GREAT SAND DUNES NATIONAL MONUMENT VEGETATION PATTERNS

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This project is designed to characterize and map the vegetation of the Great Sand Dunes National Monument, Colorado (GSDNM) and to determine if the vegetated areas in the dune field are permanent, temporary, or migratory. It is not known if the vegetation around the dunes is encroaching on the dunes, being replaced by the dunes or is stable. There are also concerns about the possible effect a proposed water export project adjacent to GSDNM would have on the dunes and their vegetation.

♦ METHODS

Vegetation patterns were characterized by establishing a grid system of plots throughout GSDNM based on section corners and ongoing sand trap dune movement assays (Fig. 1A). The grid was supplemented by additional plots in smaller and more unique vegetative communities. Fewer plots were put in the large vegetatively depauperate sand dune areas. Circular plots (0.01 ha) were marked with the placement of 30 cm steel bars. Plot sampling was by the releve methodology developed by the Zurich-Montpellier School of Plant Ecology (Shimwell 1971, Harper et al. 1988). Each plot was photographed, its parental geological material recorded (Johnson 1969, Tweto 1979), vascular plant species identified (Welsh et al. 1987, Weber 1990) and classified by cover class (< 1 %, = + , 1 - 5 % = 1, 6 - 25 % = 2, 26 - 50 % = 3, 51 - 75 % = 4, 76 - 95 % = 5, > 95 % = 6; modified from Daubenmire 1959) and sociability class (single, widely spaced individuals = 1, small groups = 2, small patches = 3, extensive patches = 4, nearly pure stands = 5; Harper et al. 1988), and a summary of the plot's cover made by percent tree layer, shrub layer, herb layer, cryptogamic layer, litter, rock (> 1 cm), and bare soil.

Plant communities were objectively identified by using multivariate statistical techniques we developed. We used two complementary clustering methods. Both methods are based on the co-occurrence of species. However, in the prevalence method, Prevalence Affinity, $P_A = N_{S2}/N_{S1}$, where N_{S1} = number of plots with species 1 in the species plots under consideration and N_{S2} = number of plots with species 2 co-occurring with species 1. In the uniqueness method, corrected for random expectation, Uniqueness Affinity, $U_A = (N_{S2} * N_{TS})/(N_{S1} * N_{T1})$, where N_{TS} = total number of plots in the study, N_{T1} = total number of plots of species 1 in the complete study, and the other symbols are as in the P_A model.

Concurrent with our travel to and from study plots we supplemented the existing list of vascular plants (Great Sand Dunes National Monument Staff 1986) by collecting herbarium specimens of plants heretofore unknown from GSDNM which have been deposited in the herbaria of GSDNM, the Shrub Sciences Laboratory (SSLP), and Snow College.

♦ RESULTS AND DISCUSSION

Data from the 118 plots (Fig. 1A) subjected to P_A and U_A clustering sorted the plots into three prevalance clusters (Stabilized and Active Dunes, Wetlands, and Mountainside) and six complementary uniqueness clusters, two each for the prevalance clusters (Active Dunes, Stabilized Dunes, Marsh, Streambank, and two Mountainside clusters) (Table 1). The two clustering proceedures objectively classify natural vegetation communities (Fig. 1B, 1C, 1D). The dry sand communities are either on the large active dune mass or on adjacent smaller stabilized dunes. All the active dune species are found on the stabilized dunes as well but the converse is not true. The wetland communities are along the steam courses or at other locations of surface water or high water tables. The tightest clustering in the whole study is the Marsh Uniqueness cluster. Mountainside communities are poorly differentiated because the relative small area included few plots for our study. Mountainside communities are on the slopes of the Sangre de Cristo Mountains which flank GSDNM on the north and east and are included only at the edge of GSDNM. The usefulness of our clustering method is illustrated by comparing means within cluster vs. means between clusters: P_A is 217.8 vs. 78.2; U_A is 291.2 vs. 93.1. We discovered 59 species from 26 familes new to the flora of the monument.

♦ ADDITIONAL RESEARCH

The plot data are "ground truth" data. We will match these ground truth data points with vegetative patterns characteristic on aerial photographs taken in 1936 and 1990. We can then make an assessment of stability of the dunes and vegetative patterns and produce vegetation maps.

The 59 species we added to the known flora of GSDNM represent an increase of 20 % over the number of species previously known to occur at GSDNM (Great Sand Dunes National Monument Staff 1986). This increased number was obtained in an incidental way as we recorded plot data and traveled to and from plots. We believe a systematic search for new species would be productive.

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Table 1. Vegetative communities as determined by prevalence and uniqueness clustering.

Prevalence Clustering

Stabilized and Active Dune Species (78 plots, plus 8 mixed)

Clustered species	Plots	Relative affinity
Redfieldia flexuosa	61	207.5
Psoralea lanceolata	60	181.5
Oryzopsis hymenoides	56	199.5
Helianthus petiolaris	56	217.0
Chrysothamnus nauseosus	49	176.6
Senecio sparteoides	47	160.6
Lygodesmia juncea	37	211.1
Sporobolus cryptandrus	31	197.8
Stipa comata	30	158.6
Corispermum nitidum	28	240.7
Oenothera coronopifolia	28	222.2
Cryptantha fedleri	18	174.6
Yucca glauca	16	165.1
Ambrosia acanthicarpa	15	226.1
Muhlenbergia pungens	14	208.1
Crypthantha jamesii	13	201.8
Salsola kali	13	196.8
Penstemon angustifolius	11	198.9
Eriogonum cernuum	10	201.2
Lithospermun incisum	9	200.1
<6 plots (23 species	--	225.0
Weakly Clusterd (9 sp.)	--	129.0
Shared: -none-	--	--

Uniqueness Clustering

Active Dunes (29 plots, plus 47 shared with Stabilzed Dunes, plus 9 mixed)

Clusterd species	Plots	Relative affinity
Redfieldia flexuosa	61	253.2
Helianthus petiolaris	56	248.5
Lygodesmia juncea	37	259.8
Corispermum nitidum	28	362.5
Oenothera coronopifolia	28	282.0
Ambrosia acanthicarpa	15	379.1
Salsola kali	13	278.6
<6 plots (4 species)	--	375.3
Weakly Clustered (5 sp.)	--	195.8
Shared:Stabilized Dunes (11 sp.)	--	258.1

Stabilized Dunes (47 plots, all shared with Active Dunes. plus 7 mixed)

Clustered species	Plots	Relative affinity
Sporobolus cryptandrus	31	249.7
Muhlenbergia pungens	14	257.2
Cryptantha jamesii	13	266.5
Eriogonum cernuum	10	244.7
Lithospermum incisum	9	289.2
<6 plots (8 species)	--	265.9
Weakly Clustered (9 sp.)	--	200.7
Shared:Active Dunes (11 sp.)	--	265.6

Wetlands (13 plots, plus 11 mixed)

Clustered species	Plots	Relative affinity
Agropyron smithii	14	176.8
Juncus balticus	11	294.7
Populus angustifolia	10	217.2
Bromus anomalus	10	197.0
Poa praetensis	10	265.1
Taraxacum officinale	10	259.6
Ribes leptanthum	9	217.0
Rosa woodsii	9	284.9
Salix exigua	8	294.0
Rhus trilobata	7	177.3
Carex sp.	7	278.7
Achillea lanulosa	7	285.0
Populus tremuloides	6	260.8
Alnus tenuifolia	6	317.0
Agropyron trachycaulum	6	264.4
Agrositis stolonifera	6	315.6
Muhlenbergia asperifolia	6	284.7
Aster chilensis	6	259.5
Epilobium glandulosum	6	317.0
Equisetum arvense	6	317.0
Lactuca tatarica	6	249.3
Smilacina stellata	6	227.1
<6 plots (94 species)	--	295.1
Weakly Clustered	--	126.3
Shared:Mountainside (3 sp.)	--	157.3

Marsh (2 plots, plus 4 shared with Streambands, plus 8 mixed)

Clustered species	Plots	Relative affinity
Agropyron smithii	14	272.8
Muhlenbergia asperifolia	6	569.8
Lactuca tatarica	6	396.4
<6 plots (22 species)	--	608.2
Weakly Clustered *2 sp.)	--	194.4
Shared:Streambank (48 sp.)	--	310.8

Streambank (6 plots, plus 4 shared with Marshes, plus 10 mixed)

Clustered species	Plots	Relative affinity
Populus angustifolius	10	251.9
Poa praetensis	10	289.9
Ribes leptanthum	9	239.2
Rosa woodsii	9	326.5
Salix exigua	8	303.8
Carex sp.	7	271.6
Populus tremuloides	6	322.0
Alnus tenuifolia	6	367.5
Agropyron trachycaulum	6	289.4
Equisetum arvense	6	367.5
Smilacina stellata	6	261.7
<6 plots (26 species)	--	339.3
Weakly Clustered (6 sp.)	--	195.1
Shared:Marsh (48 sp.)	--	292.7

Table 1. (cont)

Mountainside (15 plots, plus 11 mixed)

Clustered speciedd	Plots	Relative affinity
Erysimum asperum	28	181.7
Opuntia polycantha	25	171.9
Symphoricarpos oreophilus	22	182.3
Artemisia frigida	22	180.5
Heterotheca villosa	20	180.3
Juniperus scopulorum	19	170.1
Bouteloua gracilis	19	164.1
Senecio tridenticulatus	19	159.8
Sitanion hystrix	15	190.0
Pinus edulis	13	203.4
Carex rossii	13	212.9
Festuca ovina	13	201.1
Machaeranthera canescens	13	183.5
Poa fendleriana	12	201.5
Eriogonum jamesii	12	217.6
Muhlenbergia montana	11	221.5
Androsace septentrionalis	11	202.2
Cercocarpus montanus	10	223.6
Hododiscus dumosus	10	216.2
Ribes cereum	10	213.1
Oryzopsis micrantha	10	184.1
Chenopodium fremontii	10	176.1
Senecio fendleri	10	168.5
Pseudotsuga menziesii	9	202.5
Descurania pinnata	9	202.3
Gilia aggregata	9	170.8
Abies concolor	8	193.7
Arabis lignifera	8	217.9
Arabis hoelboellii	7	214.5
Chrysothamnus viscidiflorus	6	181.3
Ribes aureum	6	209.7
Koeleria nitida	6	226.7
Gilia pinnatifida	6	203.1
Lappula redowskii	6	185.7
Penstemon barbatus	6	206.1
<6 plots (51 species)	--	211.7
Weakly Clustered (9 sp.)	--	131.4
Shared:Wetlands (3 sp.)	--	160.7

Mountainside A (0 plots, 15 shared with B, plus 11 mixed)

Clustered species	Plots	Relative affinity
Poa fendleriana	12	245.2
Androsace septentrionalis	12	226.0
Ribes cereum	10	242.4
Abies concolor	8	230.2
Penstemon barbatus	6	262.4
<6 plots (5 species)	--	252.3
Weakly Clustered (25 sp.)	--	190.3
Shared:Mountainside B (22 sp.)	--	261.2

Mountainside B (0 plots, 15 shared with A, plus 11 mixed)

Clustered species	Plots	Relative affinity
Carex rossii	13	238.7
Festuca ovina	13	220.3
Eriogonum jamesii	12	246.3
Holodiscus dumosus	10	245.5
Pseudotsuga menziesii	9	228.4
Descurainia pinnata	9	229.0
Arabis hoelboellii	7	250.1
Ribes aureum	6	256.1
Gilia pinnatifida	6	233.2
<6 plots (3 species)	--	247.9
Weakly Clustered (23 sp.)	--	190.3
Shared:Mountainside A (22 sp.)	--	249.5

Unclustered species using the Uniqueness method (the Prevalence method produced no unclustered taxa):
present in 6 or more plots . . . 28 species
present in <6 plots . . . . . 23 species

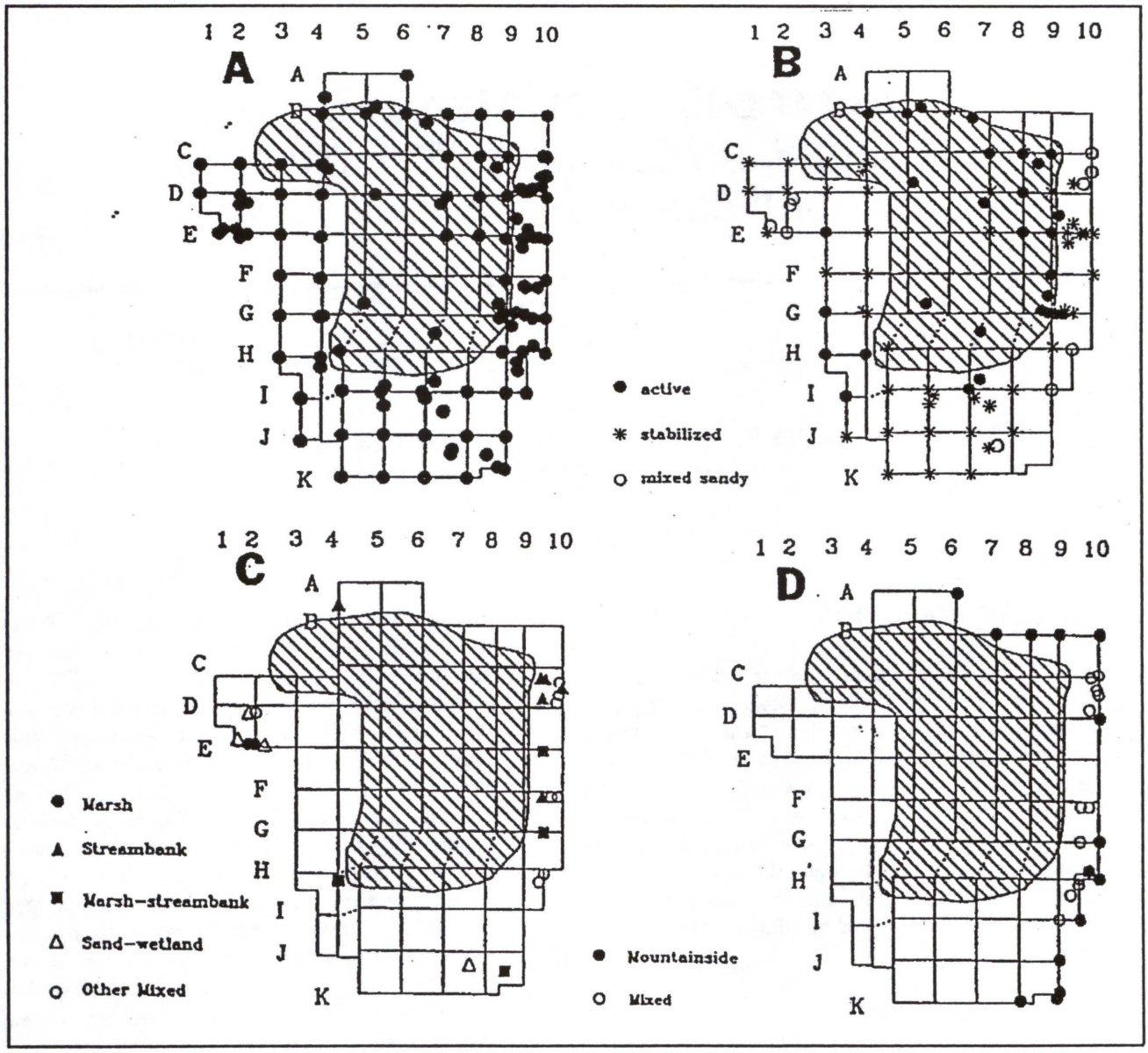

Figure 1. Locations of study plots and vegetation clusters, Great Sand Dunes National Monument. 1A. Location of vegetation survey plots. The hatched area outlines the main dune mass. The monument boundry follows the outside line. 1B. Location of dunes vegetation cluster. 1C. Location of wetlands vegetation cluster. 1D. Location of mountainside vegetation cluster.