



Environmental Affairs

A Descriptive Study of the Distribution of Riparian Plant Species and Some Associated Edaphic and Topographic Factors at Specific Sites Along the Middle Snake River Near Hagerman, Idaho

Nancy K. Cole
Plant Ecologist

Technical Report
Appendix E.3.3-C

Bliss
FERC No. 1975

Lower Salmon Falls
FERC No. 2061

Upper Salmon Falls
FERC No. 2777

November 1995

Table of Contents

List of Tables	ii
List of Figures.....	iii
List of Appendices	vii
Abstract	1
1. Introduction.....	2
2. Study Area.....	3
2.1. Location.....	3
2.2. Climate.....	3
2.3. Vegetation.....	4
2.3.1. Upland Vegetation	4
2.3.2. Riparian and Emergent Wetland Vegetation	5
2.3.3. Land Use	6
3. Methods.....	7
3.1. Field Methods.....	7
3.2. Data Analysis.....	8
4. Results.....	9
5. Discussion.....	18
6. Conclusions	20
7. Acknowledgments.....	21
8. Literature Cited.....	22

List of Tables

Table 1.	Physical description of transects sampled for gradient analysis of riparian and wetland plant communities in the Hagerman Study Area, 1991	28
Table 2.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA01, Hagerman Study Area, 1991	31
Table 3.	Soil texture at selected locations along gradient analysis transects, GA01-10, Hagerman Study Area, 1991	32
Table 4.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA02, Hagerman Study Area, 1991	33
Table 5.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA03, Hagerman Study Area, 1991	34
Table 6.	Eigenvalues and percent variance explained by Principal Components Analysis for transect GA03, Hagerman Study Area, 1991	35
Table 7.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA04, Hagerman Study Area, 1991	36
Table 8.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA05, Hagerman Study Area, 1991	37
Table 9.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA06, Hagerman Study Area, 1991	38
Table 10.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA07, Hagerman Study Area, 1991	39
Table 11.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA08, Hagerman Study Area, 1991	40
Table 12.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA09, Hagerman Study Area, 1991	41
Table 13.	Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA10, Hagerman Study Area, 1991	42

List of Figures

Figure 1.	Location of study area.....	43
Figure 2.	Köppen climate diagram for the Bliss weather station, Hagerman Study Area, southwestern Idaho	44
Figure 3.	Location of transects used for gradient analysis of riparian and wetland vegetation.....	45
Figure 4.	Elevational gradient of transects sampled for gradient analysis.....	46
Figure 5.	Distribution of individual species along transect GA01 in the Hagerman Study Area, 1991.....	48
Figure 6.	Edaphic characteristics and surface elevation profile of transect GA01, Hagerman Study Area, 1991.....	49
Figure 7.	Species/environment biplot resulting from canonical correspondence analysis of transect GA01.....	50
Figure 8.	Species/environment biplot resulting from canonical correspondence analysis of transect GA01 with plant associations (numbers 1-3) superimposed. 1 = <i>Salix exigua/Phalaris arundinaceae</i> ; 2 = <i>Salix amygdaloides/Euthamia occidentalis</i> ; and 3 = <i>Rhus trilobata</i>	51
Figure 9.	Distribution of individual species along transect GA02, Hagerman Study Area, 1991.....	52
Figure 10.	Edaphic characteristics and surface elevation profile of transect GA02, Hagerman Study Area, 1991.....	53
Figure 11.	Species/environment biplot resulting from canonical correspondence analysis of transect GA02.....	54
Figure 12.	Species/environment biplot resulting from canonical correspondence analysis of transect GA02 with plant associations (numbers 1-3) superimposed. 1 = <i>Salix amygdaloides/Chenopodium album</i> ; 2 = <i>Rosa woodsii/Urtica dioica</i> ; 3 = <i>Urtica dioica-Chenopodium album</i> ; and 4 = <i>Scirpus acutus</i>	55
Figure 13.	Distribution of individual species along transect GA03, Hagerman Study Area, 1991.....	56

Figure 14.	Edaphic characteristics and surface elevation profile of transect GA03, Hagerman Study Area, 1991.....	57
Figure 15.	Ordination diagram for vegetation data of transect GA03 produced from Principal Components Analysis.....	58
Figure 16.	Ordination diagram for vegetation data of transect GA03 produced from Principal Components Analysis showing plant association affiliation (numbers 1-4) for each species. 1 = <i>Elaeagnus angustifolia</i> / <i>Poa pratensis</i> ; 2 = <i>Elaeagnus angustifolia</i> / <i>Chenopodium album</i> ; 3 = <i>Chenopodium album</i> ; 4 = <i>Distichlis spicata</i> / <i>Bromus tectorum</i> ; and 5 = <i>Artemisia tridentata</i>	59
Figure 17	Distribution of individual species along transect GA04, Hagerman Study Area, 1991.....	60
Figure 18.	Edaphic characteristics and surface elevation profile of transect GA04, Hagerman Study Area, 1991.....	61
Figure 19.	Species/environment biplot resulting from canonical correspondence analysis of transect GA04.....	62
Figure 20	Species/environment biplot resulting from canonical correspondence analysis of transect GA04 with plant associations (numbers 1-3) superimposed. 1 = <i>Bromus tectorum</i> - <i>Kochia scoparia</i> ; 2 = <i>Distichlis spicata</i> ; and 3 = <i>Scirpus acutus</i>	63
Figure 21.	Distribution of individual species along transect GA05, Hagerman Study Area, 1991.....	64
Figure 22.	Edaphic characteristics and surface elevation profile of transect GA05, Hagerman Study Area, 1991.....	65
Figure 23.	Species/environment biplot resulting from canonical correspondence analysis of transect GA05.....	66
Figure 24.	Species/environment biplot resulting from canonical correspondence analysis of transect GA05 with plant associations (numbers 1-5) superimposed. 1 = <i>Distichlis spicata</i> - <i>Bromus tectorum</i> ; 2 = <i>Distichlis spicata</i> - <i>Kochia scoparia</i> ; 3 = <i>Juncus balticus</i> - <i>Chenopodium album</i> ; 4 = <i>Galium triflorum</i> - <i>Solanum dulcumara</i> ; and 5 = <i>Scirpus acutus</i>	67
Figure 25.	Distribution of individual species along transect GA06, Hagerman Study Area, 1991.....	68

Figure 26.	Edaphic characteristics and surface elevation profile of transect GA06, Hagerman Study Area, 1991.....	69
Figure 27.	Species/environment biplot resulting from canonical correspondence analysis of transect GA06.....	70
Figure 28.	Species/environment biplot resulting from canonical correspondence analysis of transect GA06 with plant associations (numbers 1-4) superimposed. 1 = <i>Artemisia tridentata</i> / <i>Distichlis spicata</i> ; 2 = <i>Iva axillaris</i> - mixed grasses; 3 = <i>Distichlis spicata</i> - <i>Eremopyrum triticeum</i> ; and 4 = <i>Scirpus americanus</i>	71
Figure 29.	Distribution of individual species along transect GA07, Hagerman Study Area, 1991.....	72
Figure 30.	Edaphic characteristics and surface elevation profile of transect GA07, Hagerman Study Area, 1991.....	73
Figure 31.	Species/environment biplot resulting from canonical correspondence analysis of transect GA07.....	74
Figure 32.	Species/environment biplot resulting from canonical correspondence analysis of transect GA07 with plant associations (numbers 1-5) superimposed. 1 = <i>Iva axillaris</i> / <i>Distichlis spicata</i> - <i>Eremopyrum triticeum</i> ; 2 = <i>Distichlis spicata</i> - <i>Kochia scoparia</i> ; 3 = <i>Distichlis spicata</i> - <i>Hordeum jubatum</i> ; 4 = <i>Carex nebraskensis</i> ; and 5 = <i>Typha latifolia</i>	75
Figure 33.	Distribution of individual species along transect GA08, Hagerman Study Area, 1991.....	76
Figure 34.	Edaphic characteristics and surface elevation profile of transect GA08, Hagerman Study Area, 1991.....	77
Figure 35.	Species/environment biplot resulting from canonical correspondence analysis of transect GA08.....	78
Figure 36.	Species/environment biplot resulting from canonical correspondence analysis of transect GA08 with plant associations (numbers 1-3) superimposed. 1 = <i>Celtis reticulata</i> ; 2 = <i>Artemisia tridentata</i> ; and 3 = <i>Salix exigua</i>	79
Figure 37.	Distribution of individual species along transect GA09, Hagerman Study Area, 1991.....	80
Figure 38.	Edaphic characteristics and surface elevation profile of transect GA09, Hagerman Study Area, 1991.....	81

Figure 39.	Species/environment biplot resulting from canonical correspondence analysis of transect GA09.....	82
Figure 40.	Species/environment biplot resulting from canonical correspondence analysis of transect GA09 with plant associations (numbers 1-5) superimposed. 1 = <i>Ribes aureum/Bromus tectorum</i> ; 2 = <i>Artemisia ludoviciana/Bromus tectorum</i> ; 3 = <i>Salix exigua/Glycyrrhiza lepidota-Dipsacus fullonum</i> ; 4 = mixed forbs; and 5 = <i>Veronica anagallis-aquatica-Epilobium glaberrimum</i>	83
Figure 41.	Distribution of individual species along transect GA10, Hagerman Study Area, 1991.....	84
Figure 42.	Edaphic characteristics and surface elevation profile of transect GA10, Hagerman Study Area, 1991.....	85
Figure 43.	Species/environment biplot resulting from canonical correspondence analysis of transect GA10.....	86
Figure 44.	Species/environment biplot resulting from canonical correspondence analysis of transect GA10 with plant associations (numbers 1-5) superimposed. 1 = <i>Prunus virginiana</i> ; 2 = <i>Rhus trilobata-Toxicodendron radicans</i> ; 3 = <i>Salix amygdaloides</i> ; 4 = <i>Salix exigua/Dipsacus fullonum</i> ; and 5 = <i>Polypogon monspeliensis-Veronica anagallis-aquatica</i>	87
Figure 45.	Mean monthly waterflow (cfs) and standard deviation for the Snake River at Milner Dam, Idaho, 1910-1993	88

List of Appendices

Appendix 1.	Field form for determining site conditions/disturbance	89
Appendix 2.	Two-way indicator species analysis with plant species cover data from transect GA01, Hagerman Study Area, 1991	90
Appendix 3.	Completed field forms for apparent vegetation condition for gradient analysis transects, Hagerman Study Area, 1991	91
Appendix 4.	Edaphic characteristics of transects GA01 and GA10, listed in order of occurrence along the transect	101
Appendix 5.	Two-way indicator species analysis with plant species cover data from transect GA02, Hagerman Study Area, 1991	109
Appendix 6.	Two-way indicator species analysis with plant species cover data from transect GA03, Hagerman Study Area, 1991	110
Appendix 7.	Two-way indicator species analysis with plant species cover data from transect GA04, Hagerman Study Area, 1991	111
Appendix 8.	Two-way indicator species analysis with plant species cover data from transect GA05, Hagerman Study Area, 1991	112
Appendix 9.	Two-way indicator species analysis with plant species cover data from transect GA06, Hagerman Study Area, 1991	113
Appendix 10.	Two-way indicator species analysis with plant species cover data from transect GA07, Hagerman Study Area, 1991	114
Appendix 11.	Two-way indicator species analysis with plant species cover data from transect GA08, Hagerman Study Area, 1991	115
Appendix 12.	Two-way indicator species analysis with plant species cover data from transect GA09, Hagerman Study Area, 1991	116
Appendix 13.	Two-way indicator species analysis with plant species cover data from transect GA10, Hagerman Study Area, 1991	117
Appendix 14.	Aquatic and terrestrial species occurring in the Hagerman Study Area.....	118
Appendix 15.	Associations between species and environmental factors sampled at ten transects in the Hagerman Study Area, 1991	138

Abstract

This study is part of a larger study to develop a classification scheme for plant communities along the middle Snake River. The purpose of this study is to identify environmental parameters that may influence the distribution of plant species with the riparian zone along the middle Snake River. Factors considered were position relative to water surface (distance and elevation), soil moisture content, soil rockiness and depth, and at two sites, soil texture and chemistry. Vegetation occurring at ten selected locations within the study area was sampled continuously across a transect oriented parallel to the predominant moisture gradient. Direct ordination was used to ordinate riparian and emergent wetland and edaphic characteristics. Soil moisture content (%) and distance from water were most often strongly correlated with plant species distributions. Physical characteristics such as soil depth, rock content and chemistry were also correlated, but less strongly.

1. Introduction

Discerning the factors affecting the distribution of plant species in time and space is largely a matter of scale. When examined from a continental perspective, the distribution of species relates strongly to climate (Mitsch and Gosselink 1993, Brinson et al. 1981), with physical and biological processes affecting species distributions at the geomorphic or landform level, e.g., ridges, slopes, and floodplains (Harris 1988). Riparian species tend to be less influenced by climate than upland species because of the proximity of riparian zones to water "captured" from other areas (Brinson et al. 1981), but the temporal and spacial distribution of precipitation that leads to the development of intermittent, as well as perennial, tributaries can have a profound influence on the species present (Malanson 1993). Geomorphic configuration of the channel determines the presence or absence of a floodplain. For example, bedrock streambeds tend to have vegetation development restricted to the bed margins (Brinson et al. 1981).

In addition to the influence of climate and geomorphology, random or periodic disturbance and biological factors affect the localized distribution of species. The influence of either, relative to one another, shifts back and forth, often resulting in changes in plant community composition (Mitsch and Gosselink 1993). Disturbance is an especially important characteristic of western riparian systems because of the dynamic nature of water delivery through a watershed (Malanson 1990). Natural allogenic processes, such as flooding, drought, wave action, but also land management practices, play a key role in determining species composition and spatial heterogeneity (Szaro 1989, Malanson 1993, Mitsch and Gosselink 1993). Superimposed upon the conditions imposed by climate, geology and disturbance are the biological characteristics of individual plant species. Such characteristics might include competitive performance, flooding tolerance, nutrient uptake, growth form and seed dispersal mechanisms (e.g., Ellison and Bedford 1995, Gaudet and Keddy 1995, Zimmerman and Thom 1982, Frye and Quinn 1979, Wistendahl 1958).

Plant species have been shown to distribute themselves along environmental gradients, with peak abundance reached in optimal habitats (Miles 1979). As conditions along a gradient change, species dominance changes. This response in species distributions leads to the development of zones of vegetation around wetland habitats. For example, gradients involving flood duration, soil nitrate, soil phosphorus and soil pH were found to be the critical factors determining plant species distributions within bottomland hardwood forests of Oklahoma (Hoagland and Sorrells 1992). Ice scouring and exposure to wave action have been cited as determining local species abundances in some graminoid-dominated wetland communities in southeastern Canada (Gaudet and Keddy 1995) and South Dakota (Johnson et al. 1987). Bryant et al. (1992) found the distribution of cattails in the Loxahatchee National Wildlife Refuge was clearly related to nutrient availability, especially phosphorus.

Identification of the important components of habitats can be assisted with ordination techniques (Kent and Coker 1992), among them, Principal Components Analysis (PCA), Two-way Indicator Species Analysis (TWINSPAN), Correspondence Analysis (CA) and Canonical Correspondence Analysis (CCA).

Principal Components Analysis is an indirect ordination technique that elucidates possible relationships between plant species and environmental characters. The TWINSpan technique classifies species into assemblages of least dissimilar samples by progressive refinement of single axis ordination from reciprocal averaging. Canonical Correspondence Analysis is a direct gradient analysis technique that combines ordination capabilities with correlation and regression analyses to determine the strength of relationships between the distribution of species and environmental characteristics (Kent and Coker 1992, ter Braak 1987).

This study is part of a larger study to develop a classification scheme for plant communities along the middle Snake River. The objective of the study is to identify environmental parameters that may influence community distribution and vegetative composition. This is a descriptive study focused upon the correlation of local edaphic and topographic characteristics with vegetation parameters at selected sites occurring within and adjacent to the Hagerman Study Area. Therefore, the influences of climate, geomorphology and disturbance are not considered in the analyses.

2. Study Area

2.1. Location

The Hagerman Study Area is located on the Snake River Plain in southwestern Idaho, near the communities of Hagerman and Bliss (Figure 1). It encompasses approximately 43 km of the Snake River and extends for 1.6 km on either side of the river. The elevation of the study area ranges from 762 to 1036 m above mean sea level incorporating a deeply incised basalt channel cut into the surrounding plain. Three hydroelectric projects are located in the study area: Upper Salmon Falls Dam (plants A and B; RM 581.4), Lower Salmon Falls Dam (RM 573.0), and Bliss Dam (RM 560.0), and the impoundments associated with each project. Each project has a legally defined project boundary incorporating physical structures and impoundments. All three projects are “run-of-the-river,” and have little storage capacity. There are three unimpounded reaches present. The first is the Thousand Springs Reach, between Banbury Springs (RM 589.2) and the Upper Salmon Falls impoundment (RM 585.4), the second is the Wiley Reach, between Lower Salmon Falls Dam and Bliss Reservoir (RM 565.7) and the third is the Dike Reach, located from Bliss Dam to Bancroft Springs (RM 552.9). Major tributaries to the Snake River within the study area include the Malad River (RM 571.4), Salmon Falls Creek (RM 586.9), Riley Creek (RM 583.4) and Billingsley Creek (RM 574.6). Additional significant inflows originate in the Thousand Springs complex from Niagara Springs (RM 600.8) to Owsley Bridge (RM 585.4).

2.2. Climate

The climate of the study area is semi-arid because of an orographic rainshadow created by the Cascade Mountain Range (Caldwell 1985, Franklin and Dyrness 1988, West 1988). Total precipitation

per year averages 216 mm (9.6 in.) (NOAA, Bliss weather station, 1951-1980). Mean annual temperature averages 10.6 °C (51.0 °F). Summers are typically hot and dry. Average precipitation for the summer months is 7.9 mm (0.35 in.) and daytime temperatures regularly exceed 37.8 °C (100 °F) during July (NOAA, Bliss weather station, 1951-1980). Generally, precipitation that falls during the summer does not percolate into the soil beyond the surface layer (Caldwell 1985, West 1988), instead it is primarily lost through evaporation and runoff. Winters are typically cold and moist. Most of the precipitation falls during the winter months as snow (Figure 2). Snowmelt provides most of the stored moisture in the soil profile that is available to vegetation (Caldwell 1985, West 1988).

2.3. Vegetation

Presettlement vegetation specific to the Snake River corridor is poorly known. A handful of illustrations were made in the mid to late 1800's that clearly identify *Artemisia tridentata* (big sagebrush) as the dominant overstory species (Settle 1940, Fremont 1845). There have been numerous attempts to describe the botanical features of southwestern Idaho since the first recorded collecting trips made in the early and mid 1800's by John C. Fremont and John McLeod. Unfortunately, most collectors were less interested in describing plant communities than individual species (D. Henderson, Univ. of Idaho, *pers. comm.*); thus historians are left with an incomplete picture of the historical organization of Idaho's vegetation landscapes. Descriptions of pristine vegetation are based primarily upon existing conditions at sites that are thought to be undisturbed and from historic data collected elsewhere in the Intermountain Region of the northwestern United States.

2.3.1. Upland Vegetation

The study area falls within the physiographic province identified as the Columbia-Snake River Plateau (West 1983a, 1988), also described as the Intermountain Sagebrush Province (Bailey 1978). Upland areas have been classified by West (1983b) as part of the Western Intermountain Sagebrush Steppe. Some authors include the study area within the extent of the Great Basin flora (Hidy & Kleiforth 1990), although the area does not coincide topographically with the physiographic boundaries that define the Great Basin.

Artemisia species, coupled with an understory of perennial bunchgrass including *Agropyron* (wheatgrass), *Poa* (bluegrass), *Stipa* (needle-and thread grass), and *Oryzopsis* (ricegrass) species, are typical of sagebrush steppe. Once thought to be subclimax to perennial grassland communities (Shantz and Zon 1924, Weaver and Clements 1938, Clements and Clements 1939), sagebrush-grass vegetation is now thought to be ecologically stable. Local shifts in composition can occur rapidly and frequently in response to climatic conditions (Blaisdell 1958, Sharp et al. 1990), but overall composition and abundance have been shown to be stable (Anderson and Holte 1981).

Four plant associations were identified for upland vegetation in the study area (Appendix E.3.3-A). These include two *Artemisia tridentata/Bromus tectorum* associations differing primarily in the abundance of shrub cover, a *Chrysothamnus nauseosus/Bromus tectorum* association, and a *Bromus tectorum/Sisymbrium altissimum* association. Two other upland cover types, Upland Forest and Tree Savanna, were sampled insufficiently to provide a clear classification into plant associations.

All of the associations described have exotic and weedy species contributing significantly to species composition and abundance. The prevalence of exotics is an indication of the long and varied history of disturbance that has occurred within the study area (Appendix E.3.3-A). Disturbances have included grazing, mining, fire, agriculture and associated rural development, among others.

2.3.2. Riparian and Emergent Wetland Vegetation

Juxtaposed upon the dry landscape are narrow bands of riparian vegetation that follow perennial watercourses. In this setting, trees and tall shrubs, such as *Salix* spp. (willows), replace the *Artemisia* spp. and the diversity of grasses and forbs increases (Mitsch and Gosselink 1993). Within the narrow band, numerous riparian communities are distributed along a moisture gradient from emergent wetland to vegetation transitional between wetland and upland communities (Myhre and Clements 1972, Jensen and Verhovek 1979, Tisdale 1986, Minshall et al. 1989, Johnson et al. 1992). Species are also distributed in response to local changes in soils, topography, and, at least historically, seasonal disturbance frequency, e.g. flooding (Mitsch and Gosselink 1993, Sather-Blair 1988). Flooding is a natural ecological disturbance that greatly affects the composition and arrangement of species within the riparian corridor (Szaro 1989). Most riparian species are well adapted to periodic disturbance because of the dynamic nature of their natural environment.

Flooding maintains riparian systems by creating new habitat, distributing nutrients, and by importing and exporting organic material (Etherington 1983, Mitsch and Gosselink 1988). Steep channel slopes, like those found in the study area, tend to have less widespread flooding (Mitsch and Gosselink 1988), therefore limiting the size of the riparian zone. Ultimately, hydroperiod, including flood intensity, duration, and timing, determines ecosystem function and structure (Mitsch and Gosselink 1988, Klimas 1988). Seasonal flooding also maintains wetland and riparian habitats in early successional stages (Etherington 1983), leading to a more diverse vegetation than occurs in surrounding vegetation (Klimas 1988).

Cowardin et al. (1979) provided a general classification of riparian and wetland vegetation cover types for the United States based primarily on physiognomic status, but also involving physiographic (e.g., lake/river), substrate (e.g., consolidated gravel/bedrock) and hydrologic (e.g., seasonal intermittent flow) characteristics. The classification was used to map the distribution of wetland types across the U.S. (USFWS National Wetlands Inventory, NWI). Three cover types are common on NWI maps of Idaho: *Emergent*, *Scrub-Shrub*, and *Forested Wetland* (Sather-Blair 1988). In general, *Scrub-Shrub* vegetation is dominant along the water's edge, with forested species occurring slightly up-slope (Sather-Blair 1988,

Johnson et al. 1992). Within the riparian zone, herbaceous species tend to be more common at the wetter edge of the moisture gradient (Myhre and Clements 1972, Jensen and Verhovek 1979, Johnson et al. 1992).

The dynamic nature of the wetland/riparian environment leads to the development of numerous plant associations. Studies conducted by IPC biologists identified twenty different riparian and wetland plant associations (Appendix E.3.3-A). The associations dominated by *Salix exigua* and *Elaeagnus angustifolia* tend to occur at or near the water's edge. As for upland plant associations, most of the riparian associations have exotic species as integral components.

Grazing can impact riparian vegetation because livestock tend to congregate along waterways seeking water and shade as well as forage (Szaro 1989). Impacts can include change in vegetative composition, a lowered water table, and complete loss of riparian cover (Minshall et al. 1989, Szaro 1989). Many of the native shrub species resprout after defoliation by grazing livestock, but only if sources of regeneration remain on site (Hansen 1992). Noxious weed species generally find open habitat available for colonization in heavily grazed riparian systems (Hansen 1992). Like the vegetation of the sagebrush-bunchgrass type, examples of pristine riparian vegetation on the Snake River Plain are rare.

2.3.3. Land Use

In the 1860's ranchers grazed large herds of cattle in southern Idaho (Yensen 1982) to provide food for the growing population of miners (Young 1986). By the 1880's, large cattle ranches were common. Sheep herding also became more common about this time (Yensen 1982, Young 1986). The Raft River Valley was a route commonly used to drive sheep from Utah and Nevada into the mountains of Idaho for summer grazing. Herds were also driven into Idaho during the winter to avoid grazing taxes in Utah (Yensen 1982). Young (1986) describes the Raft River Valley as a "...dust bowl as a result of the migrations." An 1880 census reported 27,326 sheep in Idaho. In 1890, a census listed 357,712 sheep (Young 1986). The years 1889 and 1890 brought two of the coldest and snowiest years recorded. Extreme weather conditions, combined with a decade of severe overgrazing, devastated herds of cattle and sheep. Subsequently, hay farming on irrigated land soon became a common practice to provide reliable winter food for cattle (Young 1986) and sheep (Yensen 1982). The Hagerman Valley surrounding Upper and Lower Salmon Falls Reservoirs was used extensively for irrigated agriculture for almost a century because of the availability of numerous springs along the east side of the Snake River. Upland areas that were not irrigated were grazed by livestock.

Following the passage of the Carey and Desert Land Entry Acts, private organizations and the federal government rushed to build irrigation facilities to divert the flow of the Snake River and tributaries onto the desert landscape in order to "reclaim" the land for agriculture. Irrigation projects became commonplace and agriculture became an important source of income for the region (Miss and Campbell 1988). One of the earliest large-scale reclamation projects undertaken on the Snake River began in the early 1900's at what is now known as the Milner Dam site. Large numbers of would-be farmers emigrated from the eastern and middle United States to take advantage of new government

regulations (e.g., Carey Act, Enlarged Homestead Act) that provided up to 320 acres of land (Yensen 1982) to any man, woman or child willing to convert the arid West into farmland (Greenwood 1987). Many of these farms failed, especially during the drought and depression years of the 1930's, leaving behind large areas denuded of vegetation.

In the late 1950's technology became available to build powerful electric pumps to irrigate upland habitats on the benches above the Snake River. Subsequently, large tracts of *Artemisia*-dominated lands were developed for agriculture (Stacy 1991). Currently, many of the upland areas on the benches, as well as much of the Hagerman Valley, are under cultivation. Nearly 500,000 acres of the surrounding counties have been converted to cropland (J. Grover, Consolidated Farm Services Agency, *pers. comm.*). This amounts to 20% and 25% of the total land acreage in Gooding and Twin Falls counties respectively. Uncultivated areas in the study area are generally grazed with exception of the Hagerman Fossil Beds National Monument. The monument has not been grazed since the early 1980's.

3. Methods

3.1. Field Methods

Prior to selection of transect locations, native and naturalized plant communities were identified based on the principal investigator's familiarity with the riparian vegetation of the study area. The communities were defined as plant associations dominated by native species and occurring repeatedly in the study area. The criteria for selection of transect locations included recent grazing history, fire history, relatively shallow slopes, and the presence of associations considered most representative of the study area. Actual transect locations were then selected from areas thought to have little recent disturbance. An attempt was made to choose locations with as many plant communities represented as possible. Ultimately, 10 locations were chosen (Figure 3). One location (GA10) was approximately 5 miles downstream of the Hagerman Study Area (T5S R11E Sec7 NE1/4 SE1/4).

Transects were selected, mapped and marked in spring 1991. A 100 m tape was laid along the moisture gradient from the outer edge of the riparian or emergent vegetation - open water interface to a point within the upland plant community where no more facultative wetland (FACW, FAC+) species (as defined by Reed 1988) occurred. A list of wetland and species and their status (Reed 1988) was used to determine which species were obligate to wetland habitats and which were facultative. The physical attributes of the transect were recorded, including aspect (degrees), elevation, slope, type and degree of disturbance. Degree of disturbance was determined from a modified version of the Natural Resources Conservation Service (NRCS) range classification standards provided in the Soil Conservation Service National Range Handbook (1976). The NRCS monitors range condition at numerous sites across the United States. In their evaluation of range condition, they take into account the composition, vigor and productivity of the vegetation, reproductive effort, percent of the plant community that represents the "potential" vegetation for the site and the degree of surface soil erosion. Riparian plant community composition is naturally more dynamic than community composition in uplands primarily because fluvial process is an important component shaping the local environment (Mitsch and Gosselink 1993). Thus, riparian communities commonly exist in a state of "dynamic equilibrium" (Szaro 1989). Therefore, rather than use "potential" vegetation as an indication of disturbance, the abundance of native species composing the existing plant associations was used. Specific attributes representing the site condition at each transect location were scored from 1 to 4 (Appendix 1). The scores were summed to obtain an estimate of site quality. The greater the sum, the less the disturbance.

The transect was sampled continuously along its entire length with a quadrat made of 2.5 cm diameter PVC pipe. The inside dimensions of the frame were 0.5 m x 1.0 m. The quadrat was centered on the tape with the long axis perpendicular to the transect. Information collected within each quadrat included: 1) the percent cover of the four dominant species in the herb layer (dominant species were those with the greatest cover); 2) a list of other species present within the quadrat; 3) a soil sample for moisture determination; 4) percent of rock cover; 5) depth of soil that could be penetrated by a 1 cm diameter steel rod; and 6) elevation of each quadrat above the water surface. In addition, soil samples were collected along two transects for soil chemistry analyses. The two transects were chosen to maximize the number of plant associations and individual species represented. A 2.5 cm diameter soil probe was used to sample soil moisture at the 20-30 cm depth of the soil profile. Soils were immediately placed in airtight containers and taken to the laboratory. The samples were weighed, dried overnight at 105°C, then reweighed. Soil moisture content was determined as the percent of the dry weight of the sample. Soil samples for chemistry analyses were collected with an auger to the same approximate 20-30 cm depth. Complete soil chemistry analysis included texture, lime (Soltanpour and Workman 1981), pH (Richards 1954), conductivity (Richards 1954), organic matter content (Greweling and Peech 1960), and macronutrients (Olson and Sommers 1982, Sims and Jackson 1971). Cover of woody shrubs and trees within the quadrat was measured using the line intercept method (Canfield 1941) along the transect line, and measured to the nearest cm.

3.2. Data Analysis

Classification of vegetation data into plant associations was achieved for each transect by using Two-Way-Indicator-Species-Analysis (TWINSPAN). Two-Way-Indicator-Species-Analysis is a polythetic, divisive method of classification that groups species and transects by "progressive refinement of single axis ordination from reciprocal averaging..." (Kent and Coker 1992). Multiple dichotomies are created until no significant dissimilarities are found within a group or a minimum sample size of three transects is reached. Generally, dichotomies beyond the third level are not considered in classification (Kent and Coker 1992, Gauch 1989, Jongman et al. 1987). The strength of each dichotomy is measured using eigenvalues calculated during each ordination. Eigenvalues describe the amount of variation explained by a particular ordination axis (Kent and Coker 1992, Gauch 1989, Jongman et al. 1987). The larger the eigenvalue, the more variation is accounted for by the axis and the more similar are members of the group relative to other groups. Eigenvalues were used to determine which dichotomies were the strongest and could be used for classification.

Canonical Correspondence Analysis (CCA) was performed on all datasets from each transect to identify factors that may influence species distributions. For one transect, CCA was insufficient to group species with associated environmental factors. For that transect, additional analysis was done using Principal Components Analysis. Both PCA and CCA produce diagrams depicting the data sets arranged along X and Y axes. The X-axis is commonly referred to as Axis I, while the Y-axis is commonly referred to as Axis II.

Canonical Correspondence Analysis is a direct ordination technique that utilizes regression of species data against environmental data in combination with ordination techniques to discern correlations between species data and environmental factors (Kent and Coker 1992, ter Braak 1988). Multiple "axes" can be identified by CCA. The axes represent one or more environmental gradients. A correlation matrix is produced such that the environmental factors represented by the axes can be identified. Eigenvalues calculated by the ordination are used to determine which axes account for the most variation in the data set. The species-environment correlations are depicted in a two dimensional graph.

Principle Components Analysis is an indirect ordination technique that "...linearly transforms an original data set into a [sic] set of uncorrelated variables that represents most of the information in the original set of variables" (Duntelman 1989). This is done by organizing the data set into groups of correlated variables that are relatively independent of one other (Tabachnick and Fidell 1989). The technique attempts to explain variation observed in the data set on the basis of a few underlying, and unmeasured, dimensions. The dimensions are thought to reflect underlying processes that have created the correlations. Principal Components Analysis has no underlying statistical model of the observed variables and focuses on explaining the total variation in the observed variables on the basis of the maximum variance properties of the principal components (Duntelman 1989). The processes that underlie the distribution of the data set are inferred through interpretation of a two (or more) dimensional graph depicting the ordination results.

4. Results

Transect GA01 was 39.5 m long with a total elevation change of 3.0 m (Table 1). Slope changed gradually for the first 26 meters then inclined more steeply for the remaining 14 meters (Figure 4). The aspect was west-facing (270°) (Table 1). Three plant associations were delineated: *Salix exigua*/*Phalaris arundinaceae*, *Salix amygdaloides*/*Euthamia occidentalis*, and *Rhus trilobata* (Table 1, Appendix 2). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity decreased rapidly as the slope became steeper (Figure 5).

Soil characteristics measured were texture, percent soil moisture, pH, conductivity, nitrogen, phosphorus, organic matter and calcium carbonate (lime) content. Soil textures were primarily loams and silt loams at the wettest end of the transect with loamy sands and sandy loams occurring in the drier zones (Appendix 4). Soil moisture ranged from 56.1% to 1.1%; pH ranged from 7.6 to 8.6 with the more neutral soils tending to occur in the wet areas (Figure 6). Soil conductivity ranged from 0.4 to 2.2 dS/m (deciSiemens/meter) with the lower values occurring in the drier soils. Calcium content was high throughout the transect, low only at the very driest end of the transect. Nitrogen content was low across the transect ranging from 0 to 8%. The running mean of percent nitrogen tended to decline with increasing distance from water. Organic matter was also low throughout the transect, but highest near the water's edge, decreasing as distance from water increased.

Axis I of the ordination is most closely correlated to the distance of a quadrat from water and its elevation relative to the water surface (Table 2, Figure 7). The moisture content and electrical conductivity of the soil are also more correlated to the first axis than to the second, though the relationships are not as strong as for the distance and elevation factors. Axis II is most closely correlated to soil phosphorus content, soil pH and texture.

The distribution of *Salix exigua* appears to be most strongly correlated with soil phosphorus and moisture content, while the other dominant woody species are not strongly correlated with any of the factors measured (Figure 7). Of the environmental variables known, *Rhus trilobata* associates most strongly with relative elevation above the water. *Salix amygdaloides* may be associated, albeit weakly, with nitrogen content and electrical conductivity of the soil. Other noteworthy correlations include the very strong correlations between *Lactuca serriola* and soil phosphorus, and between two herbaceous species, *Chenopodium album* and *Dipsacus fullonum*, and soil moisture content.

The three plant associations found on transect GA01 appear to correlate to environmental factors in a manner similar to the dominant species occurring in each association (Figure 8). The *Salix exigua*/*Phalaris arundinaceae* association (group 1 on Figure 8) is composed of species that appear at nearly the same position along Axis I, but are scattered widely along Axis II, suggesting the association is most closely correlated with soil moisture. The *Salix amygdaloides*/*Euthamia occidentalis* association (group 2) tends to be made up of species clustered near the origin of Axes I and II among the arrows describing electrical conductivity, nitrogen content and pH. The third group, the *Rhus trilobata* association, appears at the portion of Axis I that reflects lowest soil moisture content.

Transect GA02 was 40.0 m long with a total change in elevation of 3.2 m (Table 1). Although average slope for the transect was 8.0%, the bulk of the incline occurred during the last 7.0 meters (Figure 4). Most of the transect had standing water present. The aspect was northeast-facing (52[⊕]) (Table 1). Four plant associations were delineated: *Scirpus acutus*, *Urtica dioica*-*Chenopodium album*, *Salix amygdaloides*/*Chenopodium album*, and *Rosa woodsii*/*Urtica dioica* (Table 1, Appendix 5). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity was greatest on both ends of the transect (Figure 9).

Soil characteristics measured were percent soil moisture and depth. Rock was absent from the soil surface. Soil moisture ranged from 57.8% to 1.3%; depth was uniform essentially throughout the transect (Figure 10). Soil texture sampled at four sites along the transect indicated silt loam at the center surrounded by sandy loam on the wetter end and sand on the drier end (Table 3).

Axis I of the ordination is most closely correlated to the elevation relative to the water surface and soil moisture (Table 4, Figure 11). The amount of variation explained by the first axis is moderate (46.0%). Axis II is most closely correlated to the distance of the sample quadrat from water.

Most species cluster around the center of the biplot (Figure 11). Only the species typical of drier, upland soils disperse away from the center of the diagram. Two *Salsola* species and *Rosa woodsii* are correlated with relative elevation above the water surface.

The distribution of the four plant associations found on transect GA02 overlaps significantly, thus the factors influencing the location of the associations along the transect are not discernable with the factors measured (Figure 12).

Transect GA03 was 80.5 m long with a total change in elevation of 4.2 m (Table 1). The average slope for the transect was 5.2% (Figure 4). The aspect was southwest-facing (250[⊕]) (Table 1). Five plant associations were delineated: *Elaeagnus angustifolia*/*Poa pratensis*, *Elaeagnus angustifolia*/*Chenopodium album*, *Chenopodium album*, *Distichlis spicata*-*Bromus tectorum*, and *Artemisia tridentata* (Table 1, Appendix 6). Vegetation was considered to be in moderate condition with some disturbance (Appendix 3). Vegetation complexity declined slowly with increasing distance from water (Figure 13).

Soil characteristics measured included percent soil moisture, depth and percent cover by rock. Soil moisture ranged from 36.8% to 2.7%; depth ranged between 7 and 40 cm, although depth was generally 10-20 cm across the transect (Figure 14). Rock cover was high (>50%) along the river bank where riprap had been placed, but decreased to 0% after meter 2.0 (Figure 14). Soil texture sampled at four sites along the transect indicated soils near the water were sandy loam, changing to loamy sand by one-quarter of the length of the transect. Sand dominated from the middle of the transect to the end (Table 3).

Axis I of the ordination is most closely correlated to the elevation relative to the water surface (Table 5). The amount of variation explained by the first axis is 78.7%. Axis II is most closely correlated to the moisture content of the soil. These two axes together explain 99.1% of the variation found in the data set. However, species are tightly clustered about the center of the biplot produced during CCA analysis and no correlations among species and environmental factors are discernable.

A PCA performed on the vegetation data shows riparian species such as *Lycopus asper* and *Polygonum persicaria* on one end of the axis and *Artemisia tridentata* on the other end suggesting Axis I may depict a moisture gradient (Figure 15). Species with more intermediate moisture requirements, *Medicago sativa* and *Agropyron repens*, also occur at the same end of Axis I as *Artemisia tridentata*, thus the moisture gradient is not clear. The percentage variance explained by Axis I is 48.1% (Table 6). Axis II cannot be defined from the environmental data collected and there is insufficient information known about the ecology of each species to suggest what other environmental factors might correspond to the second axis.

Patterns in distribution of plant associations are discernable on the PCA diagram, although overlapping somewhat (Figure 16). The *Elaeagnus angustifolia* associations (groups 1 and 2 on Figure 16) tend to occur in moist habitats and are found on the left side of the diagram. The *Chenopodium album* association (group 3) tends to occur on the lower portion, and the *Distichlis spicata*-*Bromus tectorum* (group 4) and *Artemisia tridentata* (group 5) associations tend to occur on the right side of the diagram. The latter association occupies upland habitats. The presence of *Bromus tectorum* with *Distichlis* suggests group 4 may also tend toward upland habitats as well. The distribution of each association tends to reflect the distribution of the dominant species associated with each group with a possible moisture gradient lying between the *Elaeagnus*- and *Distichlis*-dominated associations.

Transect GA04 was 30.0 m long with a total change in elevation of 1.6 m (Table 1). A gradual increase in slope gave the transect a slope of 5.2% (Figure 4). The aspect was northeast-facing (46°) (Table 1). Three plant associations were delineated: *Scirpus acutus*, *Distichlis spicata*, and *Bromus tectorum*-*Kochia scoparia* (Table 1, Appendix 7). Riparian vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity was greatest on both ends of the transect (Figure 17). *Distichlis spicata* formed a monoculture at the center of the transect.

Soil characteristics measured were percent soil moisture and depth. Rock was absent from the soil surface. Soil moisture ranged from 59.8% to 10.6% (Figure 18). Soil depth ranged from 80 cm near the moist end of the transect to 6 cm at the drier end. Soil texture sampled at four sites along the transect indicated loam at the center bounded by sandy loams on the wet and dry ends (Table 3).

Axis I of the ordination is most closely correlated to the elevation relative to the water surface and soil depth (Table 7, Figure 19). Soil moisture correlates more strongly to Axis I than Axis II. The amount of variation explained by the first axis is high (77.0%). There are no measured environmental factors that correlated strongly to Axis II.

Species shown in the biplot (Figure 19) are arrayed horizontally by habitat: all of the upland species occur left of the center point, while all of the riparian and wetland species occur to the right. *Urtica dioica* and *Scirpus acutus* may be associated with greater soil depth as well.

The plant associations of transect GA04 tend to disperse along the first axis, with the *Scirpus acutus* association (group 3 on Figure 20) tending to occur at lower elevations and higher soil moisture. The remaining two associations are similarly positioned along Axis I, but separate from one another along Axis II. Given the weedy makeup of the *Bromus tectorum*-*Kochia scoparia* association, it is possible that Axis II represents a disturbance gradient. All of the species present in groups 1 and 2 are annual weeds, except the *Distichlis*.

Transect GA05 was 42.0 m long with a total change in elevation of 2.3 m (Table 1). The average slope for the transect was 5.5% (Figure 4). The aspect was east-facing (87°) (Table 1). Five plant associations were delineated: *Scirpus acutus*, *Galium triflorum*-*Solanum dulcamara*, *Juncus balticus*-*Chenopodium album*, *Distichlis spicata*-*Kochia scoparia*, and *Distichlis spicata*-*Bromus tectorum* (Table 1, Appendix 8). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity was greatest at the transition from emergent to riparian vegetation (Figure 21).

Soil characteristics measured included percent soil moisture and depth. Rock cover was absent except at one site where cover was 13%. Soil moisture ranged from 90.6% to 9.3%; depth ranged between 5 and 80 cm with the deepest soils at the moist end of the transect (Figure 22). Soil texture sampled at four sites along the transect indicated soils were sandy loam throughout (Table 3).

Axis I of the ordination is most closely correlated to the elevation relative to the water surface (Table 8, Figure 23). However, the amount of variation explained by the first axis is only 59.0% (Table 8). Axis II was correlated equally to the moisture content and depth of the soil. In total, 87.8% of variation in the vegetation data was explained by the two axes.

Species appear to be arranged along Axis I from riparian and wetland habitats to upland habitat (Figure 23). Upland species such as *Agropyron cristatum*, *Salsola kali*, *Bromus tectorum* and *Sisymbrium altissimum*, are associated most strongly with the relative elevation above water surface. Riparian species appear to be correlated with both axes, with *Scirpus acutus* most strongly associated with moisture while *Scutellaria galericulata*, *Solanum dulcamara*, *Lycopus asper* and *Typha latifolia* appear to be associated with soil depth.

The plant associations of transect GA05 are well dispersed along Axis I, but have considerable overlap (Figure 24). This suggests that the distribution of associations is correlated with elevation above water. The *Scirpus acutus* and *Galium triflorum*-*Solanum dulcamara* associations (groups 4 and 5 on Figure 24) tend to occur in moister soils compared to other associations. They also overlap along Axis II indicating they have similar moisture requirements.

Transect GA06 was 23.0 m long with a total change in elevation of 1.7 m (Table 1). The average slope for the transect was 7.4% (Figure 4). The aspect was southeast-facing (112°) (Table 1). Four plant associations were delineated: *Scirpus americanus*, *Distichlis spicata*-*Eremopyrum triticeum*, *Iva axillaris*-mixed grasses, and *Artemisia tridentata*/*Distichlis spicata* (Table 1, Appendix 9). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity was greatest at the transition from emergent to riparian vegetation (Figure 25).

Soil characteristics measured were percent soil moisture and depth. Rock cover was absent. Soil moisture ranged from 36.1% to 19.8%; depth ranged between 3 and 80 cm with the greatest depth near the water's edge (Figure 26). Soil texture sampled at four sites along the transect indicated soils were sandy loam across the entire transect (Table 3).

Axis I of the ordination is most closely correlated to the elevation relative to the water surface and soil moisture (Table 9, Figure 27). The amount of variation explained by the first axis is 65.9% (Table 9). Of the three measured factors, soil depth shows the strongest relationship with Axis II. However, the correlation value for depth is nearly equal for Axes I and II ($r=0.67$ and -0.62 , respectively). In total, 90.4% of variation in the vegetation data is explained by the two axes.

Veronica anagallis-aquatica and *Scirpus americanus* appear to be correlated to soil moisture content (Figure 27). The relative positions of the riparian species, *Galium triflorum* and *Chenopodium album*, and the upland species, *Lepidium perfoliatum* and *Grindelia squarrosa*, suggest soil depth may be important. The two riparian species are present on deeper soils than the two upland species occupy. *Iva axillaris*, on the other hand, is an upland species that appears to prefer deeper soils. *Polygonum persicaria* lies intermediate to the soil moisture and soil depth arrows, suggesting that both factors may be correlated with the distribution of that species.

The plant associations of transect GA06 display some overlap, especially among the two associations that occupy the drier portion of the landscape (groups 1 and 2 of Figure 28). There, the vegetative difference between the two associations is the presence of *Artemisia tridentata* (group 1). This would suggest the *Iva axillaris* association (group 2) most closely resembles an upland association at this site. Among the associations as a whole, the distribution along Axis I reflects differences in soil moisture with the emergent plant community, *Scirpus americanus* (group 4), at the “wettest” end of Axis I and the two upland communities at the opposite end. The remaining riparian association (group 3) is spread along the moisture gradient represented by Axis I, but it is also widely spread along the soil depth gradient represented by Axis II.

Transect GA07 was 20.5 m long with a total change in elevation of 1.9 m (Table 1). The average slope for the transect was 9.3% (Figure 4). The aspect was northeast-facing (70°) (Table 1). Five plant associations were delineated: *Typha latifolia*, *Carex nebraskensis*, *Distichlis spicata*-*Hordeum jubatum*, *Distichlis spicata*-*Kochia scoparia*, and *Iva axillaris*/*Distichlis spicata*-*Eremopyrum triticeum* (Table 1, Appendix 10). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity was greatest at either end of the transect (Figure 29).

Soil characteristics measured were percent soil moisture and depth. Rock cover was absent except at meters 2.0 and 2.5 where it was 5%. Soil moisture ranged from 53.3% to 18.0%; depth ranged between 2 and 80 cm and was greatest at the wet end of the transect (Figure 30). Soil texture sampled at four sites along the transect indicated soils were sandy loam across the entire transect (Table 3).

Axis I of the ordination is most closely correlated to soil depth (Table 10, Figure 31). Relative elevation above the water surface is correlated nearly equally to Axes I and II ($r=-0.73$ and -0.68 , respectively). It is the environmental variable that is the most strongly correlated with Axis II. Soil moisture was more strongly correlated to Axis I than Axis II. In total, 97.5% of variation in the vegetation data is explained by the two axes.

Species are distributed along a horizontal gradient from moist habitats (*Typha latifolia* and *Veronica anagallis-aquatica*) to dry habitats (*Kochia scoparia* and *Eremopyrum triticeum*) (Figure 31). A number of wetland and riparian species appear to be correlated with soil depth including *Typha latifolia*, *Veronica anagallis-aquatica*, *Xanthium strumarium* and *Cirsium* spp. *Lycopus asper* and *Hordeum jubatum* appear to be correlated with soil moisture.

The plant associations of transect GA07 are distributed along the soil depth and moisture gradients represented by Axis I (Figure 32). Two pairs of associations overlap: the *Distichlis spicata-Kochia scoparia* association (group 2 of Figure 32) occupies a similar position along Axis I with the *Iva axillaris*/*Distichlis spicata-Eremopyrum triticeum* association (group 1), and the two emergent plant associations, *Carex nebraskensis* (group 4) and *Typha latifolia* (group 5), share a similar position at the opposite end of Axis I. The association dominated by *Iva axillaris* also appears to correlate most strongly to elevation above water surface as compared to the other associations present.

Transect GA08 was 20.5 m long with a total change in elevation of 7.6 m (Table 1). The average slope for the transect was 37.1% (Figure 4). The aspect was east-facing (88°) (Table 1). Three plant associations were delineated: *Salix exigua*, *Celtis reticulata*, and *Artemisia tridentata* (Table 1, Appendix 11). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation was floristically simple; only six species were present, including two upland species (Figure 33).

Soil characteristics measured were percent rock cover and depth. Soils present across the lower half of the transect were shallow deposits (< 5 cm) overlying basalt boulders (Figure 34). Soil under the boulders was not accessible and therefore was not sampled. Depth was very shallow near the wet end of the transect, increasing at the center of the transect then declining somewhat as elevation increased. Cover of rock was very high (>80%) for half of the length of the transect then declined as elevation increased. Soil moisture ranged from 8.3% at the middle of the transect to 0.3% at the dry end of the transect. Soil texture sampled at four sites along the transect indicated soils were loamy sand near the center of the transect, changing to sand near the upper end (Table 3).

Axis I of the ordination appears to be most closely correlated with distance from water and percent cover of rock (Table 11, Figure 35). Axis II is most closely correlated with soil depth. Soil moisture was not included in the CCA because soil samples were not available for sampling for most of the transect. The factors associated with Axis I account for 89.7% of the variability in the vegetation data set. Together the three factors, distance from water, cover of rock and soil depth, accounted for 99.6% of the total variability.

Species are distributed along a gradient from moist habitats (*Salix exigua*, *Ribes aureum*, and *Verbascum thapsus*) to drier habitats (*Artemisia tridentata*) (Figure 35). In general, the riparian species appear to correlate most strongly with decreasing distance from water, although *R. aureum* and *S. exigua* appear to be associated with rock cover, as well. *Verbascum thapsus* may correlate with soil depth. *Celtis reticulata* occupies the center of the diagram, showing no affinity for any of the factors measured. *Artemisia tridentata* and *Bromus tectorum* appear associated with low rock cover and locations that are farthest from water.

Transect GA08 is occupied by three plant associations that sort along the axis most closely correlated with distance from water and rock cover (Figure 36). There is very little differentiation among associations along Axis II. The *Artemisia tridentata* association, an upland plant association (group 2 of Figure 36) is most positively correlated with low rock cover and a simultaneous increase in measurable soil depth. The two riparian associations, *Salix exigua* (group 3) and *Celtis reticulata* (group 1) are located similarly along Axis I and may share similar habitat characteristics.

Transect GA09 was 24.0 m long with a total change in elevation of 8.5 m (Table 1). The average slope for the transect was 35.4% (Figure 4). The aspect was north-facing (0°) (Table 1). Five plant associations were delineated: *Veronica anagallis-aquatica-Epilobium glaberrimum*, mixed forbs, *Salix exigua/Glycyrrhiza lepidota-Dipsacus fullonum*, and *Artemisia ludoviciana/Bromus tectorum* (Table 1, Appendix 12). Vegetation was in good condition with little disturbance (Appendix 3). Vegetation complexity was lowest at the dry end of the transect (Figure 37).

Soil characteristics measured were percent cover of rock and depth. Rock cover was 100% for most of the first 12.5 m of the transect, declining to near 0% at 16 m (Figure 38). Depth varied with rock cover. Where soil was present, depth ranged from 3 to 53 cm. Soil samples were not available for most of the transect because of rock cover, so soil moisture was not determined for most of the transect. The samples that could be collected had moisture contents ranging from 6.7% to 1.6%. Soil texture sampled at three sites along the transect indicated soil changed from sandy loam at meter 4.0 to loamy sand at meter 24.0 (Table 3).

Axis I of the ordination is most closely correlated to the elevation relative to the water surface and surface rock content (Table 12, Figure 39). Soil depth and cover by rock are equally, and oppositely, correlated with Axis II ($r=-0.50$ and 0.49 , respectively). The percent variation explained by the first axis is 58.1%. Total variation in the vegetation database explained by both axes is high (96.1%).

Celtis reticulata and *Agropyron spicatum* appear to be correlated with rock cover and elevation

above the water surface (Figure 39). *Sisymbrium altissimum* appears to be most sensitive to soil depth. *Ribes aureum* lies intermediate to the soil depth and elevation arrows on the biplot, suggesting both factors could influence the species. Wetland species, such as *Veronica anagallis-aquatica*, and riparian species that typically occur in very moist soils, such as *Polypogon monspeliensis* and *Plantago major*, are clustered near the center of the biplot possibly associated somewhat with elevation above water surface.

Most of the plant associations on transect GA09 are clustered together along Axis I (Figure 40). One association, the *Ribes aureum/Bromus tectorum* association (group 1 of Figure 40), stands separately, appearing to be correlated with the highest elevations above water. The remaining associations show some species overlap and occur at elevations closer to water. These associations sort themselves along this elevation gradient, but also along the second axis representing soil depth and percent rock cover. Because of the limited availability of soil depth data, the correlation between soil depth and plant community distribution should be interpreted with caution.

Transect GA10 was 23.5 m long with a total change in elevation of 7.5 m (Table 1). Average slope for the transect was 31.9% (Figure 4). The aspect was north-facing (21 $\frac{\pi}{4}$) (Table 1). Five plant associations were delineated: *Polypogon monspeliensis-Veronica anagallis-aquatica*, *Salix exigua/Dipsacus fullonum*, *Salix amygdaloides*, *Rhus trilobata-Toxicodendron radicans*, and *Prunus virginiana* (Table 1, Appendix 13). Vegetation was considered to be in good condition with little disturbance (Appendix 3). Vegetation complexity was greatest near the water's edge (Figure 41).

Soil characteristics measured included texture, percent soil moisture, pH, conductivity, nitrogen, phosphorus, organic matter and calcium content. Soil textures were predominately sandy loam interspersed with pockets of loamy sand. A sandy clay loam was found at meter 6.0 (Appendix 4). Soil moisture ranged from 38.7% to 2.4%; pH ranged from 6.9 to 8.0 with no particular distribution pattern apparent (Figure 42). Soil conductivity ranged from 0.4 to 2.6 dS/m with the lower values occurring in the drier soils. Calcium content varied throughout the transect from none to high (Appendix 4). Calcium content tended to be lower near the drier end of the transect. Nitrogen content was low across most of the transect, ranging from 0 to 29% (Figure 42). The running mean of percent nitrogen was greatest at the center and near the dry end of the transect. Organic matter was low near the wet end of the transect, increased just above midslope, then declined. Phosphorus followed a pattern similar to that of organic matter although phosphorus content varied more along the transect.

Axis I of the ordination is most closely correlated with the calcium content, elevation relative to the water surface and soil organic matter (Table 13, Figure 43). The three factors explain less than 30% of the total variation. The moisture content and phosphorus content of the soil are also more correlated with the first axis than the second, although the correlations are not as strong as for the first three factors. Axis II is most closely correlated to soil pH and texture. The total variation explained by the two axes is 51.4%.

The distribution of wetland species, such as *Veronica anagallis-aquatica* and *Scirpus validus*, appears to be most strongly associated with soil moisture (Figure 43). The riparian species, *Salix*

exigua, *Castilleja exilis*, and *Dipsacus fullonum* were closely allied with the calcium (CA) content of the soil. Other riparian species, including *Ribes aureum*, *Prunus virginiana* and *Clematis ligusticifolia*, appears to correlate with organic matter and phosphorus content. *Artemisia tridentata*, a common upland species, appears to correlate with texture and pH.

Three of the five plant associations found on transect GA10 are clustered at the center of the ordination diagram (Figure 44). The species composing the *Prunus virginiana* (group 1 on Figure 44), *Rhus trilobata-Toxicodendron radicans* (group 2) and *Salix amygdaloides* (group 3) associations are positioned in close proximity to one another near the center of the diagram, suggesting no clear correlation with the environmental data collected. The species in the *Salix exigua/Dipsacus fullonum* (group 5) and *Polypogon monspeliensis-Veronica anagallis-aquatica* (group 4) associations do demonstrate stronger correlations with soil moisture and calcium content, respectively.

5. Discussion

A number of environmental factors can significantly influence the distribution of plant species across and within a landscape. For upland vegetation these factors can include temperature, precipitation and organic matter content of soil (Diamond and Smeins 1988) and competition for nutrients (Wilson and Tilman 1995). Numerous studies, undertaken during development of a legal definition for wetlands, related riparian and wetland vegetation to soil water content and inundation period (Baad, 1988, Nachlinger 1988, Erickson and Leslie 1987). Other studies have identified landform (morphology) and/or disturbance as important influences (Bendix 1994, Nilsson et al. 1994, Baker 1989, Evenden 1989, Warren and Anderson 1985, Hupp 1982, Miller 1976). Limited availability of appropriate germination sites was identified as a key factor for *Populus* and *Salix* species (McLeod and McPherson 1973, McBride and Strahan 1984). The two genera are among the most common species dominating riparian zones of the western U.S. (Mitsch and Gosselink 1993).

While allogenic factors such as disturbance and landform were not assessed in this study, their influence often determines the quantity and quality of local habitats. A brief discussion of the role of such factors, in this case specifically disturbance, is worthy of inclusion. Disturbance can result in number of outcomes within a riparian system (Mitsch and Gosselink 1993). For example, flood events often destroy existing vegetation in localized areas while providing new habitats (scoured areas or newly deposited point bars) for plant establishment. Grazing can alter floristic composition and species abundances (Szaro 1989). Dams can divert all of the water from a stream channel or stabilize flows and eventually lead to development of more stable plant communities (Mitsch and Gosselink 1993). Disturbances to the riparian and wetland vegetation of the Hagerman Study Area have taken place at watershed and local levels. Significant water diversion and flow regulation have taken place on the Snake River since the early 1900's. Regulation and diversion for irrigation located upstream of the study area have altered the distribution of water within the river channel, reducing the magnitude and frequency of flood events (Idaho Water Resource Board 1993). However, flows vary greatly among months as well as years and thus can still have a significant influence on vegetation establishment and persistence. The mean volume of water (cfs) passing through the Snake River below Milner Dam (RM 638.7) varies greatly among the months of May through September (Figure 45), but the variability in flow is greater during the early growing season (May and June) than later (July, August, and September). Plant establishment is occurring during the early portion of the growing season. Thus, flows during this time are likely to have a profound influence on establishment in any given year.

Localized disturbances within the study area have included grazing, mining, agriculture, recreation, commercial and residential development, and landslides. Lack of historic baseline vegetation data and specific studies precludes determination of the actual impacts of these activities on the local vegetation. Given the body of knowledge describing the response of vegetation to anthropogenic disturbance (e.g., Milchunas and Lauenroth 1993, Brinson 1991 and Szaro 1989) it is likely that local historic land disturbance events have led to changes in the riparian vegetation, many of them probably still bearing influence upon the distribution of plant species across the current riparian landscape. Thus, the results reported in this study reflect species and community responses to local site differences that are likely to have been influenced in some unquantified way by environmental conditions beyond those studied directly.

The transects placed at the ten sites selected for study were all oriented along the local moisture gradient. It is not surprising then, that soil moisture content or related factors (distance from water and elevation above water surface) often were identified as the factor(s) most closely correlated with the first axis of the CCA. Increases in elevation result in decreases in soil water content as the distance from the water source increases, thus the relationship between the two can be nearly parallel, especially when the slope of the terrain is shallow and even. Any of these three factors could be strongly correlated with Axis I and thus indicate a soil moisture gradient.

Analyses of two of the ten transects resulted with Axis I most closely correlated with factors other than soil moisture. Transect GA07 was most strongly associated with soil depth and transect GA10 was most strongly associated with calcium content. For both transects however, soil moisture was also

strongly correlated with Axis I.

The factors correlating most strongly with Axis II were often edaphic characteristics that are not influenced, at least directly, by soil moisture. These included soil depth (GA08, GA09), texture (GA01, GA10), pH (GA01, GA10) and rock (GA09). Transect GA04 had no measured factors strongly correlated with Axis II. Transects GA02, GA03, GA05 and GA07 were correlated with moisture and 'distance' factors. Soil texture can influence soil moisture content through the greater moisture holding capacity inherent in the large surface area characteristic of finer textured soils, especially clays (Brady 1974). Clay fraction of riparian soils has been cited as having an important influence on the distribution of riparian communities in the southwestern US (e.g., *Tamarix pentandra*; (Gary 1965)).

Soil phosphorus content was among the factors with a significant correlation to Axis I at transect GA10. Delivery of phosphorus occurs during the sediment transport associated with flood events (Mitsch et al. 1979). Several studies have indicated that phosphorus is a "...relatively immobile nutrient that once imported should remain within the ecosystem...." (Boggs and Weaver 1994) especially in areas not frequently flooded.

Numerous studies have identified factors influencing the distribution of species and assemblages within the riparian zone. Soil depth was identified as one of the factors most strongly influencing the distribution of floodplain species at the Raritan River in New Jersey (Frye and Quinn 1979). Substrate (silt and peat) was found to play an important role in the Vindel watershed in Sweden (Nilsson et al. 1994). Soil fertility (measured as phosphorus content) was identified as a principle explanation for wetland species' distributions along the Ottawa River in Canada (Day et al. 1988). Competitive ability among selected species along a water depth gradient has also been identified as a critical factor affecting species distributions (Gaudet and Keddy 1995). Clearly, a number of factors can affect species distributions within wetland and riparian habitats. Within the context of this study, a few riparian species were sampled repeatedly enough to determine distinct correlations with edaphic and topographic characteristics. *Salix exigua* was correlated positively with increased phosphorus content and soil moisture content. *Typha latifolia* appeared to associate with moderately deep soils (> 30cm). *Veronica anagallis-aquatica* consistently correlated most strongly with saturated soil conditions (high soil moisture and low elevation relative to water surface). Several species exhibited a wide amplitude of ecological tolerance, occurring across a large proportion of a transect or on multiple transects, including *Phalaris arundinaceae* (GA01) and *Celtis reticulata* (GA08, GA09).

The ordination of edaphic and topographic characters in combination with the vegetation characters of the ten transects has provided an indication of what factors might affect the distribution of plant species within the riparian zone of the middle Snake River. The descriptive nature of this study precludes determination of causality and the direct nature of the relationship between a species or species assemblage and specific habitat attributes.

6. Conclusions

Ten transects, representing a broad range of riparian and wetland plant associations, were ordinated using CCA or PCA to identify possible edaphic and topographic factors correlating with the distributions of species and associations. The transects were established along the moisture gradient at each site. In most cases, the moisture gradient was the factor represented on Axis I that most strongly correlated with species distributions. However, analyses of two of the ten transects resulted with Axis I most closely correlated with factors other than soil moisture. Transect GA07 was most strongly associated with soil depth and transect GA10 was most strongly associated with calcium content. For both transects however, soil moisture was also strongly correlated with Axis I. Axis II of the ordinations was often correlated with edaphic characteristics. These included soil depth (GA08, GA09), texture (GA01, GA10), pH (GA01, GA10) and rock (GA09).

Although the study was designed to examine local site conditions, it must be recognized that allogenic factors such as disturbances are influencing species distributions in ways that may not be detectable within the context of this study.

7. Acknowledgments

Several people deserve recognition for their participation in this study. Data were collected by Lorna Anness, Caitlin Cray, Von Pope, Steve Ripple, Matt Walker and Kelly Wilde. Sonny Cabbage assisted with data entry. Dr. Toni Holthuijzen provided guidance with ordination techniques. Frank Mynar and Chris Huck provided expert and timely GIS assistance.

8. Literature Cited

- Anderson, J. E. and K. E. Holte. 1981. Vegetation development over 25 years without grazing on sagebrush-dominated rangeland in southeastern Idaho. *J. Range Manage.* 34(1):25-29.
- Baad, M. F. 1988. Soil-vegetation correlations within the riparian zone of Butte Sink in the Sacramento Valley of northern California. U.S. Dept. Inter., Fish and Wildl. Serv. Biol. Rep. 88(25). 50pp.
- Bailey, R. G. 1978. Descriptions of the ecoregions of the United States. U.S. Dept. Agric., For. Serv. Ogden, UT. 77pp.
- Baker, W. L. 1989. Macro- and micro-scale influences on riparian vegetation in western Colorado. *Annals. Assoc. Am. Geogr.* 79:65-78.
- Bendix, J. 1994. Among-site variation in riparian vegetation of the southern California transverse ranges. *Amer. Midl. Natur.* 132(1):136-151.
- Blaisdell, J. P. 1958. Seasonal development and yield of native plants on the Upper Snake River Plains and their relation to certain climatic factors. U.S. Dept. Agric., Tech. Bull. No. 1190. 63pp.
- Boggs, K. and T. Weaver. 1994. Changes in vegetation and nutrient pools during riparian succession. *Wetlands* 14(3):98-109.
- Brady, N. C. 1974. The nature and property of soils. 8th Edition. McMillan Publ. Co., N. Y. 637pp.
- Brinson, M. M., B. L. Swift, R. C. Plantico, and J. S. Barclay. 1981. Riparian ecosystems: their ecology and status. U.S. Dept. Inter., Fish and Wildl. Serv. Rep. FWS/OBS-81/17. 155pp.
- Bryant, W. L., J. R. Richardson and W. M. Kitchens. 1992. Vegetation relationships to sediment chemistry and hydrology in the Loxahatchee National Wildlife Refuge. Page 391 *in* Wetlands, Proceedings of the 13th Annual Conference, Society of Wetland Scientists, New Orleans, La.
- Caldwell, M. M. 1985. Cold desert. Pages 108-212 *in* B.F. Chabot and H.A. Mooney, eds. Physiological ecology of North American plant communities. Chapman and Hall, New York.
- Canfield, R. 1941. Application of line interception in sampling range vegetation. *J. Forestry* 39:388-394.
- Clements, F. E. and E. S. Clements. 1939. The sagebrush disclimax. *Carnegie Instit. Wash. Yearbook* 38:139-140.
- Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Dept. Inter., U.S. Fish and Wildl. Serv. Rep. FWS/OBS-79/31.

- Day, R. T., P. A. Keddy, J. McNeill and T. Carleton. 1988. Fertility and disturbance gradients: a summary model for riverine marsh vegetation. *Ecol.* 69(4):1044-1054.
- Diamond, D. D. and F. E. Smeins. 1988. Gradient analysis of remnant True and Upper Coastal Prairie grasslands of North America. *Can. J. Bot.* 66:2152-2161.
- Dunteman, G. H. 1989. Principal components analysis. Sage University Paper series on quantitative applications in the social sciences, Series No. 69. Sage Publications, Newbury Park, CA. 96pp.
- Ellison, A. M. and B. L. Bedford. 1995. Response of a wetland vascular plant community to disturbance: a simulation study. *Ecol. Appl.* 5(1):109-123.
- Erickson, N. E. and D. M. Leslie, Jr. 1987. Soil-vegetation correlations in the Sandhills and Rainwater Basin wetlands of Nebraska. U.S. Dept. Inter., Fish and Wildl. Serv. Biol. Rep. 87(11). 72pp.
- Etherington, J. R. 1983. Wetland ecology. Studies in Biology No. 154. Edward Arnold Publ. Ltd., London. 66pp.
- Evenden, A. G. 1989. Ecology and distribution of riparian vegetation in the Trout Creek Mountains of southeastern Oregon. Ph.D. Dissertation, Oregon State Univ., Corvallis. 156pp. plus figs.
- Franklin, J. F. and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State Univ. Press, Corvallis. 452pp.
- Fremont, J. C. 1845. Report of the exploring expedition to the Rocky Mountains in the year 1842 and to Oregon and north California in the years 1843-44. Gales and Seaton, Printers, Washington, D.C.
- Frye, R. J. II and J. A. Quinn. 1979. Forest development in relation to topography and soils on a floodplain of the Raritan River, New Jersey. *Bull. Torrey Bot. Club* 106(4):334-345.
- Gauch, Jr., H. G. 1982. Multivariate analysis in community ecology. Cambridge Studies in Ecology. Cambridge University Press, Cambridge. 298pp.
- Gaudet, C. L. and P. A. Keddy. 1995. Competitive performance and species distribution in shoreline plant communities: a comparative approach. *Ecology* 76(1):280-291.
- Gary, H. L. 1965. Some site relations in three flood-plain communities in central Arizona. *J. Ariz. Acad. Sci.* 3:209-212.
- Greenwood, A. P. 1987. We sagebrush folks. University of Idaho Press, Moscow. 489pp.
- Greweling, T. and M. Peech. 1960. Chemical soil tests. Cornell Univ. Agric. Exp. Stn. Bull. No. 960. 58pp.

- Hansen, P. L. 1992. Classification and management of riparian-wetland shrub sites in Montana. Pages 68-78 in W. P. Clary, E. D. McArthur, D. Bedunah and C. L. Wambolt, eds. Proceedings--Symposium on ecology and management of riparian shrub communities, May 29-31, 1991, Sun Valley, ID. U.S. Dept. Agric., U.S.F.S. Interm. Res. Stn. Gen. Tech. Rep. INT-289.
- Harris, R. R. 1988. Associations between stream valley geomorphology and riparian vegetation as a basis for landscape analysis in the eastern Sierra Nevada, California, USA. *Environ. Manage.* 12(2):219-228.
- Hidy, G. M. and H. E. Klieforth. 1990. Atmospheric processes affecting the climate of the Great Basin. Pages 17-45 in C. B. Osmond, L. F. Pitelka and G. M. Hidy, eds. *Plant biology of the basin and range*. Springer-Verlag, New York.
- Hitchcock, C. L. and A. Cronquist. 1973. *Flora of the Pacific Northwest*. Univ. of Washington Press, Seattle. 730pp.
- Hoagland, B. W. and L. Sorrells. 1992. Classification and ordination of bottomland forests in McCurtain County, Oklahoma. Page 200 in *Wetlands, Proceedings of the 13th Annual Conference, Society of Wetland Scientists*, New Orleans, La.
- Hupp, C. R. 1982. Stream-grade variation and riparian-forest ecology along Passage Creek, Virginia. *Bull. Torr. Bot. Club* 190(4):488-499.
- Hupp, C. R. 1983. Vegetation patterns on channel features in the Passage Creek Gorge, Virginia. *Castanea* 48:62-72.
- Idaho Water Resource Board. 1993. Comprehensive state water plan. Snake River: Milner Dam to King Hill. Idaho Water Resource Board, Boise, Id. 92pp.
- Jensen, D. and L. Verhovek. 1979. Studies of water use on the Snake River, southern Idaho: vegetation analysis. Univ. of Calif., Irvine.
- Johnson, W. C., M. Dixon, G. Larson and R. Simons. 1992. Riparian vegetation along the Snake River, Idaho, below Swan Falls Dam: past, present and future. Final report to Idaho Power Co. 85pp. plus tables, figs. and append.
- Johnson, W. C., T. L. Sharik, R. A. Mayes and E. P. Smith. 1987. Nature and cause of zonation discreteness around glacial prairie marshes. *Can. J. Bot.* 65:1622-1632.
- Jongman, R. H. G., C. J. F. ter Braak, and O. F. R. van Tongeren. 1987. *Data analysis in community and landscape ecology*. Centre for Agriculture Publish. and Documentation (Pudoc), Wageningen, The Netherlands. 299pp.

- Kartesz, J. T. and R. Kartesz. 1980. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Vol. II. The biota of North America. The Univ. of North Carolina Press, Chapel Hill. 498pp.
- Kent, M. and P. Coker. 1992. Vegetation description and analysis, a practical approach. CRC Press, Boca Raton, Fla. 363pp.
- Klimas, C. V. 1988. River regulation effects on floodplain hydrology and ecology. Pages 40-49 in D. D. Hook, W. H. McKee, Jr., H. K. Smith, J. Gregory, V. G. Burrell, Jr., M. R. DeVoe, R. E. Sojba, S. Gilbert, R. Banks, L. H. Stolzy, C. Brooks, T. D. Matthews and T. H. Shear, eds. The ecology and management of wetlands, Vol. 1, Timber Press, Portland, Oreg.
- Malanson, G. P. 1993. Riparian landscapes. Cambridge University Press, Cambridge, England. 296pp.
- McBride, J. R. and J. Strahan. 1984. Establishment and survival of woody riparian species on gravel bars of an intermittent stream. Amer. Midl. Natur. 112(2):235-245.
- McLeod, D. W. and J. K. McPherson. 1973. Factors limiting the distribution of *Salix nigra*. Bull. Torr. Bot. Club 199(2):102-110.
- Milchunas, D. G. and W. K. Lauenroth. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecol. Monogr. 63(4):327-366.
- Miles, J. 1979. Vegetation dynamics. Chapman and Hall, London. 80pp.
- Miller, T. B. 1976. Ecology of riparian communities dominated by white alder in western Idaho. M.S. Thesis, Coll. For. Wildl. and Range Sci., Univ. of Idaho, Moscow. 154pp.
- Minshall, G. W., S. E. Jensen and W. S. Platts. 1989. The ecology of stream and riparian habitats of the Great Basin Region: a community profile. U.S. Dept. Inter., Fish and Wildl. Serv./EPA, Biol. Rep. 85(7.24). 143pp.
- Miss, C. J. and S. K. Campbell. 1988. Cultural resources survey for the A. J. Wiley hydroelectric project. Report No. 88-3, Northwest Archaeological Assoc., Inc. Seattle, Wash. 67pp.
- Mitsch, W. J., C. L. Dorge and J. R. Wiemhoff. 1979. Ecosystem dynamics and a phosphorus budget of an alluvial cypress swamp in southern Illinois. Ecol. 60:1116-1124.
- Mitsch, W. J. and J. G. Gosselink. 1988. Wetlands. Van Nostrand/Reinhold Publ. 539pp.
- Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. Second ed. Van Nostrand/Reinhold Publ. 539pp.
- Myhre, J. and A. Clements. 1972. A study of the flora of the islands and the shorelines of the Snake River between Grandview, Idaho, and Guffey Butte, Owyhee County, Idaho: July 1972. Snake River Reg. Stud. Cent., College of Idaho, Caldwell. 23pp.

- Nachlinger, J. B. 1988. Soil-vegetation correlations in riparian and emergent wetlands, Lyon County, Nevada. U.S. Dept. Inter., Fish and Wildl. Serv. Biol. Rep. 88(17). 42pp.
- Nilsson, C. A. Ekblad, M. Dynesius, S. Backe, M. Gardfjell, B. Carlberg, S. Hellqvist and R. Jansson. 1994. A comparison of species richness and traits of riparian plants between a main river channel and its tributaries. J. Ecol. 82:281-295.
- Olsen, S. R. and L. E. Sommers. 1982. Phosphorus soluble in sodium bicarbonate. In A. L. Page, R. Miller and D. R. Keeney, eds. Methods of soil analysis. Part 2: chemical and microbiological properties. Second ed. Agronomy 9, Am. Soc. Agron. Madison, WI.
- Reed Jr., P. B. 1988. National list of plant species that occur in wetlands: Northwest (Region 9). U.S. Dept. Inter., Fish and Wildl. Serv., Biol. Rep. 88 (26.9). Washington, D.C.
- Richards, L. A. 1954. Diagnosis and improvement of saline and alkali soils. Agriculture Handbook No. 60. U.S. Dept. Agric., Washington, D.C.
- Sather-Blair, S. 1988. Western riparian wetland losses and degradation: status and trends. Influence of federal water and private hydroelectric projects. U.S. Dept. Inter., Fish and Wildl. Serv., Boise, Id. Draft, unpubl. rep.
- Settle, R. W. 1940. The march of the mounted rifleman. First United States military expedition to travel the full length of the Oregon Trail from Fort Leavenworth to Fort Vancouver, May to October, 1849. The Arthur Clark Company, Glendale, Calif. 380pp.
- Shantz, H. L. and R. Zon. 1924. Atlas of American agriculture. Part 1. The physical basis of agriculture. Sec. E. Natural vegetation, U.S. Dept. Agric., Washington, D.C.
- Sharp, L. A., K. Sanders and N. Rimbey. 1990. Forty years of change in a shadscale stand in Idaho. Rangelands 12(6):313-328.
- Sims, J. R. and G. Jackson. 1971. Rapid analysis of soil nitrate with chromotropic acid. Soil Sci. Soc. Amer. Proc. 35:603-606.
- Soil Conservation Service. 1976. National Range Handbook. U.S.D.A. - Soil Conserv. Serv., Washington, D.C. Unnum.
- Soltanpur, P. N. and S. M. Workman. 1981. Soil testing methods used at Colorado State University soil testing laboratory. Tech. Bull. 142. 22pp.
- Stacy, S. M. 1991. Legacy of light: a history of Idaho Power Company. Id. Power Co., Boise. 256pp.
- Szaro, R. C. 1989. Riparian forest and scrubland community types of Arizona and New Mexico. Desert Plants 9(3-4):1-138.

- Tabachnick, B. G. and L. S. Fidell. 1989. Using multivariate statistics. 2nd Ed. Harper Collins Publ. 746pp.
- ter Braak, C. J. F. 1987. Ordination. Pages 91-173 in R. H. G. Jongman, C. J. F. ter Braak and O. F. R. van Tongeren, eds. Data analysis in community and landscape ecology. Centre for Agriculture (Pudoc) Publish. and Documentation. Wageningen, The Netherlands.
- Tisdale, E. W. 1986. Native vegetation of Idaho. *Rangelands* 8(5):202-207.
- Warren, P. L. and D. S. Anderson. 1985. Gradient analysis of a Sonoran Desert wash. Pages 150-155 in R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott and R. H. Hamre. Riparian ecosystems and their management: reconciling conflicting uses. Proceedings of the first North American Riparian Conference. U.S. Dept. Agric., For. Serv. Gen. Tech. Rep. RM-120.
- Weaver, J. E. and F. E. Clements. 1938. Plant ecology. McGraw-Hill, New York. 601pp.
- West, N. E. 1983a. Overview of North American temperate deserts and semi-deserts. Pages 321-330 in N. E. West, ed. Ecosystems of the world 5. Temperate deserts and semi-deserts. Elsevier Sci. Publ. Co., New York.
- West, N. E. 1983b. Western intermountain sagebrush steppe. Pages 351-374 in N. E. West, ed. Ecosystems of the world 5. Temperate deserts and semi-deserts. Elsevier Sci. Publ. Co., New York.
- West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands. Pages 209-230 in M. G. Barbour and W. D. Billings, eds. North American terrestrial vegetation. Cambridge Univ. Press, Cambridge.
- Wilson, S. C. and D. Tilman. 1995. Competitive responses of eight old-field plant species in four environments. *Ecol.* 76(4):1169-1180.
- Wistendahl, W. A. 1958. The flood plain of the Raritan River, New Jersey. *Ecol. Monogr.* 28(2):129-153.
- Yensen, D. 1982. A grazing history of southwestern Idaho with emphasis on the Birds of Prey Study Area. U.S. Dept. Inter., Bur. Land Manage. 82pp.
- Young, J. A. 1986. Snake River country--a rangeland heritage. *Rangelands* 8(5):199-202.
- Young, J. A., R. A. Evans and P. T. Tueller. 1976. Great Basin plant communities--pristine and grazed. Pages 186-215 in R. Elston, ed. Holocene environmental change in the Great Basin. Nevada Archeol. Surv. Res. Pap. No. 6. Nevada State Museum, Reno.
- Zimmermann, R. C. and B. G. Thom. 1982. Physiographic plant geography. *Progress Phys. Geog.* 6(1):45-59.

Table 1. Physical description of transects sampled for gradient analysis of riparian and wetland plant communities in the Hagerman Study Area, 1991.

Transect No.	Total Length (m)	Aspect	Maximum Change in Elevation (m)	Slope (%)	Disturbance	Plant Association
GA01	39.5	270°	3.0	7.6	Low	<i>Salix exigua</i> / <i>Phalaris arundinaceae</i> <i>Salix amygdaloides</i> / <i>Euthamia occidentalis</i> <i>Rhus trilobata</i>
GA02	40.0	52°	3.2	8.0	Low	<i>Scirpus acutus</i> <i>Urtica dioica</i> - <i>Chenopodium album</i> <i>Salix amygdaloides</i> / <i>Chenopodium album</i> <i>Rosa woodsii</i> / <i>Urtica dioica</i>
GA03	80.5	250°	4.2	5.2	Moderate	<i>Elaeagnus angustifolia</i> / <i>Poa pratensis</i> <i>Elaeagnus angustifolia</i> / <i>Chenopodium album</i> <i>Chenopodium album</i> <i>Distichlis spicata</i> - <i>Bromus tectorum</i> <i>Artemisia tridentata</i>
GA04	30.0	46°	1.6	5.3	Low	<i>Scirpus acutus</i> <i>Distichlis spicata</i> <i>Bromus tectorum</i> - <i>Kochia scoparia</i>

Table 1 (continued)

Transect No.	Total Length (m)	Aspect	Maximum Change in Elevation (m)	Slope (%)	Disturbance	Plant Association
GA05	42.0	87°	2.3	5.5	Low	<i>Scirpus acutus</i> <i>Galium triflorum-Solanum dulcamara</i> <i>Juncus balticus-Chenopodium album</i> <i>Distichlis spicata-Kochia scoparia</i> <i>Distichlis spicata-Bromus tectorum</i>
GA06	23.0	112°	1.7	7.4	Low	<i>Scirpus americanus</i> <i>Distichlis spicata-Eremopyrum triticeum</i> <i>Iva axillaris/mixed grasses</i> <i>Artemisia tridentata/Distichlis spicata</i>
GA07	20.5	70°	1.9	9.3	Low	<i>Typha latifolia</i> <i>Carex nebraskensis</i> <i>Distichlis spicata-Hordeum jubatum</i> <i>Distichlis spicata-Kochia scoparia</i> <i>Iva axillaris/Distichlis spicata-Eremopyrum triticeum</i>

Table 1 (continued)

Transect No.	Total Length (m)	Aspect	Maximum Change in Elevation (m)	Slope (%)	Disturbance	Plant Association
GA08	20.5	88°	7.6	37.1	Low	<i>Salix exigua</i> <i>Cellis reticulata</i> <i>Artemisia tridentata</i>
GA09	24.0	0°	8.5	35.4	Low	<i>Veronica anagallis-aquatica-Epilobium glaberrimum</i> mixed forbs <i>Salix exigua</i> / <i>Glycyrrhiza lepidota</i> - <i>Dipsacus fullonum</i> <i>Artemisia ludoviciana</i> / <i>Bromus tectorum</i> <i>Ribes aureum</i>
GA10	23.5	21°	7.5	31.9	Low	<i>Polypogon monspeliensis-Veronica anagallis-aquatica</i> <i>Salix exigua</i> / <i>Dipsacus fullonum</i> <i>Salix amygdaloides</i> <i>Rhus trilobata-Toxicodendron radicans</i> <i>Prunus virginiana</i>

The Distribution of Plant Species and Some Associated Factors

Table 2. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA01, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Distance from water (FROMH2O)	-0.96	-0.04
Elevation above water surface (ABVH2O)	-0.87	0.23
Soil moisture (MOISTUR)	0.53	0.18
Electrical conductivity (EC)	0.50	-0.24
Soil phosphorus (PHOS)	0.37	0.71
Soil nitrogen (NITR)	0.19	-0.19
Soil pH (PH)	0.08	-0.66
Soil organic matter (OM)	0.08	0.28
Soil texture (TEXT)	0.05	0.65
Soil calcium (CA)	<0.01	0.16
Eigenvalue	0.88	0.53
Percentage variance explained	47.5	28.3
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 75.8		

Hagerman Study Area

Table 3. Soil texture at selected locations along gradient analysis transects, GA02-10, Hagerman Study Area, 1991.

Transect	Meter	Texture
GA02	0	sandy loam
	13	silt loam
	26	silt loam
	39	sand
GA03	0	sandy loam
	26.5	loamy sand
	52	sand
	79	sand
GA04	0	sandy loam
	8	loam
	17	loam
	25.5	sandy loam
GA05	0	sandy loam
	13	sandy loam
	27	sandy loam
	41	sandy loam
GA06	0	sandy loam
	8	sandy loam
	15	sandy loam
	22	sandy loam
GA07	0	sandy loam
	6	sandy loam
	13	sandy loam
	20	sandy loam
GA08	10.5	loamy sand
	13	loamy sand
	16	sand
	20	sand
GA09	4	sandy loam
	19	sandy loam
	24	loamy sand
GA10	0	sand
	9	loamy sand
	16	loamy sand
	23	loamy sand

The Distribution of Plant Species and Some Associated Factors

Table 4. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA02, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Elevation above water surface (ABVH2O)	0.74	0.67
Soil moisture (MOISTUR)	-0.70	-0.50
Distance from water (FROMH2O)	-0.26	0.95
Eigenvalue	0.59	0.56
Percentage variance explained	46.0	43.3
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 89.3		

Hagerman Study Area

Table 5. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA03, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Elevation above water surface (ABVH2O)	1.00	-0.02
Soil moisture (MOISTUR)	-0.60	0.75
Soil depth (DEPTH)	0.07	-0.06
Eigenvalue	0.85	0.22
Percentage variance explained	78.7	20.4
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 99.1		

The Distribution of Plant Species and Some Associated Factors

Table 6. Eigenvalues and percent variance explained for the Principal Components Analysis of transect GA03, Hagerman Study Area, 1991.

Axes	I	II	III	IV
Eigenvalues	0.48	0.37	0.09	0.03
Percentage variance explained	48.1	36.9	8.8	3.3
Cumulative percentage variance explained by the first two axes		85.0		

Hagerman Study Area

Table 7. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA04, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Elevation above water surface (ABVH2O)	-0.99	0.12
Soil depth (DEPTH)	0.91	0.38
Soil moisture (MOISTUR)	0.74	-0.25
Eigenvalue	0.88	0.23
Percentage variance explained	77.1	19.8
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 96.9		

The Distribution of Plant Species and Some Associated Factors

Table 8. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA05, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Elevation above water surface (ABVH2O)	1.00	-0.07
Soil moisture (MOISTUR)	-0.64	0.66
Soil depth (DEPTH)	-0.63	-0.64
Eigenvalue	0.88	0.43
Percentage variance explained	59.0	28.8
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 87.8		

Hagerman Study Area

Table 9. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA06, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Elevation above water surface (ABVH2O)	-0.93	-0.35
Soil moisture (MOISTUR)	0.76	0.06
Soil depth (DEPTH)	0.67	-0.62
Eigenvalue	0.78	0.29
Percentage variance explained	65.9	24.5
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 90.4		

The Distribution of Plant Species and Some Associated Factors

Table 10. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA07, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Soil depth (DEPTH)	1.00	0.04
Elevation above water surface (ABVH2O)	-0.73	-0.68
Soil moisture (MOISTUR)	0.60	0.40
Eigenvalue	0.80	0.24
Percentage variance explained	75.5	22.0
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 97.5		

Hagerman Study Area

Table 11. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA08, Hagerman Study Area, 1991.

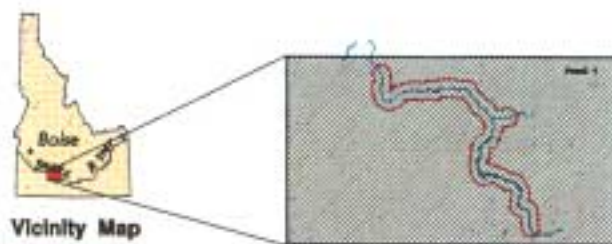
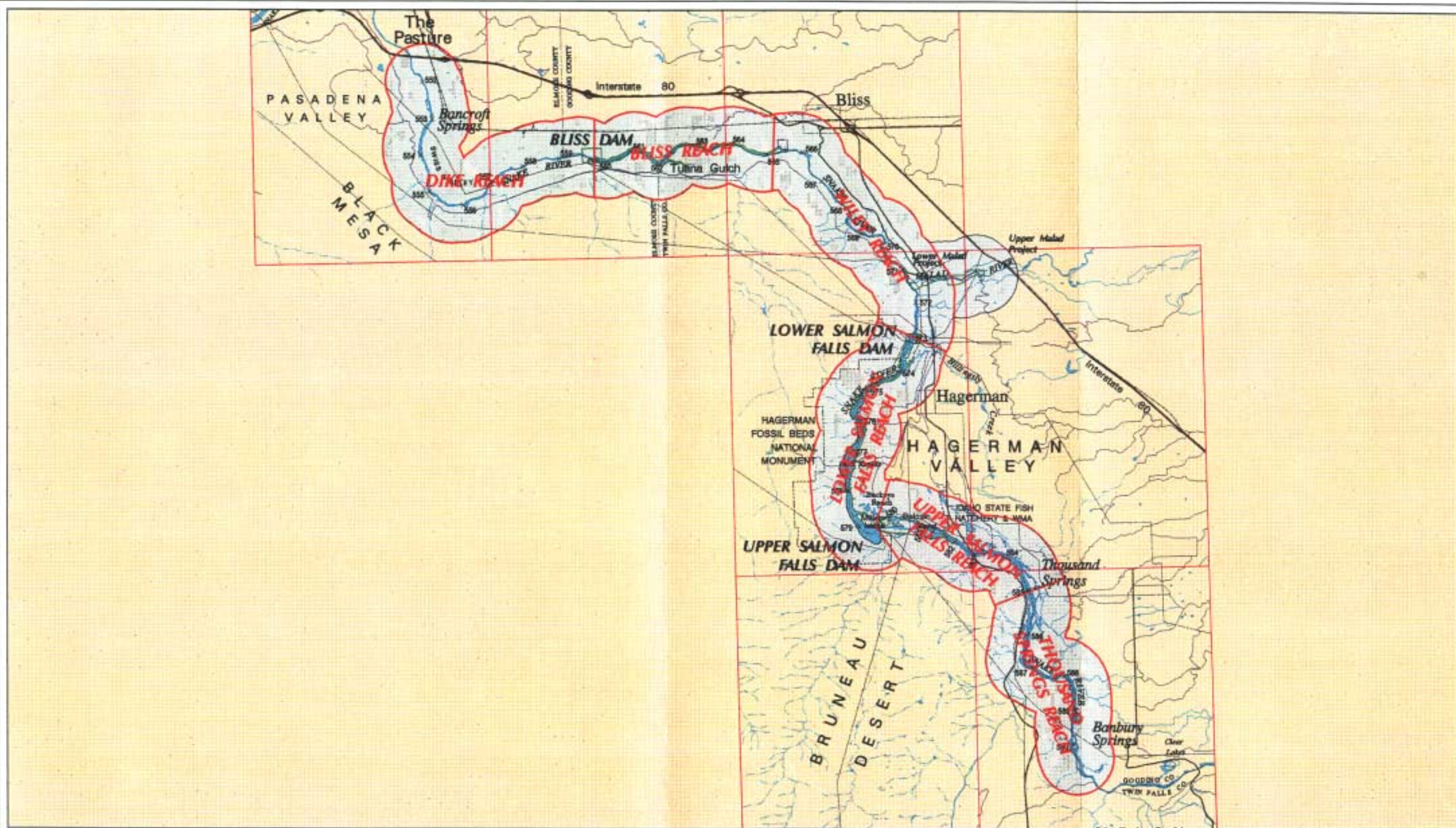
Factor	Axis I	Axis II
Distance from water (FROMH2O)	0.95	0.18
Cover by rock (ROCK)	-0.68	0.16
Soil depth (DEPTH)	0.26	0.64
Eigenvalue	0.36	0.04
Percentage variance explained	89.7	9.9
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 99.6		

Table 12. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA09, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Elevation above water surface (ABVH2O)	0.99	-0.08
Cover by rock (ROCK)	-0.87	0.49
Soil depth (DEPTH)	0.69	-0.50
Eigenvalue	0.96	0.62
Percentage variance explained	58.1	38.0
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 96.1		

Table 13. Correlations of species ordination axes with environmental factors, eigenvalues and percentage variances explained for transect GA10, Hagerman Study Area, 1991.

Factor	Axis I	Axis II
Calcium (CA)	0.94	-0.01
Elevation above water surface (ABVH2O)	-0.86	0.47
Soil organic matter (OM)	-0.75	0.01
Soil moisture (MOISTUR)	0.62	-0.24
Soil phosphorus (PHOS)	-0.62	0.12
Soil pH (PH)	0.55	0.56
Soil nitrogen (NITR)	-0.40	0.19
Electrical conductivity (EC)	-0.27	0.11
Soil texture (TEXT)	0.19	0.62
Cover by rock (ROCK)	0.15	<0.01
Soil depth (DEPTH)	-0.14	0.20
Eigenvalue	0.97	0.75
Percentage variance explained	29.0	22.4
Cumulative percentage variance explained by the first two axes of the joint species/environment biplot = 51.4		



Vicinity Map

Panel 1 of 1

Base Features Legend

- | | |
|------------------------------|-------------------------|
| Primary Route | Wildlife Mgt. Area Bdy. |
| Secondary Route | Quadrangle Bdy. |
| Railroad | IPCo Project Facility |
| Transmission Line | Study Area Corridor |
| Perennial River or Stream | Water Body |
| Intermittent River or Stream | River Mile |
| Ditch or Canal | |
| IPCo Project Bdy. | |
| Political Bdy. | |
| National Monument Bdy. | |

Thematic Features Legend

- | |
|----------------------|
| River Reach Boundary |
|----------------------|

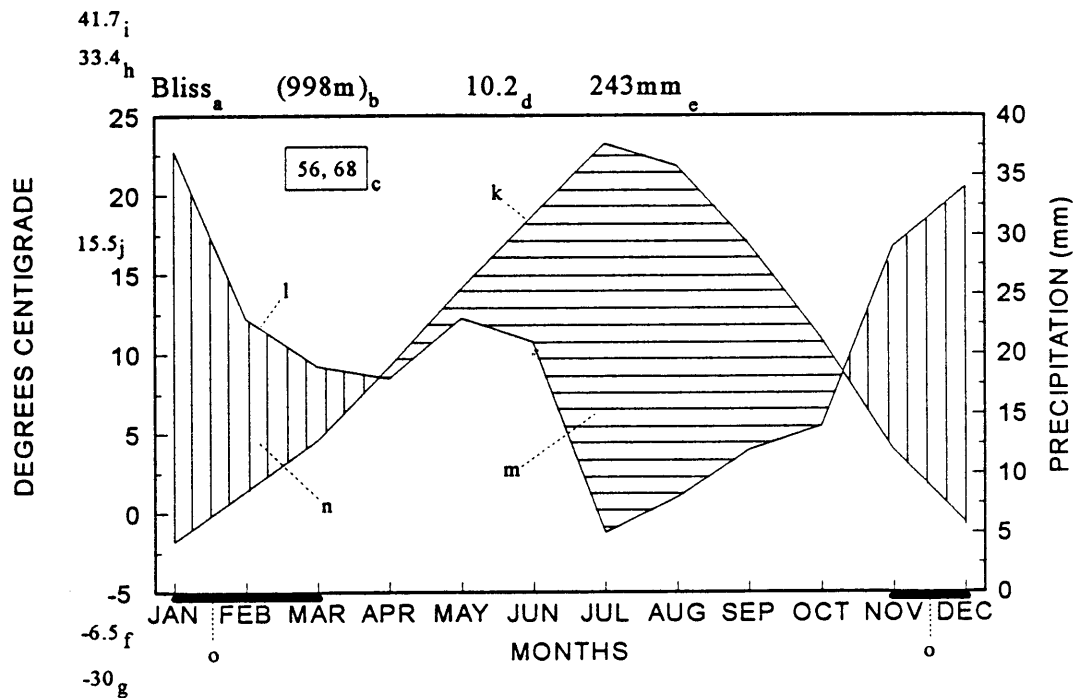


UTM GRID AND 1982
MAGNETIC NORTH DECLINATION
AT CENTER OF HAGERMAN QUADRANGLE

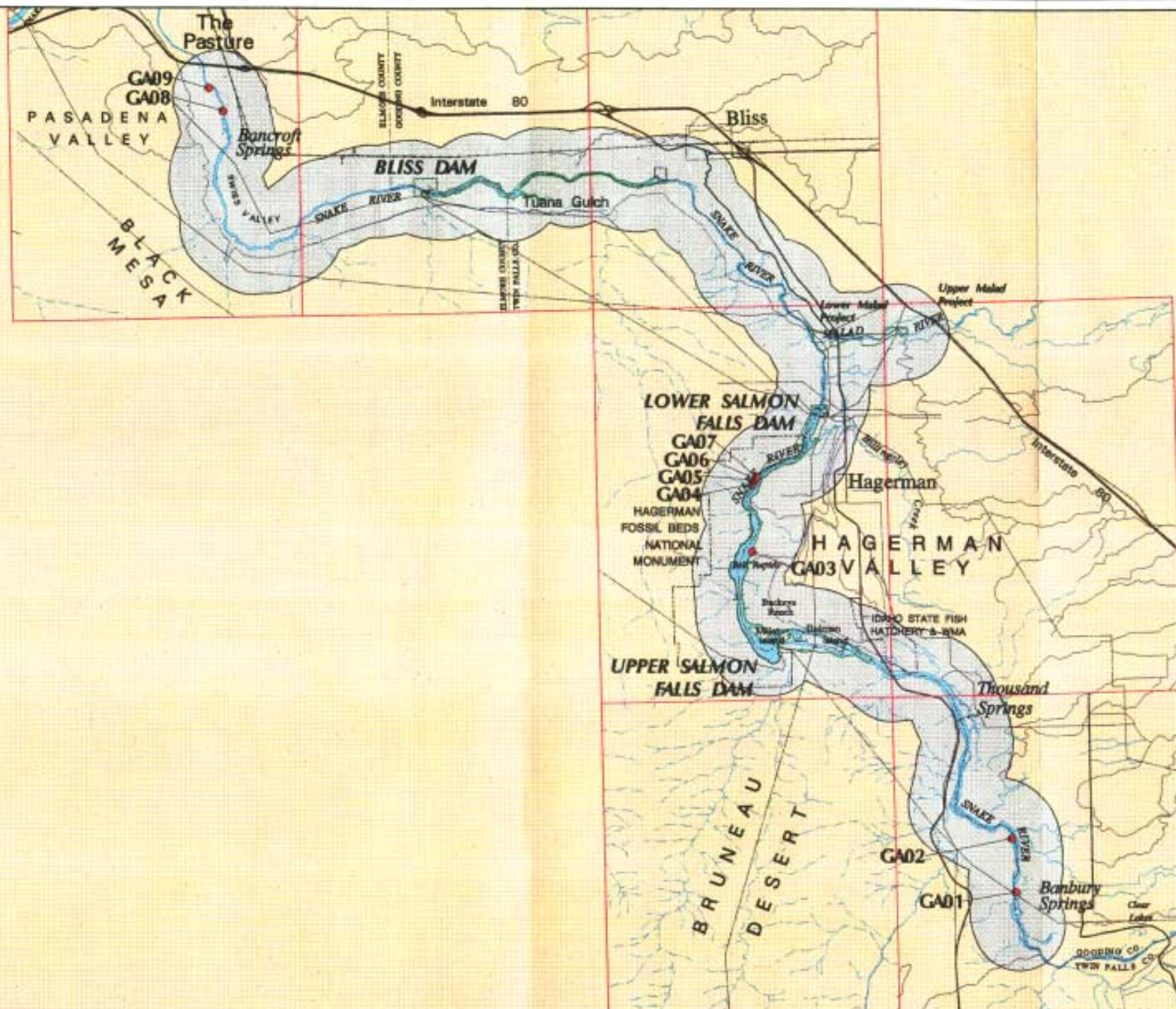
Figure 1
Location of the
Hagerman Study Area

1 0.5 1 2 3 MILES

Figure 2. Köppen climate diagram for the Bliss weather station, Hagerman Study Area, southwestern Idaho.



- a: Station
- b: Elevation
- c: Number of years of observation (temperature, precipitation)
- d: Mean annual temperature in °C
- e: Mean annual precipitation in millimeters
- f: Mean daily minimum of the coldest month
- g: Lowest recorded temperature
- h: Mean daily maximum of the hottest month
- i: Highest recorded temperature
- j: Mean daily temperature range
- k: Monthly means of temperature in °C
- l: Monthly means of precipitation in millimeters
- m: Arid period (horizontal hatched)
- n: Humid period (vertical hatched)
- o: Months with an absolute minimum below 0 °C



Base Features Legend

- | | | | |
|--|------------------------------|--|-------------------------|
| | Primary Route | | Wildlife Mgt. Area Bdy. |
| | Secondary Route | | Quadrangle Bdy. |
| | Railroad | | IPCo Project Facility |
| | Transmission Line | | Study Area Corridor |
| | Perennial River or Stream | | Water Body |
| | Intermittent River or Stream | | |
| | Ditch or Canal | | |
| | IPCo Project Bdy. | | |
| | Political Bdy. | | |
| | National Monument Bdy. | | |

Thematic Features Legend

- Gradient Sample Site



UTM GRID AND 1982
MAGNETIC NORTH DECLINATION
AT CENTER OF HAGERMAN QUADRANGLE

Figure 3
Gradient Analysis Transects in
the Hagerman Study Area

1 2 3 4 5 MILES

Figure 4. Elevational gradient of transects sampled for gradient analyses. Figures are standardized for comparison.

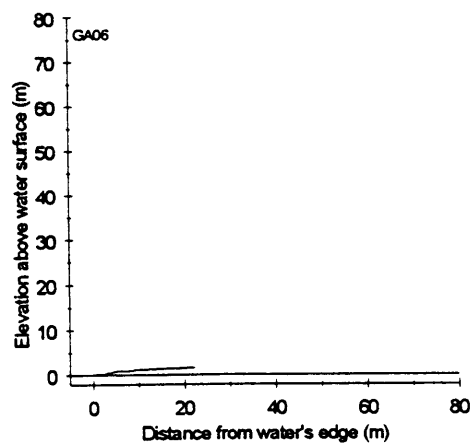
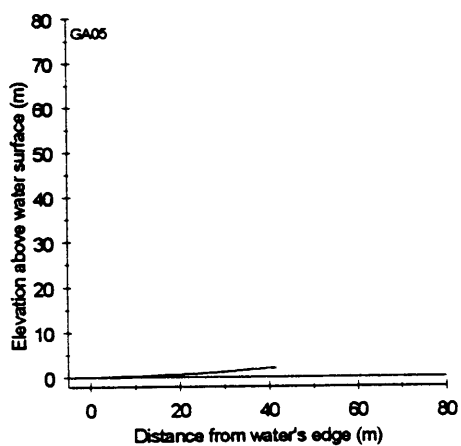
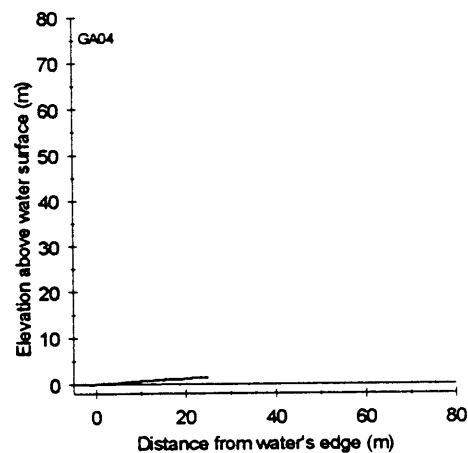
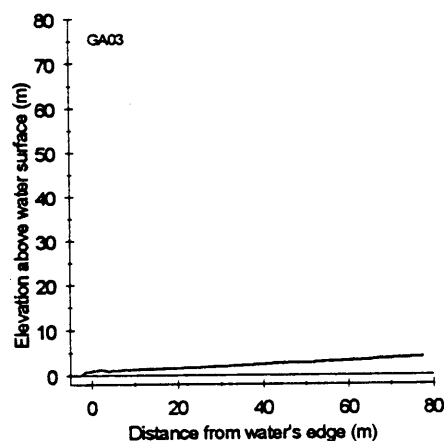
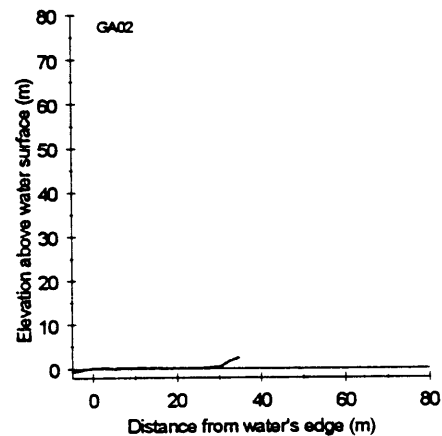
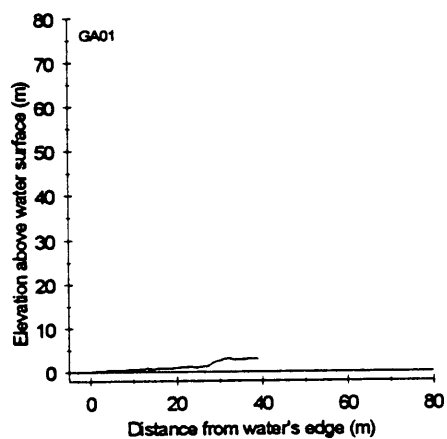


Figure 4 (continued)

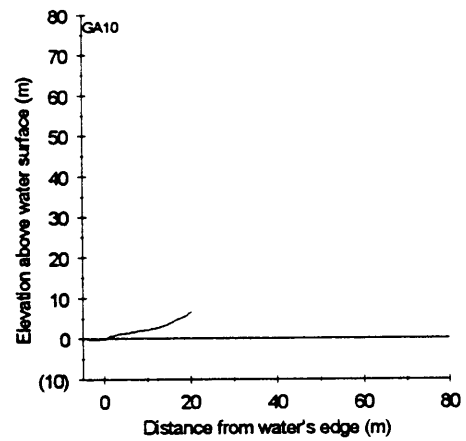
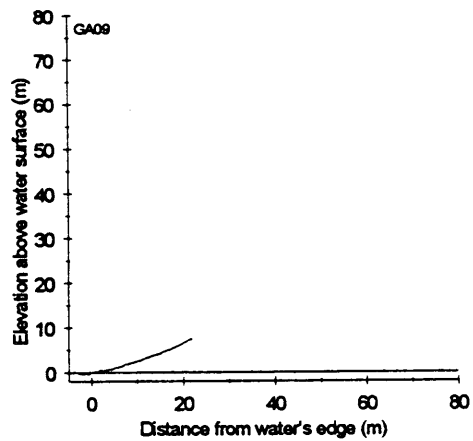
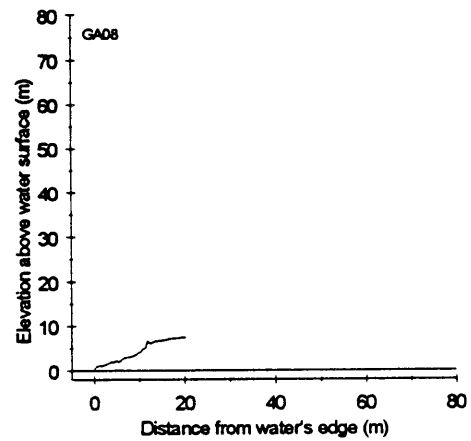
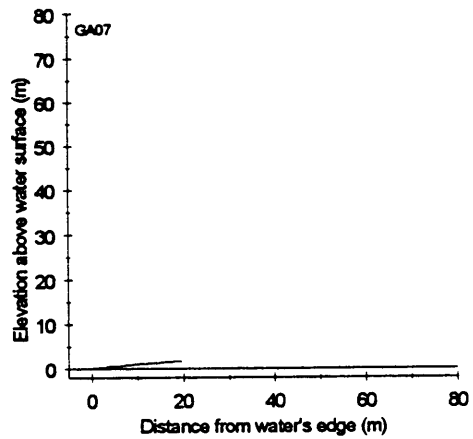


Figure 5. Distribution of species abundances (% cover) for transect GA01. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 80). Data were divided among several graphs to facilitate interpretation.

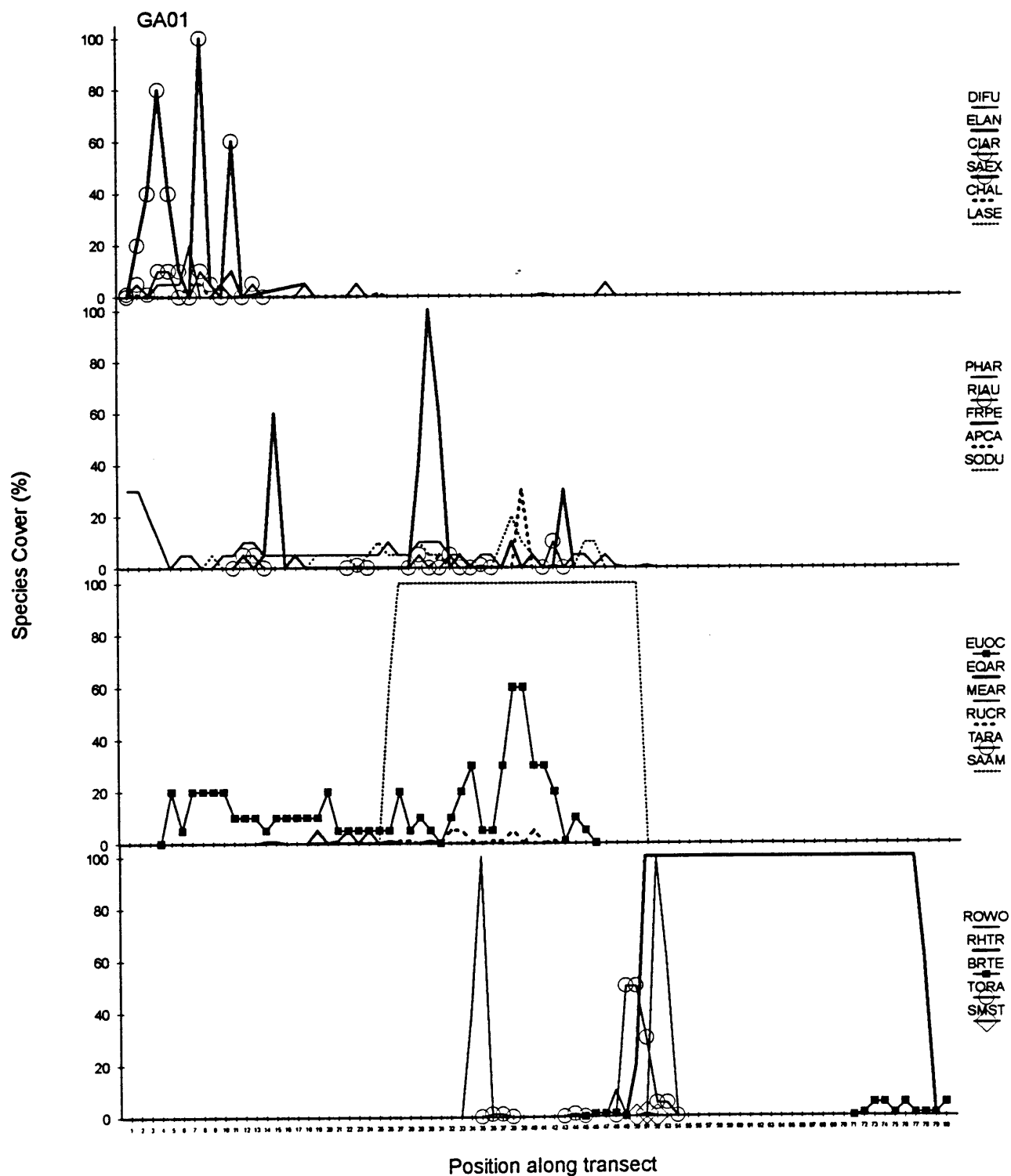


Figure 6. Edaphic characteristics and surface elevation profile of transect GA01, Hagerman Study Area, 1991. Edaphic data are presented as running means.

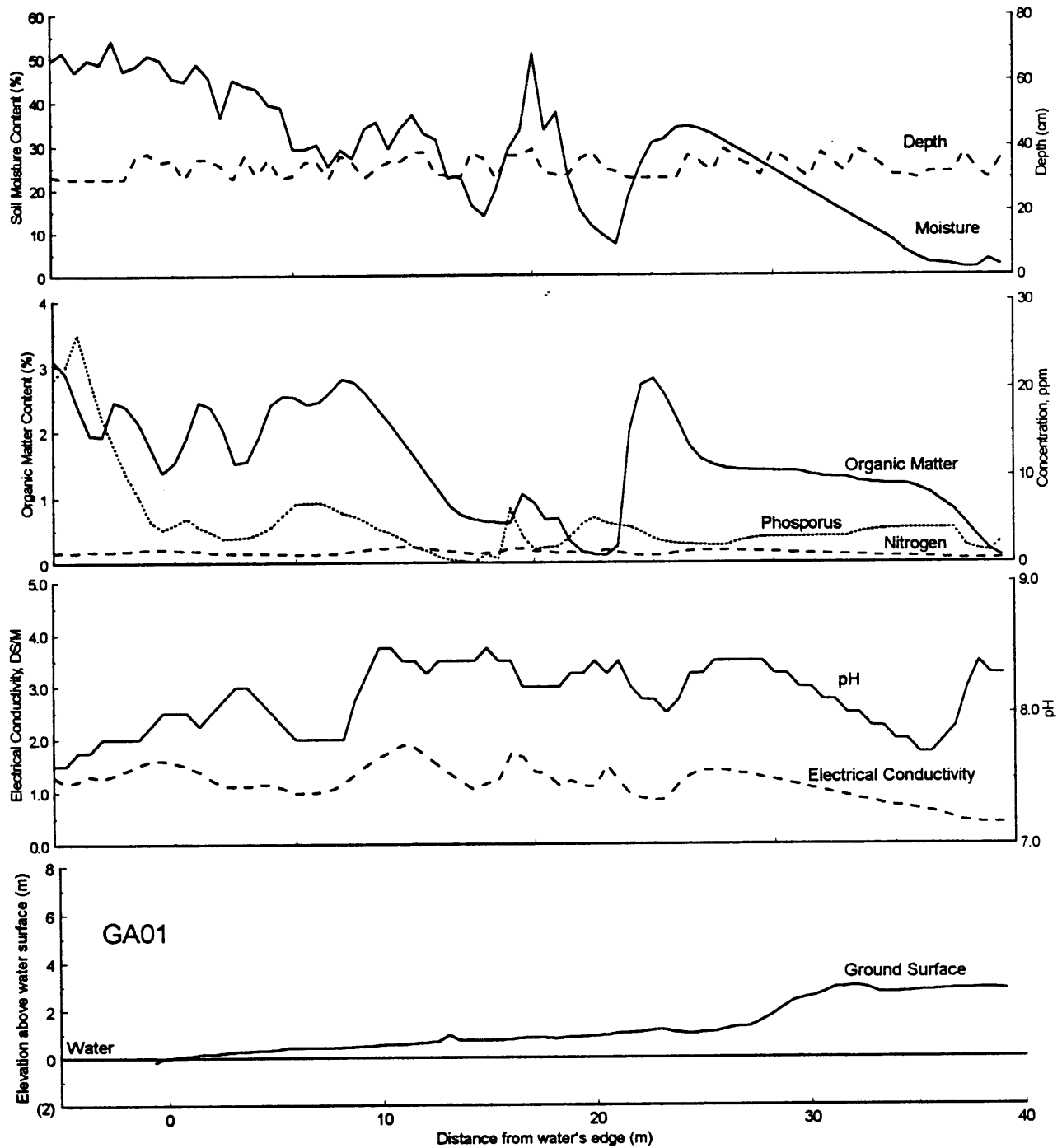


Figure 7. Species/environment biplot resulting from canonical correspondence analysis of transect GA01. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 2.

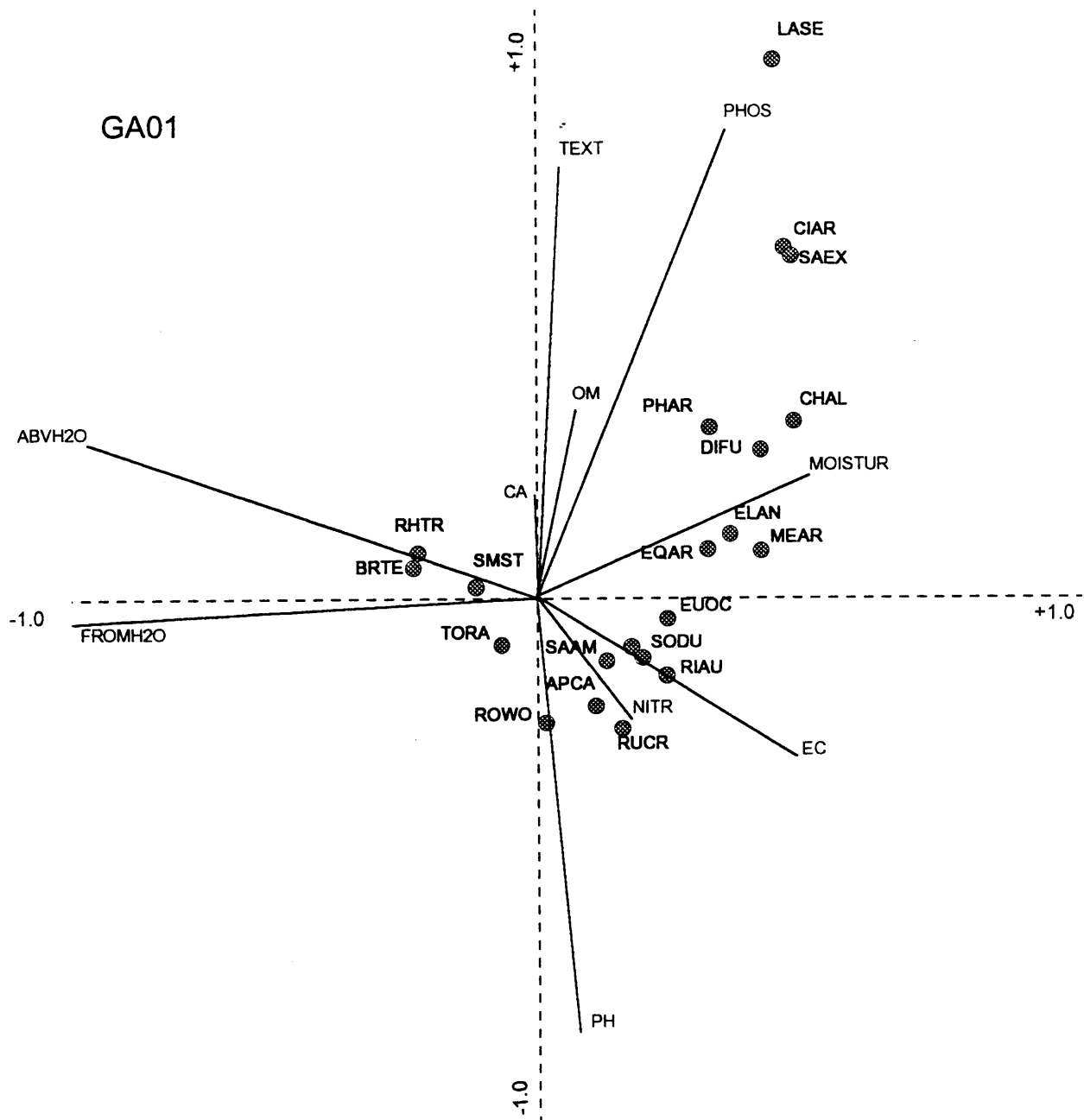


Figure 8. Species/environment biplot resulting from canonical correspondence analysis of transect GA01 with plant associations (numbers 1-3) superimposed. 1 = *Salix exigua*/*Phalaris arundinaceae*; 2 = *Salix amygdaloides*/*Euthamia occidentalis*; and 3 = *Rhus trilobata*. Codes for environmental factors are defined in Table 2.

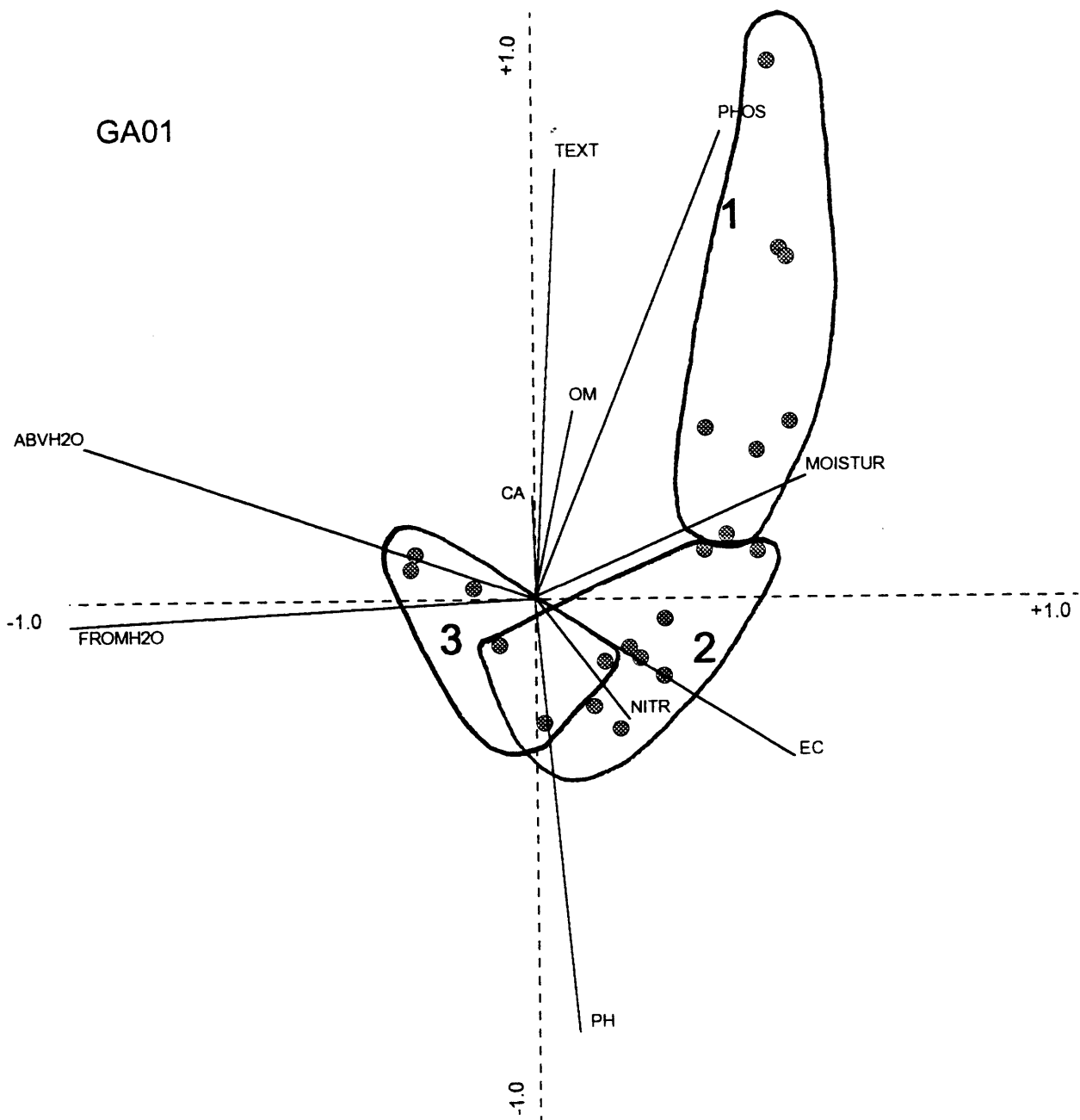


Figure 9. Distribution of species abundances (% cover) for transect GA02. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 80). Data were divided among several graphs to facilitate interpretation.

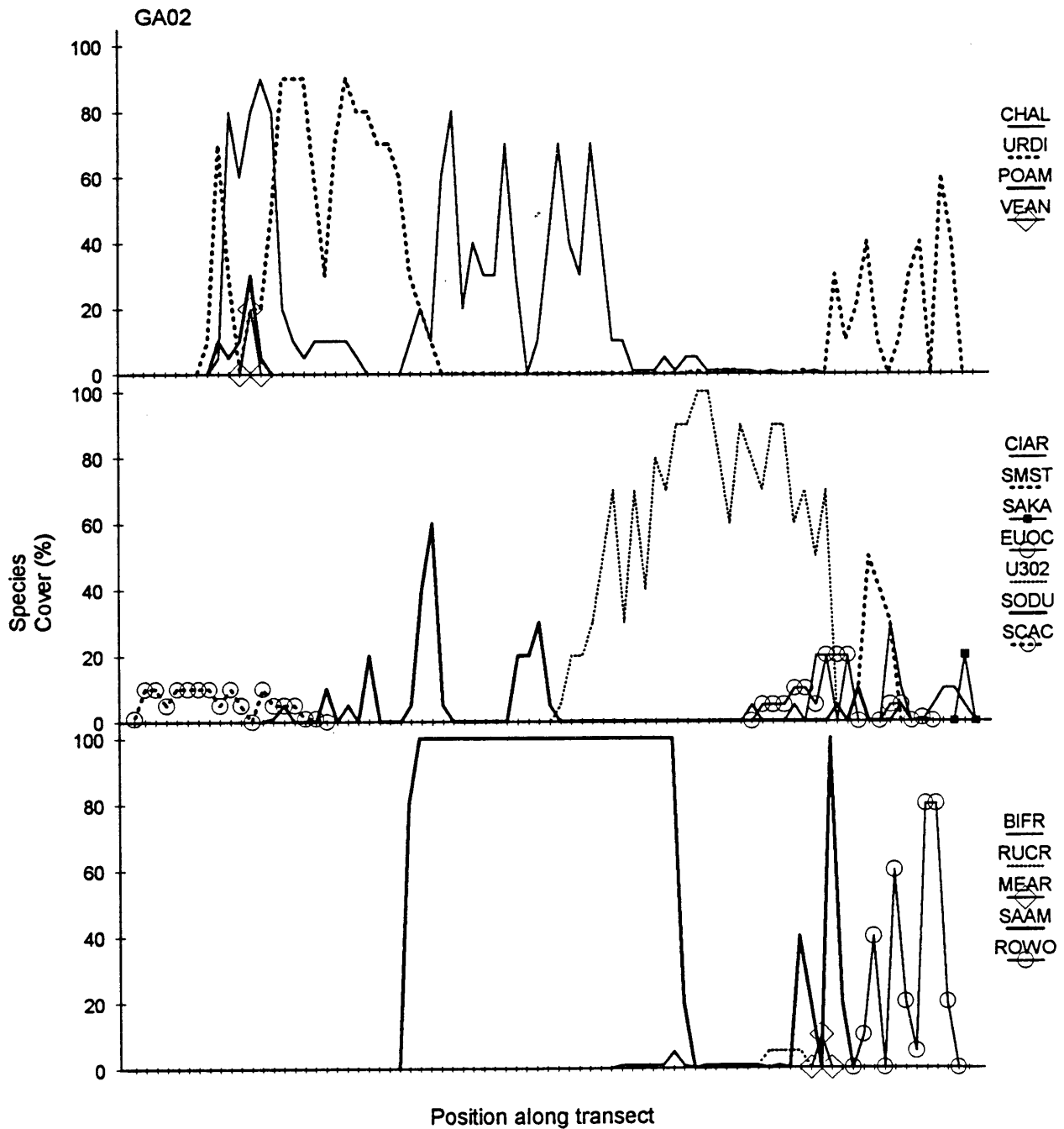


Figure 10. Edaphic characteristics and surface elevation profile of transect GA02, Hagerman Study Area, 1991. Edaphic data are presented as running means.

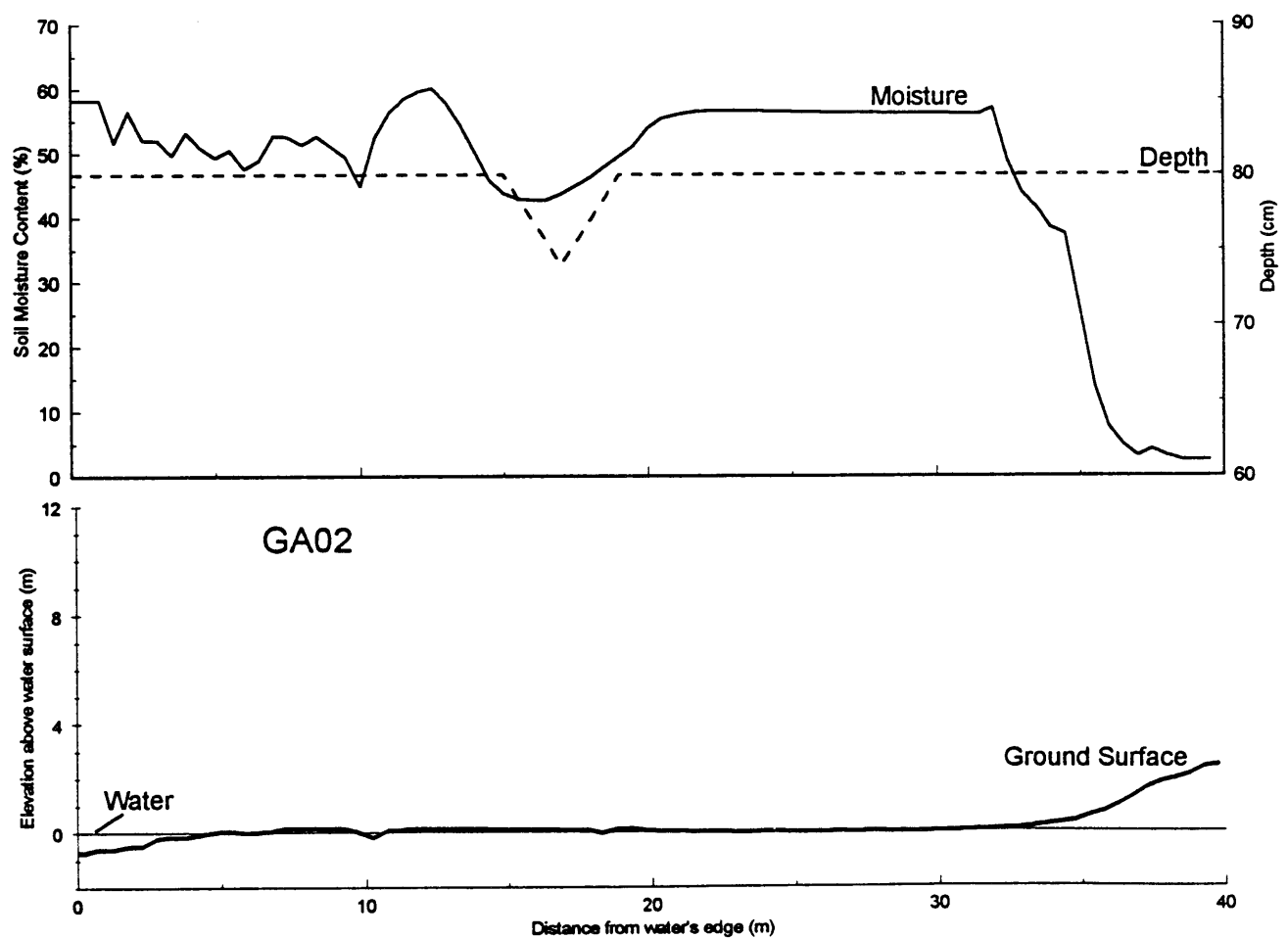


Figure 11. Species/environment biplot resulting from canonical correspondence analysis of transect GA02. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 4.

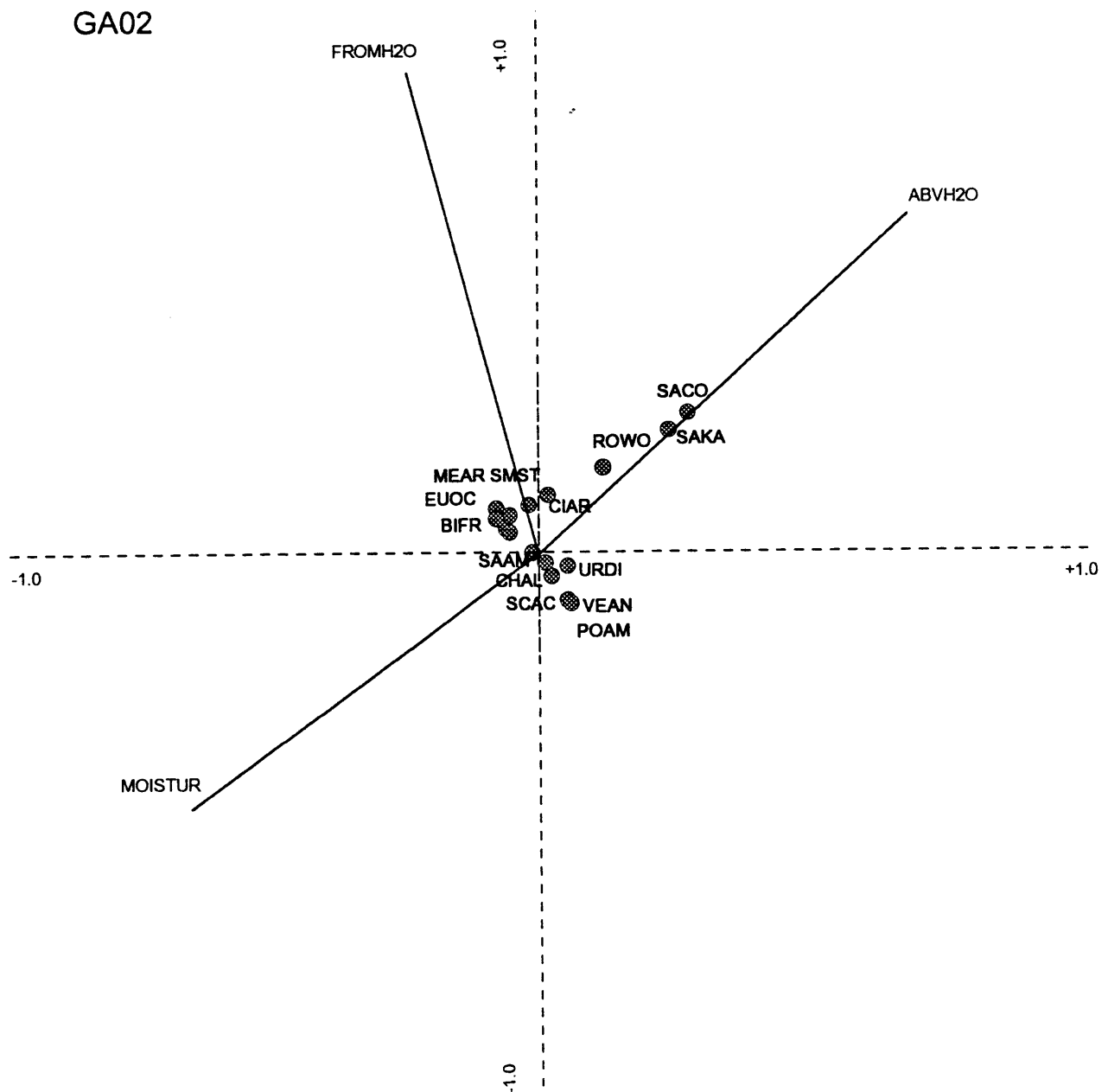


Figure 12. Species/environment biplot resulting from canonical correspondence analysis of transect GA02 with plant associations (numbers 1-4) superimposed. 1 = *Salix amygdaloides*/*Chenopodium album*; 2 = *Rosa woodsii*/*Urtica dioica*; 3 = *Urtica dioica* - *Chenopodium album*; and 4 = *Scirpus acutus*. Codes for environmental factors are defined in Table 2.

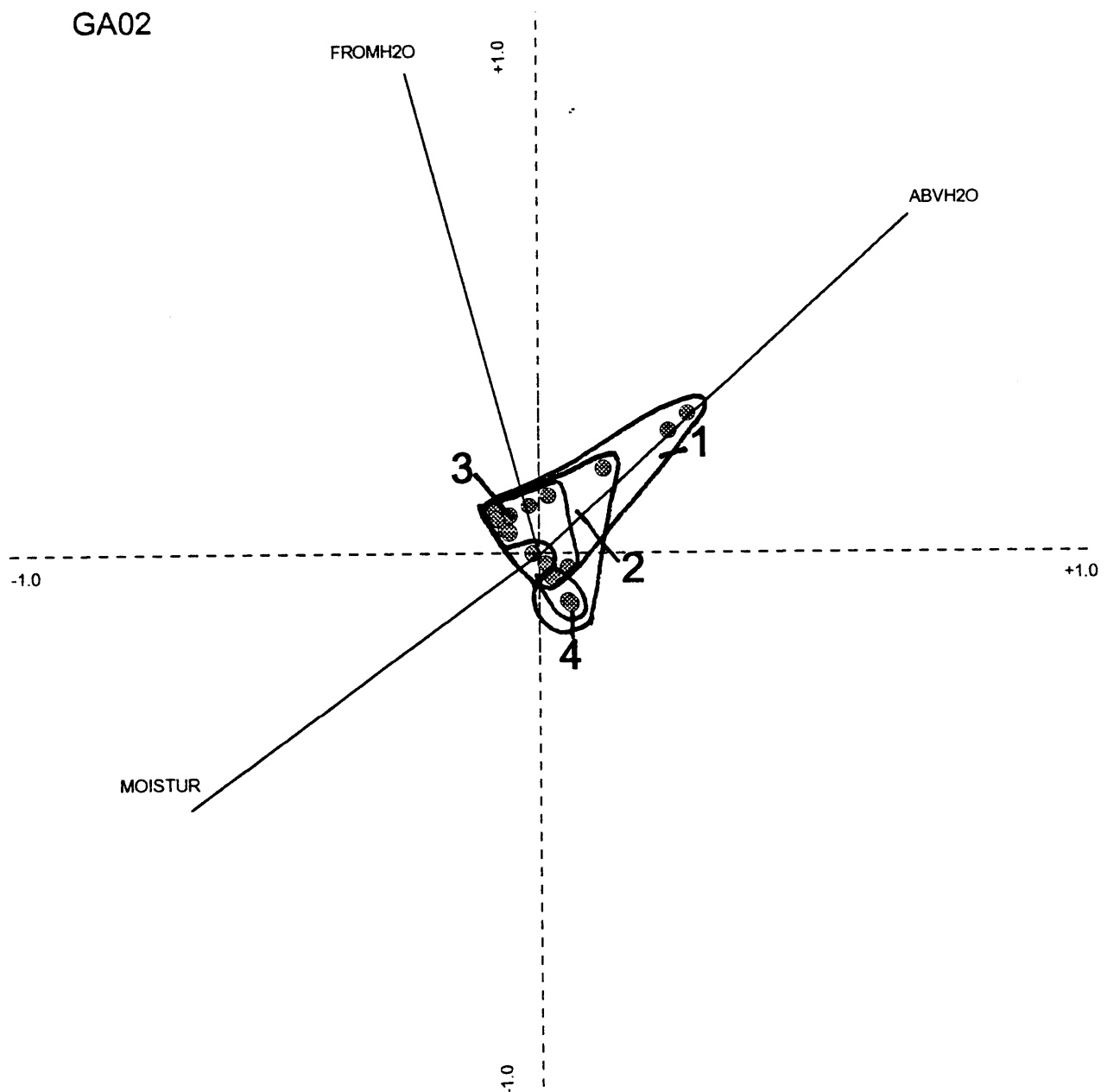


Figure 13. Distribution of species abundances (% cover) for transect GA03. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 160). Data were divided among several graphs to facilitate interpretation.

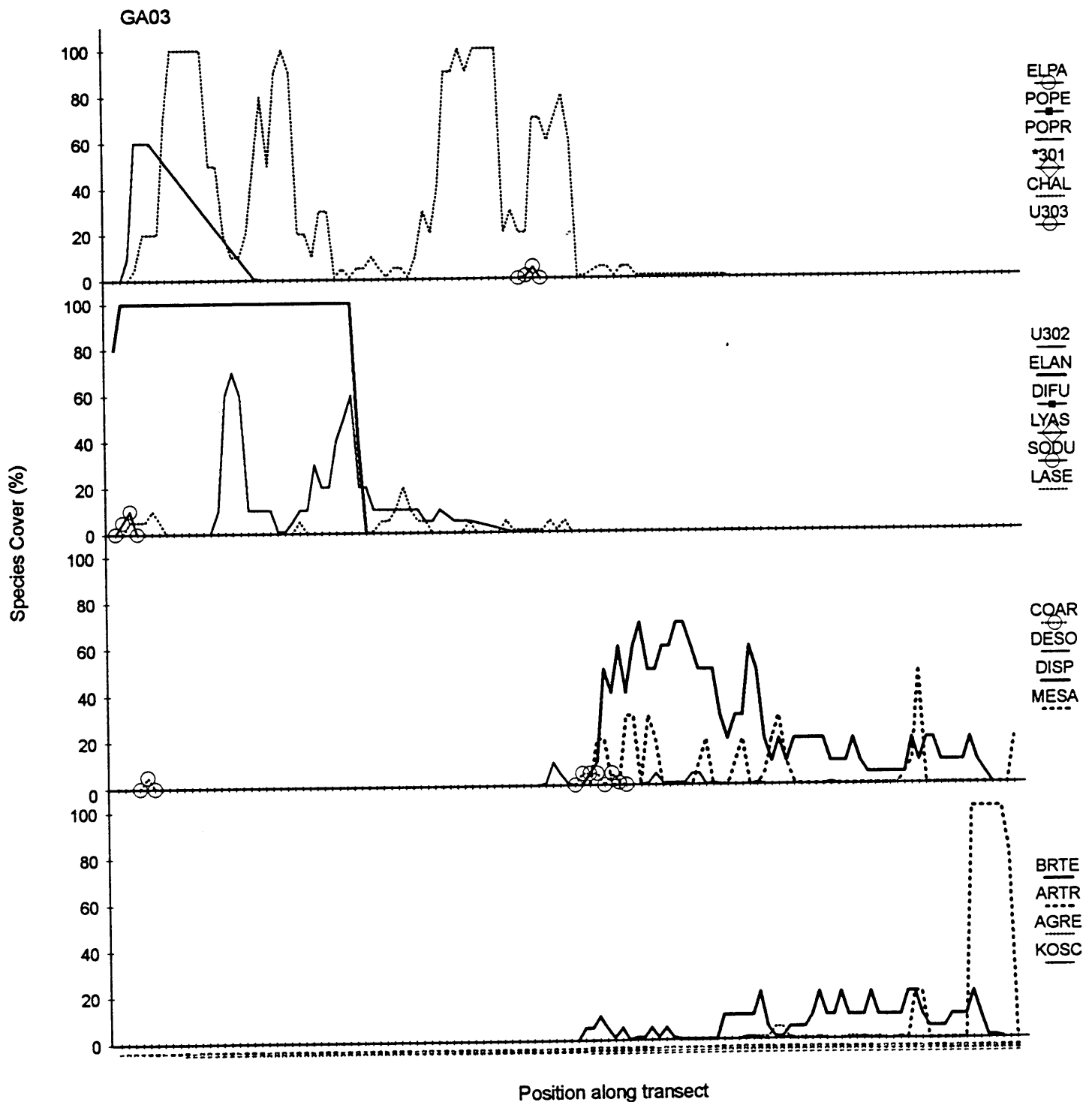


Figure 14. Edaphic characteristics and surface elevation profile of transect GA03, Hagerman Study Area, 1991. Edaphic data are presented as running means.

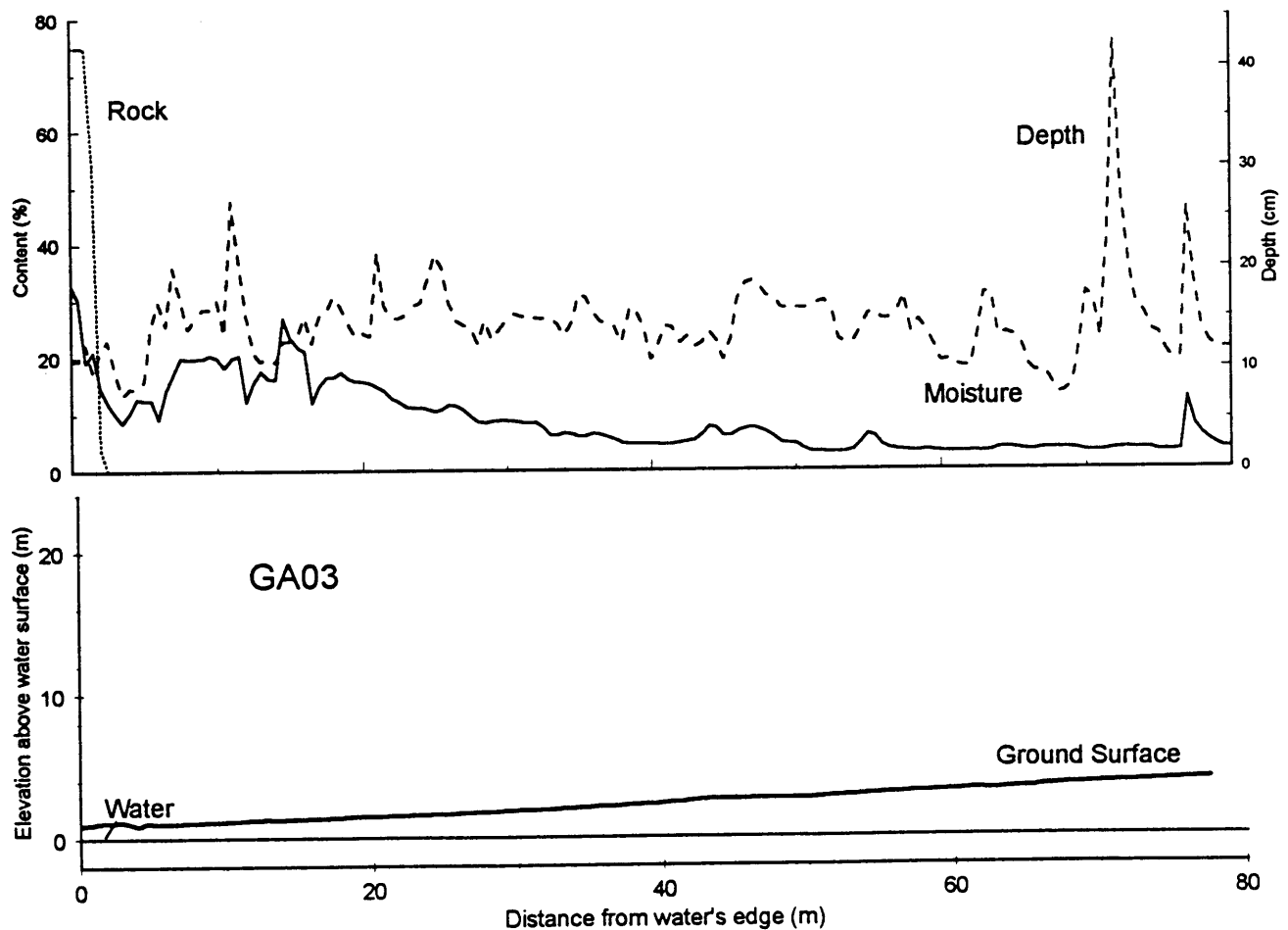
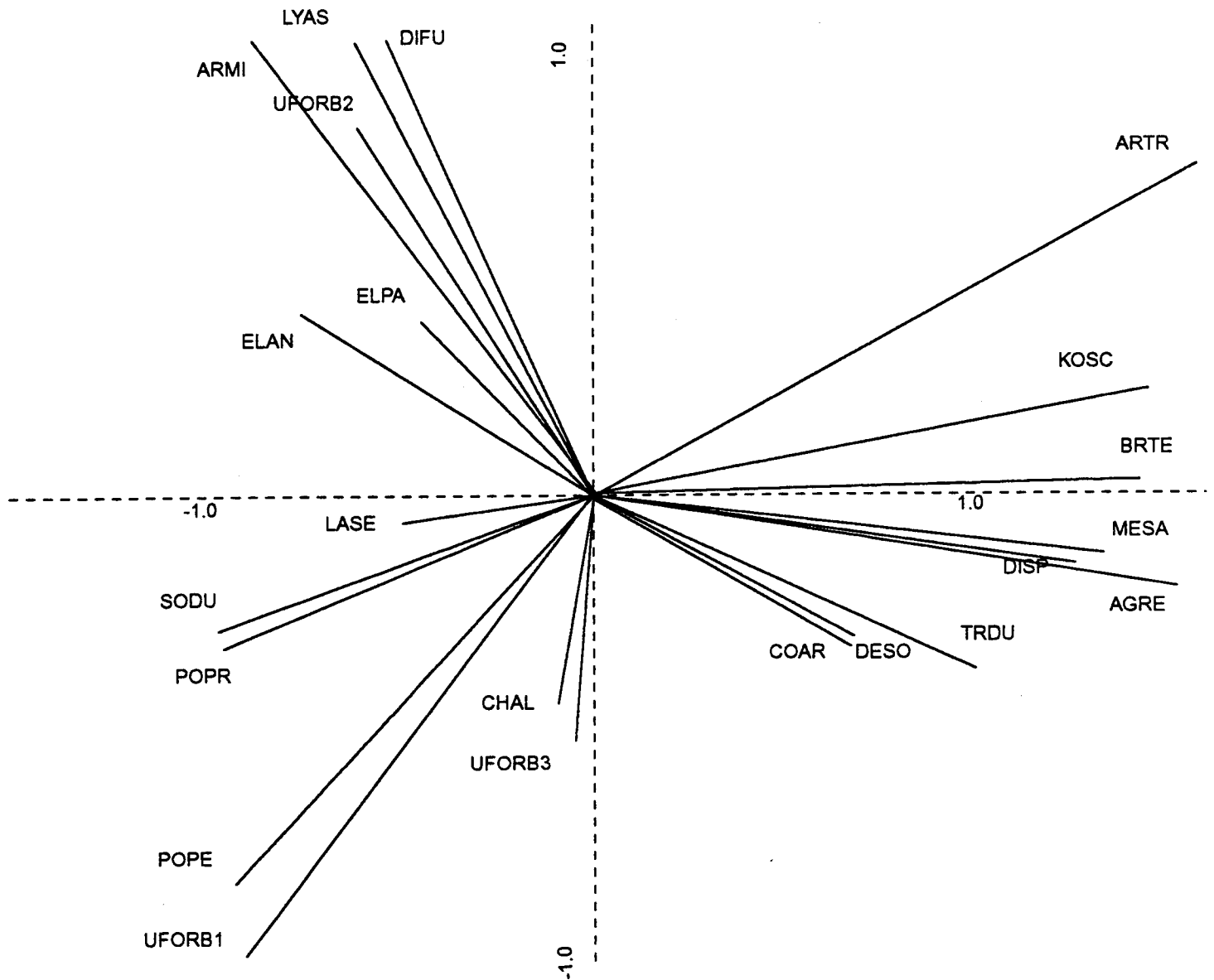


Figure 15. Ordination diagram for vegetation data of transect GA03 produced from Principal Components Analysis. Species codes are defined in Appendix 14.



Components Analysis showing plant association affiliation for each species. 1 = *Elaeagnus angustifolia*/*Poa pratensis*; 2 = *Elaeagnus angustifolia*/*Chenopodium album*; 3 = *Chenopodium album*; 4 = *Distichlis spicata*-*Bromus tectorum*; and 5 = *Artemisia tridentata*.

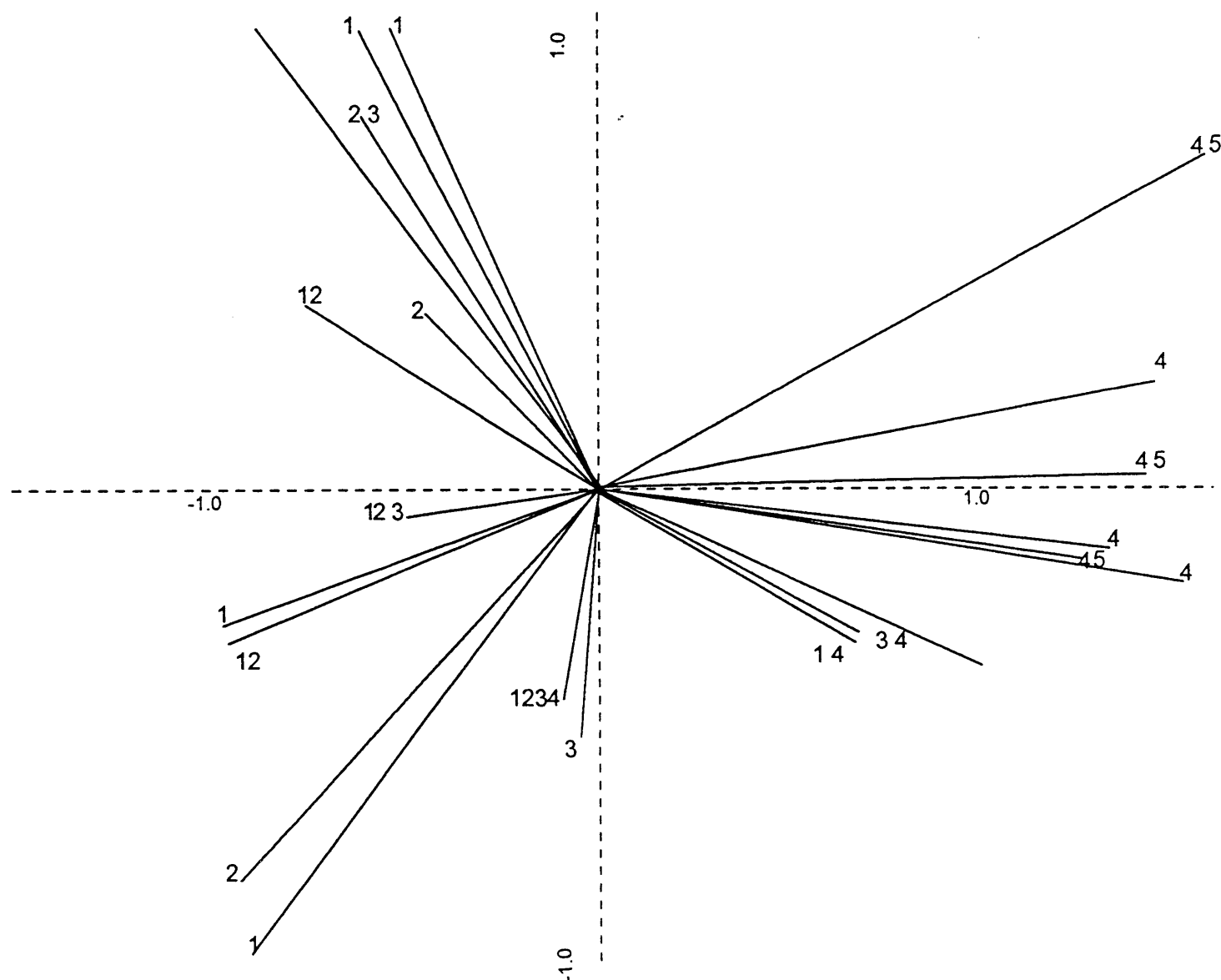


Figure 17. Distribution of species abundances (% cover) for transect GA04. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 52). Data were divided among several graphs to facilitate interpretation.

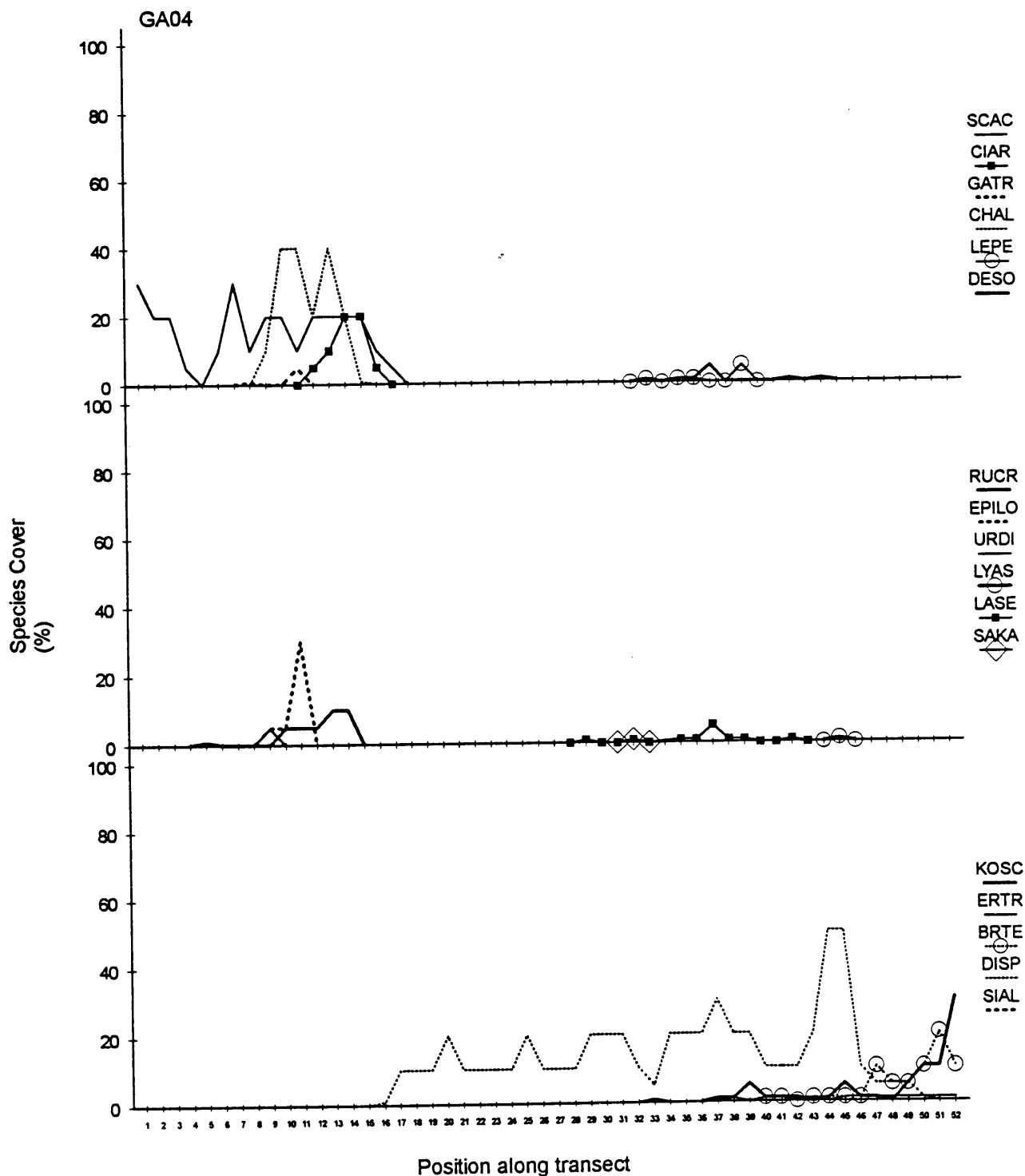


Figure 18. Edaphic characteristics and surface elevation profile of transect GA04, Hagerman Study Area, 1991. Edaphic data are presented as running means.

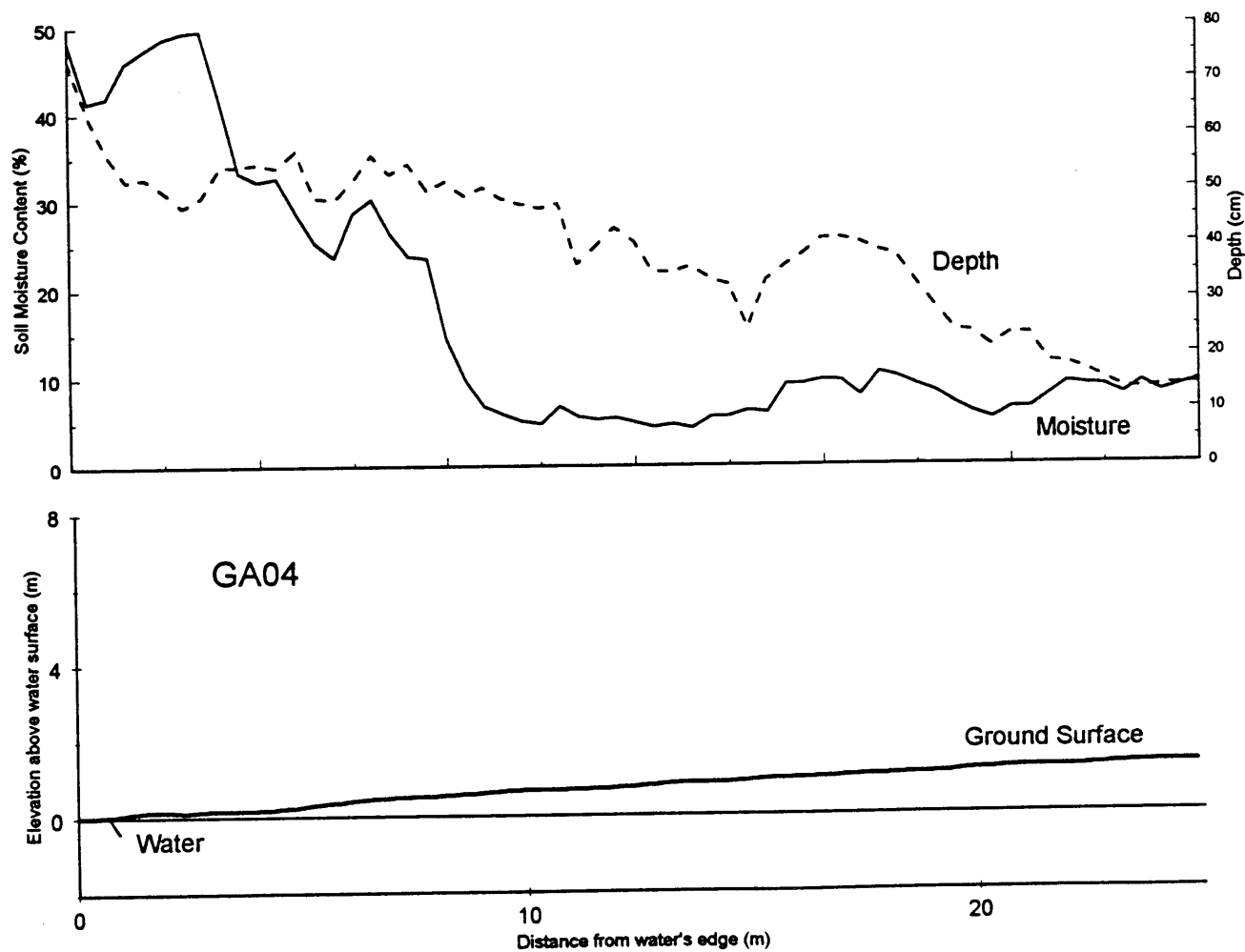


Figure 19. Species/environment biplot resulting from canonical correspondence analysis of transect GA04. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 6.

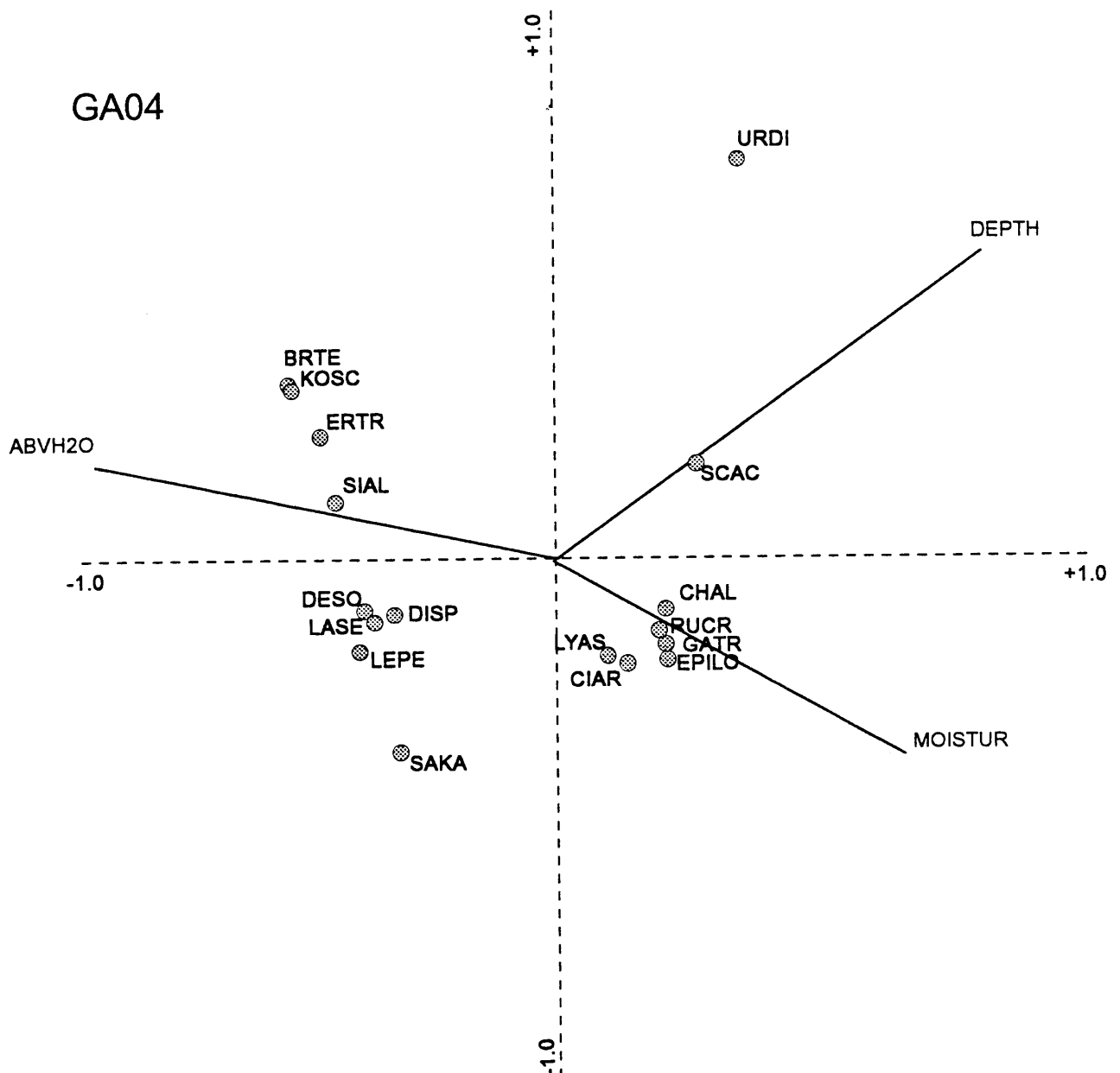


Figure 20. Species/environment biplot resulting from canonical correspondence analysis of transect GA04 with plant associations (numbers 1-3) superimposed. 1 = *Bromus tectorum*-*Kochia scoparia*; 2 = *Distichlis spicata*; and 3 = *Scirpus acutus*. Codes for environmental factors are defined in Table 2.

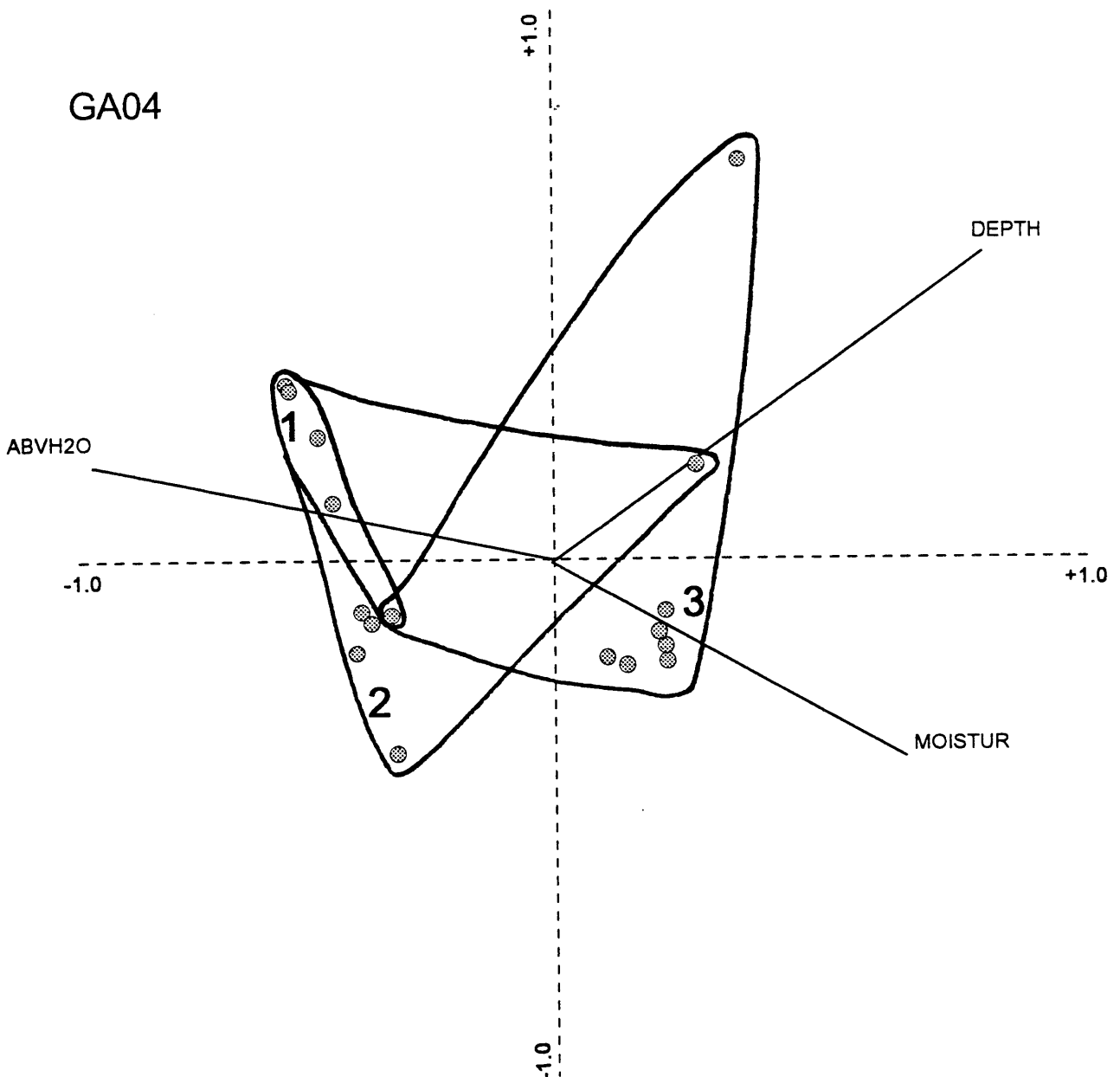


Figure 21. Distribution of species abundances (% cover) for transect GA05. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 84). Data were divided among several graphs to facilitate interpretation.

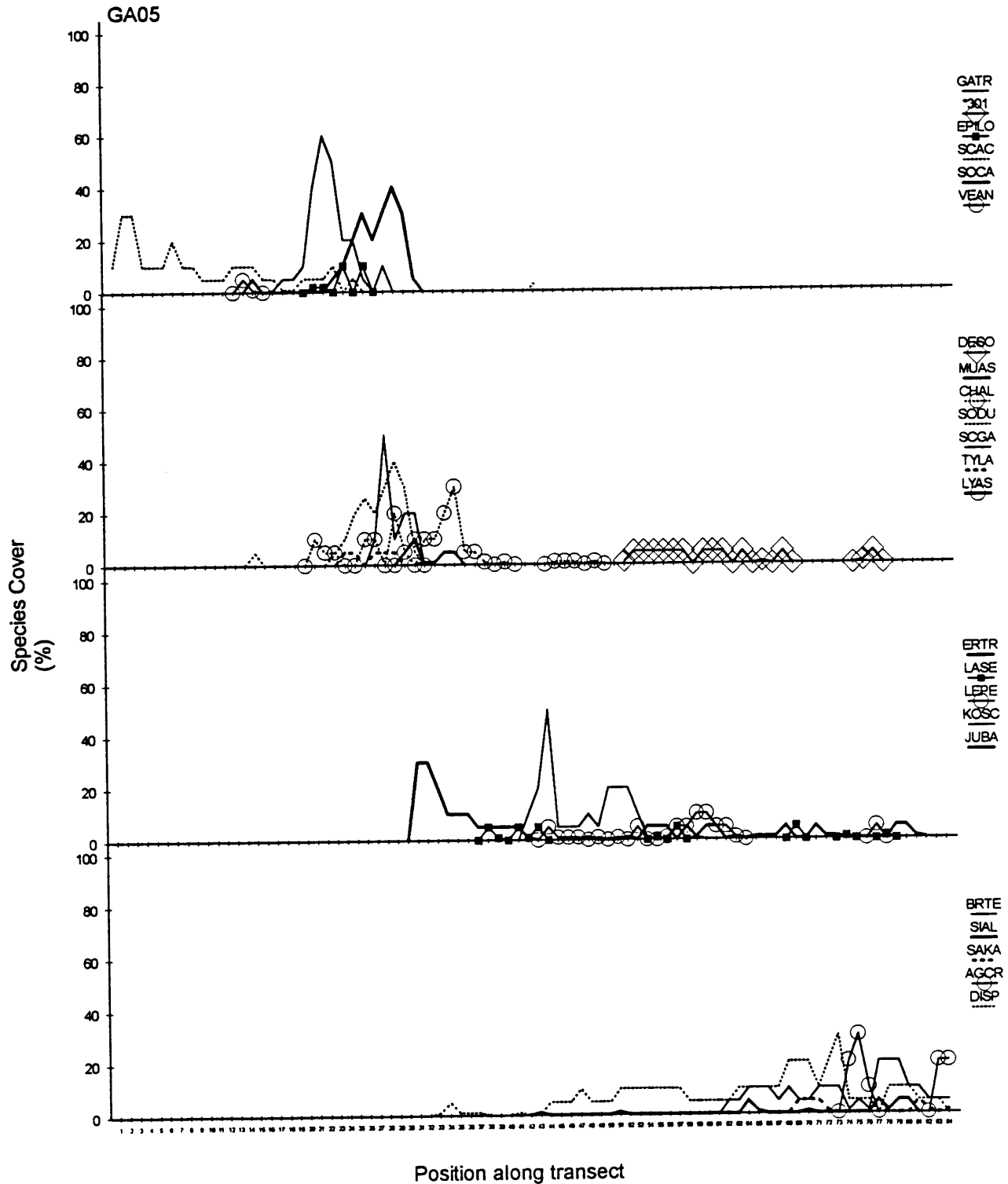


Figure 22. Edaphic characteristics and surface elevation profile of transect GA05, Hagerman Study Area, 1991. Edaphic data are presented as running means.

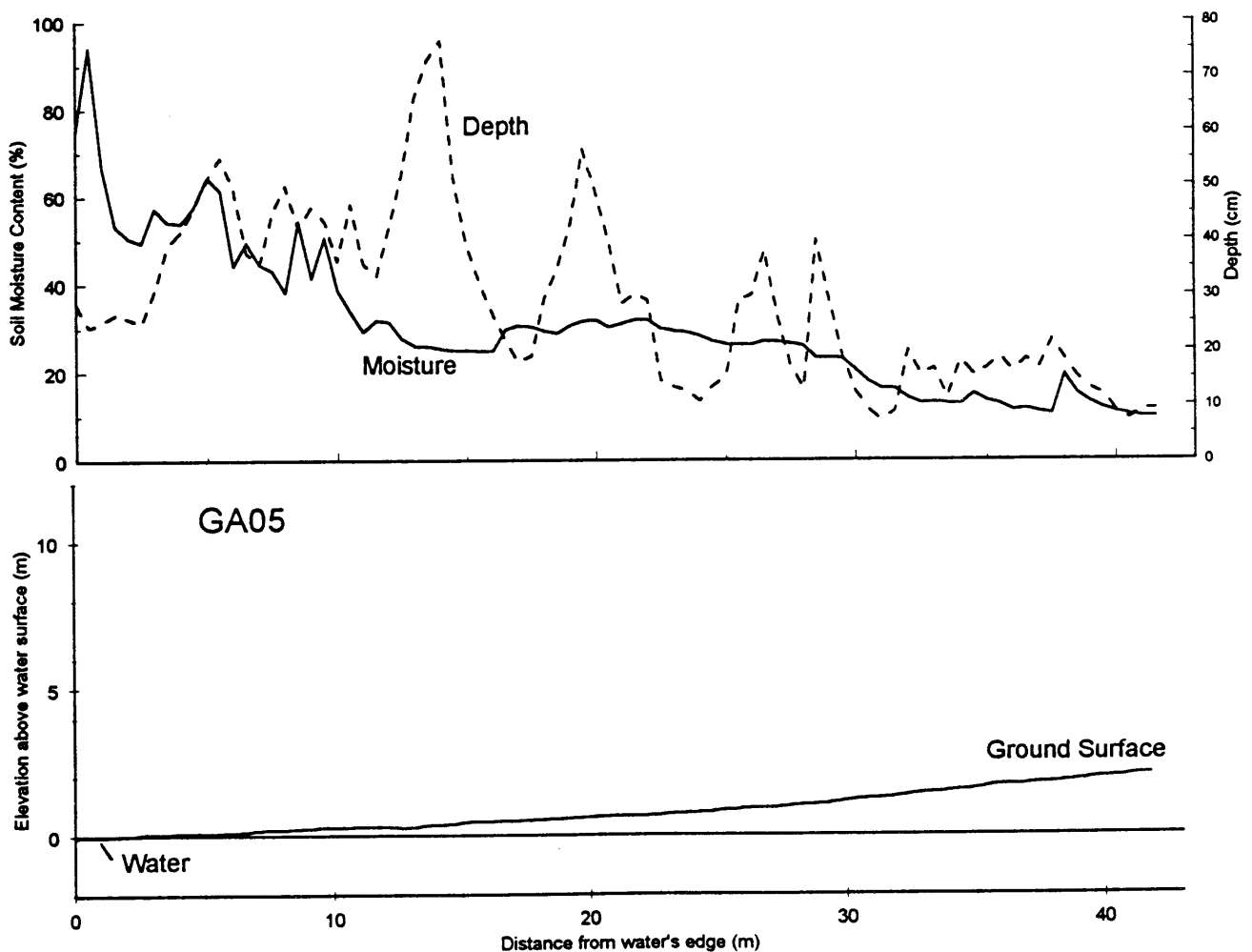


Figure 23. Species/environment biplot resulting from canonical correspondence analysis of transect GA05. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 7.

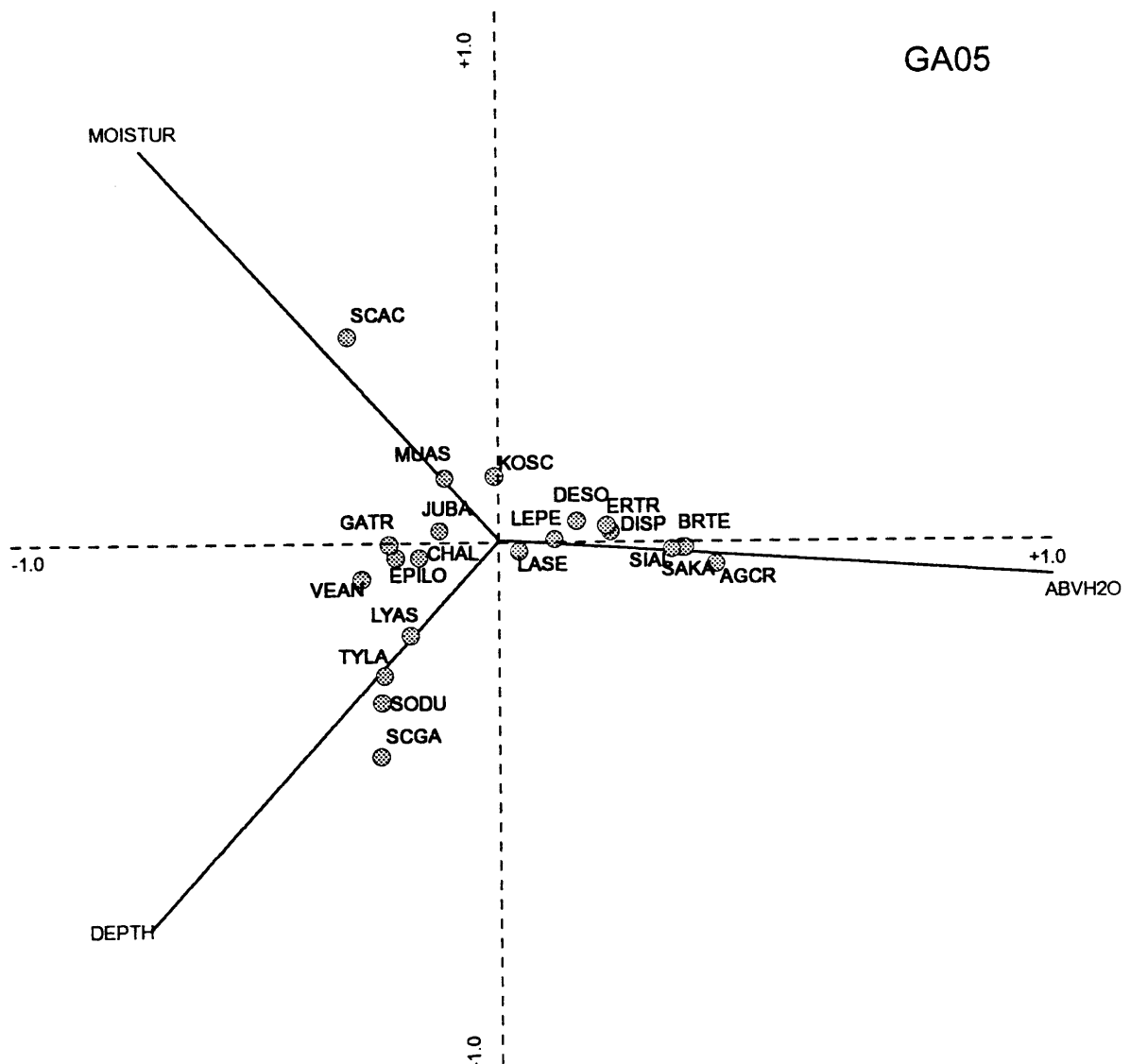


Figure 24. Species/environment biplot resulting from canonical correspondence analysis of transect GA05 with plant associations (numbers 1-5) superimposed. 1 = *Distichlis spicata*-*Bromus tectorum*; 2 = *Distichlis spicata*-*Kochia scoparia*; 3 = *Juncus balticus*-*Chenopodium album*; 4 = *Galium triflorum*-*Solanum dulcamara*; and 5 = *Scirpus acutus*. Codes for environmental factors are defined in Table 2.

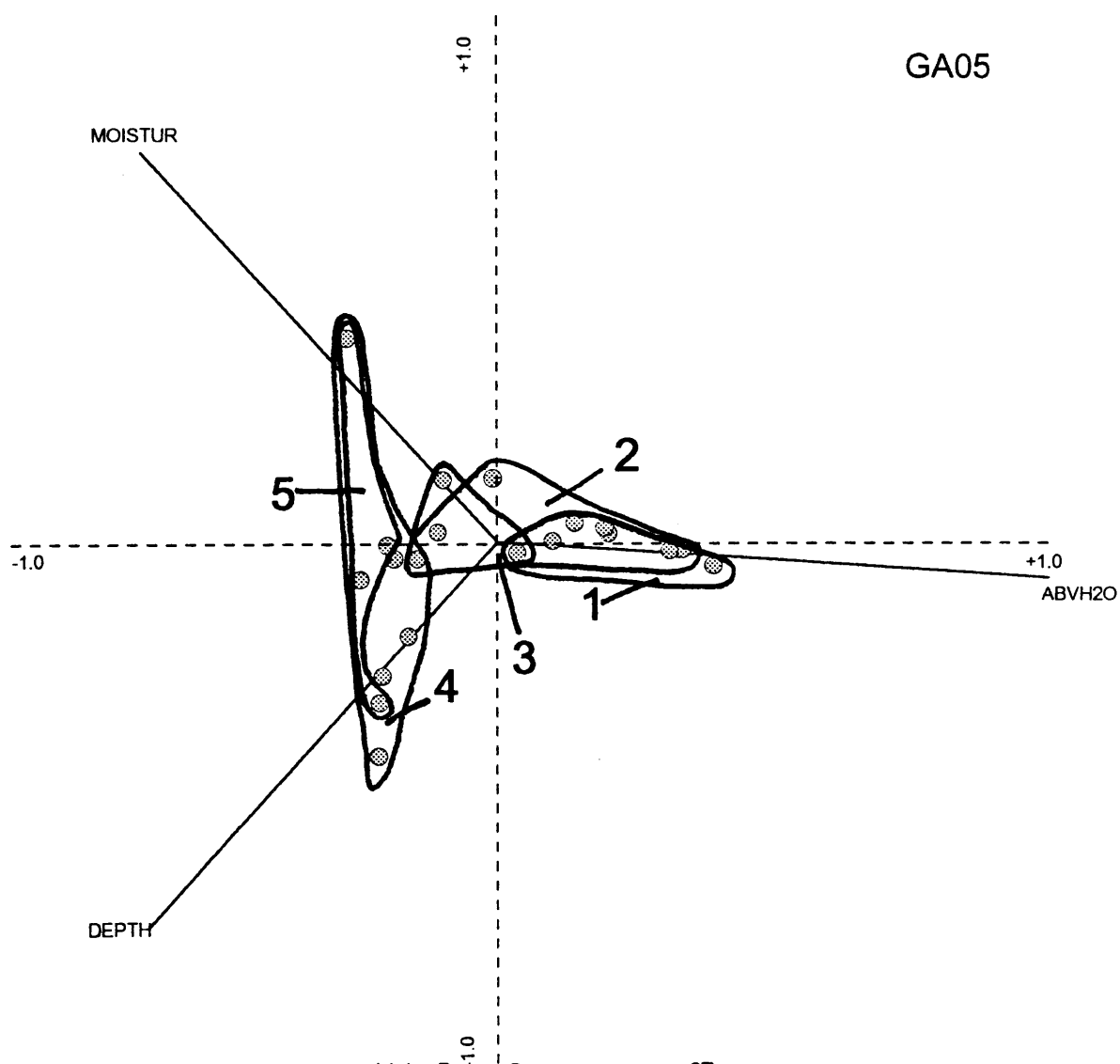


Figure 25. Distribution of species abundances (% cover) for transect GA06. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 45). Data were divided among several graphs to facilitate interpretation.

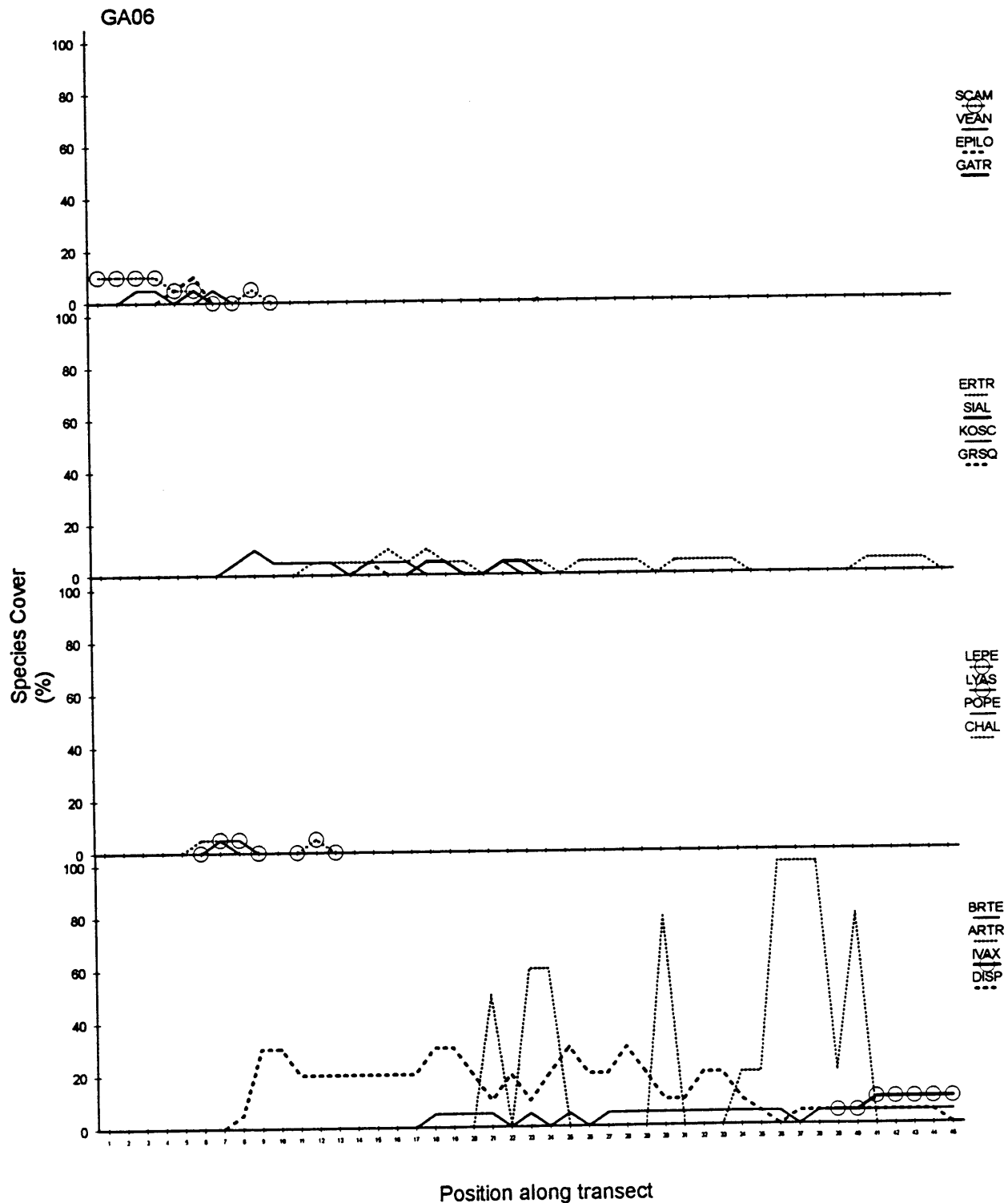


Figure 26. Edaphic characteristics and surface elevation profile of transect GA06, Hagerman Study Area, 1991. Edaphic data are represented as running means.

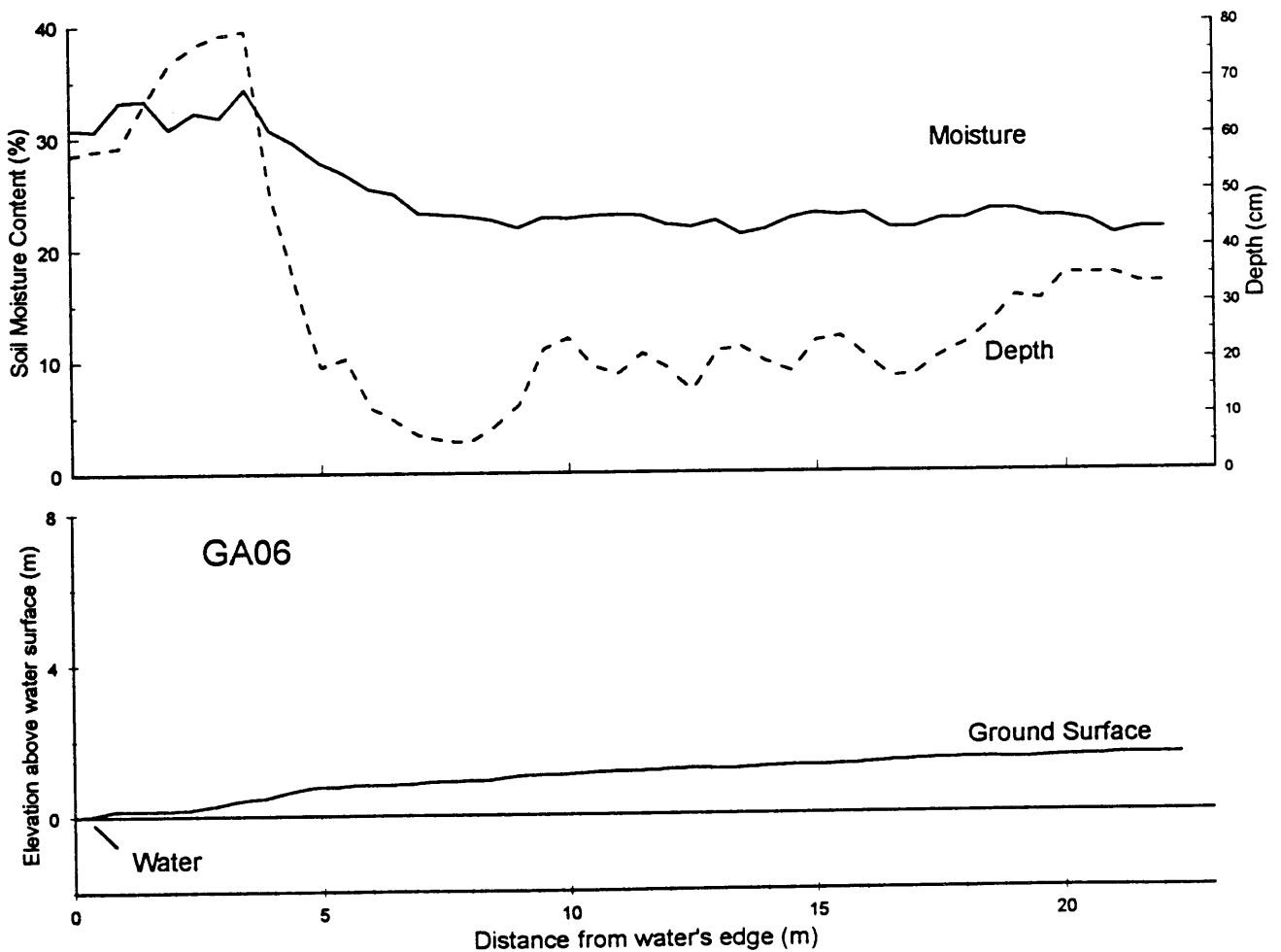


Figure 27. Species/environment biplot resulting from canonical correspondence analysis of transect GA06. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 8.

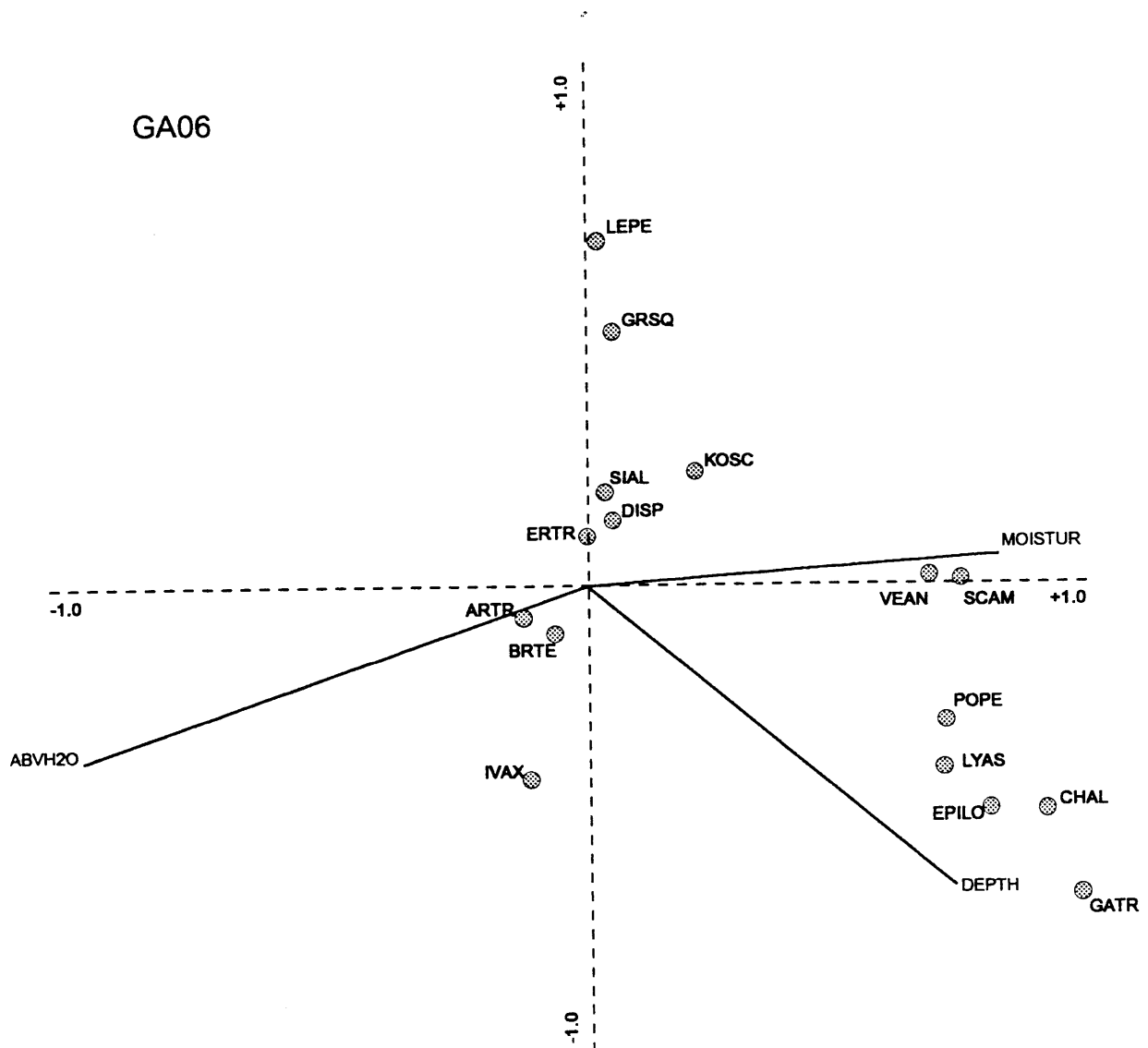


Figure 28. Species/environment biplot resulting from canonical correspondence analysis of transect GA06 with plant associations (numbers 1-4) superimposed. 1 = *Artemisia tridentata*/*Distichlis spicata*; 2 = *Iva axillaris*-mixed grasses; 3 = *Distichlis spicata*-*Erymopyrum triticeum*; and 4 = *Scirpus americanus*. Codes for environmental factors are defined in Table 2.

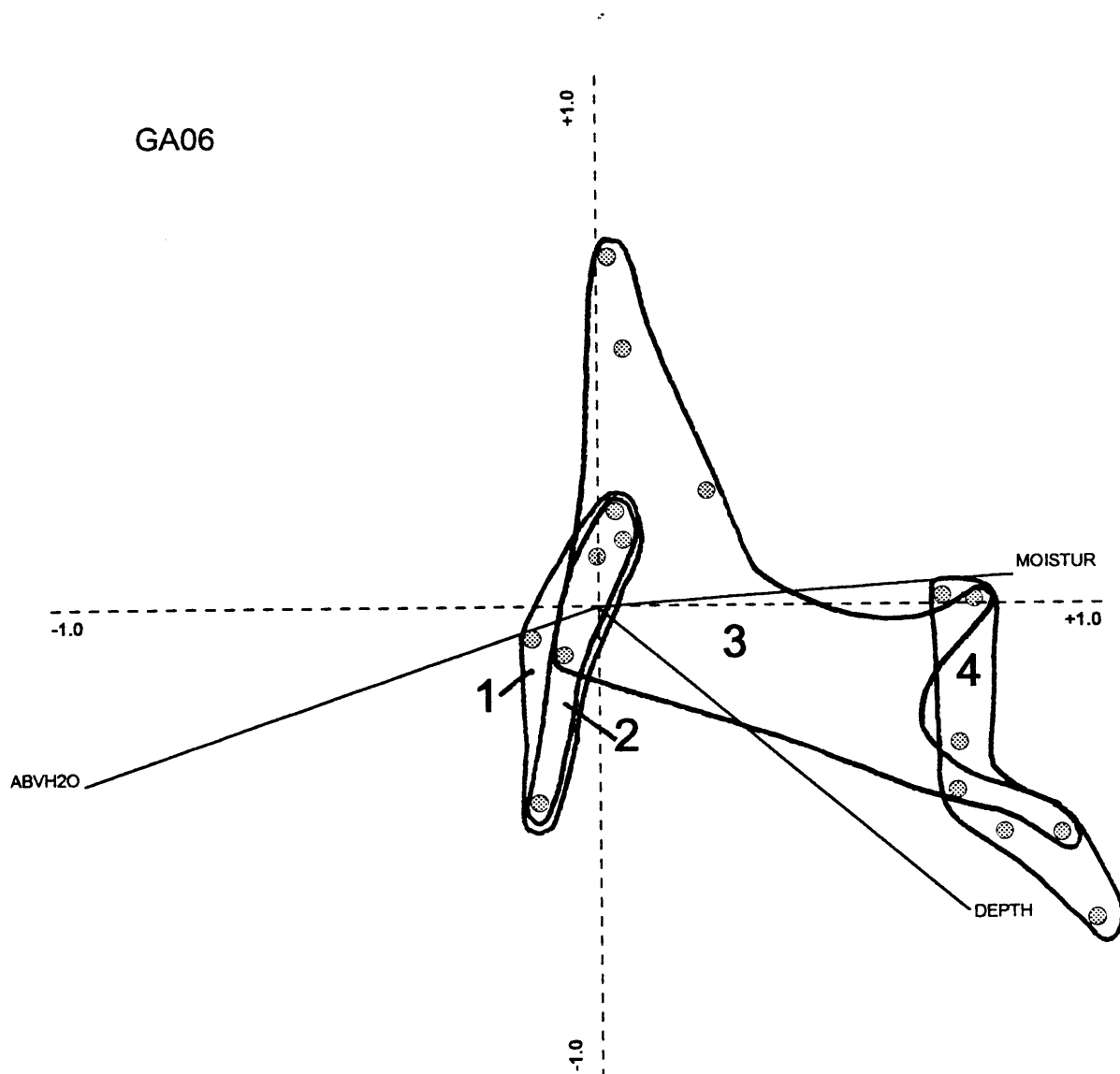


Figure 29. Distribution of species abundances (% cover) for transect GA07. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 41). Data were divided among several graphs to facilitate interpretation.

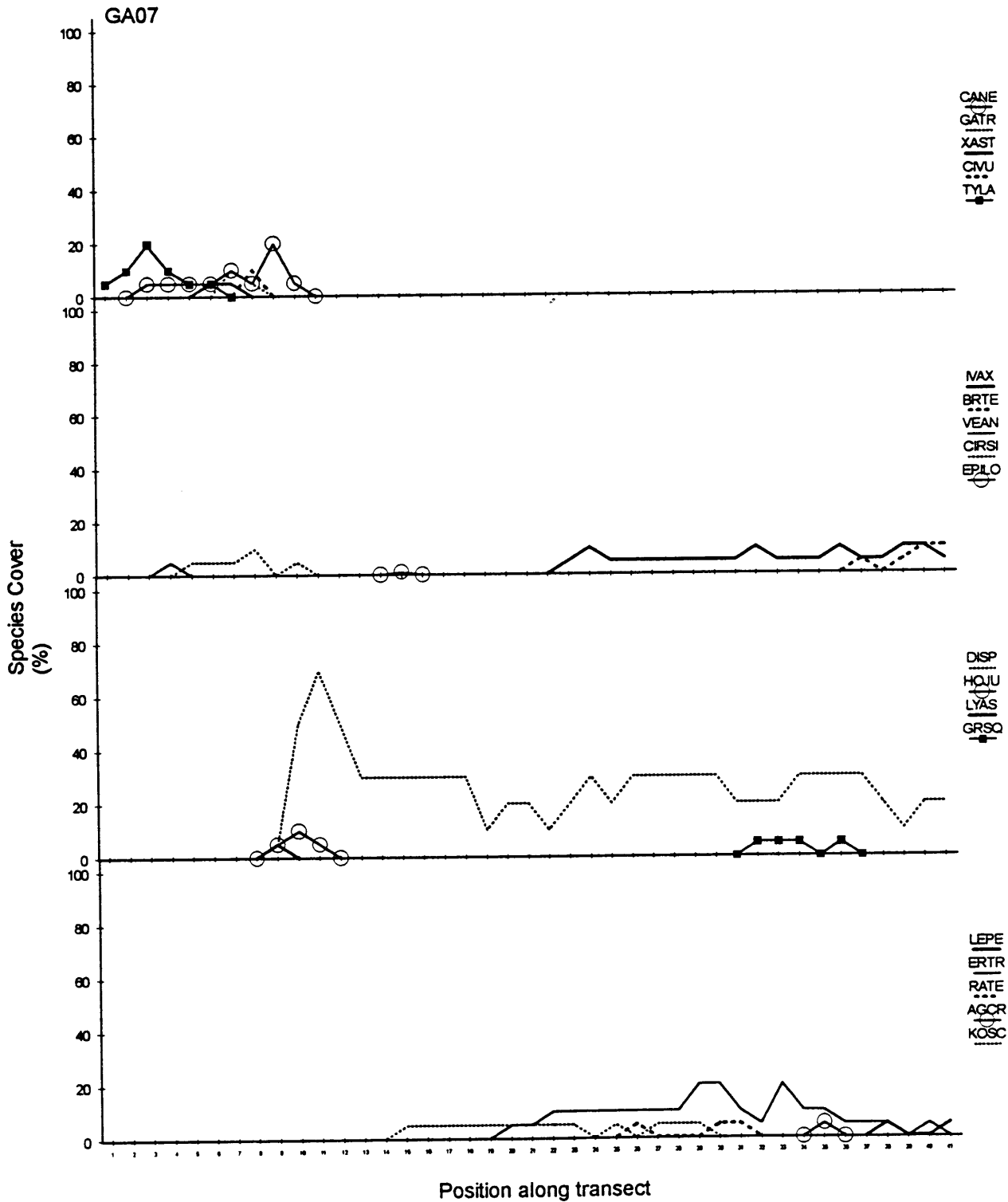


Figure 30. Edaphic characteristics and surface elevation profile of transect GA07, Hagerman Study Area, 1991. Edaphic data are presented as running means.

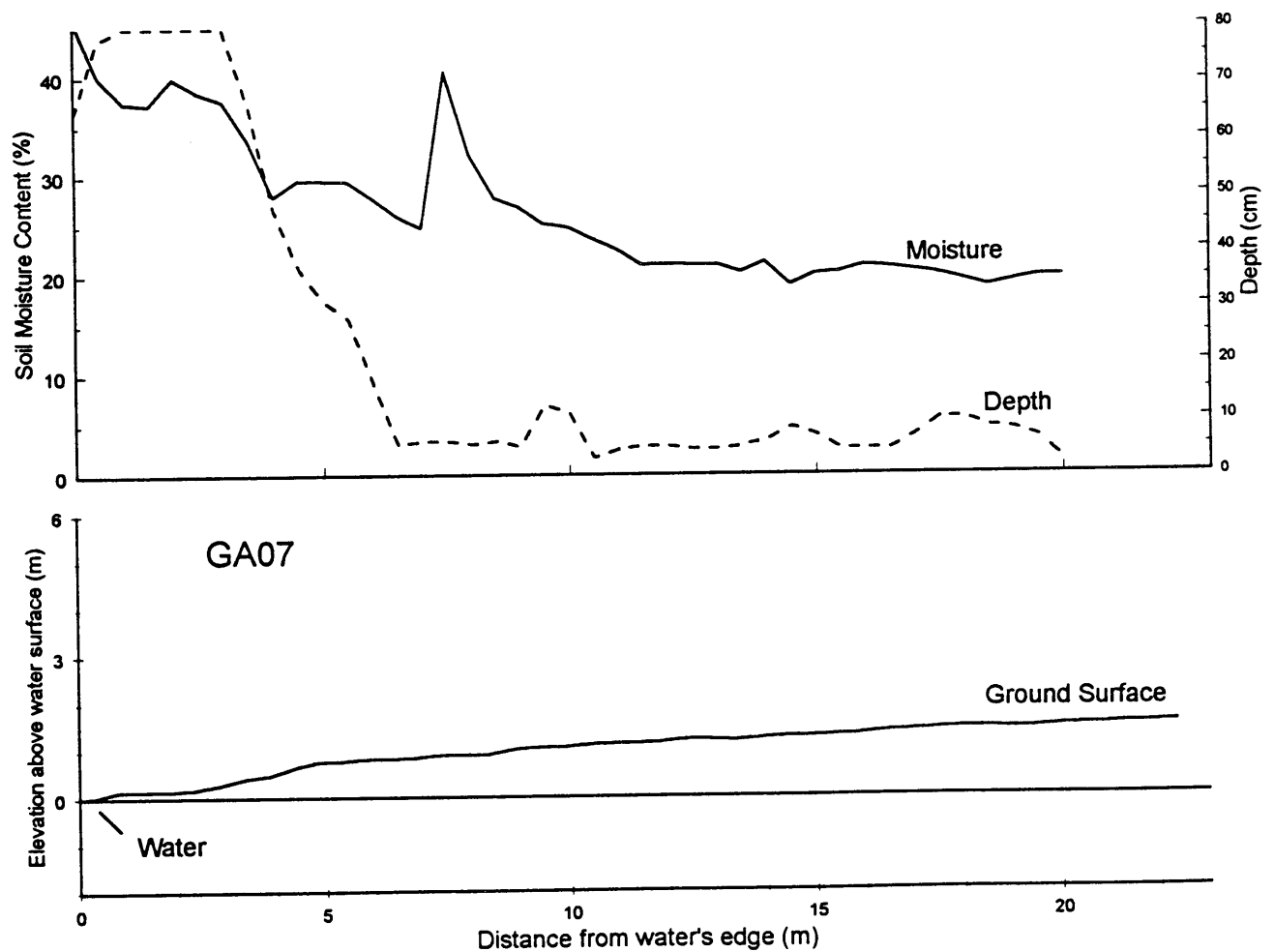


Figure 31. Species/environment biplot resulting from canonical correspondence analysis of transect GA07. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 9.

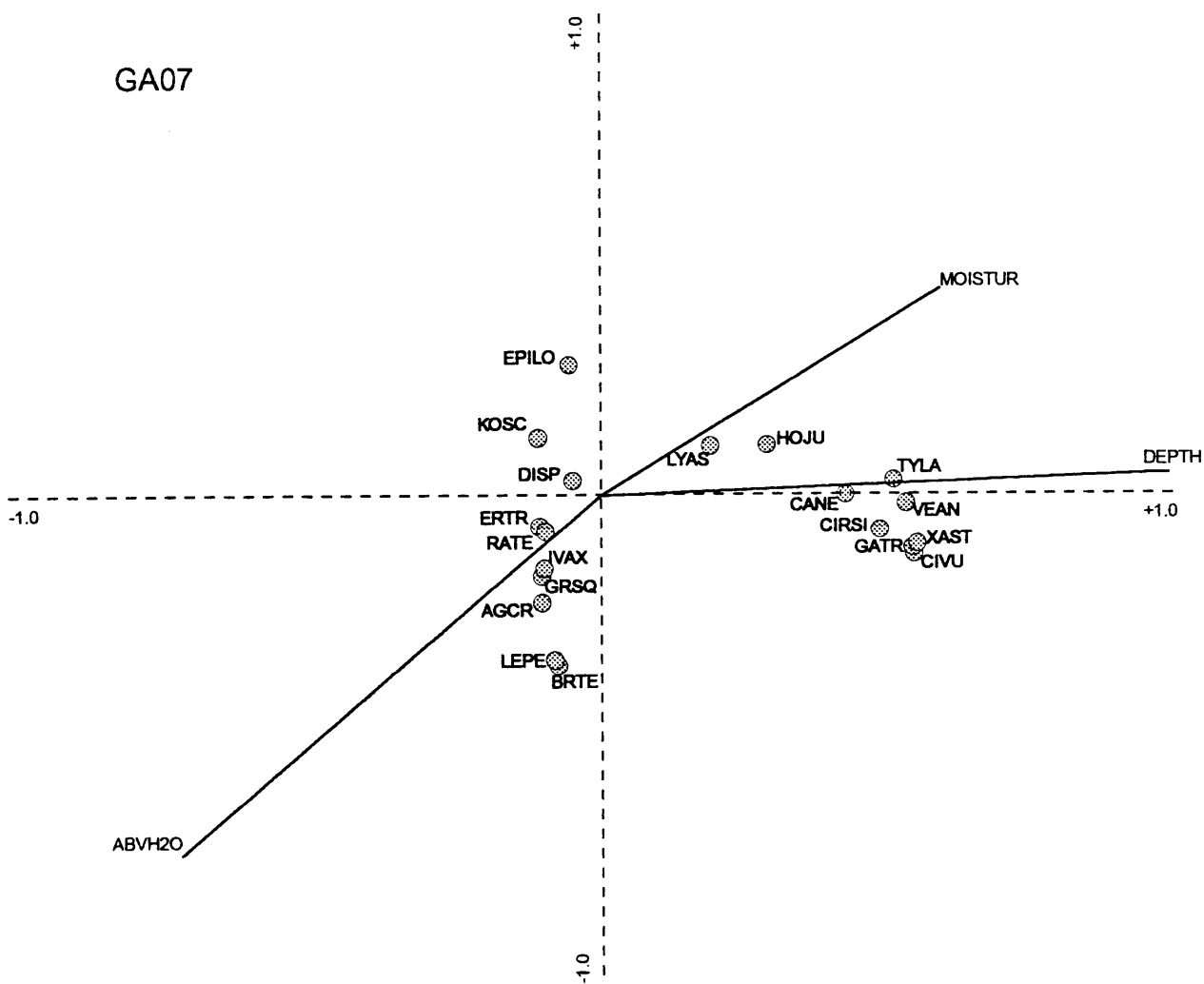


Figure 32. Species/environment biplot resulting from canonical correspondence analysis of transect GA06 with plant associations (numbers 1-5) superimposed. 1 = *Iva axillaris*/*Distichlis spicata*-*Eremopyrum triticeum*; 2 = *Distichlis spicata*-*Kochia scoparia*; 3 = *Distichlis spicata*-*Hordeum jubatum*; 4 = *Carex nebraskensis*; and 5 = *Typha latifolia*. Codes for environmental factors are defined in Table 2.

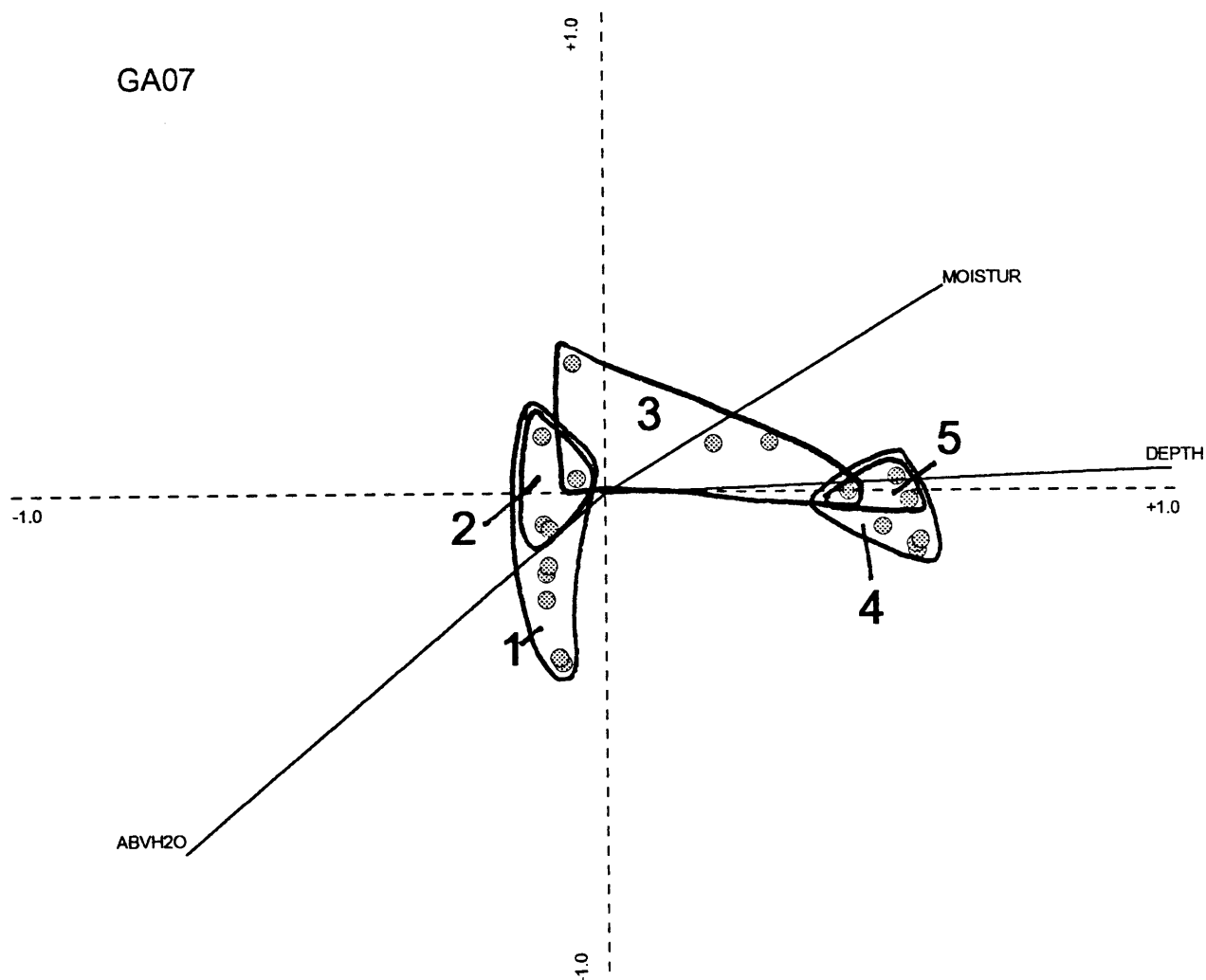


Figure 33. Distribution of species abundances (% cover) for transect GA08. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 42). Data were divided among several graphs to facilitate interpretation.

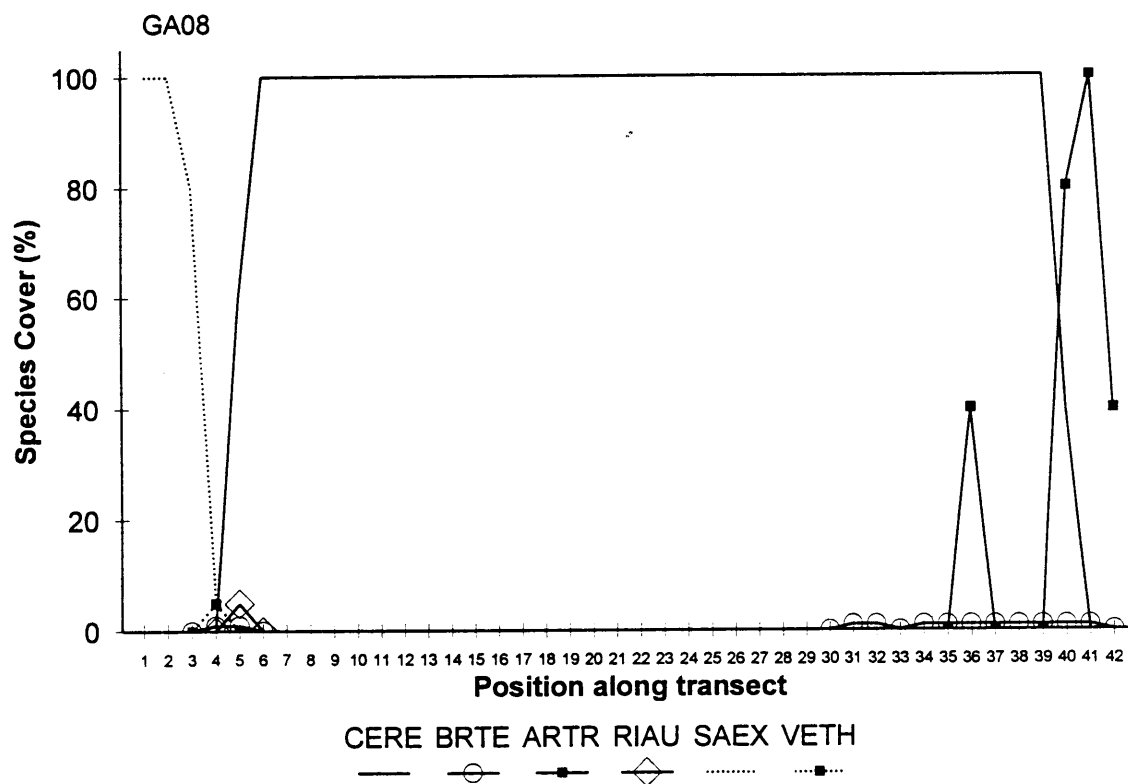


Figure 34. Edaphic characteristics and surface elevation profile of transect GA08, Hagerman Study Area, 1991. Edaphic data are presented as running means.

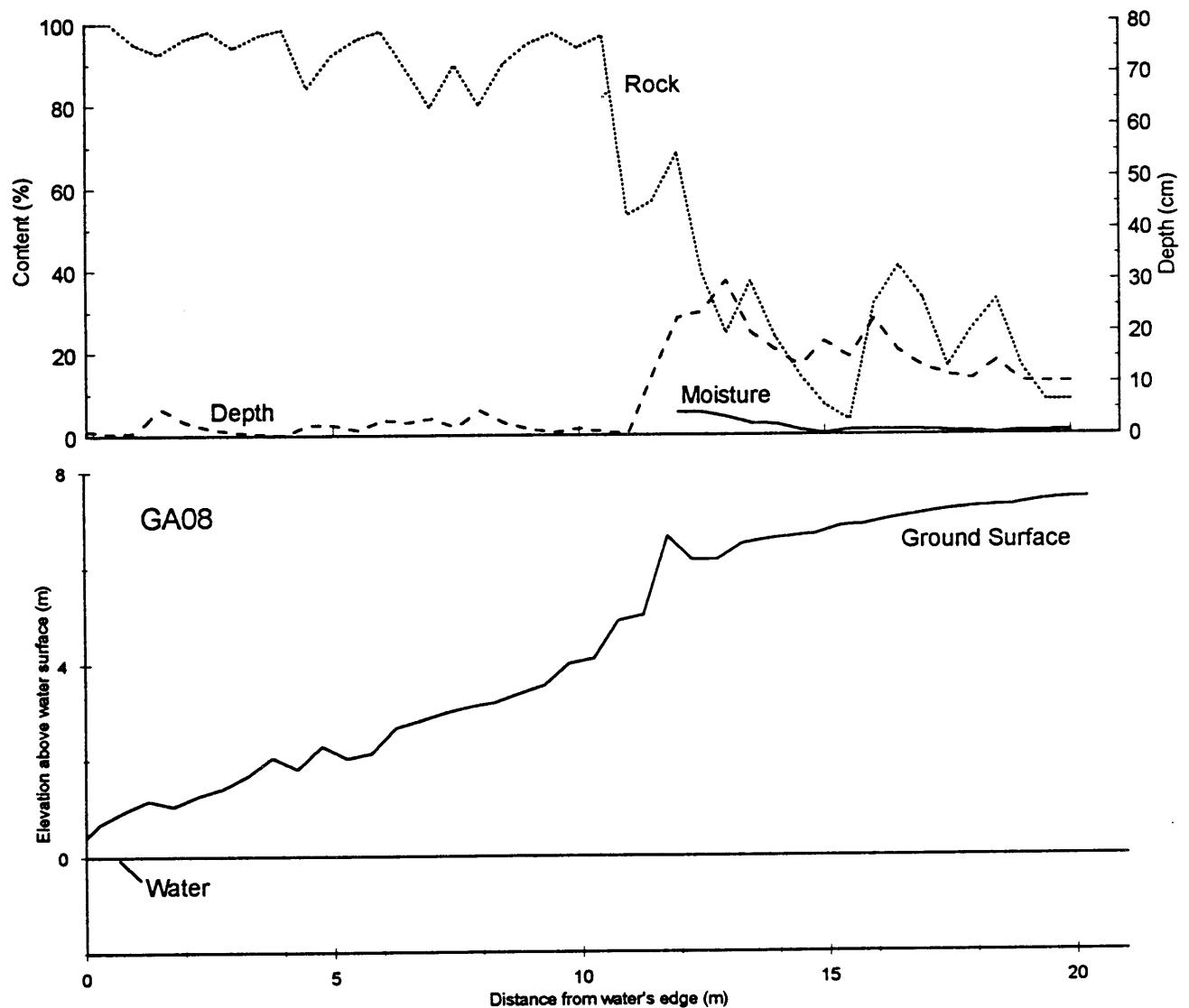


Figure 35. Species/environment biplot resulting from canonical correspondence analysis of transect GA08. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 10.

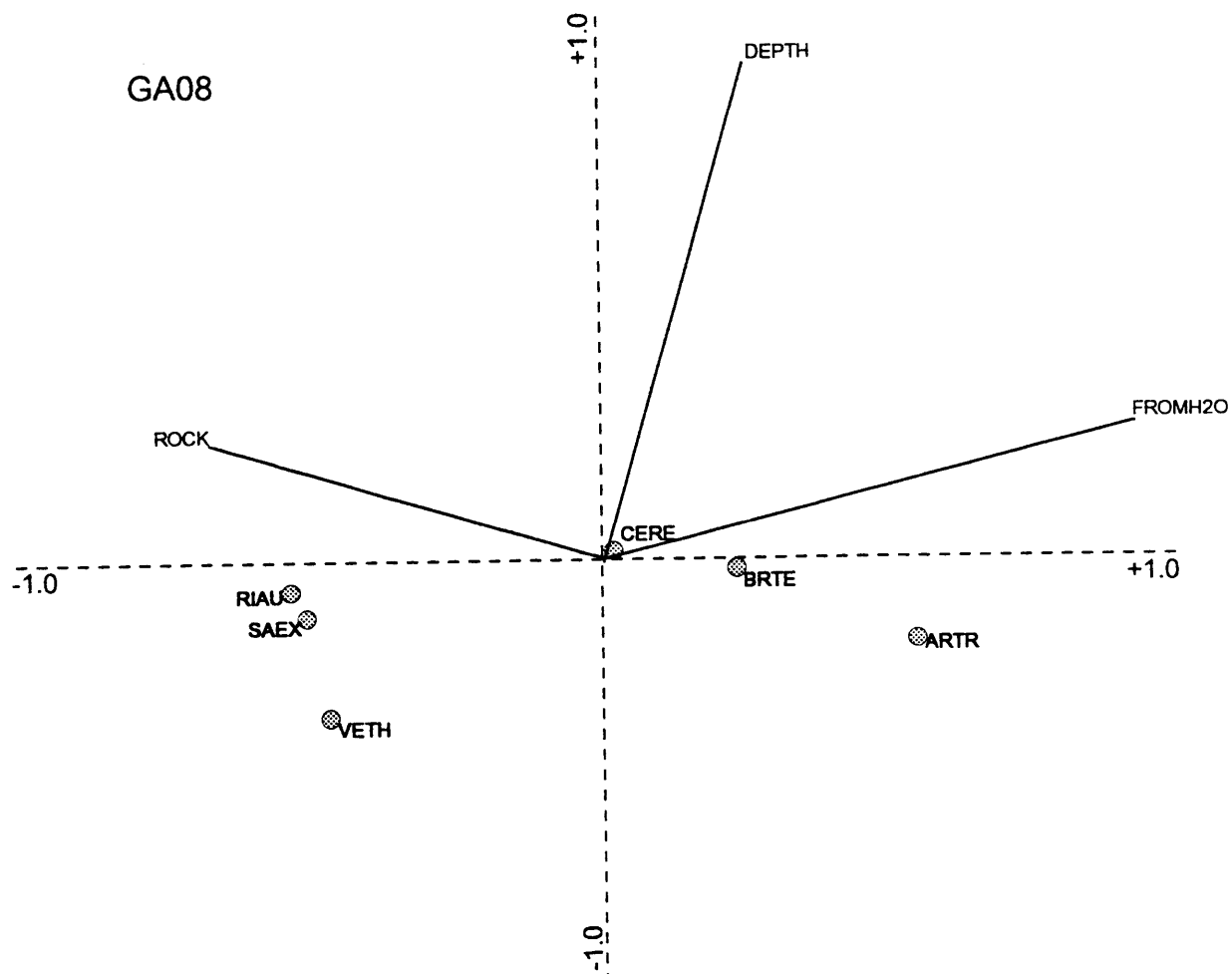


Figure 36. Species/environment biplot resulting from canonical correspondence analysis of transect GA08 with plant associations (numbers 1-3) superimposed. 1 = *Celtis reticulata*; 2 = *Artemisia tridentata*; and 3 = *Salix exigua*. Codes for environmental factors are defined in Table 2.

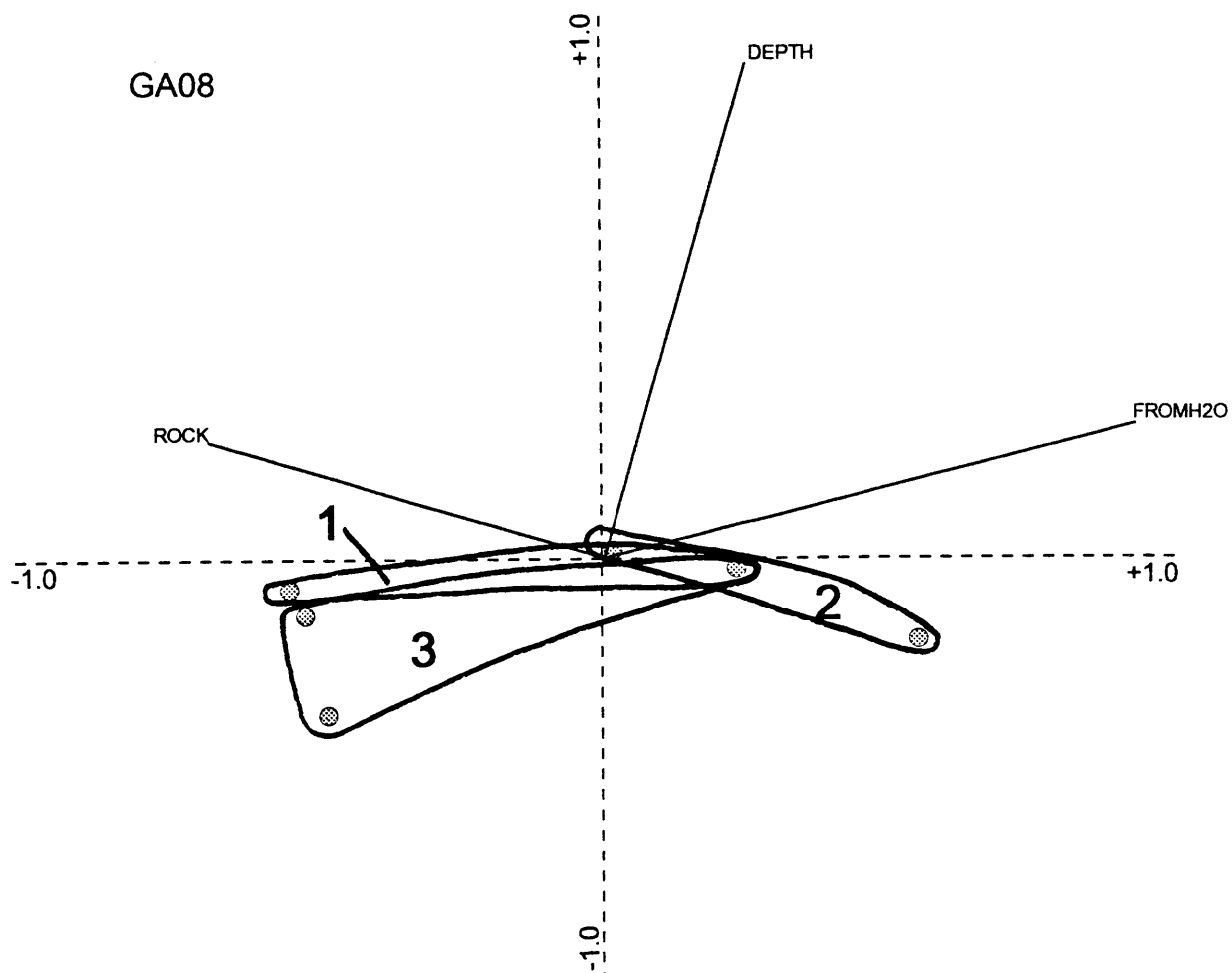


Figure 37. Distribution of species abundances (% cover) for transect GA09. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 49). Data were divided among several graphs to facilitate interpretation.

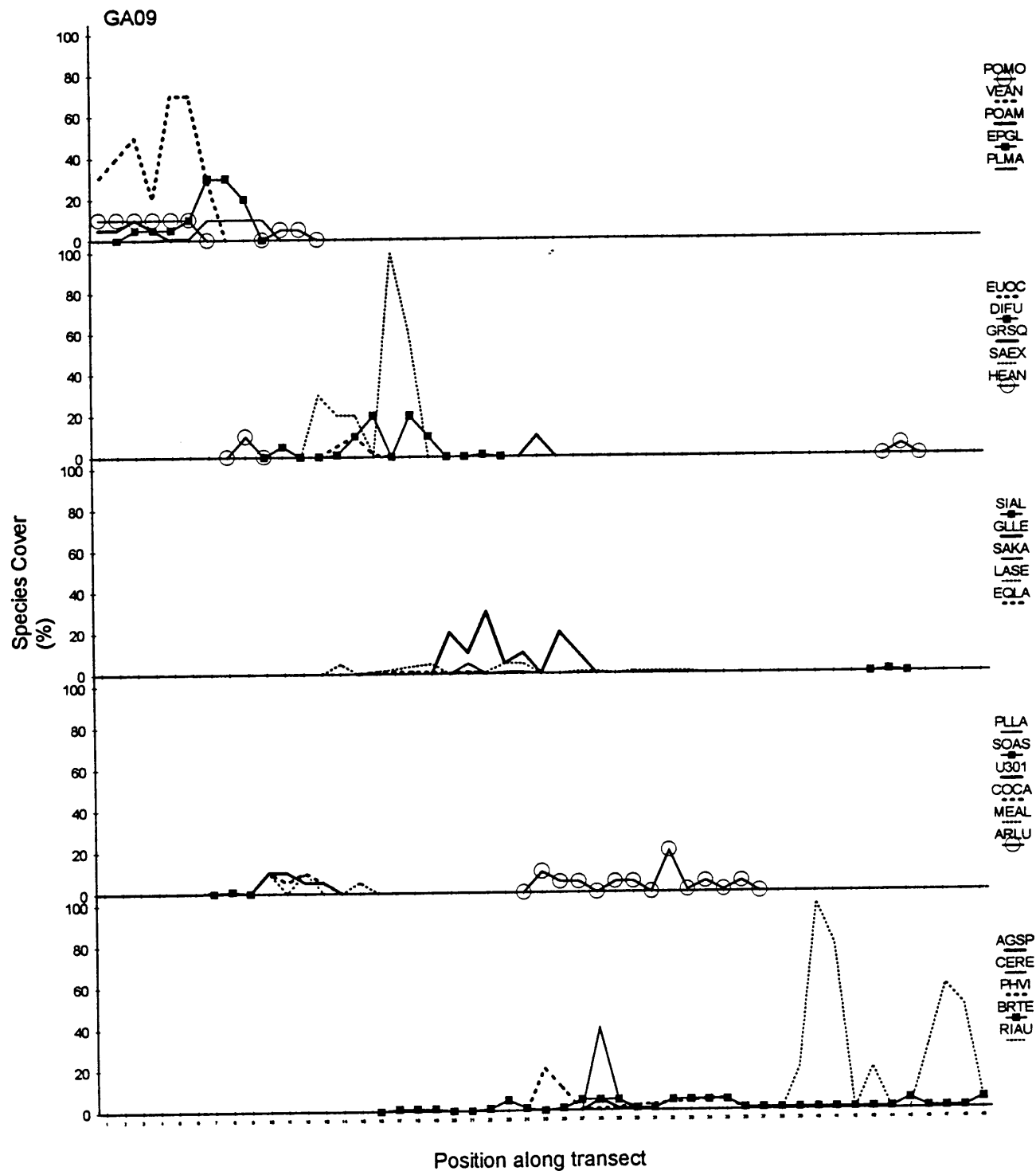


Figure 38. Edaphic characteristics and surface elevation profile of transect GA09, Hagerman Study Area, 1991. Edaphic data are presented as running means.

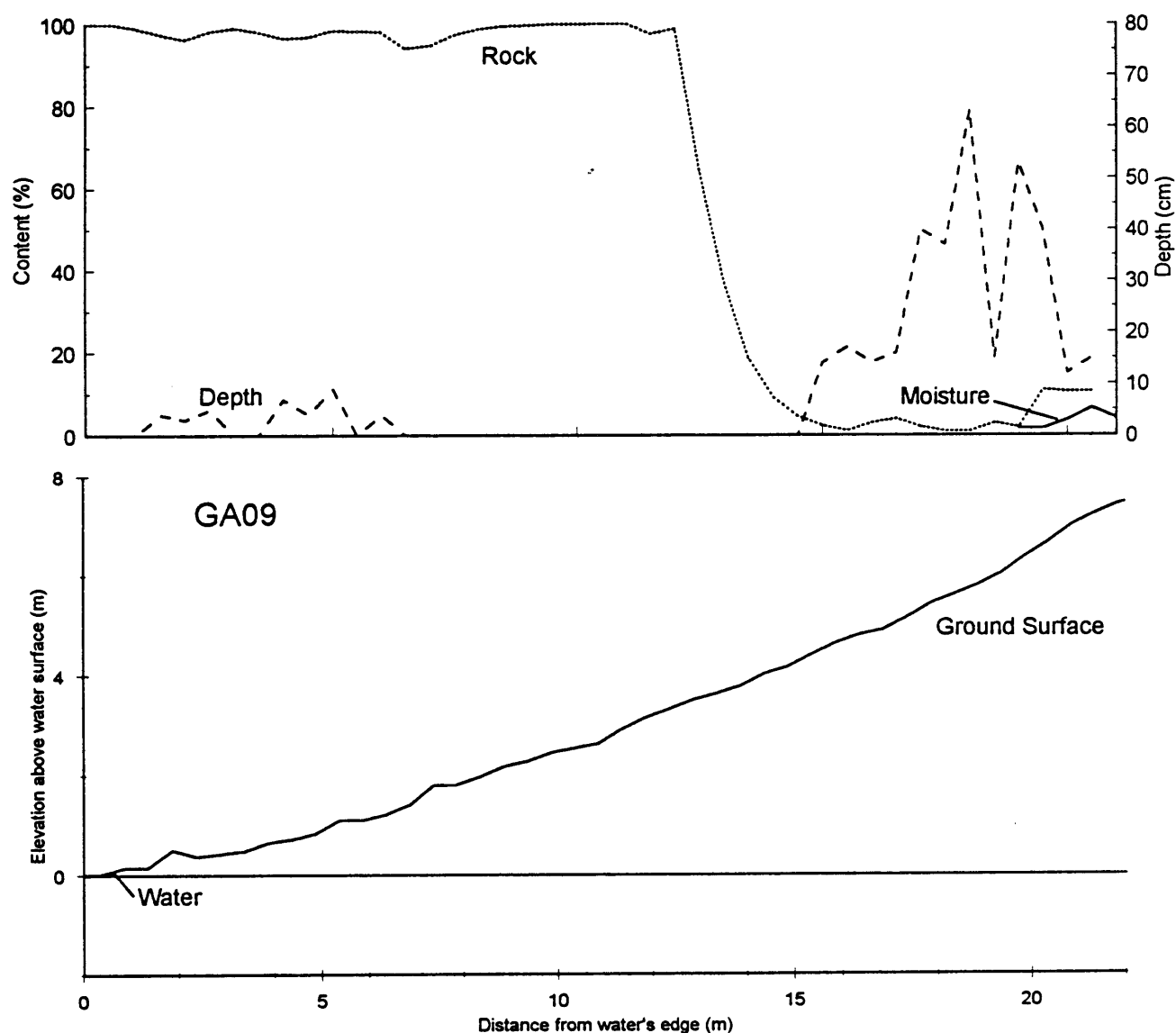


Figure 39. Species/environment biplot resulting from canonical correspondence analysis of transect GA09. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 11.

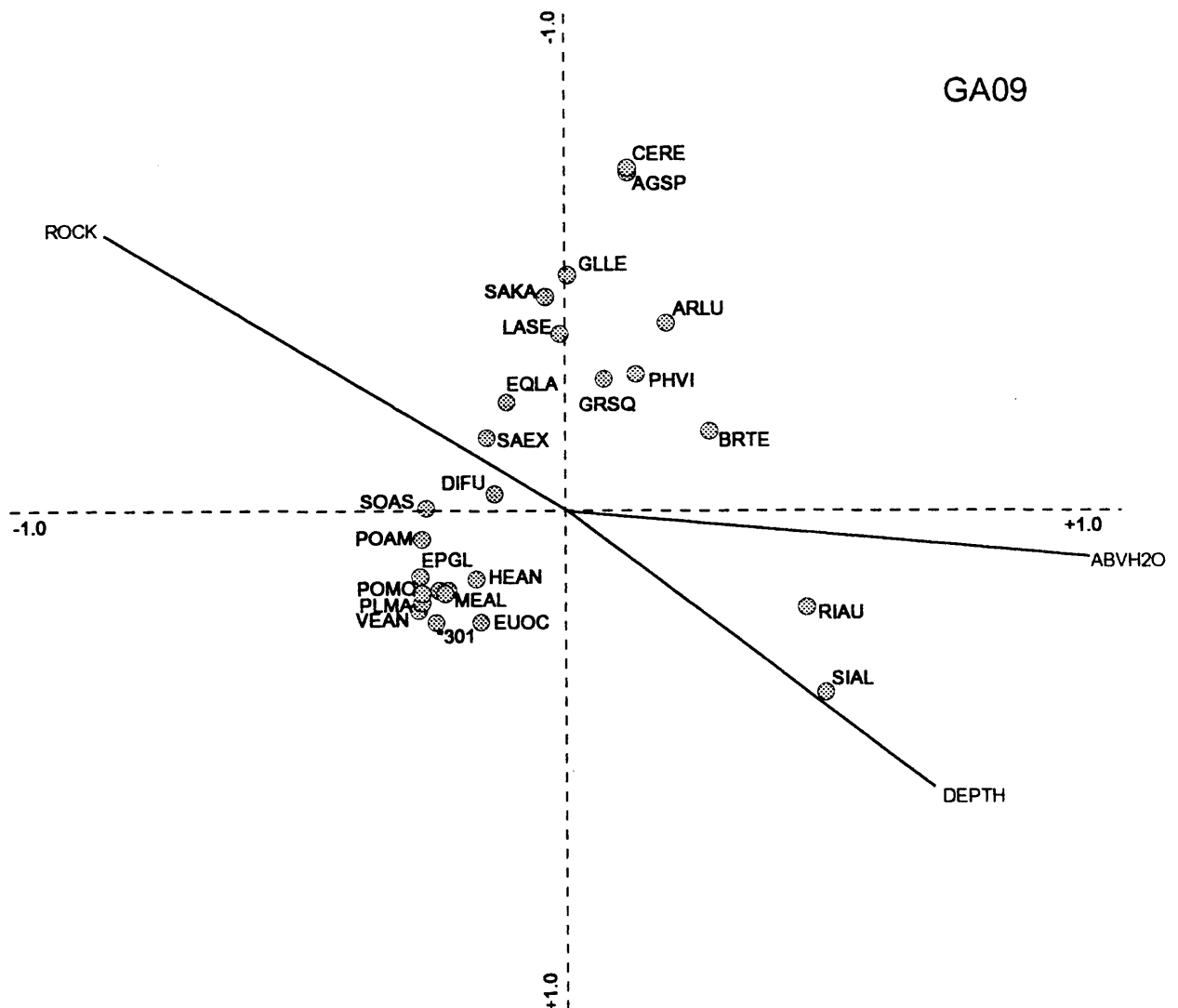


Figure 40. Species/environment biplot resulting from canonical correspondence analysis of transect GA09 with plant associations (numbers 1-5) superimposed. 1 = *Ribes aureum/Bromus tectorum*; 2 = *Artemisia ludoviciana/Bromus tectorum*; 3 = *Salix exigua/Glycyrrhiza lepidota-Dipsacus fullorum*; 4 = mixed forbs; and 5 = *Veronica anagallis-aquatica-Epilobium glaberrimum*. Codes for environmental factors are defined in Table 2.

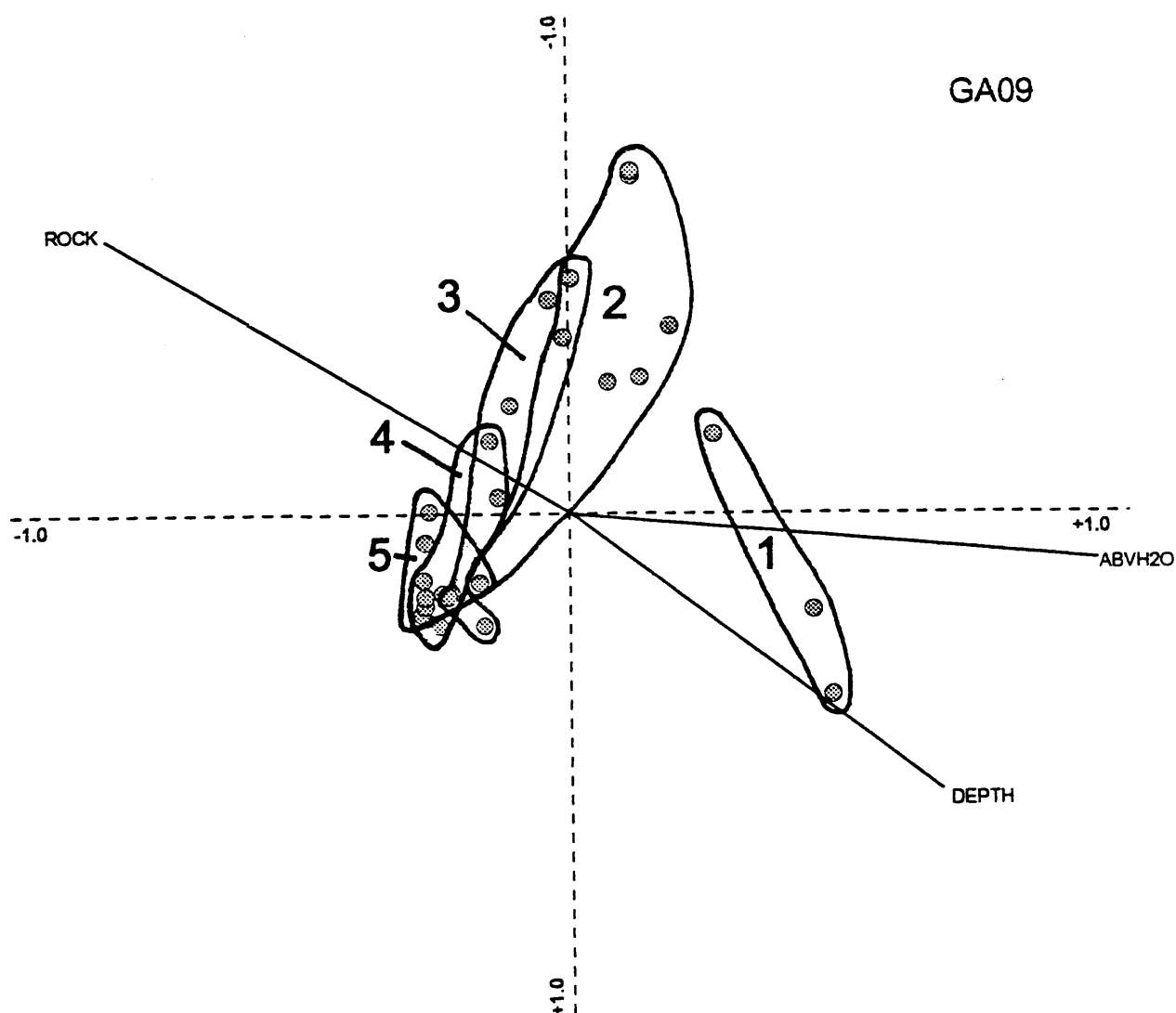


Figure 41. Distribution of species abundances (% cover) for transect GA10. The x-axis is arranged in order from the water's edge (quadrat number 1) to the upland vegetation (quadrat number 45). Data were divided among several graphs to facilitate interpretation.

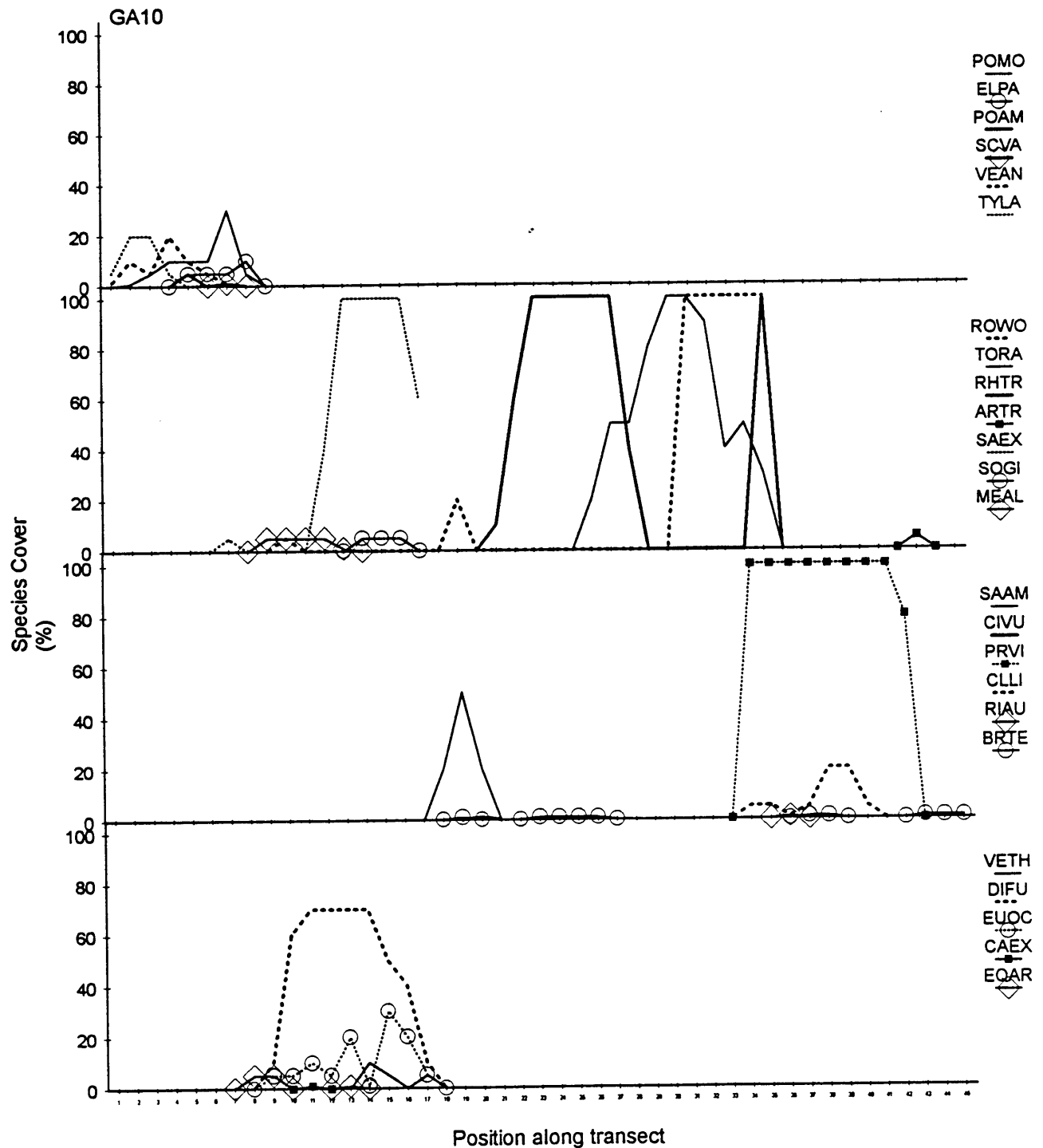


Figure 42. Edaphic characteristics and surface elevation profile of transect GA10, Hagerman Study Area, 1991. Edaphic data are presented as running means.

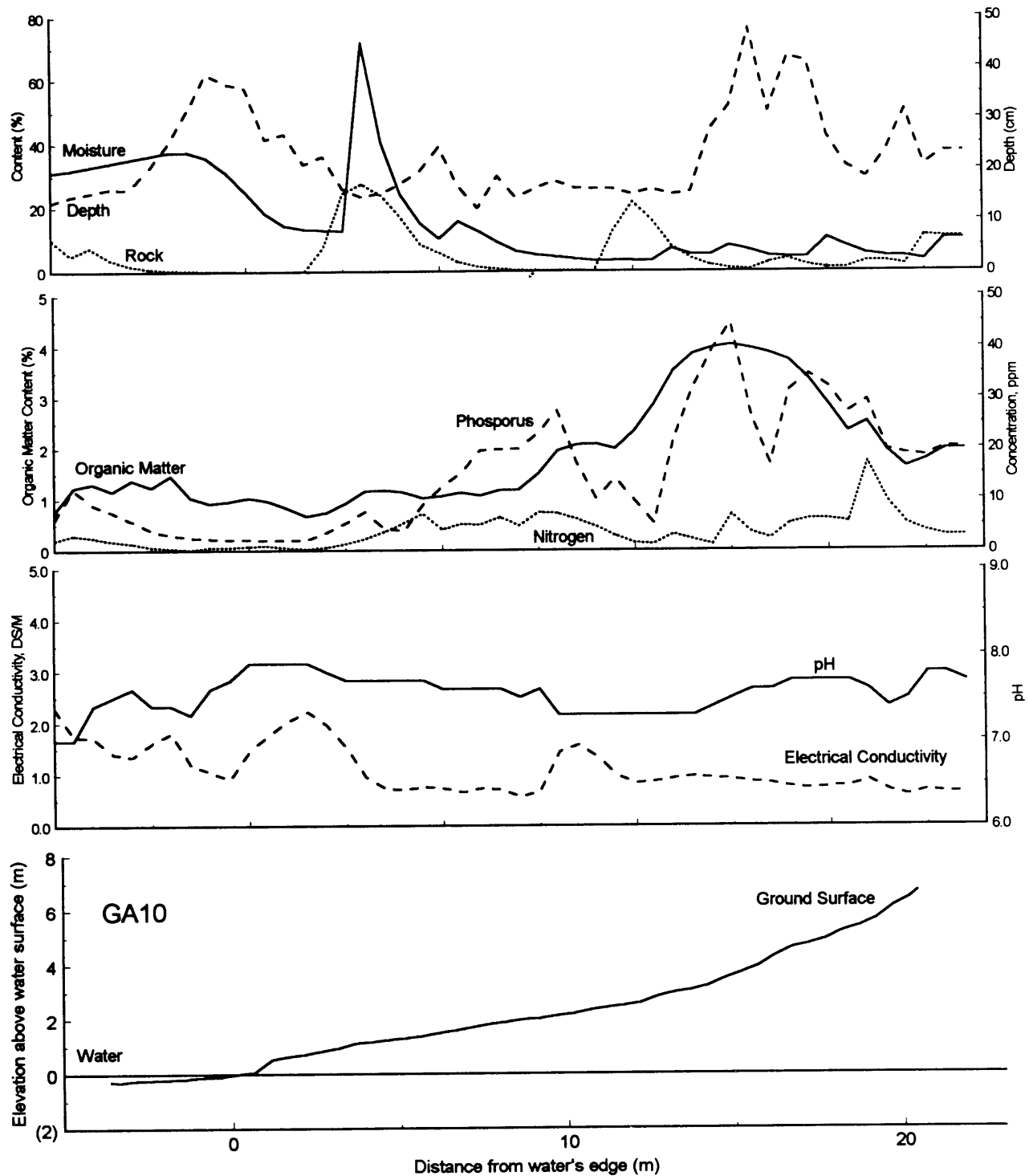


Figure 43. Species/environment biplot resulting from canonical correspondence analysis of transect GA10. Species codes are defined in Appendix 14. Codes for environmental factors are defined in Table 12.

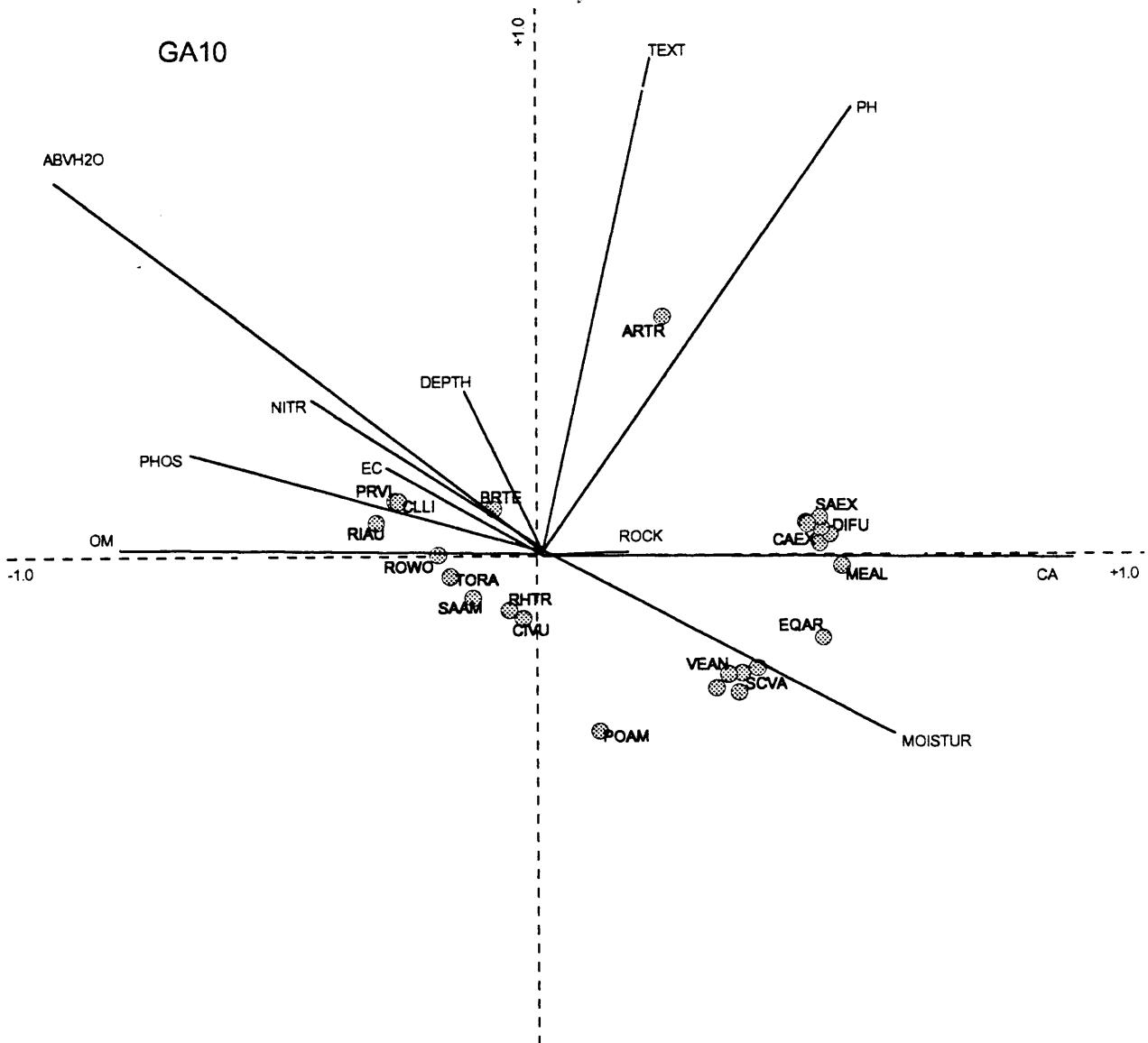


Figure 44. Species/environment biplot resulting from canonical correspondence analysis of transect GA10 with plant associations (numbers 1-5) superimposed. 1 = *Prunus virginiana*; 2 = *Rhus trilobata*-*Toxicodendron radicans*; 3 = *Salix amygdaloides*; 4 = *Salix exigua*/*Dipsacus fullonum*; and 5 = *Polypogon monspeliensis*-*Veronica anagallis-aquatica*. Codes for environmental factors are defined in Table 2.

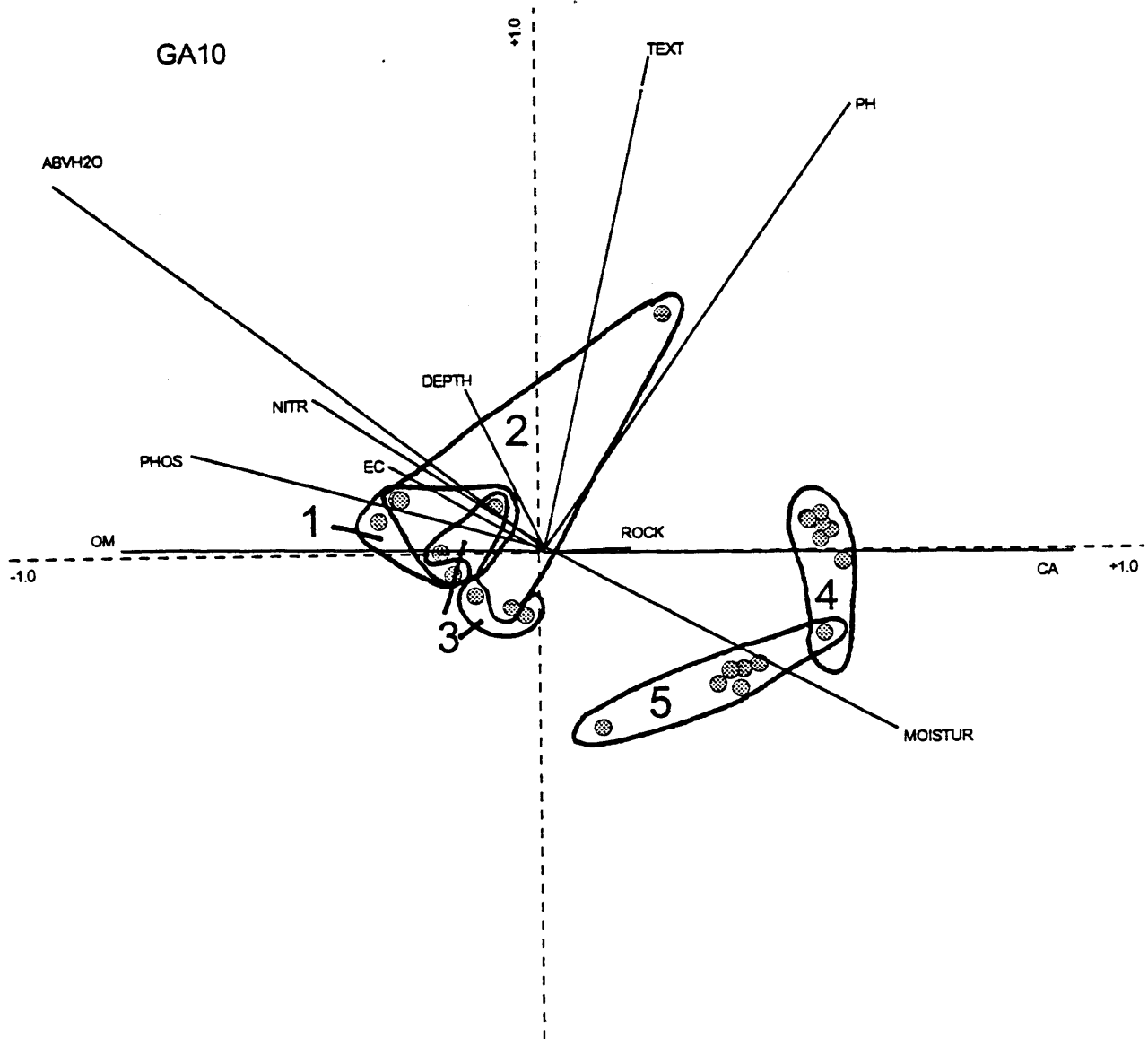
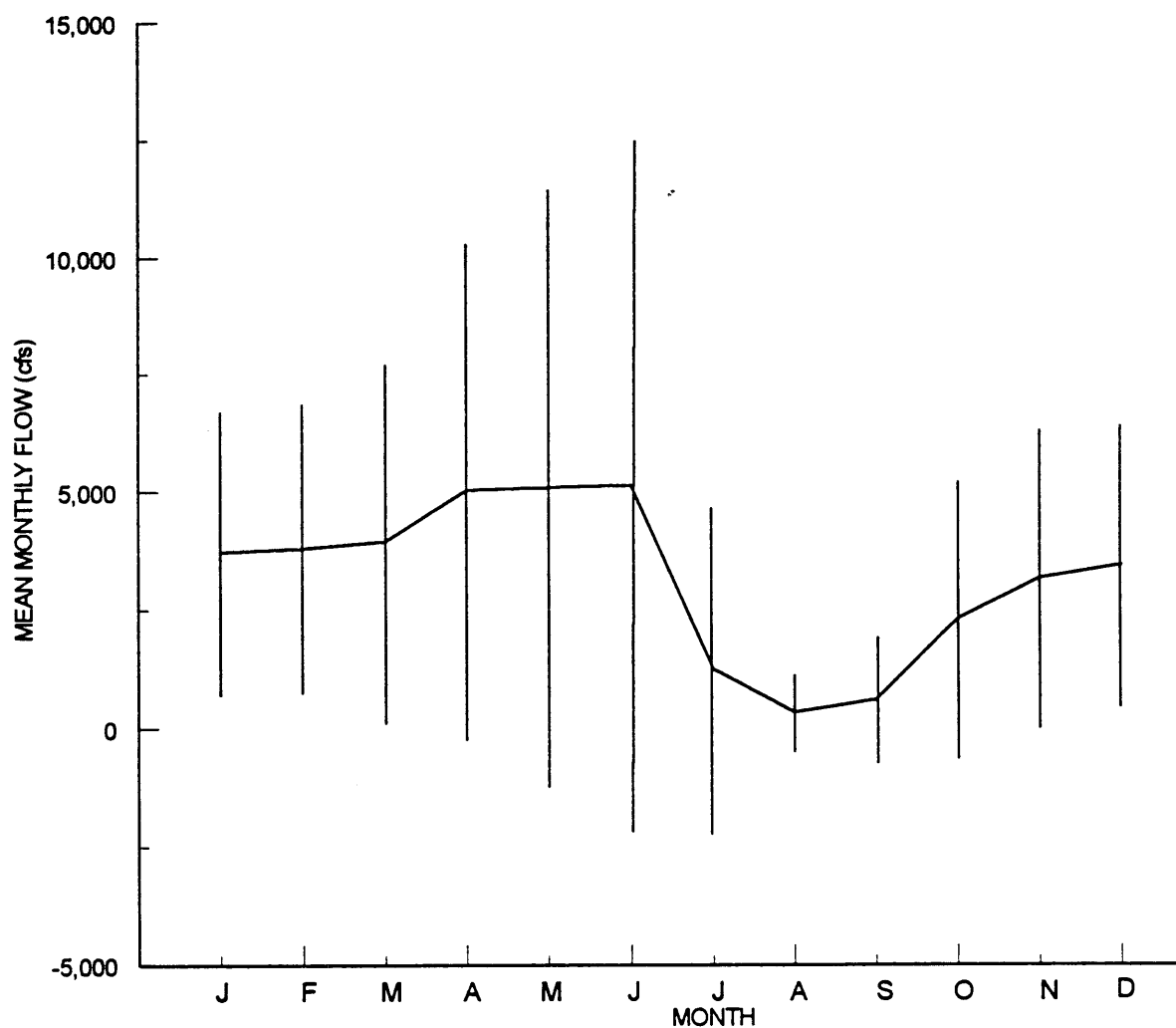


Figure 45. Mean and standard deviation of monthly water volume (cfs) for the Snake River at Milner Dam, Idaho, 1910-1993. Data were collected at the Milner gauge (RM 638.7) (US Geological Survey, Water Resources Data for the Snake River above King Hill).



Appendix 1. Field form for determining site condition/disturbance.

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
Native species compose $< 25\%$ of the species present. 1 pt

☐

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
various aged plants 4 pts
Native species not reproducing 1 pt

☐

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
Native species appear weak, poorly rooted, dying 1 pt

☐

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
erosion being healed by vegetation 4 pts
Soil surface not friable, very obvious accelerated erosion, past
erosion not being stabilized 1 pt

☐

Sum the total number of points, rank them by the following categories
and record the rank on the Species List: SUM:

☐

L-low (> 10 pts)
M-moderate (> 6 but ≤ 10 pts)
H-high (≤ 5 pts)

Appendix 3. Completed field forms for apparent vegetation condition for gradient analysis transects, Hagerman Study Area, 1991. Sites were scored in the field.

Transect GA01, July 25, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

4

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

3

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

3

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

14

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA02, July 17, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

2

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

2

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

4

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

12

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA03, July 12, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

2

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

2

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

2

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

4

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

10

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA04, July 18, 1991

Apparent Vegetation Condition

Composition:

- Native species compose $\geq 75\%$ of the species present 4 pts
- Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
- Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
- Native species compose $< 25\%$ of the species present. 1 pt

3

- Abundance of Seedlings and Young Plants (interpolate between 4 and 1):
- Abundance of native seedlings present, plant composition of various aged plants 4 pts
- Native species not reproducing 1 pt

3

- Plant Vigor(interpolate between 4 and 1):
- Native species appear healthy, robust, well rooted, not dying 4 pts
- Native species appear weak, poorly rooted, dying 1 pt

4

- Soil Surface Condition (interpolate between 4 and 1):
- Soil surface friable, no visible signs of accelerated erosion, past erosion being healed by vegetation 4 pts
- Soil surface not friable, very obvious accelerated erosion, past erosion not being stabilized 1 pt

2

Sum the total number of points, rank them by the following categories and record the rank on the Species List: SUM:

12

- L-low (> 10 pts)
- M-moderate (> 6 but ≤ 10 pts)
- H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA05, July 16, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

2

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

3

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

3

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

4

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

12

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA06, July 11, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

4

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

4

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

3

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

15

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA07, July 10, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

3

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

3

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

2

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

12

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA08, July 24, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

4

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

4

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

4

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

16

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA09, July 26, 1991

Apparent Vegetation Condition

Composition:

- Native species compose $\geq 75\%$ of the species present 4 pts
- Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
- Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
- Native species compose $< 25\%$ of the species present. 1 pt

4

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

- Abundance of native seedlings present, plant composition of
various aged plants 4 pts
- Native species not reproducing 1 pt

3

Plant Vigor(interpolate between 4 and 1):

- Native species appear healthy, robust, well rooted, not dying 4 pts
- Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

- Soil surface friable, no visible signs of accelerated erosion, past
erosion being healed by vegetation 4 pts
- Soil surface not friable, very obvious accelerated erosion, past
erosion not being stabilized 1 pt

4

Sum the total number of points, rank them by the following categories
and record the rank on the Species List: SUM:

15

- L-low (> 10 pts)
- M-moderate (> 6 but ≤ 10 pts)
- H-high (≤ 5 pts)

Appendix 3 (continued)

Transect GA10, July 23, 1991

Apparent Vegetation Condition

Composition:

Native species compose $\geq 75\%$ of the species present 4 pts
 Native species compose $< 75\%$ but $\geq 50\%$ of species present. . . . 3 pts
 Native species compose $< 50\%$ but $\geq 25\%$ of species present. . . . 2 pts
 Native species compose $< 25\%$ of the species present. 1 pt

4

Abundance of Seedlings and Young Plants (interpolate between 4 and 1):

Abundance of native seedlings present, plant composition of
 various aged plants 4 pts
 Native species not reproducing 1 pt

3

Plant Vigor(interpolate between 4 and 1):

Native species appear healthy, robust, well rooted, not dying 4 pts
 Native species appear weak, poorly rooted, dying 1 pt

4

Soil Surface Condition (interpolate between 4 and 1):

Soil surface friable, no visible signs of accelerated erosion, past
 erosion being healed by vegetation 4 pts
 Soil surface not friable, very obvious accelerated erosion, past
 erosion not being stabilized 1 pt

3

Sum the total number of points, rank them by the following categories
 and record the rank on the Species List: SUM:

14

L-low (> 10 pts)
 M-moderate (> 6 but ≤ 10 pts)
 H-high (≤ 5 pts)

Appendix 4. Edaphic characteristics of transects GA01 and GA10, listed in order of occurrence along the transect.

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA01</u>									
0.0	30.5	12	0.0	0.7	2	1	2.0	6	3
0.5	31.6	15	20.1	0.8	2	2	2.6	6	1
1.0	32.8	16	0.0	1.7	1	2	1.2	18	4
1.5	34.0	16	10.0	1.4	1	3	1.7	6	2
2.0	35.1	17	0.0	1.0	2	0	1.1	6	1
2.5	36.3	16	0.0	1.6	2	3	1.3	4	1
3.0	37.5	24	0.0	1.1	2	3	1.9	2	0
3.5	38.7	30	0.0	1.7	2	3	2.0	2	0
4.0	37.8	38	0.0	0.6	2	3	0.6	2	0
4.5	33.7	46	0.0	0.8	2	3	0.9	2	1
5.0	26.5	35	0.0	1.0	2	3	0.8	2	0
5.5	19.0	35	0.0	1.1	3	3	2.0	2	1
6.0	11.5	16	0.0	0.9	3	3	2.1	2	1
6.5	10.4	28	0.0	0.7	2	3	2.3	2	0
7.0	12.1	15	0.0	0.5	2	3	2.4	2	0
7.5	12.7	24	15.1	0.8	2	3	1.7	5	1
8.0	12.5	10	41.2	1.1	1	3	1.1	7	2
8.5	131.3	13	30.5	1.4	1	2	0.4	10	3

The Distribution of Plant Species and Some Associated Factors

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA01</u>									
9.0	9.3	16	20.1	1.2	1	2	0.5	1	5
9.5	7.7	19	10.0	1.1	1	2	0.7	3	7
10.0	6.1	22	0.0	0.9	1	0	0.8	14	9
10.5	5.2	29	3.0	1.1	2	0	0.7	16	1
11.0	21.2	9	0.0	1.2	2	0	0.6	18	6
11.5	9.5	8	0.0	1.0	1	1	0.8	24	5
12.0	5.5	25	0.0	1.3	1	0	0.7	20	8
12.5	3.4	10	0.0	1.2	1	0	0.4	20	3
13.0	4.1	18	0.0	1.8	1	1	0.8	26	10
13.5	3.7	19	0.0	2.4	1	1	2.2	32	7
14.0	3.3	15	0.0	2.2	1	1	1.7	7	5
14.5	2.4	16	0.0	2.1	1	1	1.1	3	3
15.0	3.6	16	25.3	1.9	1	1	0.6	18	1
15.5	3.2	14	30.5	2.7	1	1	0.7	5	0
16.0	3.0	17	10.0	3.4	2	1	0.9	1	1
16.5	10.9	14	0.0	4.2	2	1	1.0	38	5
17.0	3.6	16	0.0	4.2	2	1	1.0	42	1

Hageman Study Area

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA01</u>									
17.5	4.9	40	0.0	4.1	2	1	0.9	47	0
18.0	10.9	37	0.0	4.1	2	1	0.9	50	13
18.5	5.0	63	0.0	3.9	2	1	0.8	9	0
19.0	3.1	15	5.0	3.8	2	0	0.8	7	1
19.5	3.7	53	5.0	3.6	2	0	0.7	46	8
20.0	4.8	40	0.0	3.0	2	0	0.7	38	7
20.5	16.3	12	0.0	2.4	3	0	0.8	30	6
21.0	5.2	15	1.0	1.8	3	0	0.8	22	5
21.5	3.1	16	5.0	2.7	2	0	1.0	32	29
22.0	3.8	28	3.0	1.4	2	0	0.5	10	2
22.5	4.4	40	1.0	1.3	2	3	0.5	18	1
23.0	2.5	10	20.1	1.9	2	3	0.8	18	2
23.5	16.7	26	10.0	2.2	2	2	0.6	22	2
<u>Transect GA10</u>									
0.0	30.5	31	0	3.5	7.5	3	1.4	20	4
0.5	53.2	30	0	2.7	7.6	3	1.2	22	3

The Distribution of Plant Species and Some Associated Factors

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
Transect GA10									
1.0	42.6	30	0	1.9	7.7	3	10.0	24	2
1.5	52.4	30	0	1.5	7.7	3	1.3	30	2
2.0	47.9	30	0	1.9	7.9	3	1.4	16	4
2.5	59.6	30	0	3.0	7.7	3	1.2	12	3
3.0	40.2	30	0	2.3	7.8	3	1.4	10	5
3.5	49.6	37	0	1.9	7.9	3	1.5	7	0
4.0	53.2	38	0	1.4	8.0	3	1.6	5	1
4.5	48.7	35	0	1.0	8.1	3	1.7	2	3
5.0	41.2	36	0	1.7	8.0	3	1.6	3	1
5.5	44.1	30	0	2.3	7.9	3	1.5	5	0
6.0	52.8	36	0	3.0	7.9	3	1.4	6	8
6.5	42.5	36	0	2.3	8.1	3	1.3	3	0
7.0	27.3	34	0	1.7	8.2	3	1.1	3	1
7.5	53.8	30	0	1	8.3	3	1	2	3
8.0	42.5	37	0	1.6	8.2	3	1.1	3	1
8.5	42.2	31	0	2.3	8.0	3	1.1	3	0
9.0	35.7	36	0	2.9	7.7	3	1.2	4	5

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA10</u>									
9.5	38.1	30	0	2.7	7.7	3	1.1	5	0
10.0	20.0	31	0	2.5	7.8	3	1.0	7	1
10.5	29.3	35	0	2.3	7.8	3	0.9	8	3
11.0	31.3	35	0	2.5	7.8	3	1.0	7	1
11.5	20.2	30	0	2.8	7.8	3	1.0	7	0
12.0	33.1	37	0	3	7.8	3	1.1	6	5
12.5	25.1	35	0	2.7	8.2	3	1.3	5	1
13.0	40.5	30	0	2.4	8.5	3	1.5	5	0
13.5	37.1	33	0	2.1	8.6	3	1.7	4	1
14.0	23.1	35	0	1.9	8.5	3	1.8	3	1
14.5	38.4	35	0	1.6	8.4	3	1.9	3	0
15.0	40.1	38	0	1.4	8.3	3	2.0	2	3
15.5	28.6	38	0	1.1	8.3	3	1.8	1	3
16.0	29.9	31	0	0.9	8.4	3	1.5	1	3
16.5	13.7	31	1	0.6	8.4	3	1.3	0	3
17.0	23.7	30	5	0.6	8.4	3	1.2	0	2
17.5	9.7	38	10	0.6	8.5	3	1.0	0	1

The Distribution of Plant Species and Some Associated Factors

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA10</u>									
18.0	11.2	36	5	0.6	8.5	3	0.9	0	0
18.5	26.1	30	5	0.6	8.3	3	1.3	2	3
19.0	38.7	37	0	0.6	8.3	3	1.3	0	0
19.5	37.7	37	0	1.5	8.1	2	2.2	12	2
20.0	68.5	39	0	0.8	8.1	3	1.6	0	3
20.5	16.0	32	0	0.4	8.3	2	1.1	0	0
21.0	41.6	31	0	0.7	8.2	3	1.3	2	3
21.5	8.2	31	0	0.0	8.4	2	0.9	2	0
22.0	7.4	36	0	0.0	8.3	2	1.3	4	4
22.5	7.9	38	0	0.1	8.4	3	10.	6	1
23.0	6.8	33	0	0.1	8.3	3	1.1	6	1
23.5	5.3	32	0	0.4	8.5	3	1.9	4	2
24.0	29.2	30	0	3.8	7.6	3	0.9	4	5
24.5	32.5	30	0	3.4	8.0	3	0.7	4	3
25.0	35.8	30	0	2.9	8.0	3	0.8	3	1
25.5	32.3	30	0	2.3	8.0	3	0.8	2	4
26.0	36.4	30	0	1.8	8.1	3	0.9	2	5

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA10</u>									
26.5	34.7	37	0	1.4	8.4	3	1.4	2	1
27.0	33.0	35	0	1.4	8.4	3	1.5	2	0
27.5	31.3	32	0	1.4	8.4	3	1.5	2	0
28.0	29.5	39	0	1.4	8.4	3	1.4	2	0
28.5	27.9	36	0	1.4	8.4	3	1.4	2	0
29.0	26.2	34	0	1.4	8.4	3	1.3	3	1
29.5	24.5	31	0	1.4	8.3	3	1.3	3	1
30.0	22.9	38	0	1.4	8.3	3	1.2	3	1
30.5	21.3	36	0	1.4	8.2	3	1.2	3	1
31.0	19.6	33	0	1.4	8.2	3	1.1	3	1
31.5	17.9	30	0	1.3	8.1	3	1.1	3	2
32.0	16.3	38	0	1.3	8.1	3	1.0	3	0
32.5	14.7	35	0	1.3	8.0	3	1.0	3	0
33.0	13.0	32	0	1.3	8.0	3	0.9	3	0
33.5	11.4	39	0	1.2	7.9	3	0.9	3	0
34.0	9.8	37	0	1.2	7.9	3	0.8	4	1
34.5	8.1	34	0	1.2	7.8	3	0.8	4	1

The Distribution of Plant Species and Some Associated Factors

Appendix 4 (continued)

Meter	Moisture (%)	Depth (cm)	Rock (%)	Organic Matter (%)	pH	Calcium	Electrical Conductivity (dS/m)	Phosphorus (ppm)	Nitrogen (ppm)
<u>Transect GA10</u>									
35.0	6.5	31	0	1.2	7.7	3	0.7	4	1
35.5	3.3	31	0	1.2	7.7	3	0.7	4	1
36.0	2.6	30	0	1.1	7.6	3	0.7	4	3
36.5	1.6	32	0	1.0	7.8	3	0.6	4	1
37.0	2.5	32	0	0.8	7.9	3	0.6	4	0
37.5	2.0	32	0	0.7	8.0	2	0.5	4	2
38.0	1.2	38	0	0.4	8.3	2	0.4	4	3
38.5	1.7	33	2	0.2	8.5	2	0.4	0	2
39.0	5.6	30	10	0	8.3	1	0.4	1	1
39.5	1.1	36	20	0	1.1	1	0.4	1	1

Appendix 5. Two-way indicator species analysis with plant species cover data from transect GA02, Hagerman Study Area, 1991. Values in the table denote categories of abundance. Cut levels used were the default values 1, 2, 5, 10, and > 20% cover. Shaded areas separate classes at level 2. Bold line separates species at level 1. Species codes are defined in Appendix 14.

Idaho Power Company page 109

Appendix 7. Two-way indicator species analysis with plant species cover data from transect GA04, Hagerman Study Area, 1991. Values in the table denote categories of abundance. Cut levels used were the default values 1, 2, 5, 10, and > 20% cover. Shaded areas separate classes at level 3. Bold line separates species at level 1. Species codes are defined in Appendix 14.

Idaho Power Company page 111

Appendix 8. Two-way indicator species analysis with plant species cover data from transect GA05, Hagerman Study Area 1991. Values in the table denote categories of abundance. Cut levels used were the default values 1, 2, 5, 10, and > 20% cover. Shaded areas separate classes at level 3. Bold line separates species at level 1. Species codes are defined in Appendix 14.

Appendix 9. Two-way indicator species analysis with plant species cover data from transect GA06, Hagerman Study Area, 1991
Values in the table denote categories of abundance. Cut levels used were the default values 1, 2, 5, 10 and > 20% cover.
Shaded areas separate classes at level 3. Bold line separates species at level 1. Species codes are defined in Appendix 14.

[illegible]

Appendix 11. Two-way indicator species analysis with plant species cover data from transect GA08, Hagerman Study Area, 1991. Values in the table denote categories of abundance. Cut levels used were the default values 1, 2, 5, 10, and > 20% cover. Shaded areas separate classes at level 2. Bold line separates species at level 1. Species codes are defined in Appendix 14.

Idaho Power Company page 115

Appendix 12. Two-way indicator species analysis with plant species cover data from transect GA09, Hagerman Study Area, 1991. Values in the table denote categories of abundance. Cut levels used were the default values 1, 2, 5, 10, and > 20% cover. Shaded areas separate classes at level 3. Bold line separates species at level 2. Species codes are defined in Appendix 14.

Idaho Power Company page 116

Shaded areas separate classes at level 3. Bold lines separate species at level 2. Species codes are defined in Appendix 14.

Idaho Power Company page 117

Appendix 14. Aquatic and terrestrial species occurring in the Hagerman Study Area, arranged alphabetically by family, followed by the field code, life-form (Soil Conservation Service 1980), and wetland status (Reed 1988) and common name. Superscripts refer to taxonomic changes not noted in Hitchcock and Cronquist (1973). NI = no information available.

Family	Species	Species Code	Life-form	Common Name
ACERACEAE:	<i>Acer negundo</i>	ACNE	IT	box elder
	<i>Acer saccharinum</i>	ACSA	IT	silver maple
ALISMACEAE ¹ :	<i>Alisma plantago-aquatica</i>	ALPL	PNEF	American waterplantain
	<i>Sagittaria cuneata</i>	SACU	PNEF	duckpotato, arrowhead
AMARANTHACEAE:	<i>Amaranthus</i>	AMARA		
	<i>Amaranthus albus</i>	AMAL	ANF	white pigweed
	<i>Amaranthus californicus</i>	AMCA	ANF	California amaranth
	<i>Amaranthus powellii</i>	AMPO	ANF	Powell amaranth
	<i>Amaranthus retroflexus</i>	AMRE	AIF	
ANACARDIACEAE:	<i>Rhus trilobata</i>	RHTR	NS	skunkbrush
	<i>Toxicodendron radicans</i> ²	TORA	NS	poison ivy
APIACEAE ⁴³ :	<i>Berula erecta</i>	BEER	PIF	stalky berula
	<i>Cicuta douglasii</i>	CIDO	PNF	western water hemlock
	<i>Conium maculatum</i>	COMA	BIF	poison hemlock
	<i>Cymopterus acaulis</i>	CYAC	PNF	stemless spring parsley
	<i>Cymopterus petraeus</i>	CYPE	PNF	stone spring parsley
	<i>Daucus carota</i>	DACA	BIF	wild carrot
	<i>Lomatium dissectum</i>	LODI	PNF	fernleaf biscuitroot
	<i>Lomatium foeniculaceum</i>	LOFO	PNF	desert biscuitroot
	<i>Lomatium triternatum</i>	LOTR	PNF	nineleaf biscuitroot
	<i>Pastinaca sativa</i>	PASA	PIF	garden parsnip
	<i>Sium suave</i>	SISU	PNF	hemlock water-parsnip
APOCYNACEAE:	<i>Apocynum cannabinum</i>	APCA	PNF	indianhemp, dogbane
ASCLEPIADACEAE:	<i>Asclepias cryptoceras</i>	ASCR	PNF	pallid milkweed

The Distribution of Plant Species and Some Associated Factors

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Asclepias fascicularis</i>	ASFA	PNF	Mexican whorled milkweed
	<i>Asclepias incarnata</i>	ASIN	PIF?	swamp milkweed
	<i>Asclepias speciosa</i>	ASSP	PNF	showy milkweed
	<i>Asclepias tuberosa</i>	ASTU	PIF	butterfly weed
ASTERACEAE ⁸ :	<i>Achillea millefolium</i>	ACMI	PNF	common yarrow
	<i>Ambrosia acanthicarpa</i>	AMAC	ANF	bursage, ragweed
	<i>Ambrosia artemisiifolia</i>	AMAR	ANF	annual ragweed
	<i>Antennaria dimorpha</i>	ANDI	PNF	low pussytoes
	<i>Arctium lappa?</i>	ARLA	BIF	great burdock
	<i>Arctium minus</i>	ARMI	BIF	common burdock
	<i>Artemisia biennis</i>	ARBI	AIF	biennial sagewort
	<i>Artemisia dracunculus</i>	ARDR	PNF	herbaceous sagewort
	<i>Artemisia ludoviciana</i>	ARLU	PNF	Louisiana sagewort
	<i>Artemisia spinescens</i>	ARSP	NS	bud sagebrush
	<i>Artemisia tridentate</i>	ART	NS	big sagebrush
	<i>Aster</i>	ASTER		aster
	<i>Aster foliaceus</i> ⁴⁷	ASFO	PNF	
	<i>Aster eatonii</i>	ASEA	PNF	Eaton's aster
	<i>Aster ericoides</i> ⁹	ASER	PNF	heath-leaved aster
	<i>Aster hesperius</i>	ASHE	PNF	siskiyou aster
	<i>Balsamorhiza sagittata</i>	BASA	PNF	arrowleaf balsamroot
	<i>Bidens</i>	BIDEN		beggarticks
	<i>Bidens cernua</i>	BICE	ANF	nodding beggarticks
	<i>Bidens frondosa</i>	BIFR	ANF	devil's beggarticks
	<i>Brickellia microphylla</i>	BRMI	NS	littleleaf brickellbush
	<i>Carduus nutans</i>	CANU2	BIF	musk thistle
	<i>Centaurea</i>	CENTA		knapweed
	<i>Centaurea diffusa</i>	CEDI	AIF	diffuse knapweed
	<i>Centaurea repens</i>	CERE2	AIF	Russian knapweed
	<i>Chaenactis douglasii</i>	CHDO	BNF	Douglas dusky maiden
	<i>Chondrilla juncea</i>	CHJU	PIF	rush skeletonweed

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Chrysothamnus nauseosus</i>	CHNA	NS	rubber rabbitbrush
	<i>Chrysothamnus viscidiflorus</i>	CHVI	NS	tall green rabbitbrush
	<i>Cichorium intybus</i>	CIIN	PIF	chicory
	<i>Cirsium arvense</i>	CIAR	PIF	Canada thistle
	<i>Cirsium vulgare</i>	CIVU	BIF	bull thistle
	<i>Conyza canadensis</i>	COCA	ANF	horseweed
	<i>Crepis acuminata</i>	CRAC	PNF	tapertip hawksbeard
	<i>Crepis modocensis</i>	CRMO	PNF	common hawksbeard
	<i>Crepis occidentalis</i>	CROC	PNF	western hawksbeard
	<i>Erigeron poliospermus</i>	ERPO	PNF	cushion fleabane
	<i>Erigeron pumilus</i>	ERPU	ANF	low fleabane
	<i>Eriophyllum lanatum</i>	ERLA	PNF	woolly eriophyllum
	<i>Euthamia occidentalis</i> ¹²	EUOC	PNF	western goldenrod
	<i>Gnaphalium chilense</i>	GNCH	AIF	cottonbatting cudweed
	<i>Gnaphalium palustre</i>	GNPA	ANF	lowland cudweed
	<i>Grindelia squarrosa</i>	GRSQ	BNF	curlycup gumweed
	<i>Gutierrezia sarothrae</i>	GUSA	NHS	snakeweed
	<i>Helenium autumnale</i>	HEAU	PNF	common sneezeweed
	<i>Helianthus annuus</i>	HEAN	ANF	common sunflower
	<i>Helianthus nuttallii</i>	HENU	PNF	Nuttall's sunflower
	<i>Iva axillaris</i>	IVAX	PNF	povertyweed
	<i>Iva xanthifolia</i>	IVXA	ANF	marshelder
	<i>Lactuca serriola</i>	LASE	BIF	prickly lettuce
	<i>Lactuca tatarica</i> ¹⁰	LATA	PNF	beautiful prickly lettuce
	<i>Lygodesmia juncea</i>	LYJU	PNF	rush skeletonweed
	<i>Machaeranthera canescens</i>	MACA	BNF	hoary machaeranthera
	<i>Malacothrix sonchoides</i> ¹¹	MASO	ANF	desert dandelion
	<i>Matricaria maritima</i>	MAMA	APIF	scentless may-weed
	<i>Solidago</i>	SOLID		goldenrod
	<i>Solidago canadensis</i>	SOCA	PNF	Canada goldenrod
	<i>Solidago gigantea</i>	SOGI	PNF	giant goldenrod
	<i>Sonchus</i>	SONCH		sowthistle

The Distribution of Plant Species and Some Associated Factors

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Sonchus asper</i>	SOAS	AIF	spiny sowthistle
	<i>Sonchus oleraceus</i>	SOOL	AIF	annual sowthistle
	<i>Stephanomeria exigua</i>	STEX	ANF	small wirelettuce
	<i>Stephanomeria tenuifolia</i>	STTE	ANF	narrow leaved skeletonweed
	<i>Tanacetum vulgare</i>	TAVU	PIF	tansy
	<i>Taraxacum officinale</i>	TAOF	PIF	dandelion
	<i>Tetradymia canescens</i>	TECA2	NS	gray horsebrush
	<i>Tetradymia glabrata</i>	TEGL	NS	little-leaf horsebrush
	<i>Tetradymia spinosa</i>	TESP	NS	spiny horsebrush
	<i>Townsendia florifer</i>	TOFL	ABPNF	showy townsendia
	<i>Townsendia leptotes</i>	TOLE	PNF	common townsendia
	<i>Tragopogon dubius</i>	TRDU	ABIF	salsify
	<i>Xanthium strumarium</i>	XAST	ANF	heartleaf cocklebur
BETULACEAE:	<i>Betula occidentalis</i>	BEOC	NT	water birch
BIGNONIACEAE:	<i>Catalpa speciosa</i>	CASP	IT	catalpa
BORAGINACEAE:	<i>Amsinckia retrorsa</i>	AMRE	ANF	rough fiddleneck
	<i>Amsinckia menziesii</i>	AMME	ANF	Menzies fiddleneck
	<i>Asperugo procumbens</i>	ASPR	AIF	madwort
	<i>Cryptantha circumscissa</i>	CRCI	ANF	matted cryptantha
	<i>Cryptantha fenderli</i>	CRFE	ANF	Fendler's cryptantha
	<i>Cryptantha interrupta</i>	CRIN	PNF	invested cryptantha
	<i>Cryptantha pterocarya</i>	CRPT	ANF	winged cryptantha
	<i>Cryptantha watsonii</i>	CRWA	ANF	Watson cryptantha
	<i>Cynoglossum officinale</i>	CYOF	BIF	houndstongue
	<i>Lappula redowskii</i>	LARE	AIF	Redowski tickweed
	<i>Tiquilia nuttallii</i> ³	TINU	ANF	Nuttall's coldenia
BRASSICACEAE ¹⁴ :	<i>Brassica nigra</i>	BRNI	AIF	black mustard
	<i>Camelina microcarpa</i>	CAMI	AIF	smallseed falseflax

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Capsella bursa-pastoris</i>	CABU	AIF	shepherd's purse
	<i>Caulanthus crassicaulis</i>	CACR	PNF	thickstem wild cabbage
	<i>Chorispora tenella</i>	CHTE	AIF	blue mustard
	<i>Conringia orientalis</i>	COOR	AIF	treacle hares' ear
	<i>Descurainia sophia-pinnata</i>	DESO	AIF	flixweed
	<i>Descurainia richardsonii</i>	DERI	BNF	Richardson tansy mustard
	<i>Erophila verna</i> ¹³	ERVE	AIF	spring whitlow-grass
	<i>Erysimum asperum</i>	ERAS	AIF	asperum wallflower
	<i>Erysimum inconspicuum</i>	ERIN	PNF	smallflower wallflower
	<i>Erysimum repandum</i>	ERRE	AIF	bushy wallflower
	<i>Lepidium latifolium</i>	LELA	AIF	perennial pepperweed
	<i>Lepidium perfoliatum</i>	LEPE	ABNF	yellowflower pepperweed
	<i>Nasturtium officinale</i> ¹⁶	NAOF	AIF	watercress
	<i>Rorippa palustris</i> ⁴⁴	ROPA	ANF	yellowcress
	<i>Sisymbrium altissimum</i>	SIAL	ABIF	tall tumble mustard
	<i>Stanleya pinnata</i>	STPI	NHS	desert princesplume
	<i>Streptanthella longirostris</i>	STLO	ANF	longbeak streptanthella
	<i>Thelypodium laciniatum</i>	THLA	BNF	cutleaved thelypody
	<i>Thelypodium integrifolium</i>	THIN	BNF	entireleaved thelypody
CACTACEAE:	<i>Opuntia polyacantha</i>	OPPO	NS4S	prickly-pear cactus
	<i>Opuntia fragilis</i>	OPFR	NS4S	brittle cactus
CAPPARIDACEAE:	<i>Cleome lutea</i>	CLLU	ANF	yellow beeplant
CAPRIFOLIACEAE:	<i>Lonicera sempervirens</i>	LOSE	IS	honeysuckle
	<i>Sambucus cerulea</i>	SACE	NS	blue elderberry
CARYOPHYLLACEAE:	<i>Arenaria franklinii</i>	ARFR	NHS	Franklin sandwort
	<i>Cerastium arvense</i>	CEAR	PIF	starry chickweed
	<i>Vaccaria pyramidata</i> ⁴	VAPY	AIF	cowcockle

The Distribution of Plant Species and Some Associated Factors

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
CERATOPHYLLACEAE:	<i>Ceratophyllum demersum</i>	CEDE	PNF2F	homwort
CHARACEAE:	<i>Chara</i>	CHARA		
CHENOPODIACEAE:	<i>Atriplex canescens</i>	ATCA	NS	fourwing saltbush
	<i>Atriplex patula</i> var. <i>hastata</i>	ATPA	ANF	spearleaf saltweed
	<i>Atriplex confertifolia</i>	ATCO	NS	shadscale
	<i>Atriplex rosea</i>	ATRO	AIF	tumbling saltweed
	<i>Bassia hyssopifolia</i>	BAHY	AIF	fivehook bassia
	<i>Ceratoides lanata</i>	CELA	NHS	winterfat
	<i>Chenopodium album</i>	CHAL	AIF	common lamb's quarters
	<i>Chenopodium botrys</i>	CHBO	AIF	Jerusalem oak goosefoot
	<i>Chenopodium foliosum</i>	CHFO	AIF	leafy goosefoot
	<i>Chenopodium incanum</i> ⁶	CHIN	ANF	Fremont's goosefoot
	<i>Chenopodium leptophyllum</i>	CHLE	ANF	slimleaf goosefoot
	<i>Chenopodium polyspermum</i>	CHPO	AIF?	
	<i>Chenopodium rubrum</i>	CHRU	ANF	
	<i>Grayia spinosa</i> ⁵	GRSP	NS	spiny hopsage
	<i>Halogeton glomeratus</i>	HAGL	AIF	halogeton
	<i>Kochia scoparia</i>	KOSC	AIF	kochia
	<i>Monolepis nuttalliana</i>	MONU	ANF	Nuttall monolepis
	<i>Salsola collina</i>	SACO	AIF	
	<i>Salsola kali</i>	SAKA	AIF	Russian thistle
	<i>Sarcobatus vermiculatus</i>	SAVE	NS	greasewood
	<i>Suaeda torreyana</i> ⁷	SUTO	NHS	torrey seepweed
CONVOLVULACEAE:	<i>Convolvulus arvensis</i>	COAR	PIF	morning glory
	<i>Cuscuta indecora</i> ¹⁷	CUIN	PNP2F	dodder
CORNACEAE:	<i>Cornus sericea</i> ¹³	COSE	NS	red-osier dogwood
CUCURBITACEAE:	<i>Echinocystis lobata</i> ¹⁷	ECLO	ANF	wild mockcucumber

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
CUPRESSACEAE:	<i>Juniperus osteosperma</i>	JUOS	NT	Utah juniper
	<i>Juniperus scopulorum</i>	JUSC	NT	Rocky Mountain juniper
CYPERACEAE:	<i>Carex hystrixina</i>	CAHY	PNGL	bottlebrush sedge
	<i>Carex lanuginosa</i>	CALA	PNEGL	woolly sedge
	<i>Carex nebrascensis</i>	CANE	PNGL	Nebraska sedge
	<i>Carex rostrata</i>	CARO	PNEGL	beaked sedge
	<i>Carex simulata</i>	CASI	PNGL	mack sedge
	<i>Carex vulpinoidea</i>	CAVU	PNEGL	fox sedge
	<i>Cyperus</i>	CYPER		flat sedge
	<i>Cyperus aristatus</i>	CYAR	ANGL	bearded flatsedge
	<i>Cyperus erythrorhizos</i>	CYER	ANGL	redroot flatsedge
	<i>Eleocharis palustris</i>	ELPA	PNEGL	common spikerush
	<i>Eleocharis bella</i>	ELBE	PNGL	beautiful spikerush
	<i>Scirpus</i>	SCIRP		bulrush
	<i>Scirpus acutus</i>	SCAC	PNEGL	tule bulrush
	<i>Scirpus americanus</i> ¹⁹	SCAM	PNEGL	Olney's bulrush
	<i>Scirpus fluviatilis</i>	SCFL	PNEGL	river bulrush
	<i>Scirpus maritimus</i>	SCMA	PNEGL	saltmarsh bulrush
	<i>Scirpus pungens</i> ¹⁸	SCPU	PNEGL	American bulrush
	<i>Scirpus tabernaemontani</i> ⁴⁵	SCTA	PNEGL	soft stem bulrush
DIPSACACEAE	<i>Dipsacus fullonum</i> ²²	DIFU	BIF	teasel
ELAEAGNACEAE	<i>Elaeagnus angustifolia</i>	ELAN	IS	Russian olive
EQUISETACEAE	<i>Equisetum arvense</i>	EQAR	PNH	field horsetail
	<i>Equisetum hyemale</i>	EQHY	PNH	scouring rush
	<i>Equisetum laevigatum</i>	EQLA	PNH	braun horsetail
	<i>Equisetum variegatum</i>	EQVA	PNH	variegated horsetail

The Distribution of Plant Species and Some Associated Factors

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
EUPHORBIACEAE:	<i>Euphorbia</i>	EUPHO		spurge
	<i>Chamaesyce glyptosperma</i> ²⁰	CHGL	ANF	corrugate-seeded spurge
	<i>Chamaesyce serpyllifolia</i> ²⁰	CHSE	ANF	thyme-leaf spurge
FABACEAE ³²	<i>Astragalus</i>	ASTRA		
	<i>Astragalus atratus</i>	ASAT	PNF	mourning locoweed
	<i>Astragalus atropubescens</i>	ASAT2	PNF	Kelsey's milkvetch
	<i>Astragalus caricinus</i>	ASCA	PNF	buckwheat locoweed
	<i>Astragalus eremiticus</i>	ASER	PNF	hermit locoweed
	<i>Astragalus filipes</i>	ASFI	PNF	stipate locoweed
	<i>Astragalus geyeri</i>	ASGE	PNF	Geyer locoweed
	<i>Astragalus iodanthus</i>	ASIO	PNF	Humbolt river milkvetch
	<i>Astragalus lentiginosus</i>	ASLE	PNF	specklepod locoweed
	<i>Astragalus malacus</i>	ASMA	PNF	shaggy locoweed
	<i>Astragalus nudisiliquus</i>	ASNU	PNF	cobblestone locoweed
	<i>Astragalus purshii</i>	ASPU	PNF	Pursh locoweed
	<i>Astragalus purshii ophiogenes</i>	ASPUO	PNF	woolly-pod locoweed
	<i>Astragalus toanus</i>	ASTO	PNF	toano poison locoweed
	<i>Caragana arborescens</i>	CAAR	IS	Siberian peashrub
	<i>Dalea ornatum</i> ³³	DAOR	PNF	purple prairieclover
	<i>Glycyrrhiza lepidota</i>	GLLE	PNF	American licorice
	<i>Lotus corniculatus</i>	LOCO	PIF	horned birdsfoot trefoil
	<i>Lotus tenuis</i>	LOTE	PIF	
	<i>Lupinus argenteus</i>	LUAR	PNF	silvery lupine
	<i>Lupinus pusillus</i>	LUPU	ANF	rusty lupine
	<i>Medicago lupulina</i>	MELU	AIF	black medic
	<i>Medicago sativa</i>	MESA	PIF	alfalfa
	<i>Melilotus alba</i>	MEAL	ABIF	white sweetclover
	<i>Melilotus officinalis</i>	MEOF	ABIF	yellow sweetclover
	<i>Psoralea lanceolata</i>	PSLA	PNF	shoestring psoralea
	<i>Robinia pseudo-acacia</i>	ROPS	IT	black locust
	<i>Trifolium</i>	TRIFO		clover

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Trifolium fragiferum</i>	TRFR	PIF	strawberry clover
	<i>Trifolium pratense</i>	TRPR	BPIF	red clover
	<i>Trifolium repens</i>	TRRE	PIF	white clover
GENTIANACEAE:	<i>Centaurium exaltatum</i>	CEEX	ANF	exalted centaury
	<i>Centaurium muhlenbergii</i>	CEMU	ANF	Muhlenberg centaury
GERANIACEAE:	<i>Erodium cicutarium</i>	ERCI	AIF	redstem filaree
HALAGORACEAE:	<i>Myriophyllum exalbescent</i>	MYEX	PNS3F	water-milfoil
HYDROCHARITACEAE:	<i>Elodea canadensis</i>	ELCA	PNS3F	Canada waterweed
	<i>Elodea longivaginata</i>	ELLO	PNS3F	
	<i>Elodea nuttallii</i>	ELNU	PNS3F	western waterweed
HYDROPHYLLACEAE:	<i>Nama aretioides</i>	NAAR	ANF	ground nama
	<i>Nama densum</i>	NADE	ANF	leafy nama
	<i>Phacelia hastata</i>	PHHA	PNF	spear shaped phacelia
	<i>Phacelia glandulifera</i>	PHGL	ANF	oak phacelia
IRIDACEAE:	<i>Iris</i>	IRIS	PIF	iris
JUGLANDACEAE:	<i>Juglans regia</i>	JURE	IT	English walnut
JUNCACEAE:	<i>Juncus articulatus</i>	JUAR	PNGL	jointed rush
	<i>Juncus balticus</i>	JUBA	PNGL	arctic rush
	<i>Juncus bufonius</i>	JUBU	ANGL	toad rush
	<i>Juncus torreyi</i>	JUTO	PNGL	Torrey's rush
	<i>Juncus ensifolius</i>	JUEN	PNGL	dagger-leaf rush
	<i>Juncus nodosus</i>	JUNO	PNGL	tuberous rush
LAMIACEAE ³¹ :	<i>Lycopus americanus</i>	LYAM	PNF	American bugleweed

The Distribution of Plant Species and Some Associated Factors

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Lycopus asper</i>	LYAS	PNF	rough bugleweed
	<i>Marrubium vulgare</i>	MAVU	PIF	white horehound
	<i>Mentha arvensis</i>	MEAR	PNF	field mint
	<i>Mentha spicata</i>	MESP	PIF	spearmint
	<i>Nepeta cataria</i>	NECA	PIF	catnip
	<i>Scutellaria galericulata</i>	SCGA	PNF	littlecap skullcap
	<i>Teucrium canadense</i>	TECA	PNF	Canada germander
LEMNACEAE:	<i>Lemna</i>	LEMNA		duckweed
	<i>Lemna minor</i>	LEMI	PNF2F	common duckweed
	<i>Lemna trisulca</i>	LETR	PNF2F	star duckweed
LILIACEAE:	<i>Allium acuminatum</i>	ALAC	PNF	tapertip onion
	<i>Allium textile</i>	ALTE	PNF	textile onion
	<i>Asparagus officinalis</i>	ASOF	PIF	garden asparagus
	<i>Calochortus bruneaunis</i>	CABR	PNF	Bruneau mariposalily
	<i>Calochortus nuttallii</i>	CANU	PNF	sego mariposalily
	<i>Leucocrinum montanum</i>	LEMO	PNF	sandlily
	<i>Smilacina stellata</i>	SMST	PNF	starry false Solomon seal
	<i>Zigadenus venosus</i>	ZIVE	PNF	deathcamas
LOASACEAE:	<i>Mentzelia albicaulis</i>	MEAL1	ANF	whitestem stickleaf
	<i>Mentzelia laevicaulis</i>	MELA	BNF	smoothstem blazingstar
	<i>Mentzelia torreyi acerosa</i>	METO	ANF	Torrey's blazingstar
LYTHRACEAE:	<i>Lythrum salicaria</i>	LYSA	PIF	purple loosestrife
MALVACEAE:	<i>Malva neglecta</i>	MANE	ABIF	common mallow
	<i>Malvella leprosa</i> ³⁴	MALE	PNF	alkali-mallow
	<i>Sphaeralcea coccinea</i>	SPCO	PNF	scarlet globemallow
	<i>Sphaeralcea grossulariaefolia</i>	SPGR	PNF	gooseberry globemallow
	<i>Sphaeralcea munroana</i>	SPMU	PNF	munro globemallow

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
MORACEAE:	<i>Morus alba</i>	MOAL	IS	mulberry
NYCTAGINACEAE:	<i>Abronia mellifera</i>	ABME	PNF	white sandverbena
OLEACEAE	<i>Fraxinus pennsylvanica</i>	FRPE	IT	green ash
ONAGRACEAE:	<i>Boisduvalia densiflora</i>	BODE	ANF	dense spike primrose
	<i>Camissonia boothii</i> ³⁵	CABO	ANF	Booth's evening-primrose
	<i>Camissonia scapoidea</i> ³⁶	CASC	ANF	naked-stemmed evening-primrose
	<i>Epilobium</i> spp.	EPILO		willowweed
	<i>Epilobium ciliatum</i>	EPCI	PNF	hairy willowweed
	<i>Epilobium glaberrimum</i>	EPGL	PNF	smooth willowweed
	<i>Epilobium paniculatum</i> ?	EPPA	ANF	autumn willowweed
	<i>Epilobium pringleanum</i> ?	EPPR	IT	
	<i>Gaura parviflora</i>	GAPA	ANF	smallflower gaura
	<i>Gayophytum ramosissimum</i>	GARA	ANF	branch groundsmoke
	<i>Oenothera biennis</i>	OEBI	BIF	common evening-primrose
	<i>Oenothera caespitosa</i>	OECA	PNF	tufted evening-primrose
	<i>Oenothera hookeri</i>	OEHO	PBNF	hooker evening-primrose
	<i>Oenothera pallida</i>	OEPA	PNF	pale evening-primrose
ORCHIDACEAE:	<i>Epipactis gigantea</i>	EPGI	PNF	chatterbox orchid
OROBANCHACEAE:	<i>Orobanche</i>	OROB	PNP2F	broomrape
	<i>Orobanche californica</i>	ORCA	PNP2F	California broomrape
	<i>Orobanche fasciculata</i>	ORFA	PNP2F	clustered broomrape
PLANTAGINACEAE:	<i>Plantago lanceolata</i>	PLLA	PIF	buckhorn plantain
	<i>Plantago major</i>	PLMA	PIF	broadleaf plantain
	<i>Plantago patagonica</i>	PLPA	ANF	Indianwheat plantain

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
POACEAE ²¹ :	<i>Agropyron</i>	AGROP		wheatgrass
	<i>Agropyron cristatum</i>	AGCR	PIG	crested wheatgrass
	<i>Agropyron dasystachyum</i>	AGDA	PNG	thickspike wheatgrass
	<i>Agropyron intermedium</i>	AGIN	PIF	intermediate wheatgrass
	<i>Agropyron pectiniforme</i>	AGPE	PIG	crested wheatgrass
	<i>Agropyron repens</i>	AGRE	PIG	quackgrass
	<i>Agropyron smithii</i>	AGSM	PNG	western wheatgrass
	<i>Agropyron spicatum</i>	AGSP	PIG	bluebunch wheatgrass
	<i>Agrostis exarata</i>	AGEX	PNG	spike bentgrass
	<i>Agrostis stolonifera</i> ²⁴	AGST	PIG	carpet bentgrass
	<i>Aristida purpurea</i> ⁴⁸	ARLO	PNG	three-awn
	<i>Bromus carinatus</i>	BRCA	PNG	California brome
	<i>Bromus commutatus</i>	BRCO	AIG	hairy brome
	<i>Bromus inermis</i>	BRIN	PIG	smooth brome
	<i>Bromus japonicus</i>	BRJA	AIG	Japanese brome
	<i>Bromus tectorum</i>	BRTE	AIG	downy brome
	<i>Dactylis glomerata</i>	DAGL	PIG	orchardgrass
	<i>Digitaria sanguinalis</i>	DISA	AIG	large crabgrass
	<i>Diplachne fascicularis</i> ²⁷	DIFA	ANG	loose flowered sprangletop
	<i>Distichlis spicata</i> ²⁵	DISP	PNG	saltgrass
	<i>Echinochloa crusgalli</i>	ECCR	AIG	barnyard grass
	<i>Elymus cinereus</i>	ELCI	PNG	basin wildrye
	<i>Elymus flavescens</i>	ELFL	PNG	yellow wildrye
	<i>Elymus triticoides</i>	ELTR	PNG	creeping wildrye
	<i>Eragrostis cilianensis</i>	ERCI2	AIG	stink lovegrass
	<i>Eragrostis pectinacea</i>	ERPE	ANG	tufted lovegrass
	<i>Eremopyrum triticeum</i> ²³	ERTR	AIG	annual wheatgrass
	<i>Festuca</i>	FESTU		fescue
	<i>Festuca arundinacea</i>	FEAR	PIG	tall fescue
	<i>Glyceria borealis</i>	GLBO	PNG	northern mannagrass
	<i>Glyceria grandis</i>	GLGR	PNG	American mannagrass
	<i>Hordeum glaucum</i>	HOGL	AIG	seagreen barley

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Hordeum jubatum</i>	HOJU	PNG	foxtail barley
	<i>Hordeum pusillum</i>	HOPU	AIG	little barley
	<i>Leersia oryzoides</i>	LEOR	PNG	rice cutgrass
	<i>Lolium perenne</i>	LOPE2	PIG	perennial rye
	<i>Muhlenbergia asperifolia</i>	MUAS	PNG	alkali muhly
	<i>Oryzopsis hymenoides</i>	ORHY	PNG	Indian ricegrass
	<i>Panicum capillare</i>	PACA	ANG	witchgrass
	<i>Phalaris arundinaceae</i>	PHAR	PNG	reed canarygrass
	<i>Phragmites australis</i> ²⁸	PHAU	PNG	common reed
	<i>Poa compressa</i>	POCO2	PNG	Canada bluegrass
	<i>Poa palustris</i>	POPA	PNG	fowl bluegrass
	<i>Poa pratensis</i>	POPR	PIG	Kentucky bluegrass
	<i>Poa secunda</i> ⁴⁹	POSE	PNG	bluegrass
	<i>Poa scabrella</i>	POSC	PNG	pine bluegrass
	<i>Polypogon monspeliensis</i>	POMO	AIG	rabbitfoot grass
	<i>Setaria glauca</i> ²⁹	SEGL	AIG	yellow bristlegrass
	<i>Setaria viridis</i>	SEVI	AIG	green bristlegrass
	<i>Sitanion hystrix</i>	SIHY	PNG	bottlebrush squirreltail
	<i>Spartina pectinata</i>	SPPE	PNG	prairie cordgrass
	<i>Sphenopholis obtusata</i>	SPOB	PNG	wedgegrass
	<i>Sporobolus airoides</i>	SPAI	PNG	alkali sacaton, dropseed
	<i>Sporobolus cryptandrus</i>	SPCR	PNG	sand dropseed
	<i>Stipa comata</i>	STCO	PNG	needle-and-thread grass
	<i>Stipa thurberiana</i>	STTH	PNG	thurber needlegrass
	<i>Taenitherum caput-medusae</i>	TACA	AIG	medusahead
	<i>Triticum aestivum</i>	TRAE	AIG	common wheat
	<i>Vulpia octoflora</i> ²⁶	VUOC	ANG	six-weeks fescue
POLEMONIACEAE:	<i>Eriastrum wilcoxii</i>	ERSP	PNF	eriastrum
	<i>Gilia leptomeria</i>	GILE	ANF	slender gilia
	<i>Gilia minutiflora</i>	GIMI	ANF	small-flowered gilia
	<i>Gilia sinuata</i>	GISI	ANF	rosy gilia

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Ipomopsis congesta</i> ³⁷	GICO	PNF	scarlet gilia
	<i>Langloisia setosissima</i>	LASE1	ANF	moth langloisia
	<i>Leptodactylon pungens</i>	LEPU	NS	granite pricklygilia
	<i>Microsteris gracilis</i>	MIGR	ANF	slender falsephlox
	<i>Phlox</i>	PHLOX		
	<i>Phlox aculeata</i>	PHAC	PNF	sagebrush phlox
	<i>Phlox longifolia</i>	PHLO	PNF	long-leaf phlox
	<i>Polemonium micranthum</i>	POMI	ANF	Jacob's ladder
POLYGONACEAE:	<i>Eriogonum cernuum</i>	ERCE	ANF	nodding eriogonum
	<i>Eriogonum caespitosum</i>	ERCA	NHS	mat buckwheat
	<i>Eriogonum microthecum</i>	ERMI	NHS	slenderbrush eriogonum
	<i>Eriogonum ochrocephalum</i>	EROC	PNF	woolly eriogonum
	<i>Eriogonum ovalifolium</i>	EROV	PNF	cushion eriogonum
	<i>Eriogonum shockleyi</i>	ERSH	PNF	cowpie buckwheat
	<i>Eriogonum vimineum</i>	ERVI	ANF	broom eriogonum
	<i>Eriogonum watsonii</i>	ERWA	PNF	Watson's buckwheat
	<i>Polygonum</i> spp.	POLYG		knotweed
	<i>Polygonum amphibium</i> ³⁸	POAM	PNF	water knotweed
	<i>Polygonum aviculare</i>	POAV	ANF	prostate knotweed
	<i>Polygonum coccineum</i>	POCO	PNF	water smartweed
	<i>Polygonum hydropiper</i>	POHY1	AIF	marshpepper knotweed
	<i>Polygonum hydropiperoides</i>	POHY	PNF	swamp knotweed
	<i>Polygonum lapathifolium</i>	POLA	ANF	curltop ladysthumb
	<i>Polygonum persicaria</i>	POPE	AIF	ladysthumb
	<i>Polygonum punctatum</i>	POPU	ANEF	water smartweed
	<i>Polygonum setaceum</i>	POSE2	NI	
	<i>Polygonum Douglasii</i> ³⁹	PODO	ANF	Douglas knotweed
	<i>Rumex</i>	RUMEX		dock
	<i>Rumex crispus</i>	RUCR	PNF	curly dock
	<i>Rumex dentatus</i>	RUDE	AIF	toothed dock
	<i>Rumex maritimus</i> ⁴⁰	RUMA	ANF	golden dock

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Rumex venosus</i>	RUVE	PNF	veiny dock
POLYPODIACEAE:	<i>Cystopteris fragilis</i>	CYFR	PNF3	brittle bladderfern
PORTULACACEAE:	<i>Claytonia perfoliata</i> ⁴⁶	CLPE	ANF	miner's lettuce
	<i>Portulaca oleracea</i>	POOL	AIF	common purslane
POTAMOGETONACEAE:	<i>Potamogeton filiformis</i>	POFI	PNS3F	slender-leaved pondweed
	<i>Potamogeton nodosus</i>	PONO	PNS3F	long-leaved pondweed
	<i>Potamogeton pectinatus</i>	POPE2	PNS3F	fennel-leaved pondweed
	<i>Potamogeton pusillus</i>	POPU2	PNS3F	small pondweed
	<i>Potamogeton strictifolius</i>	POST	PNS3F	
	<i>Potamogeton crispus</i>	POCR	PNS3F	curly pondweed
RANUNCULACEAE:	<i>Aquilegia formosa</i>	AQFO	PNF	Sitka columbine
	<i>Clematis ligusticifolia</i>	CLLI	NWV	western virgins-bower
	<i>Delphinium nuttallianum</i>	DENU	PNF	Nuttall larkspur
	<i>Myosurus aristatus</i>	MYAR	ANF	sedge mousetail
	<i>Myosurus minimus</i>	MYMI	ANF	tiny mousetail
	<i>Ranunculus</i>	RANUN		buttercup
	<i>Ranunculus aquatilis</i>	RAAQ	PNS3F	water buttercup
	<i>Ranunculus cymbalaria</i>	RACY	PNEF	alkali buttercup
	<i>Ranunculus glaberrimus</i>	RAGL	PNF	sagebrush buttercup
	<i>Ranunculus sceleratus</i>	RASC	PNEF	celeryleaf buttercup
	<i>Ranunculus testiculatus</i>	RATE	AIF	testiculate buttercup
RHAMNACEAE:	<i>Rhamnus cathartica</i>	RHCA	IS	buckthorn
ROSACEAE:	<i>Amelanchier alnifolia</i>	AMAL2	NS	saskatoon serviceberry
	<i>Crataegus</i>	CRATA	NS	hawthorn
	<i>Potentilla</i>	POTEN		cinquefoil
	<i>Potentilla anserina</i>	POAN	PNF	goosegrass cinquefoil

The Distribution of Plant Species and Some Associated Factors

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Potentilla biennis</i>	POBI	ANF	biennial cinquefoil
	<i>Potentilla norvegica</i>	PONO	ANF	Norwegian cinquefoil
	<i>Prunus americana</i>	PRAM	NT	American plum
	<i>Prunus institia</i>	PRIN	IT	bullace plum
	<i>Prunus mahaleb</i>	PRMA	IT	grafting cherry
	<i>Prunus spinosa</i>	PRSP	IT	blackthorn
	<i>Prunus virginiana</i>	PRVI	NT	chokecherry
	<i>Purshia tridentata</i>	PUTR	NS	antelope bitterbrush
	<i>Pyrus</i>	PYRUS	IT	pear
	<i>Rosa woodsii</i>	ROWO	NS	Wood's rose
	<i>Rubus discolor</i>	RUDI	IS	Himalayan blackberry
RUBIACEAE:	<i>Galium</i>	GALIU		
	<i>Galium aparine</i>	GAAP	ANF	catchweed bedstraw
	<i>Galium trifidum</i>	GATR	PNF	threelute bedstraw
SALICACEAE:	<i>Populus alba</i>	POAL	IT	white poplar
	<i>Populus balsamifera</i> ⁴¹	POBA	NT	black cottonwood
	<i>Populus deltoides</i>	PODE	IT	eastern cottonwood
	<i>Salix</i>	SALIX		willow
	<i>Salix amygdaloides</i>	SAAM	NT	peach-leaved willow
	<i>Salix exigua</i>	SAEX	NS	coyote willow
SAXIFRAGACEAE:	<i>Lithophragma parviflora</i>	LIPA	PNF	smallflower woodlandstar
	<i>Ribes aureum</i> ³⁰	RIAU	NS	golden currant
	<i>Ribes cereum</i> ³⁰	RICE	NS	squaw currant
SCROPHULARIACEAE:	<i>Castilleja angustifolia</i>	CAAN	PNF	northwestern indian paintbrush
	<i>Castilleja exilis</i>	CAEX	ANF	small indian paintbrush
	<i>Collinsia parviflora</i>	COPA	ANF	blue-eyed Mary
	<i>Linaria genistifolia</i>	LIGE	PIF	brown-leaved toadflax
	<i>Mimulus guttatus</i>	MIGU	ANF	yellow monkeyflower

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
	<i>Penstemon acuminatus</i>	PEAC	PNF	sharpleaf penstemon
	<i>Penstemon cyaneus</i>	PECY	PNF	dark blue penstemon
	<i>Penstemon deustus</i>	PEDE	PNS	scabland penstemon
	<i>Penstemon humilis</i>	PEHU	PNF	low penstemon
	<i>Penstemon radicosus</i>	PERA	PNF	matroot penstemon
	<i>Penstemon speciosus</i>	PESP	PNF	royal penstemon
	<i>Verbascum blattaria</i>	VEBL	BIF	moth mullein
	<i>Verbascum thapsus</i>	VETH	BIF	common mullein
	<i>Veronica anagallis-aquatica</i>	VEAN	BPNEF	water speedwell
	<i>Veronica peregrina</i>	VEPE	ANEF	purslane speedwell
SIMAROUBACEAE:	<i>Ailanthus altissima</i>	AIAL	IT	giant tree-of-heaven
SOLANACEAE:	<i>Nicotiana attenuata</i>	NIAT	ANF	coyote tobacco
	<i>Physalis virginiana</i> ⁴²	PHVI	PNF	
	<i>Solanum</i>	SOLAN		
	<i>Solanum dulcamara</i>	SODU	PIF	bitter nightshade
	<i>Solanum nigrum</i>	SONI	AIF	black nightshade
	<i>Solanum triflorum</i>	SOTR	ANF	cutleaf nightshade
TAMARICACEAE:	<i>Tamarix parviflora</i>	TAPA	IS	smallflower saltcedar
TYPHACEAE:	<i>Typha latifolia</i>	TYLA	PNEF	cattail
ULMACEAE	<i>Celtis reticulata</i>	CERE	NT	netleaf hackberry
	<i>Ulmus pumila</i>	ULPU	IT	Siberian elm
URTICACEAE:	<i>Parietaria pensylvanica</i>	PAPE	ANF	pellitory
	<i>Urtica dioica</i>	URDI	PIF	stinging nettle
VERBENACEAE:	<i>Verbena bracteata</i>	VEBR	PNF	prostrate vervain
	<i>Verbena hastata</i>	VEHA	PNF	blue verbena

--- The Distribution of Plant Species and Some Associated Factors ---

Appendix 14 (continued)

Family	Species	Species Code	Life-form	Common Name
VITACEAE:	<i>Parthenocissus quinquefolia</i>	PAQU	IWV	Virginia creeper
	<i>Vitis lambrusaca</i>	VILA	IWV	grape
	<i>Vitis vinifera</i>	VIVI	IWV	canyon grape
ZANNICHELLIACEAE:	<i>Zannichellia palustris</i>	ZAPA	PNS3F	marsh pondweed
ZYGOPHYLLACEAE:	<i>Tribulus terrestris</i>	TRTE	AIF	puncture vine

Life-forms: A=Annual , B=Biennial, P=Perennial, N=Native, I=Introduced, E=Emergent, F=Forb, G=Grass, GL=Grasslike, H=Horsetail, S=Shrub, T=Tree, WV=Woody vine, HS=Half shrub, F2F=Floating forb, P2F=Parasitic forb, S3F=Submerged forb, F3=Fern

Appendix 14 (continued)

Synonymy--Species list reflects current taxonomic standards (Kartesz and Kartesz 1980) that may not occur in Hitchcock and Cronquist (H&C; 1978). A list of synonyms (indicated by superscripts within the list) is provided below. "var." indicates variety, "ssp." indicates subspecies.

Number	Current name	H&C
1	<i>Alismaceae</i>	<i>Alismataceae</i>
2	<i>Toxicodendron radicans</i>	<i>Rhus radicans</i>
3	<i>Tiquilia nuttallii</i>	<i>Coldenia nuttallii</i>
4	<i>Vaccaria pyramidata</i>	<i>V. segetalis</i>
5	<i>Grayia spinosa</i>	<i>Atriplex spinosa</i>
6	<i>Chenopodium incanum</i> var. <i>incanum</i>	<i>C. fremontii</i>
7	<i>Suaeda torreyana</i> var. <i>torreyana</i>	<i>S. intermedia</i>
8	<i>Asteraceae</i>	<i>Compositae</i>
9	<i>Aster ericoides</i> ssp. <i>pansus</i>	<i>A. pansus</i>
10	<i>Lactuca tatarica</i> var. <i>pulchella</i>	<i>L. pulchella</i>
11	<i>Malacothrix sonchoides</i> var. <i>torreyi</i>	<i>M. torreyi</i>
12	<i>Euthamia occidentalis</i>	<i>Solidago occidentalis</i>
13	<i>Cornus sericea</i> ssp. <i>sericea</i>	<i>C. stolonifera</i>
14	<i>Brassicaceae</i>	<i>Cruciferae</i>
15	<i>Erophila verna</i>	<i>Draba verna</i>
16	<i>Nasturtium officinale</i>	<i>Rorippa nasturtium-aquaticum</i>
17	<i>Cuscuta indecora</i> was included in the <i>Cuscutaceae</i> previously	
18	<i>Scirpus pungens</i>	<i>S. americanus</i>
19	<i>Scirpus americanus</i>	<i>S. olneyi</i>
20	<i>Chamaesyce</i>	<i>Euphorbia</i>
21	<i>Poaceae</i>	<i>Graminae</i>
22	<i>Dipsacus fullonum</i>	<i>D. sylvestris</i>
23	<i>Eremopyrum triticeum</i>	<i>Agropyron triticeum</i>
24	<i>Agrostis stolonifera</i> (2 var.) var. <i>stolonifera</i> & var. <i>palustris</i>	<i>A. alba</i>
25	<i>Distichlis spicata</i> var. <i>stricta</i>	<i>D. stricta</i>
26	<i>Vulpia octoflora</i>	<i>Festuca octoflora</i>
27	<i>Diplachne fascicularis</i>	<i>Leptochloa fascicularis</i>
28	<i>Phragmites australis</i>	<i>P. communis</i>
29	<i>Setaria glauca</i>	<i>S. lutescens</i>

Appendix 14 (continued)

Number	Current name	H&C
30	<i>Ribes</i> was included in <i>Grossulariaceae</i> previously	
31	<i>Lamiaceae</i>	<i>Labiatae</i>
32	<i>Fabaceae</i>	<i>Leguminosae</i>
33	<i>Dalea ornatum</i>	<i>Petalostemon ornatum</i>
34	<i>Malvella leprosa</i>	<i>Sida hederacea</i>
35	<i>Camissonia boothii</i> ssp. <i>alyssoides</i>	<i>Oenothera boothii</i>
36	<i>Camissonia scapoidea</i>	<i>Oenothera scapoidea</i>
37	<i>Ipomopsis congesta</i>	<i>Gilia congesta</i>
38	<i>Polygonum amphibium</i> var. <i>emersum</i>	<i>P. coccineum</i>
39	<i>Polygonum sawatchense</i>	<i>P. douglasii</i> v. <i>johnstonii</i>
40	<i>Rumex maritimus</i> var. <i>persicarioides</i>	<i>R. persicarioides</i>
41	<i>Populus balsamifera</i> ssp. <i>trichocarpa</i>	<i>P. trichocarpa</i>
42	<i>Physalis virginia</i> var. <i>sonorae</i>	<i>P. longifolia</i>
43	<i>Apiaceae</i>	<i>Umbelliferae</i>
44	<i>Rorippa palustris</i>	<i>R. islandica</i> (depends on variety)
45	<i>Scripus tabernaemontanii</i>	<i>S. validus</i>
46	<i>Claytonia perfoliata</i>	<i>Montia perfoliata</i>
47	<i>Aster foliosus</i>	<i>A. chilensis</i>
48	<i>Aristida purpurea</i>	<i>A. longiseta</i>
49	<i>Poa secunda</i>	<i>P. nevadensis</i> and <i>P. sandbergii</i>

Appendix 15. Associations between species and environmental factors sampled at ten transects in the Hagerman Study Area, 1991. Positive (+) and negative (-) correlations are noted. ** indicates an association occurred on more than one transect.

Percent Soil Moisture		Soil Depth		Elevation above Water Surface		Rock Content		Phosphorus		Nitrogen, Electical Conductivity		Calcium	
<i>Chenopodium album</i>	+	<i>Cirsium</i> spp.	+	<i>Agropyron cristatum</i>	+	<i>Agropyron spicatum</i>	-	<i>Lactuca serriola</i>	+	<i>Salix amygdaloides</i>	+	<i>Salix exigua</i>	+
<i>Dipsacus fullonum</i>	+	<i>Iva axillaris</i>	+	<i>Bromus tectorum</i>	+	<i>Celtis reticulata</i>	+	<i>Salix exigua</i>	+				
<i>Hordeum jubatum</i>	+	<i>Lycopus asper</i>	+	<i>Plantago major</i>	-	<i>Ribes aureum</i>	+						
<i>Lycopus asper</i>	+	<i>Polygonum persicaria</i>	+	<i>Polypogon monspeliensis</i>	-								
<i>Ribes aureum</i>	--	<i>Scirpus acutus</i>	+	<i>Rhus trilobata</i>	+								
<i>Salix exigua</i> **	+	<i>Sisymbrium altissimum</i> **	+	<i>Rosa woodstii</i>	+								
<i>Scirpus americanus</i>	+	<i>Solanum dulcamara</i>	+	<i>Salsola kali</i>	+								
<i>Scirpus validus</i>	+	<i>Typha latifolia</i> **	+	<i>Sisymbrium altissimum</i>	+								
<i>Verbascum thapsis</i>	-	<i>Urtica dioica</i>	+	<i>Veronica anagallis-aquatica</i>	-								
<i>Veronica anagallis-aquatica</i>	+	<i>Verbascum thapsis</i>	-										
		<i>Veronica anagallis-aquatica</i>	+										
		<i>Xanthium strumarium</i>	+										