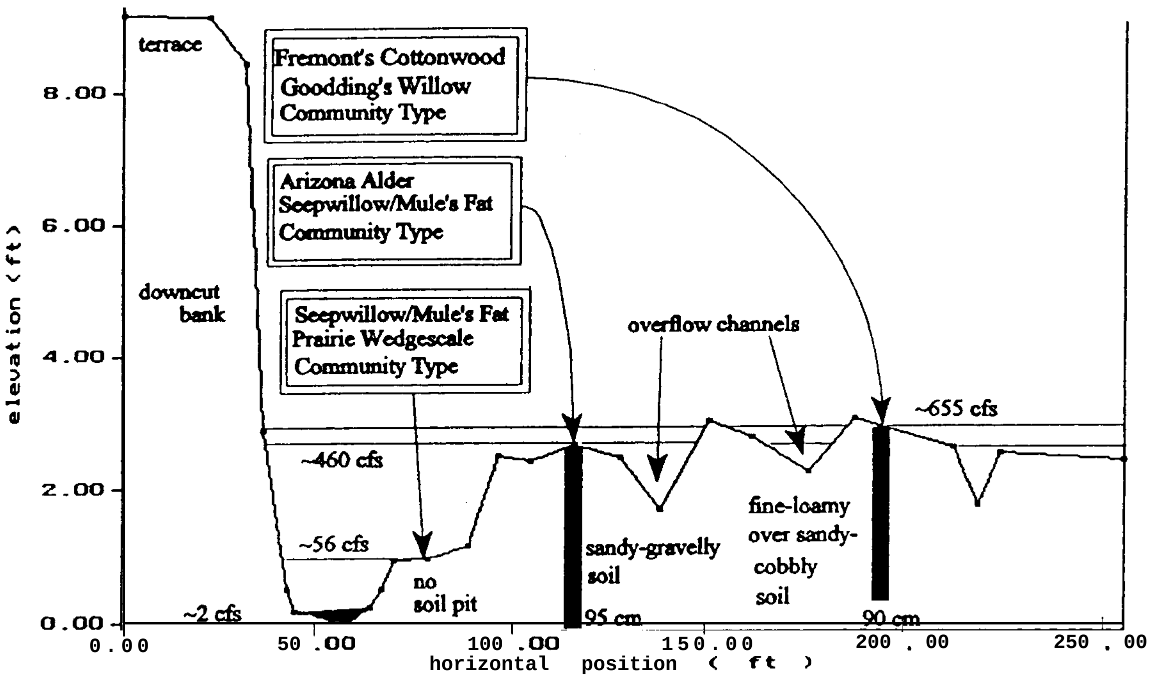

Figure 4. Cross-sectional profile of Palomas Creek depicting the location of three different Southwest riparian/wetland communities, the predominant soil textures of each type and depths of soil pits (black bar). Streamflows on the day of sampling were measured at 2 cubic feet per second. Based on hydraulic analyses flows of approximately 1900 cfs would scour the lowest bars at 5 year intervals , while flows of 50-350 cfs would flood the communities every 2-5 years. Streamflows of approximately 655 cfs would flood the oldest forested community (Fremont's Cottonwood – Goodding's Willow Community Type) at 10-25 year return intervals.

along the Chama River, the dynamics of the communities are driven by a relatively intact hydrological regime that still allows for natural reproduction of obligate riparian/wetland species. At this site the cobbly channel is moderately entrenched and slightly confined by the valley. The lowest depositional bars adjacent to the channel support the Narrowleaf Cottonwood/Coyote Willow Community Type characterized by young cottonwood saplings and seedlings intermixed with willows, and various shrubs and forbs. Stratified layers of vegetation are well developed and the community is species rich. Bearberry honeysuckle and redosier dogwood are common sub-canopy shrub species while forbs and grasses include cutleaf coneflower, cowparsnip, field horsetail, Kentucky bluegrass and meadow fescue. These sites are currently flooded at one- to two-year intervals. Recurring floods over time have built higher terraces between three and six feet above the active channel that support the Narrowleaf Cottonwood-Thinleaf Alder Community Type. Communities closest to the main channel are younger, dense and diverse, while forests further from the channel are older and thinner. With additional floods at up to five year intervals new sites are created for cottonwood regeneration. But as the interval increases, the sites elevated high above the active channel become drier. Soils closest to the channel are fairly well drained Aeric Fluvaquents with water saturation indicators within 75 cm of the surface, while soils furthest from the active channel tend to be coarser Oxyaquic Udifluvents with hydric indicators found deep within the soil profile. On the driest sites cottonwood reproduction ceases and the stands of trees mature and ultimately die. Narrowleaf cottonwood dominated communities, like their lower-elevation relatives require flooding to reset the community. Otherwise, the trees will generally grow old and die and will only be replaced by an occasional root sucker.

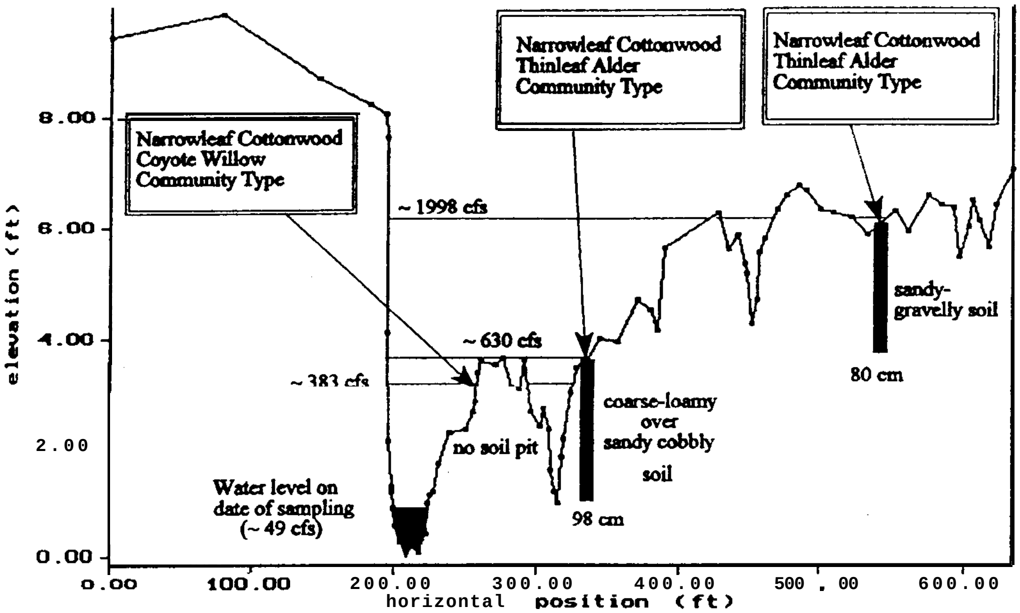

Figure 5. Cross-sectional profile of the Rio Chama near Chama, NM depicting the location of two Montane riparian/wetland communities, the predominant soil textures of each type and depths of soil pits (black bar). Streamflows on the day of sampling were measured at 49 cubic feet per second. The highest terraces which support a mature Narrowleaf cottonwood-Thinleaf alder community would require streamflows of nearly 2000 cubic feet per second to reset the community every 50-100 years, while intermediate-aged stands on lower sites require 630 cfs every 10-25 years. The lowest sites adjacent to the river support Narrowleaf cottonwood/Coyote willow communities and are flooded every 2-10 years with flows of approximately 380 cfs.

DISCUSSION

The high number of community types identified in this study reflects the high diversity of the riparian zones in New Mexico. This classification is based on a limited sample pool, and there will likely be more types that will be identified in the future, particularly with respect to high montane communities, and herbaceous/emergent wetlands in general. The herbaceous emergent and persistent wetlands identified here are under-represented in the landscape as a whole. This may be a reflection of the highly altered condition of the middle Rio Grande, where modification of flows and the channel have resulted in a tree-dominated ecosystem, rather than a more diverse matrix of forests, shrublands and herbaceous communities.

The classification has provided a structure for the analysis and discussion of riparian ecosystem species composition and dynamics. We have identified several naturalized "exotic" community types dominated by Russian olive or salt cedar, and we are further investigating the conditions under which these communities thrive. Through the classification we are developing models for testing concepts on site progression originally outlined by Leonard et al. (1992), both under naturally occurring or artificially controlled systems. This we hope will lead to a greater understanding of the impacts of hydrological manipulations by humans.

We believe the classification developed here will prove useful for comprehensive inventory and quality assessment of New Mexico's riparian/wetland resources. The process itself of developing the classification was important as a tool for initially evaluating the quality of specific occurrences of riparian ecosystems in the state. This in turn has led to the first steps in the protection planning process of identifying high quality, functional or restorable wetlands (see Durkin et al. 1995). The classification process has amplified a definite need to implement riparian/wetland ecosystem protection planning in New Mexico. Of the 109 sites evaluated in the study area, only 18 (16%) were assessed as high quality, i.e., sites lacking significant impacts of hydrological modifications and landuse, and were not greatly impacted by exotic vegetation. Further, many of the best sites were in the higher elevations of more remote tributaries where hydrological modifications were limited. Although this survey was selective for reaches previously known to have extant riparian vegetation, it also points towards a general downward trend of the condition of riparian/wetland communities in New Mexico.

The natural and restorable riparian/wetland ecosystems of New Mexico are an invaluable resource for the state. Their protection enhances not only biological diversity, but also economic stability and environmental quality. With planning, these highly productive ecosystems can be managed in a natural, cost-efficient way that can be compatible with many uses such as livestock grazing, recreation, and even agriculture and urbanization, and still maintain their overall biological diversity. Such an effort will require a systematic, comprehensive inventory based on the classification system and site quality evaluation criteria developed here, along with a program of ongoing research and monitoring to ensure the long term sustainability of these vital resources. Through careful wetlands protection planning and implementation, the so called "train wrecks" over issues such as rare and endangered species and water pollution may possibly be avoided.

ACKNOWLEDGMENTS

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LITERATURE CITED

Bourgeron, P.S. and L.D. Engelking. eds. 1994. A preliminary vegetation classification of the United States. Unpublished report prepared by the Western Heritage Task Force for The Nature Conservancy, Boulder, CO.

Braun-Blanquet, J. 1965. Plant Sociology: the Study of Plant Communities. English translation of Pflanzensoziologie revised and edited by Fuller, G.D., and H.S. Conrad. Hafner Publishing Co., London, England.

Brown, D.E., C.H. Lowe, C.P. Pase. 1979. A digitized classification system for the biotic communties of North America, with community (series) and association examples for the Southwest. Desert Plants 4 (l-4): 302-315.

Bullard, T.F. and S.G. Wells. 1992. Hydrology of the middle Rio Grande from Velarde to Elephant Butte Reservoir, New Mexico. Resource publ. no. 179, U.S. Department of the Interior Fish and Wildlife Service, Washington, DC.

Bureau of Reclamation. 1995. Hydrologic and hydraulic analysis for a riparian and wetland vegetation classification. Unpublished report prepared by U.S. Department of the Interior, Bureau of Reclamation Technical Assistance to States Program, Albuquerque Projects Office for the New Mexico Environment Dept., Santa Fe, NM and the New Mexico Natural Heritage Program, Albuquerque, NM.

Busch, D.E. and M.L. Scott. 1995. Western riparian ecosystems. In: Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac eds. U.S. Department of the Interior-National Biological Service, Washington, DC.

Carothers, SW. 1977. Importance, preservation and management of riparian habitat: an overview. In: Importance, Preservation and Management of Riparian Habitat: A Symposium. R.R. Johnson and D.A. Jones tech coord. Gen. Tech. Rep. RM-43: U.S. Department of Agriculture Forest Service.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. USDI Fish and Wildlife Service, Washington, DC.

Crawford, C.S., Cully, A.C., Leutheuser, R., Sifuentes, M.S., White, L.H., Wilber, J.P. 1993. Middle Rio Grande ecosystem: bosque biological management plan. R. Robino, technical coordinator. U.S. Department of the Interior Fish and Wildlife Service, Albuquerque, NM.

Daubenmire, R.F. 1968. Plant Communities: A Textbook of Plant Synecology. Harper & Row, New York, NY.

Donahue, R.L., R.W. Miller and J.C. Shickluna. 1983. Soils: An Introduction to Soils and Plant Growth. Fifth ed. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Driscoll, R.S., D.L. Merkel, D.L. Radloff, D.E. Snyder and J.S. Hagihara. 1984. An ecological land classification framework for the United States. USDA Forest Service Misc. publ. no. 1439. U.S. Government Printing Office, Washington, DC.

Durkin, I'., M. Bradley, S.E. Carr, E. Muldavin and I'. Mehlhop. 1995. Riparian/ Wetland Vegetation Communities of the Rio Grande: A Classification and Site Evaluation. Unpublished final report submitted to the New Mexico Environment Department, Surface Water Quality Bureau, Santa Fe, NM.

Fenner, P., W.W. Brady, and D.R. Patton. 1985. Effects of regulated water flows on regeneration of Fremont cottonwood. Journal of Range Management, 38 (2): 135-138.

Grant, G.E., J.E. Duval, G.J. Koerper and J.L. Fogg. 1992. XSPRO: A Channel Cross Section Analyzer. U.S. Department of the Interior- Bureau of Land Management and U.S. Department of Agriculture Forest Service, Technical Note 387, BLM/SC/PT-92/001 + 7200, Denver, CO.

Hink, V.C. and R.D. Ohmart. 1984. Middle Rio Grande biological survey. Unpublished final report submitted in fulfillment of Army Corps of Engineers Contract No. DACW47-81-0015.

Howe, W.H. and F.L. Knopf. 1991. On the imminent decline of Rio Grande cottonwoods in central New Mexico. The Southwestern Naturalist 36 (2): 218-224.

Knopf, F.L., Johnson, R.R., Rich, T., Samson, F.B. and R.C. Szaro. 1988. Conservation of riparian ecosystems in the United States. Wilson Bulletin 100: 272-284.

Leonard, S.G., G.J. Staidl, K.A. Gebhardt, and D.E. Prichard. 1992. Viewpoint: range site/ecological site information requirements for classification of riverine riparian ecosystems. Journal of Range Management 45 (5): 431-435.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York, NY.

National Wetlands Inventory. 1984. Wetlands of the United States: current status and recent trends. U.S. Department of the Interior Fish and Wildlife Service, Washington, DC.

Pase, C.P. and E.F. Layser. 1977. Classification of riparian habitat in the southwest. In: Importance, Preservation and Management of Riparian Habitat: A Symposium. R.R. Johnson and

D.A. Jones tech coord. Gen. Tech. Rep. RM-43: U.S. Department of Agriculture Forest Service.

Podani, J. 1990. SYNTAX IV: Computer Programs for Data Analysis in Ecology and Systematics on IBM-PC and MacIntosh Computers. United Nations Industrial Development Organization. International Centre for Earth, Environmental and Marine Sciences and Technologies. Exeter Publishing, Ltd., Setauket, NY.

Roelle, J.E. and W.W. Hagenbuck. 1995. Surface cover changes in the Rio Grande floodplain, 1935-89. In: Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac eds. U.S. Department of Interior—National Biological Service, Washington, DC.

Siegel, R.S. and J.H. Brock. 1990. Germination requirements of key southwestern woody riparian species. Desert Plants. University of Arizona, Boyce Thompson Southwestern Arboretum 10 (1): 3-8.

Soil Conservation Service. 1991. National Soils Handbook. USDA Soil Conservation Service. Washington, DC.

Soil Survey Staff. 1992. Keys to Soil Taxonomy. SMSS Tech. Monograph, Fifth ed. Pocahontas Ress, Inc., Blacksburg, VA.

Stromberg, J.C., B.D. Richter, D.T. Patten, and L.G. Wolden. 1993. Response of a Sonoran riparian forest to a lo-year return flood. Great Basin Naturalist 53 (2): 118-130.

Waltemeyer, SD. 1986. Techniques for estimating flood-flow frequency for unregulated streams in New Mexico. Water-Resources Investigation Report 86-4104. U.S. Geological Survey, Albuquerque, NM.