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Reevaluation of Vegetational Characteristics at the CERC Field Research Facility, Duck, North Carolina

by

Richard L. Harris, Gerald F. Levy, and James E. Perry

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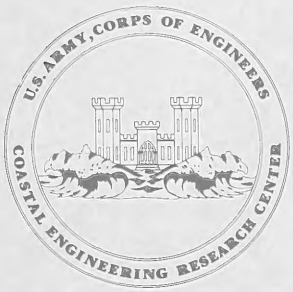

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A vegetative study of the U.S. Army Coastal Engineering Research Center's Field Research Facility at Duck, North Carolina, was undertaken from May to December 1981 to determine and document natural or manmade changes which occurred since Levy's (1976) original study. For four seasonal sampling periods (May, July, September, November), his procedures were replicated and his permanent quadrats reestablished and mapped. A vegetation map of the area was prepared using aerial infrared photos and ground-truth surveys.

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Fourteen different plant communities were delimited. Stratified random sampling produced frequency and biomass data for 12 communities and frequency and density data for the 2 shrub communities. Biomass data were obtained using the clip quadrat method. The distinctiveness of the foredune, sandgrass, sandgrass-buttonweed, sound-side disturbed-shrub, and sound-side shrub communities was borne out by the ordination techniques. The interdunal marsh, low dune grass, planted bitter panicum-planted American beachgrass, and roadside disturbed communities showed a strong similarity in all three ordination perspectives. The most visible change that had occurred since Levy's (1976) original study was the homogeneous mixing and expansion of the planted bitter panicum and planted American beachgrass communities. Floristic collections made throughout the study revealed a flora of approximately 180 species and 151 genera, representing 58 families.

PREFACE

This report is published to provide coastal engineers with a documentation of the vegetative changes at the Field Research Facility (FRF) at Duck, North Carolina, since Dr. Gerald Levy's vegetation survey in 1975 (Levy, 1976). The work was carried out under the U.S. Army Coastal Engineering Research Center's (CERC) Effects of Construction and Operations of Field Research Facility Work Unit, Environmental Impact Program, Environmental Quality Area of Civil Works Research and Development.

The report was prepared by Richard L. Harris, Gerald F. Levy, and James E. Perry of PEER Consultants, Inc. under CERC Contract No. DACW72-81-C-0010.

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A. K. Hurme was the CERC Technical Advisor for this contract under the general supervision of E. J. Pullen, Chief, Coastal Ecology Branch, and Mr. R. P. Savage, Chief, Research Division.

Technical Director of CERC was Dr. Robert W. Whalin, P.E.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

REEVALUATION OF VEGETATIONAL CHARACTERISTICS AT THE CERC FIELD RESEARCH FACILITY, DUCK, NORTH CAROLINA

by

Richard L. Harris, Gerald F. Levy, and James E. Perry

PEER Consultants, Inc.

I. INTRODUCTION

The islands of the Outer Banks of North Carolina are continually subjected to the dynamic processes of longshore currents, tides, and wave and wind action. As a result, shorelines and coastal dunes undergo constant changes that affect the natural ecology of the entire barrier island system. The natural processes responsible for the evolution of the barrier islands have been described by Oosting and Billings (1942), Dolan, Godfrey, and Odum (1973), Godfrey and Godfrey (1976), and Dolan, et al. (1979). Leatherman (1979a, b, c) has proposed an alternate hypothesis on the minimal effect barrier dunes appear to have on the long-term geologic process of landward barrier island migration. The diverse vegetational communities on the Outer Banks include maritime shrubs, forests, grasslands, and complex dune systems. This floral diversity occurs because of an overlap of northern and southern coastal species in North Carolina (Hosier and Cleary, 1979). Local factors such as salinity, nutrient availability, soil moisture and stability also contribute to the vegetative composition and distribution (Wells, 1928; Oosting and Billings, 1942; Godfrey and Godfrey, 1976).

The complex distribution of vegetation on the Outer Banks includes an ocean beach community, a foredune community, a migrating dune community in areas of excessive sand drift, sandflat communities, and arborescent communities of shrubs and trees (Levy, 1976). Each of these plant communities is subject to an array of environmental forces characteristic of the Outer Banks and plays a potential role in the formation and internal geometry of the coastal sand dunes (Goldsmith, 1973).

Before the construction of the Coastal Engineering Research Center's (CERC) Field Research Facility (FRF) at Duck, North Carolina, a vegetation study was undertaken between March 1974 and June 1975 by Levy (1976). The area studied is located on Currituck Bank between the Virginia-North Carolina border at Duck, North Carolina, and southward to Nags Head. It includes the FRF with a 549-meter-long (1,800-foot) pier, a laboratory building, and 71 hectares (175 acres) of government land. The location of the study area is shown in Figure 1. Environmental characteristics of the area have been described by Levy (1976) and Birkemeier, et al. (1981). To determine and document natural or manmade changes which might have occurred since Levy's (1976) original study, this study replicated his procedures and reestablished his quadrats. The objectives were to characterize plant commu-

nities, produce vegetational maps, and assess relationships between communities. By comparing results with those from Levy (1976), the development and change in importance of delimited vegetative communities over a span of 6 to 7 years since the construction of the FRF can be assessed.

II. PROCEDURE

1. Floristics.

Plant collections were made frequently throughout the period May through December 1981. Diagnostically mature specimens were collected in duplicate, identified, mounted, and labeled (Radford, Ahles, and Bell, 1968). Labeling information included the collection location, date, common associated species, and a brief habitat description. The plant collections have been deposited at CERC.

2. Vegetational Studies.

The objectives of this study were to (a) delimit and characterize the number and diversity of the plant communities that occurred in the study area, (b) determine various phytosociological parameters of these communities through randomized sampling procedures and seasonally sample their standing crop, (c) produce an accurate vegetational map of the study area, (d) characterize the relationships between the delimited communities, (e) relocate and map the representative series of permanent quadrats established by Levy (1976), and (f) determine and evaluate any changes which might have occurred since Levy's (1976) original study.

a. Plant Community Identifications. After an intensive review of previous work on the study site (Levy, 1976), the study area was traversed extensively to determine its vegetational diversity. An east-west base line was set up, with a transit and stadia rod, along the southern boundary of the study area. Nine 820-meter-long (approximately 2,700-foot) north-south transects were established from this base line at 91-meter (300-foot) intervals and traversed. Vegetational descriptions were made along these transects, with each vegetation type tested for homogeneity using the chi-square statistic (Curtis and McIntosh, 1951; Sokal and Rohlf, 1969). Twelve distinct community types were initially defined; as seasonal plant growth progressed, two additional community types were recognized and added.

b. Community Sampling. The subjective community identifications verified observations made before the initiation of this investigation. Three

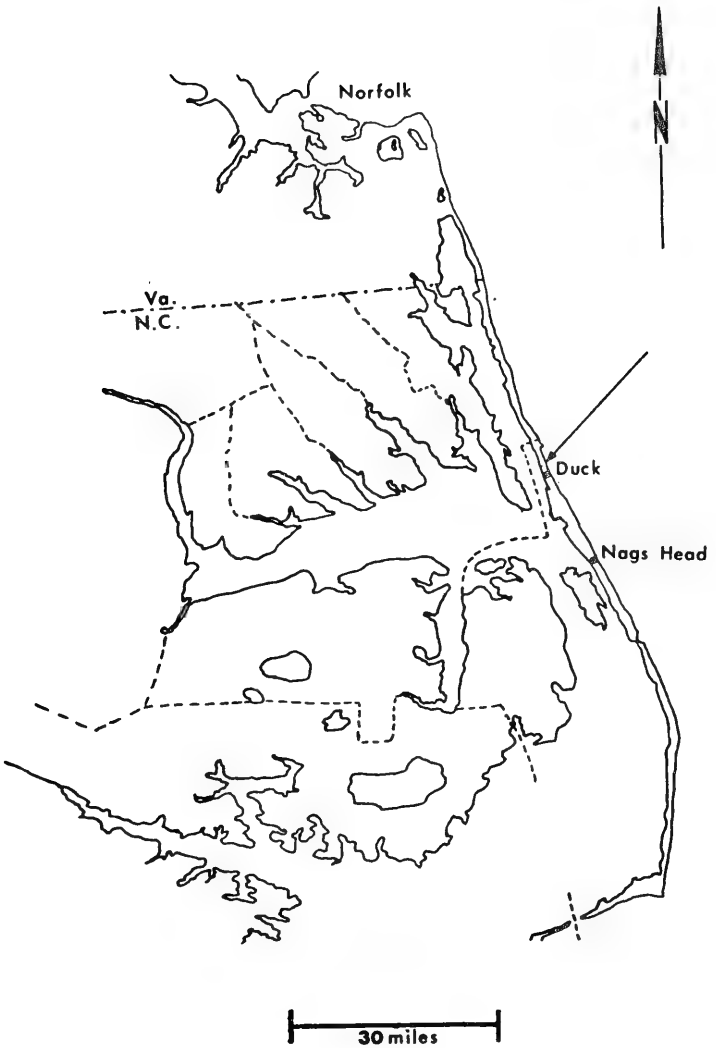

Figure 1. Location of the CERC Field Research Facility, Duck, North Carolina (Levy, 1976).

physiognomically distinct vegetational types were identified: (1) areas dominated by grasses and forbs, (2) areas dominated by shrubs, and (3) areas dominated by young trees.

Quadrats were selected, using a stratified random method, to measure plant species occurrence and abundance. Previous experience with similar vegetational types has demonstrated that 0.2-meter x 0.2-meter square quadrats arranged in a stratified random manner produce statistically valid results in grass-dominated and forb-dominated vegetation (Levy, 1970, 1976). The use of 16 square-meter (4.5-meter-diameter circular) quadrats in shrubby vegetation and in areas dominated by shrubs and small trees also produces valid results.

A running mean analysis of the dominant species in each community (Oosting, 1956; Levy, 1976) was used to determine the number of plots required for a statistically adequate sample; the mean obtained for the dominant species in the first sample quadrat was plotted against the mean of plots 1 and 2, plots 1, 2, and 3, etc. A sufficient number of plots were sampled when the regression line generated by this procedure varied no more than 10 percent from previously obtained mean values for the population. A minimum of 5 plots were sampled in the shrub-tree and shrub-dominated communities and 20 in the grass-dominated communities for two or three dominant species in each community prior to running mean analyses. Enough samples were obtained to ensure adequate sampling of all dominant species, but rarer species (those with low frequency of occurrence in the sample plots) may have been inadequately sampled.

Table 1 shows the number of quadrats required for an adequate sample in both this study and Levy (1976), the community types common to both studies, and the communities newly described in this investigation.

Quadrat frequency and species' standing crop data were collected for all communities except the sound-side and oceanside shrub communities. For the latter, frequency for all woody species and rooted stem density were determined. Standing crop was determined in grams of aboveground ovendried live tissue. Only aboveground parts were removed to avoid excessive disturbance to the area. Each quadrat was clipped, separated by species, and individual species ovendried to constant weight at 105° Celsius. Quadrat sampling dates were within a 1-week period of the following dates: 25 May, 20 July, 12 September, 6 November 1981. Ten 16 square-meter (4.5-meter-diameter circular) quadrats and 1,760 0.2-meter x 0.2-meter quadrats were examined and clipped.

c. Vegetational Mapping. Three overflights of the study area were made in June, September, and November 1981 to obtain seasonal coverage. Infrared aerial photos, taken using a Canon AE-1 35-millimeter camera with a polarizing filter and Ektachrome IE 135-20 color infrared sensitive film, were used in conjunction with ground-truth data from the previously described transect and quadrat data to produce a vegetative map of the study area with better than 90 percent accuracy.

d. Ordination of Stands. Twelve community types were arranged in an ordination model according to the method of Bray and Curtis (1957). In this method each community's frequency values were summed. Each individual

Table 1. Number of quadrats sampled per community.

Community	quadrats (this study)	quadrats (Levy, 1976)
Foredune	30	39
Oceanside intershrub	65	51
Planted bitter panicum	80	73
Sandgrass-buttonweed	55	30
Sound-side disturbed-herbaceous	35	--
Sound-side disturbed-shrub	45	37
Roadside disturbed	40	--
Low dune grass	35	45
Sound-side shrub	5	5
Oceanside shrub	5	5
Interdunal marsh	20	--
Sandgrass	30	--
Bulrush wetlands	20	20
Reed wetlands	20	
Spurge-sandgrass	--	20

species frequency in the community was divided by the total for all species and the result multiplied by 100 to yield relative frequency expressed as a percentage. The relative frequency values were then used to compare the species composition of each community with the other communities, using the Index of Similarity (IS), IS = 2w/(a + b) (Bray and Curtis, 1957). The IS values were then subtracted from 100 to yield the Index of Dissimilarity (ID), ID = 100 -IS, and used to locate the communities along an axis by means of Beals' (1960) adaptation of the Pythagorean Theorem, $x = (L^2 + (dA)^2 - (dB)^2)/2L$, and the technique of Bray and Curtis (1957). The modified standard axis extraction technique of Levy (1976) was employed. Levy's (1976) procedure for axis extraction is to sum the ID values for each vegetational unit. The stand with the highest sum is deemed the end of an axis; the opposite end of this axis is the stand least like it (i.e., having the highest ID in relation to the stand with the highest sum). The units are represented as points separated by a scale distance equal to the ID value. All other points are then located between the end points.

e. Permanent Quadrats. Three 5-meter x 5-meter quadrats were reestablished in each of Levy's (1976) nine defined communities, one in his wetlands community and one in the spurge-sandgrass community. The locations of the quadrat markers were determined by measuring the direction and distance from the U.S. Army Corps of Engineers (USACE) survey markers, following the procedure of Levy (1976). In addition, a permanent quadrat was established in the following newly recognized communities: sound-side disturbed-herbaceous, bulrush wetlands, reed wetlands, interdunal marsh, roadside disturbed, and sandgrass. Oceanside shrub permanent quadrat 3 had to be relocated as this site is now occupied by the FRF. The new location was chosen to best represent the conditions that would have been expected to exist at the original location had construction not occurred. The permanent quadrat marker established for the roadside disturbed community has recently been destroyed by new construction subsequent to the completion of field activities. Vegetative patterns, grass composition, and percent ground cover were analyzed, mapped, and compared to Levy's (1976) results.

Permanent quadrat locations are listed in Appendix A.

III. RESULTS

1. Floristics.

The flora was composed of approximately 180 species and 151 genera, representing 58 families. Levy (1976) identified approximately 178 species and 132 genera, representing 58 families. The list of species collected is presented in Table 2, with asterisks indicating the species not found by Levy (1976). Species found during Levy's (1976) study but not during the present study are shown in Table 3.

2. Vegetational Studies.

a. Phytosociology. Studies indicated that 14 community types can be delimited. Physiognomically, communities fell into three broad dominant categories: (1) grasses and forbs, (2) shrubs, and (3) small trees. The first category included communities on dry sites, which were designated the foredune, low dune, oceanside intershrub, planted bitter panicum, roadside disturbed, sandgrass-buttonweed, sound-side disturbed-herbaceous, and sand-

Table 2. CERC Field Research Facility floristics list.

Family and Species	Common Name
Alismataceae	
**Sagittaria falcata* Pursh.	Arrowhead
Amaranthaceae	
Alternanthera philoxeroides (Martius) Grisebach	Alligator weed
**Amaranthus canabinus* (L.) J. D. Sauer	Water-hemp
Anacardinaceae	
Rhus copallina L.	Winged sumac
R. radicans L.	Poison ivy
Apiaceae	
Centella asiatica (L.) Urban	
**Cicuta maculata* L.	Water hemlock
Eryngium aquaticum L.	Eryngo
Hydrocotyle umbellata L.	Water-pennywort
**H. verticillata* var. *verticillata* Thunberg	Water-pennywort
Lilaeopsis carolinensis C. & R.	
**L. chinensis* (L.) Kuntze	
Sium suave L.	Water-parsnip
Aquifoliaceae	
Ilex opaca Aiton	American holly
I. vomitoria Aiton	Yaupon
Asclepiadaceae	
**Asclepias incarnata* var. *pulchra* (Willd.) Woodson	Swamp milkweed
Asteraceae	
Achillea millifolium L.	Common yarrow
Ambrosia artemisiifolia L.	Ragweed
**Artemisia ludoviciana* Nuttal.	Dusty miller
**Aster vimineus* Lam.	Aster
Baccharis halimifolia L.	Groundsel tree
**Bidens bipinnata* L.	Beggar Ticks
**B. laevis* (L.) BSP.	Beggar Ticks
**Boltonia asteroides* (L.) L'Her.	Boltonia
**Coreopsis grandiflora* Hogg	
Eclipta alba (L.) Hasskar	Yerba-de-tago
Erigeron canadensis var. *pusillus* (Nuttall) Ahles	Horseweed
**E. quercifolius* Lam.	Oak leaf aster
**Eupatorium sèrotinum* Michaux	Mist flower'
**E. hyssopifolium* L.	Thoroughwart
**E. rotundifolium* L.	Thoroughwart
E. serotinum Michaux	Thoroughwart
Gnaphalium obtusifolium L.	Rabbit tobacco
**Helenium amarum* (Raf.) Rock	Bitter-weed
**H. autumnale* L.	Marsh sneeze-weed
Heterotheca gossypina (Michaux) Shinners	
**H. nervosa* (Willd.) Shinners	
Hieracium gronovii L.	Hawk-weed
Iva imbricata Walter	Seashore elder
Krigia virginica (L.) Willd.	Dwarf dandelion
Lactuca canadensis L.	Wild lettuce
Mikania scandens (L.) Willd.	Climbing hempweed
Pluchea foetida (L.) DC.	Marsh fleabane
P. purpurascens (Swatz) DC.	Saltmarsh fleabane

Table 2. CERC Field Research Facility floristics list-Continued.

Family and Species	Common Name
Asteraceae (continued)	
Pyrrhopappus carolinianus var. *carolinianus* (Walter) DC.	False dandelion
Solidago sempervirens L.	Seaside goldenrod
S. tenuifolia Pursh.	Narrow leaf goldenrod
**Sonchus asper* (L.) Hill.	Sow-thistle
**Veronia noveborecensis* L. Michaux	Ironweed
**Xanthium strumarium* var. *strumarium* L.	Cocklebur
Balsaminaceae	
**Impatiens capensis* Meerb.	Jewel-weed
Betulaceae	
**Alnus serrulata* (Aiton) Willd.	Tag alder
Bignoniaceae	
Campsis radicans (L.) Seeman	Trumpet vine
Brassicaceae	
Cakile edentula (Biglow) Hooker	Sea rocket
Lepidium virginicum L.	Peppergrass
**Raphanus raphanistrum* L.	Wild radish
Cactaceae	
Opuntia compressa (Salisbury) Macbride	Prickly pear
O. drummondii Graham	Fragile prickly pear
Campanulaceae	
Lobelia elongata Small	Marsh lobelia
Specularia perfoliata (L.) A.D.C.	Venus' looking glass
Caprifoliaceae	
**Lonicera japonica* var. *chinensis*	
L. japonica var. *japonica* Thunberg	Japanese honeysuckle
L. sempervirens L.	Coral honeysuckle
Chenopodiaceae	
**Atriplex arenaria* Nuttall	Seabeach orach
**Chenopodium album* L.	Lamb's-quarters, pigweed
C. ambrosioides L.	Mexican tea
**Suaeda linearis* (Ell.) Moq.	
Convolvulaceae	
Calystegia sepium (L.) R. Brown	Hedge bindweed
**Dichondra carolinensis* Michaux	
Cornaceae	
Cornus florida L.	Flowering dogwood
Cucurbitaceae	
Melothria pendula L.	Creeping cucumber
Cyperaceae	
Carex alata Torrey	Sedge
Cyperus haspan L.	
C. strigosus L.	
**Dichromena colorata* (L.) Hitchcock	
**Eleocharis obtusa* (Willd.) Schultes	Spike rush
**Fimbristylis spadicea* (L.) Vahl.	Sand rush
Fuirena squarrosa Michaux	Umbrella grass
Scirpus americanus Persoon	Chair maker's rush
S. validus Vahl.	Bulrush

Table 2. CERC Field Research Facility floristics list-Continued.

Family and Species	Common Name
Ebenaceae	
Diospyros virginiana L.	Persimmon
Euphorbiaceae	
Croton glandulosa var. *septentrionalis* Muell. Arg.	Croton
Euphorbia polygonifolia L.	Beach spurge
**E. supina* Raf.	Spurge
Fabaceae	
Apios americana Medicus	Ground peanut
Cassia fasciculata Michaux	Partridge pea
**C. nictitans* L.	Partridge pea
Desmodium strictum (Pursh)	Beggar lice
Lespideza capitata Michaux	Bush clover
L. cuneata (Dumont) G. Don	
**Rhynchosia difformis* (Ell.) DC.	
Strophostyles helvola (L.) Ell.	Wild bean
**Trifolium arvense* L.	Rabbit's foot clover
**Vicia dasycarpa* Tenore	Vetch
Fagaceae	
Quercus virginiana Miller.	Live oak
Gentianaceae	
Sabatia dodecandra (L.) B.S.P.	Sea pink
Geraniaceae	
**Geranium carolinianum*	Carolina cranesbill
Hypericaceae	
Hypericum gentianoides (L.) B.S.P.	St. John's wort
**H. hypericoides* (L.) Crantz	St. John's wort
**H. walteri* Gmelin	St. John's wort
Iridaceae	
**Sisyrinchium mucronatum* var. *atlanticum*	Blue-eyed grass
Juncaceae	
Juncus coriaceus Mackenzie	Rush
J. megacephalus M. A. Curtis	Rush
J. roemerianus Scheele	Black needle rush
Juncaginaceae	
Triglochin striata R. & P.	Arrow grass
Lamiaceae	
**Lycopus europaeus* L.	Water horehound
Monarda punctata L.	Horsemint
Salvia lyrata L.	Sage
Lauraceae	
Persea borbonia (L.) Sprengel.	Red bay
**Sassafras albidum* (Nuttall) Nees	Sassafras
Liliaceae	
**Allium vineale* L.	Wild garlic
Smilax bona-nox L.	Greenbrier
Linaceae	
Linum virginianum var. *medium* Planchon	Flax

Table 2. CERC Field Research Facility floristics list-Continued.

Family and Species	Common Name
Lythraceae	
Lythrum lineare L.	Swamp loosestrife
Magnoliaceae	
**Magnolia virginiana* L.	Sweet bay
Malvaceae	
Kosteletskya virginica (L.) Presl.	Seashore mallow, swamp mallow
Melastomataceae	
**Rhexia mariana* L.	Meadow-beauty
Myricaceae	
Myrica cerifera var. *cerifera* L.	Wax myrtle
Onagraceae	
**Ludwigia alata* Ell.	Water-primrose
Oenothera fruticosa L.	Sundrops
O. humifusa Nuttall	Evening primrose
Orchidaceae	
Spiranthes cernua var. *odorata* (Nuttall) Correll	Nodding ladies' tresses
Passifloraceae	
**Passiflora lutea* L.	Passion-flower
Phytolacaceae	
Phytolacca americana L.	Pokeweed
Plantaginaceae	
**Plantago aristata* Michaux	Plantain
P. lanceolata L.	Narrow leaf plantain
Poaceae	
Ammophilia breviligulata Fernald	American beachgrass
Andropogon elliottii Chapman	Broom straw
A. virginicus L.	Broom straw
Cenchrus tribuloides L.	Sandspurs
Digitaria sp.	
Echinochloa walteri (Pursh) Heller	Walter's barnyard grass
Elymus virginicus L.	Wild rye grass
Eragrostis elliotti	Love grass
Erianthus giganteus (Walt.) Muhl.	Beard grass
**Festuca elatior* L.	Fescue
Lolium multiflorum Lam.	
Panicum amarum Ell.	Bitter panicum, panic grass
P. dichotomum L.	Panic grass
P. fusiforme Hitchcock	Panic grass
P. virgatum L.	Panic grass
**Phragmites communis* L.	Tall reed
Polypogon sp.	Rabbit foot grass
Sacciolepis striata (L.) Nash	
**Spartina alterniflora* Loisel	Smooth cord grass, salt-marsh cord grass
S. cynosuroides (L.) Roth	Tall cord grass, giant cord grass
S. patens (Aiton) Muhl.	Salt-meadow cord grass
Triplasis purpurea (Walter) Chapman	Sand grass
Trisetum pensylvanicum (L.) Beauvois ex. R. & S.	
Uniola paniculata L.	Sea oats

Table 2. CERC Field Research Facility floristics list-Continued.

Family and Species	Common Name
Polygonaceae	
Polygonum hydropiperoides var. *opelousanum* (Riddell ex. Small) Stone	Knotweed
P. pensylvanicum L.	Knotweed
P. sagittatum L.	Tearthumb
**Rumex crispis* L.	Yellow dock
Pontederiaceae	
Pontederia cordata L.	Pickerelweed
Primulaceae	
Samolus parviflorus Raf.	Water pimpernel
Rosaceae	
Prunus serotina Ehrhart	Black cherry
Rubus betulifolius Small	Blackberry
Rubiaceae	
Diodia teres Walter	Buttonweed
D. virginiana L.	Buttonweed
**Galium hispidulum* Michaux	Bedstraw
**Oldenlandia boscii* (DC.) Chapman	
**Richardia scabra* L.	
Rutaceae	
Zanthoxylum clava-herculis L.	Hercules club
Salicaceae	
** Populus alba* L.	White popular, silver popular
Salix nigra Marshall	Black willow
Scrophulariaceae	
Agalinis purpurea (L.) Pennell	Gerardia
**Limosella subulata* Ives	Mudwort
Linaria canadensis (L.) Dumont	Toad flax
Verbascum thapsus L.	Mullein
Solanaceae	
Physalis viscosa ssp. *maritima* (M. A. Curtis) Waterfall	Ground cherry
**Solanum americanum* Miller	American nightshade
Urticaceae	
Boehmeria cylindrica (L.) Swartz	False nettle
Valerianaceae	
**Valerianella radiata* (L.) Dufr.	Corn salad
Verbenaceae	
Callicarpa americana L.	Beauty-berry, French mulberry
** Lippia lanceolata* Michaux	Fog-fruit
Vitaceae	
Parthenocissus quinquefolia (L.) Planchon	Virginia creeper
Vitis aestivalis var. *aestivalis* Michaux	Summer grape
V. rotundifolia Michaux	Muscadine
Xyridaceae	
Xyris jupicai Richard	Yellow-eyed grass

* Species not found in Levy (1976) Study.

Table 3. Species found during Levy (1976) study, but not during this (1981) study.

Family and Species	Common Name
Aceraceae	
Acer rubrum L.	Red maple
Aizoaceae	
Mollugo verticillata L.	Carpet weed
Alismataceae	
Sagitaria graminea var. *weatherbiana* (Fernald) Bogin	Arrowhead
Apiaceae	
Ptilimnium capillaceum (Michaux) Ref.	
Asclepiadaceae	
Asclepias lanceolata Walter	Milkweed
Asteraceae	
Aster tenuifolius L.	Aster
Bidens mitis (Michaux) Sherff	Beggar ticks
Carduus spinosissimus Walter	Yellow thistle
Crepis vesicaria ssp *taraxifolia* (Thuillier) Thellung	Hawk's beard
Erigeron canadensis var. *canadensis* L.	Horseweed
Eupatorium capillifolium var. *capillifolium* (Lam.) Small	Dog fennel
Gaillardia pulchella Foug.	Blanket flower
Heterotheca adenolepis (Fernald) Ahles	
Iva frutescens L.	Marsh elder
Solidago rugosa var. *rugosa* Miller	Goldenrod
Cyperaceae	
Cyperus dentatus Torrey	Sedge
C. erythrorhizos Muhl.	
C. filicinus Vahl	
C. ovularis (Michaux) Torrey	
C. rivularis Kunth	
C. sesquiflorus (Torrey) Mattfeld and Kukenthal	
C. surinamensis Rottboell	
Eleocharis tuberculosa (Michx.) R. & S.	Spike rush
Fimbristylis autumnalis (L.) R. & S.	Sand rush
F. dichotoma (L.) Vahl	
Euphorbiaceae	
Croton punctatus Jacquin	Croton
Fabaceae	
Centrosema virginianum (L.) Bentham	Butterfly pea
Desmodium paniculatum (L.) DC.	Beggar lice
D. paucifloruм (Nuttall) DC.	Beggar lice
D. strictum (Pursh) DC.	Beggar lice
Leepedeza striata (Thunberg) H. & A.	Japanese clover
L. virginica (L.) Britton	
Hamamelidaceae	
Liquidambar styraciflua L.	Sweet gum

Table 3. Species found during Levy (1976) study, but not during this (1981) study-Continued.

Family and Species	Common Name
Lamiaceae	
Stachys nuttallii Shuttlew	Hedge nettle
Liliaceae	
Yucca filamentosa L.	Bear grass
Loganiaceae	
Polypremum procumbens L.	
Lycopodiaceae	
Lycopodium appressum (Chapman) Lloyd and Underwood	Club moss
Malvaceae	
Hibiscus moscheutos L.	Rose mallow
Myricaceae	
M. pensylvanica Loisel	Bayberry
Onagraceae	
Oenothera biennis L.	Evening primrose
Poaceae	
Bromus secalinus L.	Brome grass
Cynodon dactylon (L.) Persoon	Bermuda grass
Digitaria filiformis var. *villosa* (Walter) Fernald	Crab grass
D. ischaemum (Schreber) Schreber ex Muhl.	Crab grass
D. sanguinalis (L.) Scopoli	Crab grass
Eleusine indica (L.) Gaertner	Goose grass
E. spectabilis (Pursh) Steudel	Love grass
Festuca sciurea Nuttall	Fescue
Leptoloma cognatum (Schultes) Chase	Witch grass
Panicum amarulum Hitchcock and Chase	Bitter panicum
P. dichotomiflorum Michaux	Fall ronieum
P. scoparium Lam.	
P. virgatum L.	Switch grass
Paspalum vaginatum Swartz	
Setaria geniculata (Lam.) Beauvois	Fox tail grass
Sorgum halepense (L.) Persoon	Johnson grass
Sphenopholis obtusata (Michaux) Scribner	Wedge grass
Zea mays L.	Corn
Polygonaceae	
R. verticillatus L.	Swamp dock
Ranunculaceae	
Ranunculus sardous Crantz	Buttercup
Rosaceae	
Amelanchier arborea var. *laevis* (Wiegard) Ahles	June berry
Solanaceae	
Datura stramonium L.	Jimson weed
Verbenaceae	
Lippia nodiflora (L.) Michaux	Frogbit

grass communities, as well as some on wet sites namely: the interdunal marsh, reed wetland, and bulrush wetland communities. The second category was represented by the sound-side disturbed-shrub and the oceanside shrub communities. The third category included only the sound-side shrub community (Levy, 1976) which was dominated by tree species. The phytosociological data for these stands are presented in Appendix B. Biomass data from the four sampling periods are summarized in Table 4.

The shrub- and tree-dominated communities had the greatest number of species: sound-side disturbed-shrub, 17; oceanside shrub, 16; and sound-side shrub, 14. Among the forb-grass dominated communities, the bulrush wetlands community had the highest number of species, 13; the reed wetlands had the lowest number of species, 3.

The highest standing crop was measured for the reed wetland community during the September collection (999.6 grams per square meter, Tables 4 and B-19). Six communities had peak standing crops during the September collection period (e.g., foredune, roadside disturbed, bulrush wetland) and five during the November period. The sandgrass-buttonweed community had its peak standing crop during the July sampling (Tables 4 and B-30). Three communities (i.e., low dune grass, oceanside intershrub, planted bitter panicum) had values that did not appear to be greater in November than those measured for the September period. The sandgrass and interdunal marsh communities were barren during the first collecting period and were recognized as unique vegetative assemblages only after the September collections were completed.

As noted in the procedure for community sampling, biomass data were not obtained for the oceanside and sound-side shrub communities following the approach of Levy (1976). The oceanside shrub community had a total density of 26.4 individuals per quadrat while the sound-side shrub community had a value of 5.6 individuals per quadrat.

b. Vegetational Map. The vegetational map of the study area is presented in Figure 2. For comparison, Levy's (1976) vegetational map is shown in Figure 3. A summary of the approximate number of acres of each community, the barren dune areas, roadways, etc., is presented in Table 5. Area measurements in Levy (1976) are cited as $\pm$10 percent. The method employed in this study is of a similar precision. The larger acreages measured in this study may be accounted for, at least in part, by the subsequent marsh grass (*Phragmites* and *Spartina*) and dune grass (*Panicum* and *Ammophila*) plantings by the Army Corps of Engineers. The FRF covers 71 hectares (175 acres) (Birkemeier, et al., 1981) of which 57.3 hectares (141.7 acres) are vegetated, 6.6 hectares (16.3 acres) are barren dunes, 1.5 hectares (3.7 acres) are hard-top roads and buildings, with the remainder composed of beaches and periodically submerged sandy bottoms.

c. Community Ordination. The results of the ordination techniques are presented in Figures 4, 5, and 6. The three-dimensional aspects of this model were depicted by graphing two axes at a time. The distances between individual communities were related to the relative differences

Table 4. Biomass per community, by collecting period, in grams per square meter.

Community	Collection periods 25 May	20 July	12 Sept.	6 Nov.
Foredune	110.9	139.7	227.4	172.0
Low dune grass	50.0	69.5	148.6	162.3
Oceanside intershrub	9.9	19.0	50.0	54.4
Planted bitter panicum	40.3	94.9	141.6	145.2
Reed wetland	441.6	844.1	999.6	55.3
Roadside disturbed	92.2	81.5	105.7	63.8
Bulrush wetland	122.3	270.8	589.9	368.1
Sandgrass-buttonweed	94.8	160.7	136.6	107.6
Sound-side disturbed-herbaceous	4.4	14.9	41.2	26.1
Sound-side disturbed-shrub	12.0	46.3	75.8	71.3
Sandgrass	0	trace	trace	83.6
Interdunal marsh	0	trace	trace	65.8

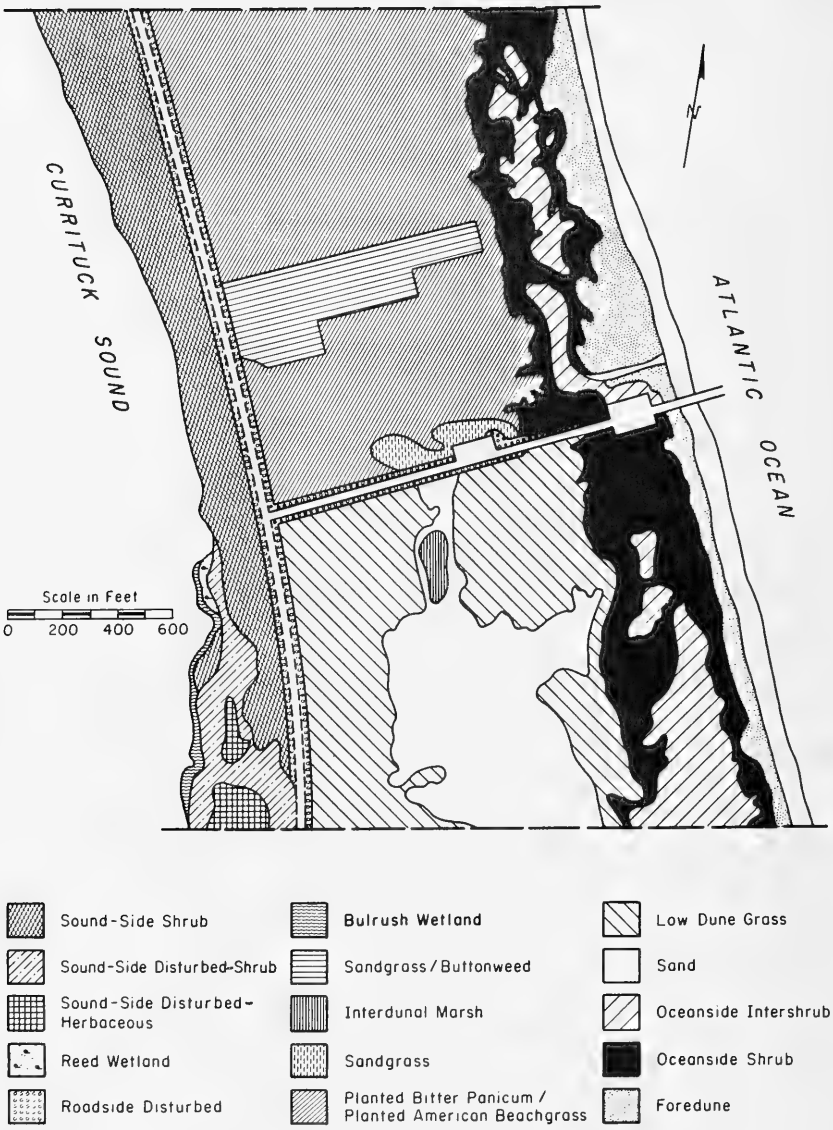

Figure 2. Vegetation map of the CERC Field Research Facility (this study).

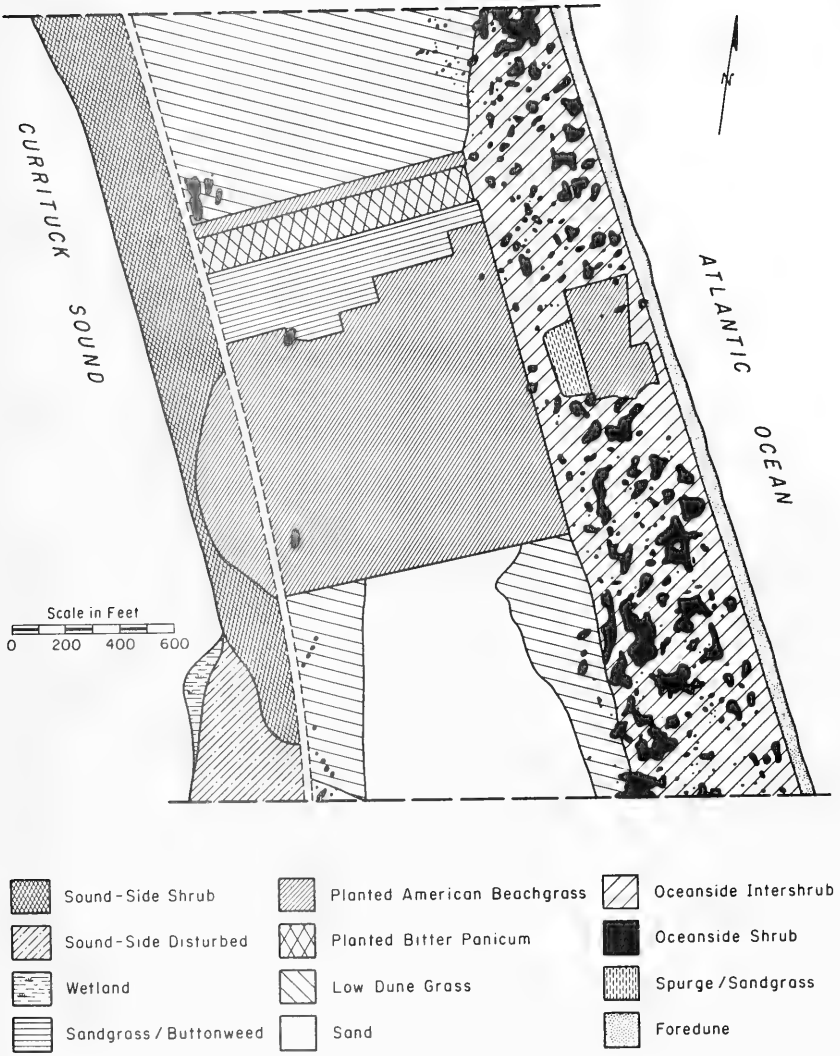

Figure 3. Vegetation map of the CERC Field Research Facility (Levy, 1976).

Table 5. Summary of community types at the CERC Field Research Facility with approximate acreage.

Community types	Hectares (acres), ±10 percent			
	Levy (1976)		Present study	
Foredune (FD)	1.4	(3.5)	3.4	(8.5)
Oceanside intershrub (OIS)	5.7	(14.0)	2.9	(7.1)
Oceanside shrub (OSS)	4.5	(11.0)	9.8	(24.1)
Planted American beachgrass (PBG)	12.1	(30.0)	18.0	(44.5)[1]
Planted bitter panicum (PBP)	1.2	(3.0)	--	(--)
Sandgrass-buttonweed (SG/BW)	2.0	(5.0)	2.6	(6.4)
Low dune grass (LDG)	16.2	(40.0)	10.4	(25.7)
Sound-side shrub (SSS)	2.8	(7.0)	6.6	(16.3)
Sound-side disturbed (SSD)	1.6	(4.0)	2.0	(5.0)[2]
Wetland (WL)	0.4	(1.0)	0.4	(1.0)[3]
Spurge-sandgrass (S/SG)	0.6	(1.5)	0	(0)
Barren sand dunes	10.9	(27.0)	6.6	(16.3)
Interdunal marsh (IDM)	--	--	0.2	(0.5)
Sandgrass (SG)	--	--	0.6	(1.5)
Roadside disturbed (RSD)	--	--	0.4	(1.1)
Roads	1.2	(3.0)	1.5	(3.7)[4]
Total	60.6	(150.0)	65.4	(161.7)

1. PBG and PBP combined in present study.

2. Separated into SSD-H (sound-side disturbed-herbaceous) (0.3 hectare, 0.8 acre) and SSD-S (sound-side disturbed-shrub) (1.7 hectares, 4.2 acres).

3. Separated into bulrush wetland (0.3 hectare, 0.8 acre) and reed wetland (0.08 hectare, 0.2 acre).

4. Buildings added since 1976.

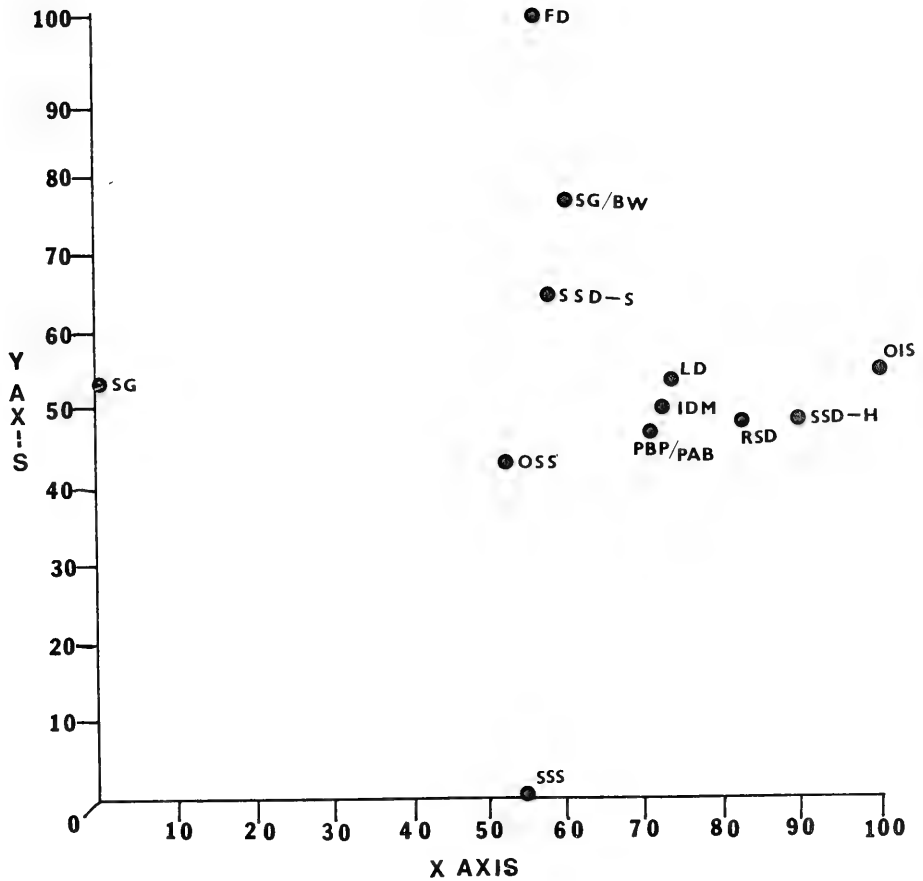

Figure 4. Ordination of plant communities at the CERC Field Research Facility, showing the x and y axes perspective (see Table 5 for definition of community type designation).

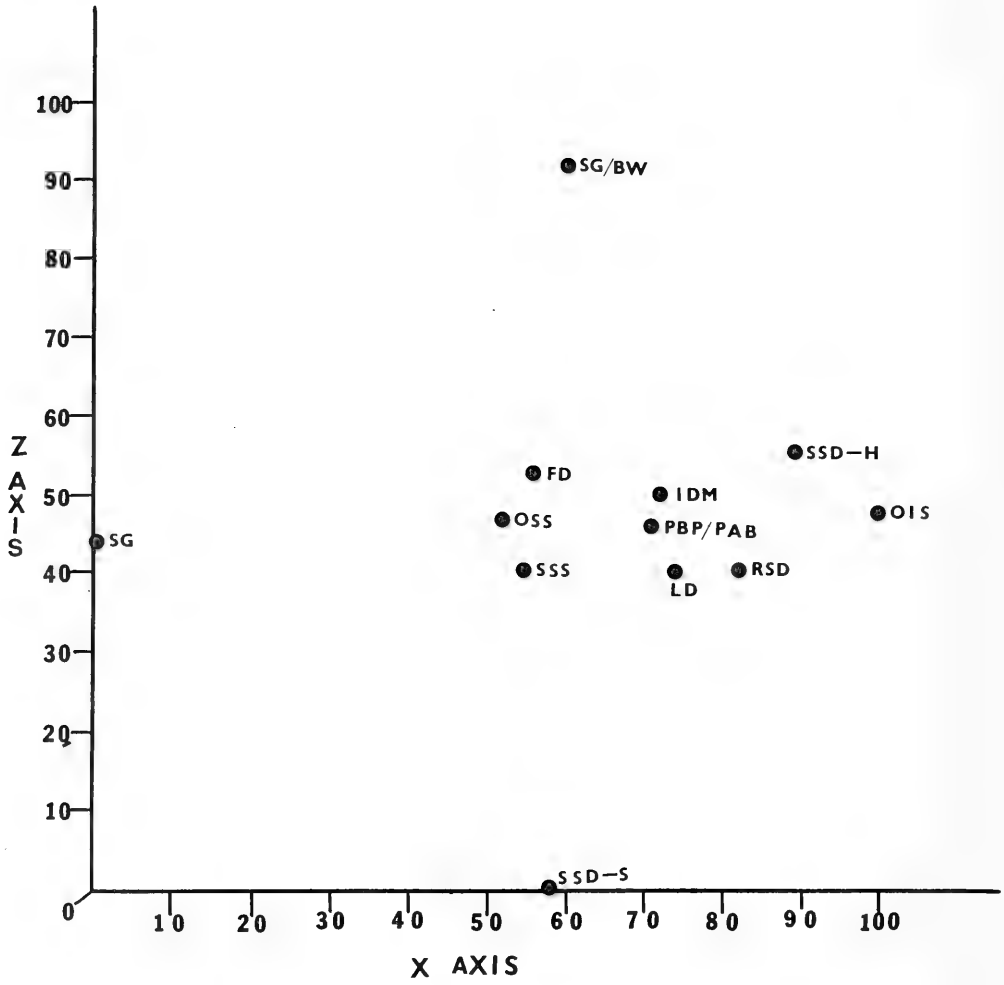

Figure 5. Ordination of plant communities at the CERC Field Research Facility showing the x and z axes perspective (see Table 5 for definition of community type designation).

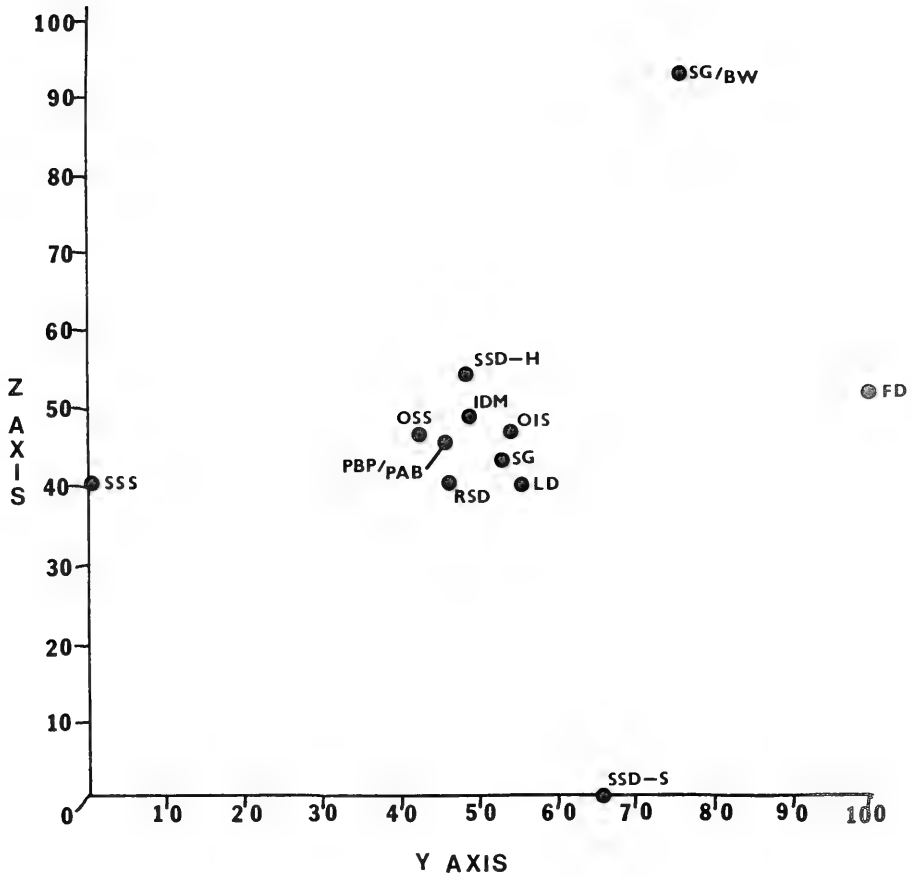

Figure 6. Ordination of plant communities at the CERC Field Research Facility showing the y and z axes perspective (see Table 5 for definition of community type designation).

between them. The more vegetationally different communities were farther apart and the more similar ones closer together.

The bulrush wetland community had a single species in common with the reed wetland community and nothing in common with any other. In addition, the reed wetland had a single species in common with one other community (sound-side disturbed-shrub). Thus these two communities had zero similarity values with most of the other delimited communities. The preliminary ordinations which were constructed with all stands had uninterpretable geometries. Therefore, these communities were omitted in order to produce the ordinations presented in this study.

The distinctiveness of the foredune (x-y and y-z axis), sandgrass (x-y and x-z axis), sandgrass-buttonweed (x-z and y-z axis), sound-side disturbed-shrub (x-z and y-z axis), and sound-side shrub (x-y and y-z axis) communities was borne out by the ordination. However, each of these shared similarities with several other communities on the remaining axis: sandgrass on y-z axis, sandgrass-buttonweed on the x-y axis, sound-side disturbed-shrub on the x-y axis, and sound-side shrub on the x-z axis (sandgrass-buttonweed and sound-side disturbed on the x-y axis, foredune and sound-side shrub on the x-z axis, and sandgrass on the y-z axis).

In contrast to the five clearly distinct communities previously noted, seven community types had strong similarities to each other. These seven can be further separated into two groups. First, the interdunal marsh, low dune grass, planted bitter panicum-planted American beachgrass, and roadside disturbed communities showed a strong similarity in all three ordination perspectives. Second, the oceanside intershrub and sound-side disturbed-herbaceous communities were separated from the former group on the x-z axis. This distinctiveness diminished on the x-y axis and totally disappeared on the y-z axis.

d. Permanent Quadrats. Vegetation patterns of the permanent quadrats for this study and Levy (1976) are provided in Appendix C. The low dune grass quadrat 2 was not diagramed by Levy (1976), as it was void of vegetation (Fig. C-9). Levy (1976) also omitted the three permanent quadrats located in the oceanside shrub community as they had 100 percent *Myrica pensylvanica* coverage (Figs. C-19, C-21, and C-23). Reestablishment of the barren dune permanent quadrats was not required for this study. Appendix A lists separately the location of each quadrat's permanent survey marker. An error was detected in the distance of sound-side disturbed permanent quadrat 1 from USACE survey marker 64 (as reported by Levy, 1976) and has been corrected in Appendix A.

IV. DISCUSSION

1. Floristics.

The Asteraceae was represented by the most species, making up 13 percent of the total flora. This compares with 13.5 percent Asteraceae found by Burk (1968) for the entire Outer Banks. The Poaceae made up 7 percent. This compared with 16 percent for the Asteraceae and 19 percent for the Poaceae reported by Levy (1976). The reversal in order of importance for the two families appeared to reflect the present, more

successional state of the area. Each of the remaining families represented 4 percent or less of the total flora.

Among the species collected, Radford, Ahles, and Bell (1968) listed three as infrequent and three as rare. The infrequent plants were *Lilaeopsis carolinensis* and *Eupatorium serotinum*. The rare species were *Eragrostis elliottii*, *Lilaeopsis chinensis*, and *Ammophila breviligulata*. The *A. breviligulata* was locally abundant due to plantings. *Lonicera japonica* var. *chinensis* is a rare escaped cultivar not yet reported naturalized in North Carolina.

Levy (1976) frequently cites *Myrica pensylvanica* as being an important component of the study area's flora. An intensive search was conducted throughout the FRF; however no specimens were found. In areas north of the FRF, *M. pensylvanica* populations were observed during this study to be undergoing replacement by *M. cerifera* and *Prunus serotina*. It is possible that specimens of *M. pensylvanica* were collected and identified by Levy (1976) who assumed all existing *Myrica* specimens were of this species. Subsequently, *M. pensylvanica* may have died out on this site.

It is important to note that this genus has long had taxonomic problems and species separation depends upon characteristics which are subject to variation caused by environmental extremes. Many authors (e.g., Radford, Ahles and Bell, 1968) recognize a third species, *M. heterophylla*, which is considered a hybrid between *M. pensylvanica* and *M. cerifera*. The resulting hybrid is named differently by others (Fernald, 1950). The correct designation of the *Myrica* growing in the study area is therefore open to question. An intensive evaluation of this technical question is beyond the scope of this study, although current thought strongly suggests that the correct designation is most likely *M. cerifera*.

2. Vegetational Studies.

The plant communities at the Field Research Facility exist in their present condition because of the natural environmental forces characteristic of the Outer Banks and a long history of manmade disturbances, some of which are common to the Outer Banks in general. Others are unique to this site, e.g., its previous use as an aircraft bombing range from 1941 to 1965 and fertilization of the study area during the springs of 1979, 1980, and 1981. Fertilization was conducted on inhouse dune stabilization experimental plantings of *Panicum amarum* and the low dune grass communities. These plantings were made in an area designated by Levy (1976) as planted American beachgrass. One impact of the planting and fertilization was the replacement of the previously existing community by *P. amarum*. Since no plant species were studied before nor during the fertilization of 32 to 36 hectares (80 to 90 acres) at the FRF from 1979 to 1981, the direct impact of the fertilization cannot be ascertained.

In this study, Levy's (1976) original designations of permanent quadrats were maintained for continuity. The above-described treatment, as well as plant successional processes, has produced vegetational changes within the permanent quadrats which in some cases now contain vegetation entirely different from that which existed during Levy's (1976) study.

As shown by the ordination (Figs. 4, 5, and 6), some plant communities were strongly delimited while others were similar. The distinct communities included the foredune community, which had been established on the artificially stabilized foredune and enriched by a series of plantings. This community, though quantitatively unique, had at least one of its species components represented in more than three-quarters of the other communities. Therefore, the species growing on the foredune were not restricted there, but represented those species able to resist the harsh environmental conditions of this habitat. The selecting factors appeared to be strong winds, the accompanying salt spray, sand abrasion, and evaporative stress, as well as extreme temperatures (Oosting, 1945; Malloch, 1971; Tyndall and Levy, 1978). The most prominent species of the area were *Spartina patens* and *Panicum amarum*, present in 36 and 25.5 percent of the sampled plots, respectively.

The oceanside shrub and oceanside intershrub communities lay landward and adjacent to the foredune community. As evident in the ordination, the two communities were vegetationally distinct from the foredune community as well as from each other. Community boundaries were sharply defined because transition zones were less than a few meters. Oceanside shrub and sound-side communities were dominated by *Myrica cerifera* shrubs. The two shrub-dominated communities (oceanside shrub and sound-side shrub) and to some extent the sound-side disturbed-shrub community appeared to have been enriched by nitrogen-fixing micro-organisms on the nodules of legumes and on the roots of *M. cerifera*, as noted for *Myrica pensylvanica* by Morris, et al. (1974). These communities thrived in areas protected from wind and salt spray by the surrounding topography, with the shrubs seldom reaching a height above the foredune system. The high number of species (17) found in the sound-side shrub community, many of which were limited in their tolerance to salt (e.g., *Melothria pendula, Phytolacca americana, Solanum americanum*), attested to the sheltered nature of the community.

The oceanside intershrub community inhabited the more exposed areas behind the foredune community and intermixed with the sound-side shrub community. Human activity and windblown sand were very high in these areas, and as a result vegetation was sparse and patchy. Biomass of the community was lower than all the other communities sampled except for the sound-side disturbed-herbaceous community (Table 4).

Inland from the three communities discussed above lay the planted bitter panicum-planted American beachgrass, low dune grass, and sandgrass-buttonweed communities. The planted bitter panicum-planted American beachgrass community constituted the greatest acreage within the study area (18.0 hectares or 44.5 acres, Table 5). Presently dominated by *Panicum virgatum* and *Erigeron canadensis* var. *pusillus*, this community was previously delimited by Levy (1976) as distinct planted bitter panicum and planted American beachgrass communities. These two communities, as suggested by their names, were originally artificially established on the most heavily bombed part of the study area (Levy, 1976). The extensive acreage observed during this study tended to suggest that the planted bitter panicum-planted American beachgrass community represented a relatively late stable stage in dune succession.

This planted bitter panicum-planted American beachgrass community was similar to the low dune grass community, as observed by Levy (1976), which

was dominated by the grass *Ammophila breviligulata* and the composite *Erigeron canadensis* var. *pusillus*. Both communities inhabited a terrain characterized by rolling dunes of loose, fine sands and heavily disturbed by manmade and natural perturbations. The low dune grass community covered the area south of the present access road to the FRF where topographical relief was stronger than on the northern section of the property. The highest dune was approximately 16.5 meters (50 feet).

Ammophila breviligulata, an introduced species to the area, had become very important as a dune stabilizer. Transition between these two communities was not clearly defined. Nearly pure stands of *A. breviligulata* existed on the berms and rills of the more active dunes, but even here strong similarities to the planted bitter panicum-planted American beachgrass community were evident, suggesting that this community would soon replace the low dune grass community.

A small, interdunal marsh community was located within a shallow (+0.6 meter or +2 feet mean sea level) depression of the low dune community. Receiving ground-water drainage from the adjacent dunes, the marsh soil remained damp throughout the study. Although narrow leaf cattails (*Typha angustifolia*) were common, the community was dominated by *Spartina patens* and *Cyperus ovularis*. The ordination perspective depicted this community as not being unique from the planted bitter panicum-planted American beachgrass and the low dune grass communities. This may be attributed to the fact that these latter communities could probably act as seed sources for the area (Van der Valk, 1974). However, the integrity of the interdunal marsh is probably related to area rainfall with wet years favoring a marsh community and dry years favoring a herbaceous dunal community, as noted by Oosting (1954).

Adjacent to the access road to the FRF and the state highway, which separated the sound-side communities from the rest, lay the roadside disturbed community (Fig. 2). The soil of the community was a mixture of sand and imported gravel-clay. The roadside was utilized as an unpaved parking area and was heavily impacted by tire ruts. This disturbance has served to introduce several new species to the area (e.g., *Plantago aristata, Geranium carolinianum,* and *Valerianella radiata*) common to new road construction sites in North Carolina. However, as seen in the ordination perspectives (Figs. 4, 5, and 6), this area was not unique from the surrounding dunal areas from which the bulk of the flora is apparently derived.

The last community found within the central part of the study area (Fig. 2) was the sandgrass community located in a highly disturbed area resulting from the construction of a visitor parking facility. *Triplasis purpurea* was by far the dominant species (Table B-41) rendering the community unique (Figs. 4 and 5). This community closely resembled Levy's (1976) original description of the sandgrass-buttonweed community and was believed to represent a pioneer stage of succession. The presence of *Panicum virgatum* indicated that this community was rapidly succeeding toward the planted bitter panicum-planted American beachgrass community. Of the several communities located on the sound-side of the study area, only one--the sound-side disturbed-herbaceous community--appeared similar to any of the previously mentioned communities. Characterized by sparse, patchy vegetation, the sound-side disturbed-herbaceous community (Tables B-33 to

B-36) shared the same dominant species *(Triplasis purpurea)* and habitat as the oceanside intershrub community (Tables B-9 to B-12). The compositional differences between these two communities appeared to be related to the fact that the former occurred farther away from salt spray than the latter. Several nonsalt tolerant plants existed in the sound-side disturbed-herbaceous area that were not found in the oceanside intershrub community (i.e., *Juncus spp.* and *Monarda punctata).*

The sound-side disturbed-shrub community comprised approximately 1.7 hectares (4.2 acres) and was located north of the sound-side disturbed-herbaceous community. This community was a mixture of shrub and herbaceous plants, the dominant species including *Spartina patens, Juncus megacephallus, Andropogon virginicus,* and *Myrica cerifera.* Many plant species, including *Vaccinium corymbosum* and *Hierachium gronovii,* were endemic to this area. The uniqueness of the area, as depicted on the ordination perspectives (Figs. 4, 5, and 6), is due in part to manmade perturbations. A high berm that existed along the eastern edge of the sound-side communities had been leveled by road-building activities in the area adjacent to the sound-side disturbed-shrub community. The loss of this protective berm exposed this community to severe winter winds and their suspended salts. Several shrub species which occurred in the sound-side disturbed-shrub community were also found in the sound-side shrub community (e.g., *Baccharis halimifolia, Cornus florida,* and *Rhus copallina).* However, now that the berm has been removed, the sound-side disturbed-shrub community will probably not become homogeneous with the sound-side shrub community.

The sound-side shrub community was the largest of the sound-side communities (6.6 hectares or 16.3 acres, Table 5). Protected on the east by a series of dunes 3.0 to 7.6 meters (10 to 25 feet) high, this community represented a maturing maritime forest of *Prunus serotina, Quercus virginiana,* and *Pinus taeda* trees, several of which had a diameter at breast height of more than 25 centimeters (10 inches). Other important species included *Cornus florida, Ilex opaca, Magnolia virginiana, Myrica cerifera,* and *Persia borbonia.* The sound-side shrub community permanent quadrat 2 (Fig. C-48) was disturbed when a road was constructed within 3.0 meters (10 feet) of the permanent quadrat marker. With the shrubs removed, the successional patterns of this community and the roadside disturbed community were similar (Fig. C-62).

The vine *Lonicera sempervirens* and the shrub *Zanthoxylum clava-herculis* were endemic to this area. The uniqueness of this area was borne out by the x-z and y-z axis perspectives (Figs. 5 and 6). The apparent similarity to the oceanside shrub community on the x-y axis was due to the mutual occurrence of large numbers of *Myrica cerifera* and *Prunus serotina.* However, this similarity did not occur when the species richness of the woody vegetation of the two areas was compared (12 versus 2 for the sound-side shrub and oceanside shrub communities, respectively).

As previously discussed, the wetland communities were not included in the ordination model. Two distinct wetland types existed: a bulrush wetland dominated by *Scirpus americanus* (Fig. C-59) and a reed wetland dominated by *Pragmites communis* (Fig. C-60). Other important species of the bulrush wetland included *Helenium autumnale, Sagittaria falcata, Spartina alterniflora, S. cynosuroides, S. patens,* and *Solidago sempervirens.* With

the exception of *Juncus coreaceus*, which was also found in the reed wetlands, all plant species of the bulrush wetlands were endemic to that area.

3. Comparative Vegetational Analysis: Levy (1976) versus Present Study.

The most visible change which occurred within the study area since Levy's (1976) original study was the homogeneous mixing and expansion of the planted bitter panicum and planted American beachgrass communities. The planted bitter panicum community was originally codominated by *Triplasis purpurea* and *Panicum amarum*. The planted American beachgrass community was dominated by *T. purpurea* and *Ammophila breviligulata*. Combined (Table 5), these communities covered 13.4 hectares (33 acres), 1.2 and 12.2 hectares (3 and 30 acres), respectively. Levy (1976) found the planted bitter panicum community had one of the most depauperate floras, the lowest biomass of areas sampled in his study, and indicated the area represented a failed planting attempt. Levy further suggested that *T. purpurea* may be important as a soil stabilizer. This indeed appeared to have been the case in both communities, as *T. purpurea* decreased from its dominant role in 1975 to a minor member of the new planted bitter panicum-planted American beachgrass community. This new community was dominated by *Panicum virgatum* and covered an area of approximately 18.0 hectares (44.5 acres). The increase in area was due to the northward expansion of the community which covered approximately 4.9 additional hectares (12 acres) previously described as low dune grass, into areas previously found dominated by *T. purpurea* or *Cenchrus tribuloides* (Levy, 1976). The expansion of this community is expected to continue southward into the current sandgrass and low dune communities (Fig. 2).

Levy's (1976) sandgrass-buttonweed (Figs. C-37 to C-42) and spurge-sandgrass (Figs. C-43 and C-44) communities had also undergone major vegetational changes. The former community, originally dominated by *T. purpurea*, was dominated by *Panicum amarum*. The change again supported Levy's (1976) theory of the pioneering nature of *T. purpurea*. The dominant *P. amarum* was the species which was planted in the original planted bitter panicum community and failed to survive. Perhaps enough rootstock or seed survived to allow reestablishment of the species in the adjacent area. At the time plantings were established, both the planted American beachgrass and planted bitter panicum communities were fertilized. The sandgrass-buttonweed community was not fertilized, which may explain the initial exclusion of *P. amarum* and the invasion of the highly competitive *P. virgatum* into the planted bitter panicum area. Similarly the successful invasion of *P. amarum* into the sandgrass-buttonweed area may be due to the lower fertility which may have excluded *P. virgatum*.

The spurge-sandgrass community of Levy's (1976) study was totally devegetated by construction activities at the FRF. The new vegetation assemblage represented a continuum between the planted bitter panicum-planted American beachgrass and the foredune communities.

The dominant species and the areal extent of the foredune community (Figs. C-1 to C-6) have changed. Originally dominated by *Uniola paniculata* and *Ammophila breviligulata* (Levy,1976), the new assemblage is dominated by

Spartina patens and *Panicum amarum*. The community area has increased from 1.4 to 3.4 hectares (3.5 acres to 8.5 acres) (Table 5). The largest increase has occurred on the north edge of the FRF. This may have been caused in part by the construction of the 549-meter (1,800-foot) pier at the facility in 1978. The bottom contours of the beach show a decrease in the slope south of the pier and an increase in the slope north of the pier (Birkemeier, et al., 1981). The result is a larger area for wave energy distribution on the south side, which decreases the probability of overwash.

The addition of the two wetland areas was in part due to sprigging of *Spartina alterniflora* as an erosion stabilizer on the soundside of the FRF (Birkemeier, et al., 1981). These grasses promote soil accretion and prepare the habitat for establishment of numerous other fresh and brackish water plants (Benner, et al., 1982).

V. SUMMARY

A vegetative study of CERC's Field Research Facility at Duck, North Carolina, was undertaken from May through December 1981 to determine and document natural or manmade changes which occurred since Levy's (1976) original study. For four sampling periods, his procedures were replicated and his permanent quadrats reestablished and mapped. A vegetation map of the area was prepared using aerial infrared photos and ground-truth surveys.

Fourteen different plant communities were delimited. Stratified random sampling of these communities produced frequency and biomass data for 12 communities and frequency and density data for the 2 shrub communities. Biomass data were obtained using the clip quadrat method. The distinctiveness of the foredune, sandgrass, sandgrass-buttonweed, sound-side disturbed-shrub, and sound-side shrub communities was borne out by the ordination techniques. The interdunal marsh, low dune grass, planted bitter panicum-planted American beachgrass, and roadside disturbed communities showed a strong similarity in all three ordination perspectives. Several of the vegetational communities delimited were considered to be in a near climatic state; i.e., the foredune, oceanside intershrub, oceanside shrub, sound-side shrub, and planted bitter panicum-planted American beachgrass communities. Although dominant species have shifted and minor floral compositional changes have occurred, all but the planted bitter panicum-planted American beachgrass community had been previously defined by Levy (1976). This community, originally delimited by Levy (1976) as distinct communities, constituted the greatest acreage within the study area.

The most visible change which occurred since Levy's (1976) original study was the homogeneous mixing and expansion of the planted bitter panicum and planted American beachgrass communities. *Triplasis purpurea* appeared to be the primary pioneering species of the barren sand areas, with *Ammophila breviligulata* becoming very important as a dune stabilizer. Floristic collections made throughout the study revealed a flora of approximately 180 species and 151 genera, representing 58 families.

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APPENDIX A

PERMANENT QUADRAT LOCATIONS

Quadrat designation	Location
Foredune No. 1	137° E. of N., 30 meters (97 feet) from U.S. Army Corps of Engineers (USACE) survey marker No. 16
Foredune No. 2	12°30' E. of N., 212 meters (696 feet) from USACE survey marker located in the SE. corner of the study area
Foredune No. 3	45° E. of N., 68 meters (224 feet) from USACE survey marker located in the SE. corner of the study area
Oceanside intershrub No. 1	9°50' W. of N., 102 meters (335 feet) from USACE survey marker No. 11
Oceanside intershrub No. 2	10° W. of N., 64 meters (209 feet) from a point located 70° W. of N., 74 meters (242 feet) from USACE survey marker in the SE. corner of the study area
Oceanside intershrub No. 3	30° W. of N., 55 meters (181 feet) from USACE survey marker in the SE. corner of the study area
Oceanside shrub No. 1	40° W. of N., 67 meters (220 feet) from USACE survey marker located in the SE. corner of the study area
Oceanside shrub No. 2	15° W. of N., 70 meters (230 feet) from USACE survey marker located in the SE. corner of the study area
Oceanside shrub No. 3	30° W. of N., 11 meters (35 feet) from oceanside intershrub No. 2
Planted American beachgrass No. 1	82° W. of N., 263 meters (864 feet) from USACE survey marker No. 11
Planted American beachgrass No. 2	168° W. of N., 238 meters (781 feet) from planted American beachgrass survey marker No. 1

Quadrat designation	Location
Planted American beachgrass No. 3	148° E. of N., 124 meters (408 feet) from planted American beachgrass survey marker No. 2
Sandgrass-buttonweed No. 1	11° W. of N., 71 meters (233 feet) from planted American beachgrass survey marker No. 1
Sandgrass-buttonweed No. 2	59° W. of N., 101 meters (332 feet) from planted American beachgrass survey marker No. 1
Sandgrass-buttonweed No. 3	83° W. of N., 166 meters (545 feet) from planted American beachgrass survey marker No. 1
Low dune grass No. 1	11° W. of N., 231 meters (759 feet) from planted American beachgrass survey marker No. 1
Low dune grass No. 2	40° W. of N., 211 meters (691 feet) from planted American beachgrass survey marker No. 1
Low dune grass No. 3	34° W. of N., 246 meters (807 feet) from planted American beachgrass survey marker No. 1
Sound-side shrub No. 1	80° W. of N., 306 meters (1004 feet) from planted American beachgrass survey marker No. 1
Sound-side shrub No. 2	88° W. of N., 248 meters (813 feet) from planted American beachgrass survey marker No. 1
Sound-side shrub No. 3	92° E. of N., 73 meters (240 feet) from sound-side disturbed survey marker No. 1
Planted panic grass No. 1	11° W. of N., 114 meters (374 feet) from planted American beachgrass survey marker No. 1
Planted panic grass No. 2	40° W. of N., 123 meters (405 feet) from planted American beachgrass survey marker No. 1
Planted panic grass No. 3	59° W. of N., 173 meters (567 feet) from planted American beachgrass survey marker No. 1

Quadrat designation	Location
Sound-side disturbed No. 1	Due south 229 meters (750 feet) from USACE survey marker No. 64
Sound-side disturbed No. 2	143° E. of N., 84 meters (274 feet) from sound-side disturbed survey marker No. 1
Sound-side disturbed No. 3	178° W. of N., 86 meters (283 feet) from sound-side disturbed survey marker No. 1
Wetlands	144° W. of N., 70 meters (230 feet) from sound-side disturbed survey marker No. 1
Spurge-sandgrass	105° W. of N., 64 meters (210 feet) from USACE survey marker No. 13
Reed wetland	127° W. of N., 99 meters (325 feet) from USACE survey marker No. 64
Bulrush wetland	105° W. of N., 36 meters (118 feet) from sound-side disturbed survey marker No. 1
Roadside disturbed	0° N., 48 meters (158 feet) from planted American beachgrass survey marker No. 3
Interdunal marsh	87° E. of N., 33 meters (107 feet) from planted American beachgrass survey marker No. 3

APPENDIX B

PHYTOSOCIOLOGICAL DATA

Table B-1. Foredune community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Spartina patens	56.7	38.6	103.2	86.0
Panicum amarum	30.0	20.5	12.7	10.6
Ammophila breviligulata	20.0	13.6	3.7	3.1
Uniola paniculata	20.0	13.6	5.1	4.3
Solidago sempervirens	16.7	11.4	7.4	6.2
Myrica cerifera	3.3	2.3	0.83	0.69
Total			133.0	110.9

[1]Based on thirty 0.2-meter x 0.2-meter quadrats.

Table B-2. Foredune community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Spartina patens	50.0	34.1	121.1	100.9
Panicum amarum	36.7	25.0	23.2	19.3
Uniola paniculata	23.3	15.9	8.2	6.8
Solidago sempervirens	20.0	13.6	3.5	2.9
Ammophila breviligulata	16.7	11.4	11.8	9.8
Total			167.8	139.7

[1]Based on thirty 0.2-meter x 0.2-meter quadrats.

Table B-3. Foredune community data for the third sampling period (12 September 1981). [1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Panicum amarum	53.3	33.3	54.0	45.0
Spartina patens	53.3	33.3	148.7	123.9
Uniola paniculata	30.0	18.8	44.6	37.2
Ammophila breviligulata	23.3	14.6	25.6	21.3
Total			272.9	227.4

[1]Based on thirty 0.2-meter x 0.2-meter quadrats.

Table B-4. Foredune community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Spartina patens	53.3	36.6	13.4	11.2
Panicum amarum	33.3	23.3	161.3	134.4
Uniola paniculata	23.3	15.9	7.2	6.0
Ammophila breviligulata	23.3	15.9	4.5	3.7
Solidago sempervirens	10.0	6.8	19.7	16.4
Myrica cerifera	3.3	2.3	0.34	0.28
Total			206.1	172.0

[1]Based on thirty 0.2-meter x 0.2-meter quadrats.

Table B-5. Low dune grass community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Ammophila breviligulata	52.5	58.3	72.4	45.3
Erigeron canadensis var. *pusillus*	27.5	30.6	7.5	4.7
Cenchrus tribuloides	10.0	11.1	0.01	0.01
Total			79.9	50.0

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-6. Low dune grass community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Ammophila breviligulata	47.5	38.0	82.3	51.4
Erigeron canadensis var. *pusillus*	32.5	26.0	24.5	15.3
Euphorbia polygonifolia	20.0	16.0	0.98	0.61
Cenchrus tribuloides	17.5	14.0	3.5	2.2
Triplasis purpurea	5.0	4.0	0.01	0.01
Diodia teres	2.5	2.0	0.01	0.01
Total			111.3	69.5

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-7. Low dune grass community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	70.0	35.4	84.0	52.5
Erigeron canadensis var. *pusillus*	55.0	27.8	44.8	28.0
Ammophila breviligulata	42.5	21.5	105.2	65.8
Diodia teres	12.5	6.3	2.4	1.5
Cenchrus tribuloides	7.5	4.0	0.92	0.58
Eragrostis elliottii	5.0	2.5	0.10	0.06
Euphorbia polygonifolia	5.0	2.5	0.30	0.19
Total			237.7	148.6

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-8. Low dune grass community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Ammophila breviligulata	57.5	33.8	174.2	108.8
Triplasis purpurea	52.5	30.9	52.1	32.6
Erigeron canadensis var. *pusillus*	42.5	25.0	32.3	20.2
Europhorbia polygonifolia	7.5	4.4	0.25	0.16
Cenchrus tribuloides	5.0	2.9	0.67	0.42
Diodia teres	2.5	1.5	0.06	0.04
Eragrostis elliottii	2.5	1.5	0.08	0.05
Total			259.7	162.3

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-9. Oceanside intershrub community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	16.9	25.6	9.1	3.5
Heterotheca gossypina	16.9	25.6	3.9	1.5
Uniola paniculata	13.8	20.9	7.9	3.0
Erigeron canadensis var. *pusillus*	7.7	11.6	3.2	1.2
Cenchrus tribuloides	4.6	7.0	0.05	0.02
Oenothera humifusa	4.6	7.0	0.75	0.29
Opuntia compressa	1.5	2.3	0.96	0.36
Total			25.9	9.9

[1]Based on sixty-five 0.2-meter x 0.2-meter quadrats.

Table B-10. Oceanside intershrub community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	44.6	38.7	7.5	2.9
Cyperus ovularis	20.0	17.3	3.5	1.4
Euphorbia polygonifolia	13.8	12.0	2.0	0.77
Uniola paniculata	10.8	9.3	27.6	10.6
Erigeron canadensis var. *pusillus*	10.8	9.3	3.7	1.4
Heterotheca gossypina	6.2	5.3	11.1	0.38
Oenothera humifusa	4.6	4.0	0.35	1.5
Cenchrus tribuloides	4.6	4.0	0.20	0.08
Total			55.9	19.0

[1]Based on sixty-five 0.2-meter x 0.2-meter quadrats.

Table B-11. Oceanside intershrub community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	52.3	33.3	15.8	6.1
Cyperus ovularis	35.4	22.5	7.3	2.8
Heterotheca gossypina	26.2	16.7	87.7	33.7
Euphorbia polygonifolia	13.8	8.8	1.8	0.69
Uniola paniculata	9.2	5.9	9.0	3.5
Erigeron canadensis var. *pusillus*	7.7	4.9	0.8	0.31
Eragrostis elliottii	6.2	3.9	7.1	2.7
Oenothera humifusa	4.6	2.9	0.3	0.12
Cenchrus tribuloides	1.5	1.0	0.1	0.04
Total			129.9	50.0

[1]Based on sixty-five 0.2-meter x 0.2-meter quadrats.

Table B-12. Oceanside intershrub community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	47.7	32.0	45.8	17.6
Heterotheca gossypina	44.6	29.9	76.6	29.5
Cyperus ovularis	10.8	7.2	0.21	0.08
Eragrostis elliottii	9.2	6.2	9.4	3.8
Oenothera humifusa	9.2	6.2	1.2	0.47
Uniola paniculata	7.7	5.2	5.1	2.0
Euphorbia polygonifolia	7.7	5.2	0.02	0.01
Erigeron canadensis var. *pusillus*	4.6	3.1	0.20	0.08
Cenchrus tribuloides	4.6	3.1	0.02	0.01
Opuntia compressa	3.1	2.1	2.4	0.91
Total			140.8	54.4

[1]Based on sixty-five 0.2-meter x 0.2-meter quadrats.

Table B-13. Planted bitter panicum-planted American beachgrass community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Erigeron canadensis var. *pusillus*	36.3	67.4	91.6	28.6
Panicum virgatum	11.3	20.9	36.2	11.30
Oenothera humifusa	2.5	4.7	0.33	0.10
Uniola paniculata	2.5	4.7	0.91	0.28
Ammophila breviligulata	1.2	2.3	0.10	0.03
Total			129.1	40.3

[1]Based on eighty 0.2-meter x 0.2-meter quadrats.

Table B-14. Planted bitter panicum-planted American beachgrass community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Erigeron canadensis var. *pusillus*	43.8	62.5	181.2	56.6
Panicum virgatum	16.3	23.2	119.4	37.3
Cyperus ovularis	6.3	8.9	1.3	0.40
Uniola paniculata	1.3	1.8	1.3	0.39
Oenothera humifusa	1.3	1.8	0.09	0.03
Heterotheca gossypina	1.3	1.8	0.61	0.19
Total			302.5	94.9

[1]Based on eighty 0.2-meter x 0.2-meter quadrats.

Table B-15. Planted bitter panicum-planted American beachgrass community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Erigeron canadensis var. *pusillus*	38.8	63.3	199.2	62.3
Panicum virgatum	12.5	20.4	249.1	77.8
Cyperus ovularis	3.8	6.1	1.2	0.38
Triplasis purpurea	3.8	6.1	2.2	0.69
Oenothera humifusa	1.3	2.0	0.01	--
Uniola paniculata	1.3	2.0	1.3	0.40
Total			453.0	141.6

[1]Based on eighty 0.2-meter x 0.2-meter quadrats.

Table B-16. Planted bitter panicum-planted American beachgrass community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Erigeron canadensis var. *pusillus*	63.8	51.0	172.1	53.8
Panicum virgatum	21.3	17.0	272.3	85.1
Triplasis purpurea	13.8	11.0	13.7	4.3
Eragrostis elliottii	11.3	9.0	3.2	1.0
Uniola paniculata	8.8	7.0	2.2	0.68
Oenothera humifusa	6.3	5.0	1.1	0.35
Total			464.6	145.2

[1]Based on eighty 0.2-meter x 0.2-meter quadrats.

Table B-17. Reed wetland community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Phragmites communis	80.0	50.0	169.7	424.1
Juncus coriaceus	40.0	25.0	5.5	13.7
Spartina alterniflora	40.0	25.0	1.5	3.8
Total			176.7	441.6

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-18. Reed wetland community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Phragmites communis	80.0	100.0	337.6	844.1
Total			337.6	844.1

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-19. Reed wetland community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Phragmites communis	90.0	100.0	399.8	999.6
Total			399.8	999.6

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-20. Reed wetland community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Phragmites communis	30.0	100.0	22.1	55.3
Total			22.1	55.3

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-21. Roadside disturbed community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	72.5	49.2	74.4	46.5
Erigeron canadensis var. *pusillus*	52.5	35.6	69.5	43.4
Oenothera humifusa	17.5	11.9	3.6	2.3
Cenchrus tribuloides	5.0	3.4	0.01	0.01
Total			147.5	92.2

[1]Based on forty 0.2-meter x 0.2-meter quadrat.

Table B-22. Roadside disturbed community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	[illegible] (grams)	[illegible]
Erigeron canadensis var. *pusillus*	77.5	57.4	71.9	44.9
Ammophila breviligulata	25.0	18.5	51.9	32.4
Cenchrus tribuloides	10.0	7.4	2.4	1.5
Oenothera humifusa	10.0	7.4	1.0	0.63
Diodia teres	5.0	3.7	0.03	0.02
Opuntia compressa	5.0	3.7	3.1	2.0
Triplasis purpurea	2.5	1.9	0.02	0.01
Total			130.3	81.5

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-23. Roadside disturbed community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total [illegible]	[illegible]
Triplasis purpurea	80.0	40.5	[illegible]	
Erigeron canadensis var. *pusillus*	45.0	22.8	44.4	23.7
Oenothera humifusa	30.0	15.2	14.3	8.5
Eragrostis elliottii	15:0	7.6	23.9	14.9
Cyperus ovularis	12.5	6.3	1.8	1.1
Cenchrus tribuloides	10.0	5.1	1.8	1.1
Digitaria sp.	5.0	2.5	0.8	0.5
Total			169.1	105.7

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-24. Roadside disturbed community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	77.5	52.5	79.3	49.6
Erigeron canadensis var. *pusillus*	40.0	27.1	17.1	10.7
Diodia teres	7.5	5.1	0.15	0.09
Cenchrus tribuloides	7.5	5.1	1.2	0.75
Oenothera humifusa	5.0	3.4	0.61	0.38
Ammophila breviligulata	5.0	3.4	2.0	1.2
Digitaria sp.	5.0	3.4	1.7	1.1
Total			102.1	63.8

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-25. Bulrush wetland community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Cyperaceae[2]	100.0	58.9	42.5	105.6
Hydrocotyle umbellata	20.0	11.7	0.10	0.25
Juncus spp.[3]	20.0	11.7	2.8	7.0
Sagittaria falcata	20.0	11.7	3.5	8.8
Lilaeopsis chinensis	10.0	5.8	0.25	0.63
Total			49.1	122.3

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

[2]*Cyperaceae* ~ 60 percent *Scirpus americanus*, 40 percent *Cyperus strigosus*.

[3]*Juncus spp.* ~ 80 percent *J. coreacius*, 20 percent *J. megacephalus*.

Table B-26. Bulrush wetland community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Cyperaceae	100.0	43.4	65.8	164.4
Spartina alterniflora	40.0	17.4	13.2	32.9
Juncus coriaceus	30.0	13.0	1.3	3.3
Boltonia asteroides	20.0	8.7	15.8	39.5
Helenium autumnalis	10.0	4.3	7.6	19.5
Hydrocotyle umbellata	10.0	4.3	0.02	0.05
Lobelia elongata	10.0	4.3	2.0	4.9
Sagittaria falcata	10.0	4.3	2.7	6.8
Total			108.3	270.8

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-27. Bulrush wetland community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Cyperaceae	90.0	36.0	132.0	329.9
Boltonia asteroides	30.0	12.0	19.2	48.1
Juncus coriaceus	30.0	12.0	0.71	1.8
Spartina alterniflora	30.0	12.0	68.0	170.0
Lythrum lineare	20.0	8.0	0.70	1.8
Pluchea purpurascens	20.0	8.0	0.20	0.50
Hydrocotyle umbellata	10.0	4.0	0.02	0.05
Helenium autumnalis	10.0	4.0	10.4	25.9
Sium suave	10.0	4.0	4.8	11.9
Total			235.9	589.9

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-28. Bulrush wetland community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Cyperus spp.	90.0	30.0	29.7	74.3
Boltonia asteroides	50.0	16.7	21.7	53.1
Juncus coriaceus	40.0	13.3	0.52	1.3
Spartina alterniflora	30.0	10.0	73.2	183.0
Lythrum lineare	20.0	6.7	0.10	0.25
Pluchea purpurascens	20.0	6.7	0.11	0.28
Hydrocotyle umbellata	10.0	3.3	0.07	0.18
Helenium autumnalis	10.0	3.3	15.7	39.3
Sium suave	10.0	3.3	1.2	3.1
Eryngium aquaticum	10.0	3.3	3.3	8.2
Lobelia elongata	10.0	3.3	2.1	5.1
Total			147.7	368.1

[1]Based on ten 0.2-meter x 0.2-meter quadrats.

Table B-29. Sandgrass-buttonweed community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Erigeron canadensis var. *pusillus*	83.6	51.0	97.3	44.2
Panicum amarum	70.9	43.3	109.0	49.6
Uniola paniculata	3.6	2.2	0.96	0.44
Heterotheca gossypina	1.8	1.1	0.01	--
Opuntia compressa	1.8	1.1	1.2	0.55
Ammophila breviligulata	1.8	1.1	0.01	--
Total			208.5	94.8

[1]Based on fifty-five 0.2-meter x 0.2-meter quadrats.

Table B-30. Sandgrass-buttonweed community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Erigeron canadensis var. *pusillus*	81.8	49.5	197.3	89.7
Panicum amarum	70.9	42.9	152.4	69.3
Eragrostis elliottii	5.5	3.3	1.6	0.73
Uniola paniculata	5.5	3.3	2.0	0.91
Heterotheca gossypina	1.8	1.1	0.20	0.09
Total			353.5	160.7

[1]Based on fifty-five 0.2-meter x 0.2-meter quadrats.

Table B-31. Sandgrass-buttonweed community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Panicum amarum	63.6	46.7	139.2	63.3
Erigeron canadensis var. *pusillus*	61.8	45.3	145.9	66.3
Triplasis purpurea	7.3	5.3	12.1	5.5
Eragrostis elliottii	1.8	1.3	2.3	1.1
Uniola paniculata	1.8	1.3	1.0	0.45
Total			300.5	136.6

[1]Based on fifty-five 0.2-meter x 0.2-meter quadrats.

Table B-32. Sandgrass-buttonweed community data for the fourth sampling period (6 November 1981).[1]

		Relative frequency	Total weight (grams)	Grams per square meter
Panicum amarum	76.4	37.5	115.4	52.4
	52.7	25.8	72.3	32.4
Triplasis purpurea	43.6	21.4	37.0	16.8
Eragrostis elliottii	25.5	12.5	7.4	3.4
Uniola paniculata	5.5	2.7	4.7	2.1
Total			236.8	107.6

[1]Based on fifty-five 0.2-meter x 0.2-meter quadrats.

Table B-33. Sound-side disturbed-herbaceous community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
	34.4	52.2	2.1	1.5
	17.1	26.1	3.2	2.3
Oenothera humifusa	8.6	13.0	0.90	0.64
Euphorbia polygoniflora	2.9	4.3	0.03	0.02
Eragrostis elliottii	2.9	4.3	0.04	0.03
			6.2	4.4

[1]Based on thirty-five 0.2-meter x 0.2-meter quadrats.

Table B-34. Sound-side disturbed-herbaceous community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	48.6	43.6	10.2	7.3
Heterotheca gossypina	20.0	17.9	6.5	4.7
Euphorbia polygoniflora	20.0	17.9	0.97	0.69
Diodia teres	8.6	7.7	0.62	0.44
Croton glandulosa var. *septentrionalis*	5.7	5.1	1.0	0.72
Digitaria sp.	2.9	2.6	0.13	0.29
Oenothera humifusa	2.9	2.6	0.40	0.29
Monarda punctata	2.9	2.6	0.96	0.69
Total			20.8	14.9

[1]Based on thirty-five 0.2-meter x 0.2-meter quadrats.

Table B-35. Sound-side disturbed-herbaceous community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	54.2	50.0	11.9	8.5
Digitaria sp.	25.7	23.7	20.8	14.9
Cyperus ovularis	17.1	15.8	0.50	0.36
Heterotheca gossypina	11.4	10.5	8.8	6.3
Eragrostis elliottii	8.6	7.9	9.5	6.8
Euphorbia polygoniflora	5.7	5.3	0.20	0.14
Panicum amarum	5.7	5.3	0.80	0.57
Croton glandulosus var. *septentrionalis*	2.9	2.6	1.3	0.93
Diodia teres	2.9	2.6	0.40	0.29
Oenothera humifusa	2.9	2.6	3.5	2.50
Total			57.7	41.2

[1]Based on thirty-five 0.2-meter x 0.2-meter quadrats.

Table B-36. Sound-side disturbed-herbaceous community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	65.7	56.1	13.7	9.8
Digitaria sp.	20.0	17.0	11.8	8.4
Heterotheca gossypina	8.6	7.3	4.5	3.2
Eragrastis elliottii	8.6	7.3	3.5	2.5
Croton glandulosa var. *septentrionalis*	5.7	4.9	2.1	1.5
Diodia teres	2.9	2.4	0.02	0.01
Euphorbia polygonifolia	2.9	2.4	0.40	0.29
Oenothera humifusa	2.9	2.4	0.60	0.43
Total			36.6	26.1

[1]Based on thirty-five 0.2-meter x 0.2-meter quadrats.

Table B-37. Sound-side disturbed-shrub community data for the first sampling period (25 May 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Spartina patens	37.8	36.2	11.2	6.2
Juncus megacephalus	20.0	19.1	1.3	0.73
Solidago sempervirens	11.1	10.6	2.0	1.1
Achillea millefolium	11.1	10.6	1.2	0.68
Erigeron canadensis var. *pusillus*	11.1	10.6	3.7	2.1
Ammophila breviligulata	6.7	6.4	1.7	0.93
Hieracium gronovii	2.2	2.1	0.29	0.16
Fimbristylis spadicea	2.2	2.1	0.08	0.04
Cyperus ovularis	2.2	2.1	0.02	0.01
Total			21.5	12.0

[1]Based on forty-five 0.2-meter x 0.2-meter quadrats.

Table B-38. Sound-side disturbed-shrub community data for the second sampling period (20 July 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Spartina patens	44.4	21.1	32.1	17.8
Andropogon virginicus	28.9	13.7	16.2	9.0
Erigeron canadensis var. pusillus	24.4	11.6	11.2	6.2
Panicum fusiforme	24.4	11.6	3.7	2.1
Juncus megacephalus	20.0	9.4	2.4	1.3
Achillea millefolium	15.6	7.4	2.0	1.1
Solidago sempervirens	15.6	7.4	6.8	3.8
Fimbristylis spadicea	11.1	5.3	1.0	0.57
Ammophila breviligulata	8.9	4.2	4.5	2.5
Hieracium gronovii	4.4	2.1	1.0	0.57
Cyperus ovularis	4.4	2.1	0.17	0.09
Eupatorium hyssopifolium	2.2	1.1	0.94	0.52
E. serotinum	2.2	1.1	1.3	0.69
Triplasis purpurea	2.2	1.1	0.05	0.03
Eragrostis spp.	2.2	1.1	0.05	0.03
Total			83.4	46.3

[1]Based on forty-five 0.2-meter x 0.2-meter quadrats.

Table B-39. Sound-side disturbed-shrub community data for the third sampling period (12 September 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Panicum fusiforme	40.0	15.3	16.3	9.1
Spartina patens	40.0	15.3	26.8	14.1
Andropogon virginicus	33.3	12.8	25.6	14.2
Eragrostis spectabilis	28.8	11.1	4.8	2.7
Erigeron canadensis var. *pusillus*	22.2	8.5	6.9	3.8
Juncus megacephalus	20.0	7.6	2.9	1.6
Ammophila breviligulata	15.5	5.9	27.6	15.3
Solidago sempervirens	15.5	5.9	2.0	1.1
Achillea millefolium	1.1	4.2	1.9	1.1
Eragrostis elliottii	8.8	3.4	4.4	2.4
Fimbristylis spadicea	6.6	2.5	0.50	0.28
Eupatorium hyssopifolium	4.4	1.7	12.4	6.9
Hieracium gronovii	4.4	1.7	0.70	0.39
Cyperus ovularis	2.2	0.80	0.10	0.06
Desmodium strictum	2.2	0.80	0.02	0.01
Eupatorium serotinum	2.2	0.80	2.2	1.2
Triplasis purpurea	2.2	0.80	1.4	0.78
Total			136.5	75.8

[1]Based on forty-five 0.2-meter x 0.2-meter quadrats.

Table B-40. Sound-side disturbed-shrub community data for the fourth sampling period (6 November 1981).[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Panicum fusiforme	46.7	17.5	31.8	17.7
Spartina patens	44.4	16.7	42.0	23.3
Andropogon virginicus	44.4	16.7	23.1	12.9
Eragrostis spectabilis	37.8	14.2	6.5	3.6
Ammophila breviligulata	20.0	7.5	11.7	6.5
Eragrostis elliottii	17.8	6.7	5.4	3.0
Fimbristylis spadicea	17.8	6.7	1.3	0.74
Juncus megacephalus	15.6	5.8	0.95	0.53
Hierachium gronovii	11.1	4.2	1.1	0.62
Solidago sempervirens	4.4	1.7	3.5	2.0
Triplasis purpurea	4.4	1.7	0.77	0.43
Erigeron canadensis var. *pusillus*	2.2	0.8	0.17	0.09
Total			128.4	71.3

[1]Based on forty-five 0.2-meter x 0.2-meter quadrats.

Table B-41. Sandgrass community data sampled in November 1981.[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Triplasis purpurea	77.5	88.6	133.4	83.4
Diodia teres	5.0	5.7	0.11	0.07
Ammophila breviligulata	2.5	2.9	0.28	0.18
Oenothera humifusa	2.5	2.9	0.02	0.01
Total			133.8	83.6

[1]Based on forty 0.2-meter x 0.2-meter quadrats.

Table B-42. Interdunal marsh community data sampled in November 1981.[1]

Species	Frequency (percent)	Relative frequency (percent)	Total weight (grams)	Grams per square meter
Digitaria sp.	80.0	47.1	39.3	49.1
Cyperus ovularis	65.0	38.2	7.8	9.8
Triplasis purpurea	15.0	8.8	3.7	4.6
Heterotheca gossypina	5.0	2.9	0.5	0.63
Spartina patens	5.0	2.9	1.3	1.6
Total			52.6	65.8

[1]Based on twenty 0.2-meter x 0.2-meter quadrats.

Table B-43. Oceanside shrub community data sampled 24 August 1981.[1]

Species	Frequency (percent)	Relative frequency (percent)	Density
Myrica cerifera	100.0	16.7	25.2
Phytolacca americana	80.0	13.3	--
Solidago sempervirens	60.0	10.0	--
Prunus serotina	40.0	6.7	0.20
Melothria	40.0	6.7	--
Solanum	40.0	6.7	--
Rubus betulifolius	40.0	6.7	--
Physalis	40.0	6.7	--
Smilax bona-nox	20.0	3.3	--
Parthenocissus quinquefolia	20.0	3.3	--
Baccharis halimifolia	20.0	3.3	1.0
Uniola paniculata	20.0	3.3	--
Eragrostis elliottii	20.0	3.3	--
Chenopodium ambrosioides	20.0	3.3	--
Ammophila breviligulata	20.0	3.3	--
Spartina patens	20.0	3.3	--

[1]Based on five 4.5-meter diameter circular quadrats.

Table B-44. Sound-side shrub community data sampled 24 August 1981.[1]

Species	Frequency (percent)	Relative frequency (percent)	Density
Prunus serotina	100.0	13.2	4.0
Rhus radicans	80.0	10.5	--
Smilax bona-nox	80.0	10.5	--
Vitis aestivals	80.0	10.5	--
Parthenocissus quinquefolia	60.0	7.9	--
Rhus copallina	60.0	7.9	0.20
Rubus betulifolia	60.0	7.9	--
Diospyros virginiana	40.0	5.3	0.60
Erigron canadensis var. *pusillus*	40.0	5.3	--
Solidago sempervirens	40.0	5.3	--
Achillea millefolium	20.0	2.6	--
Baccharis halimifolia	20.0	2.6	--
Galium hispidulum	20.0	2.6	--
Lonicera japonica	20.0	2.6	--
Pyropappus caroliniana	20.0	2.6	--
Salix nigra	20.0	2.6	0.80

[1]Based on five 4.5-meter diameter circular quadrats.

APPENDIX C

VEGETATIVE PATTERNS

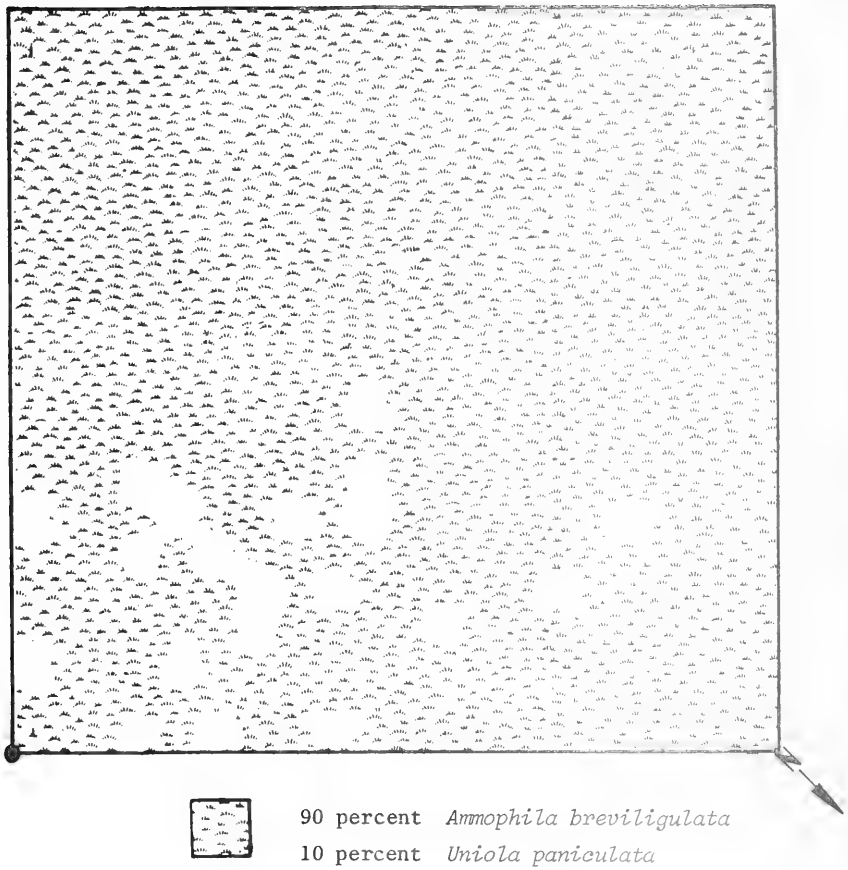
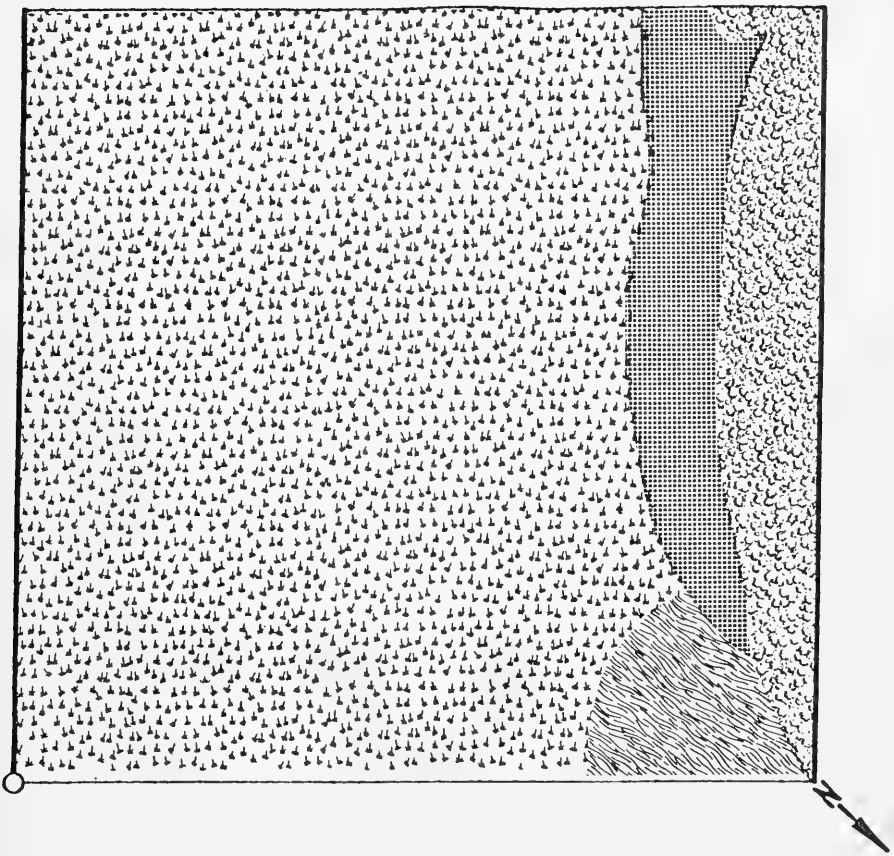


Figure C-1. Foredune community permanent quadrat 1 (Levy, 1976).



Myrica cerifera

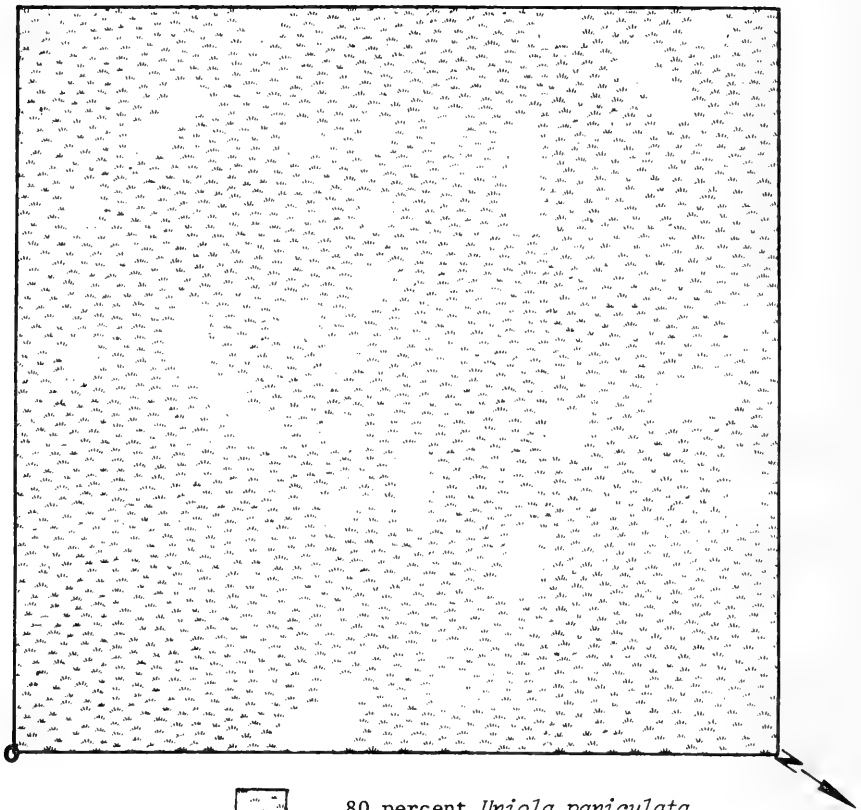
Physalis viscosa ssp. *maritima*

Solidago sempervirens

50 percent *Spartina patens*
25 percent *Physalis viscosa* ssp. *maritima*
25 percent *Uniola paniculata*

Total ground cover - 75 percent

Figure C-2. Foredune community permanent quadrat 1.

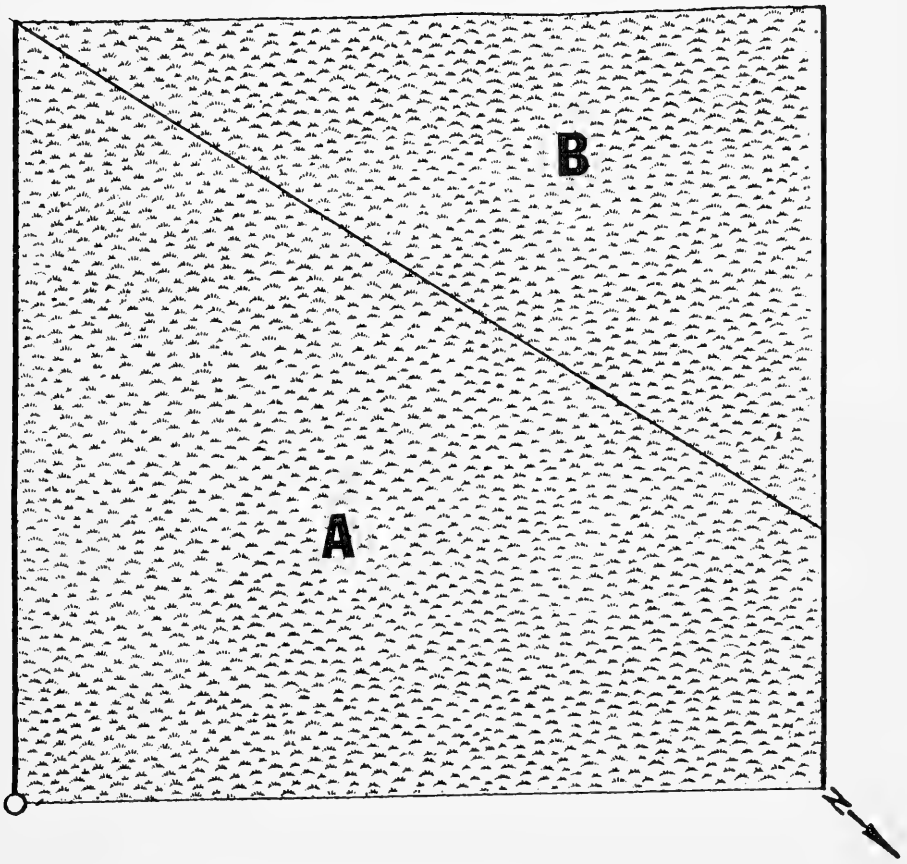


80 percent *Uniola paniculata*

20 percent *Panicum amarum*

Total ground cover - 90 percent

Figure C-3. Foredune community permanent quadrat 2 (Levy, 1976).



A — 60 percent *Uniola paniculata*
40 percent *Panicum amarum*

B — 70 percent *Panicum amarum*
20 percent *Uniola paniculata*
10 percent *Smilax bona-nox*

Total ground cover - 72 percent

Figure C-4. Foredune community permanent quadrat 2.

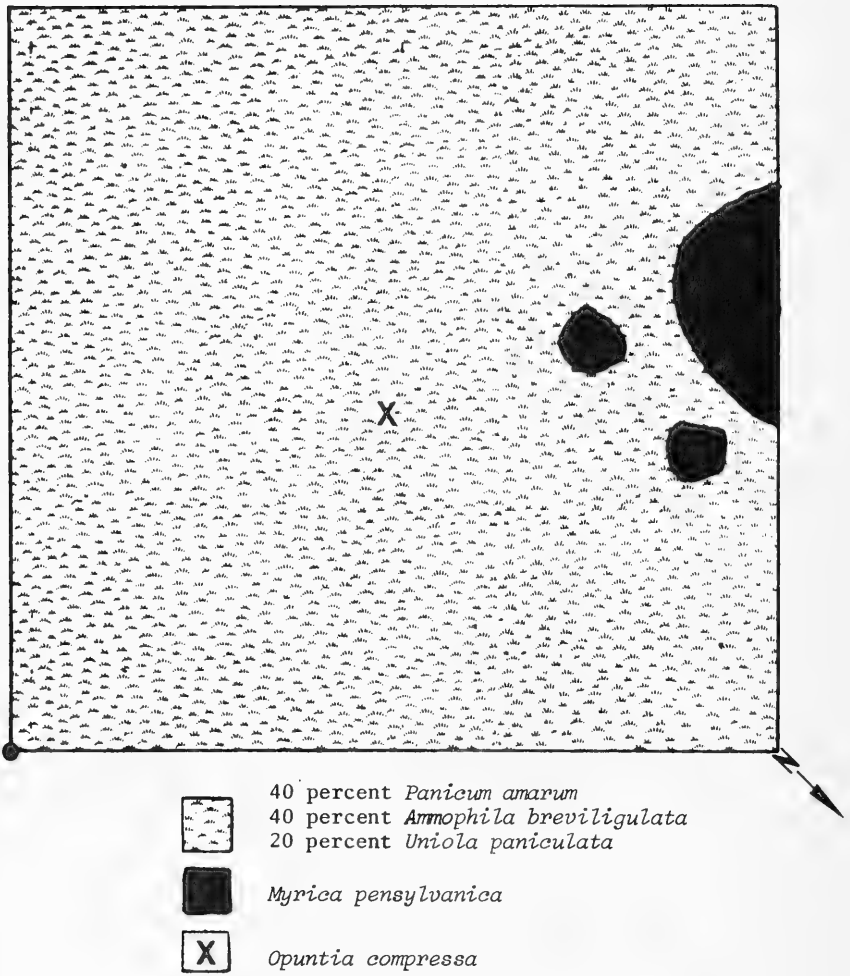
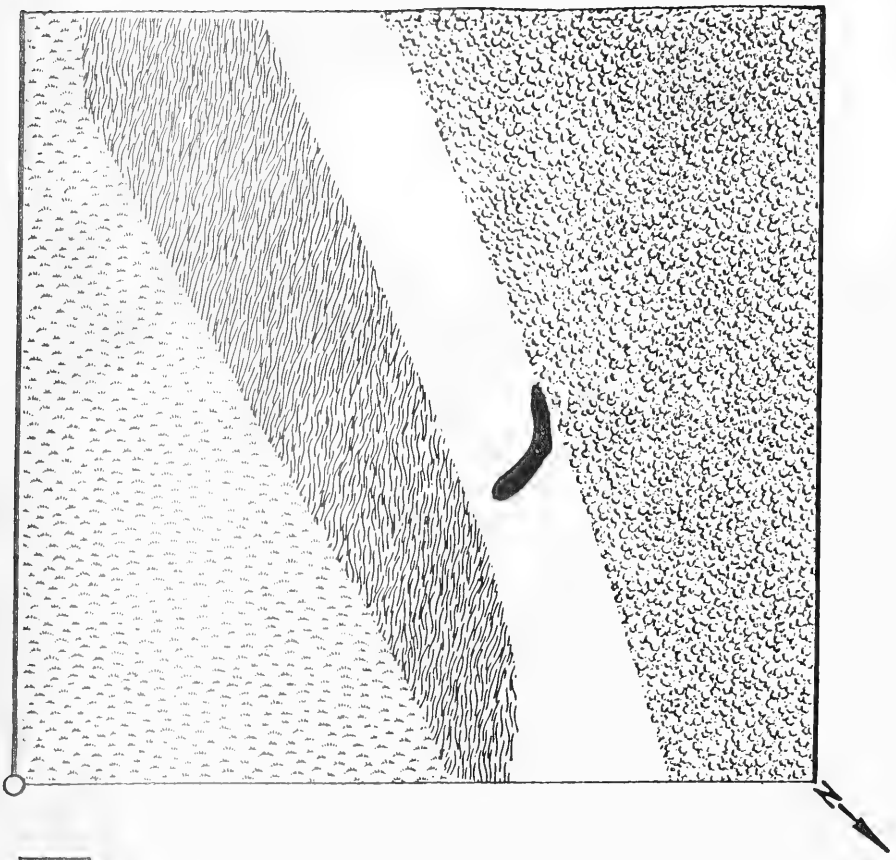


Figure C-5. Foredune community permanent quadrat 3 (Levy, 1976).



Opuntia compressa

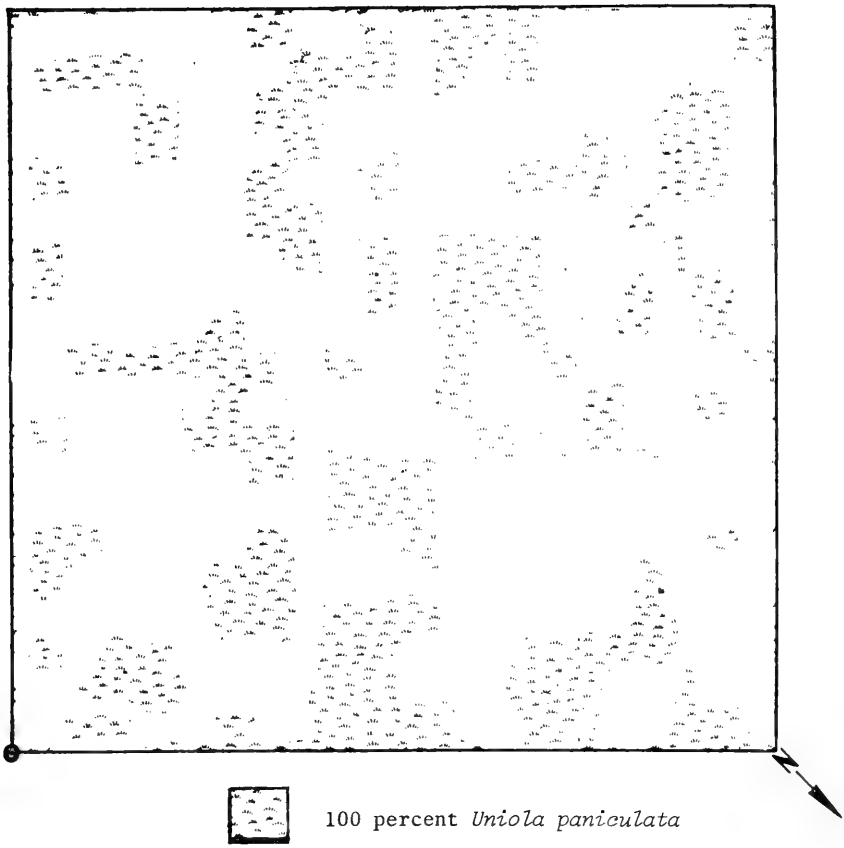
70 percent *Uniola paniculata*
30 percent *Solidago sempervirens*

90 percent *Solidago sempervirens*
5 percent *Ammophila breviligulata*
5 percent *Myrica cerifera*

50 percent *Myrica cerifera*
40 percent *Solidago sempervirens*
5 percent *Ammophila breviligulata*
5 percent *Spartina patens*

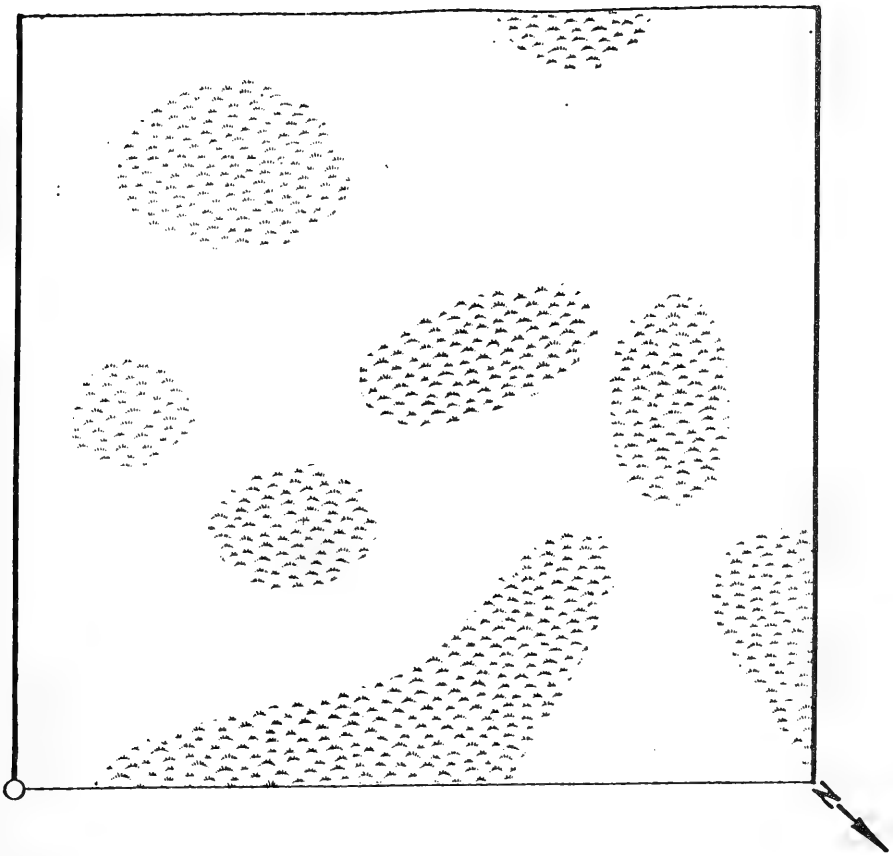
Total ground cover - 55 percent

Figure C-6. Foredune community permanent quadrat 3.



Total ground cover - 35 percent

Figure C-7. Low dune grass community permanent quadrat 1 (Levy, 1976).

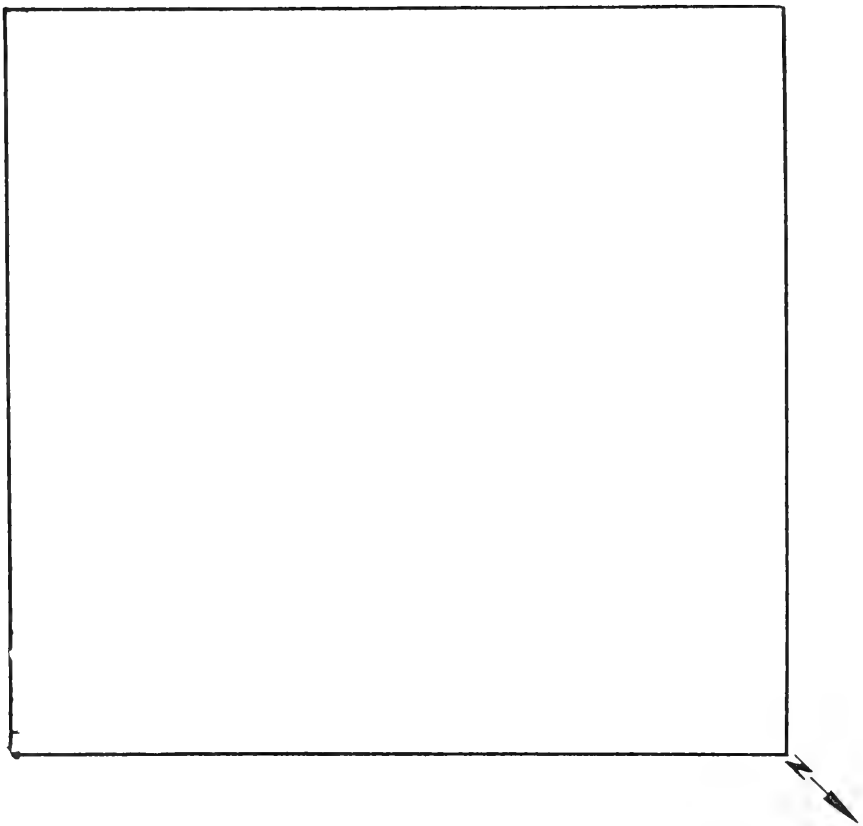


Panicum virgatum

40 percent *Uniola paniculata*
40 percent *Ammophila breviligulata*
20 percent *Eragrostis elliottii*

Total ground cover - 25 percent

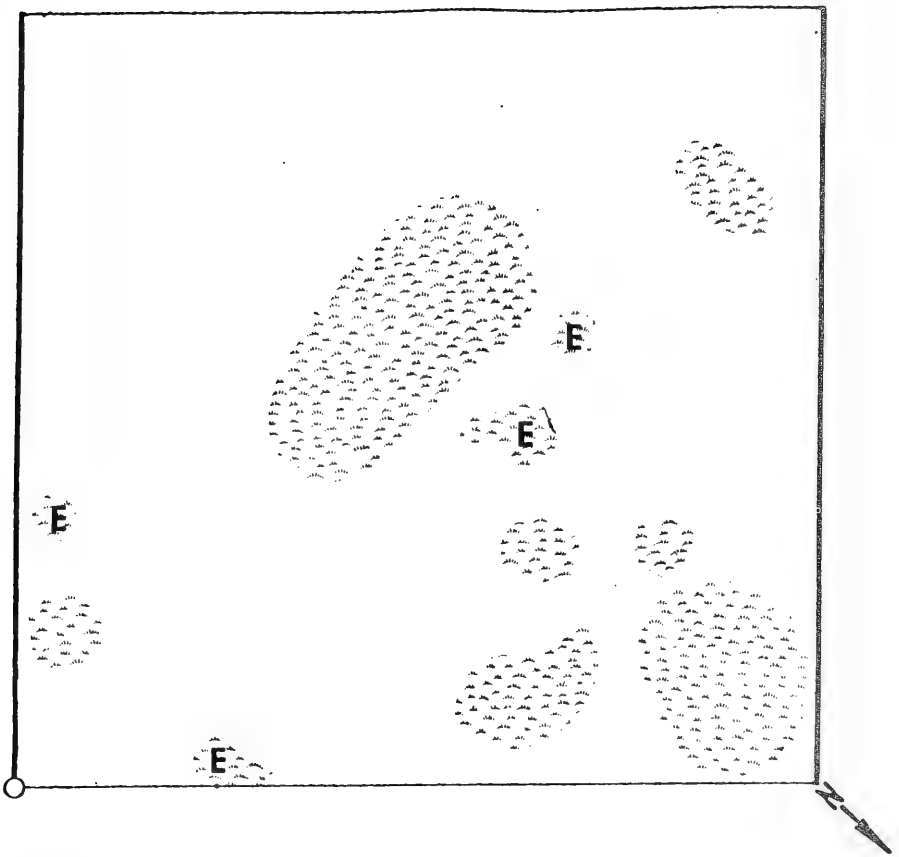
Figure C-8. Low dune grass community permanent quadrat 1.



Void of vegetation

Total ground cover - 0 percent

Figure C-9. Low dune grass community permanent quadrat 2 (Levy, 1976).



E *Eragrostis elliottii*

Panicum virgatum

70 percent *Erigeron canadensis* var. *pusillus*
20 percent *Carex alata*
10 percent *Oenothera humifusa*

Total ground cover - 20 percent

Figure C-10. Low dune grass community permanent quadrat 2.

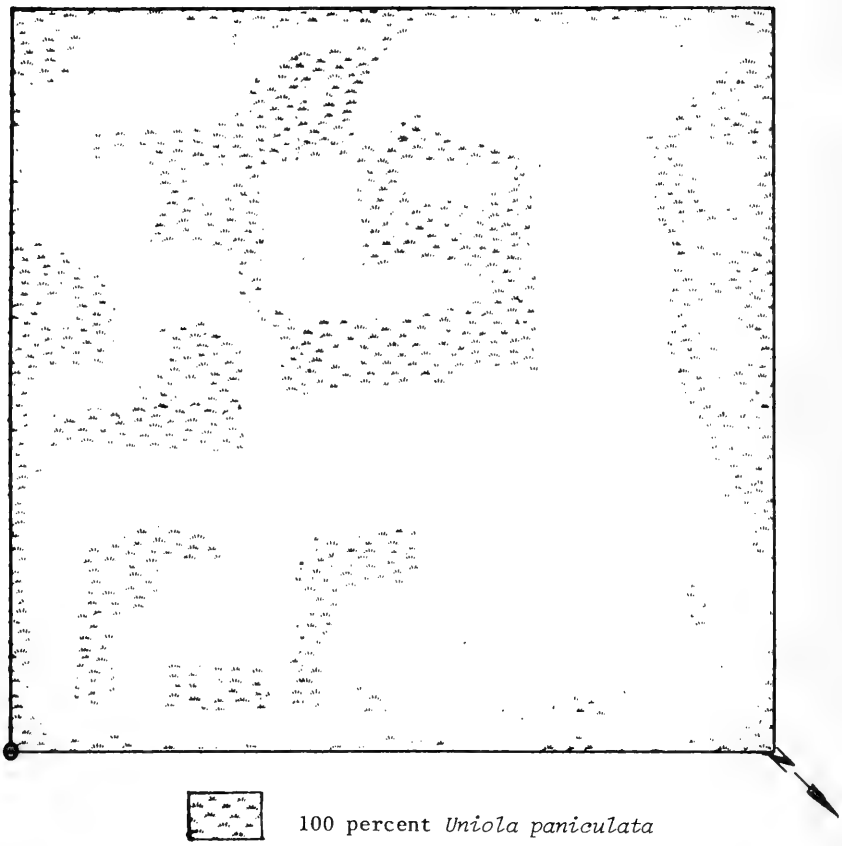
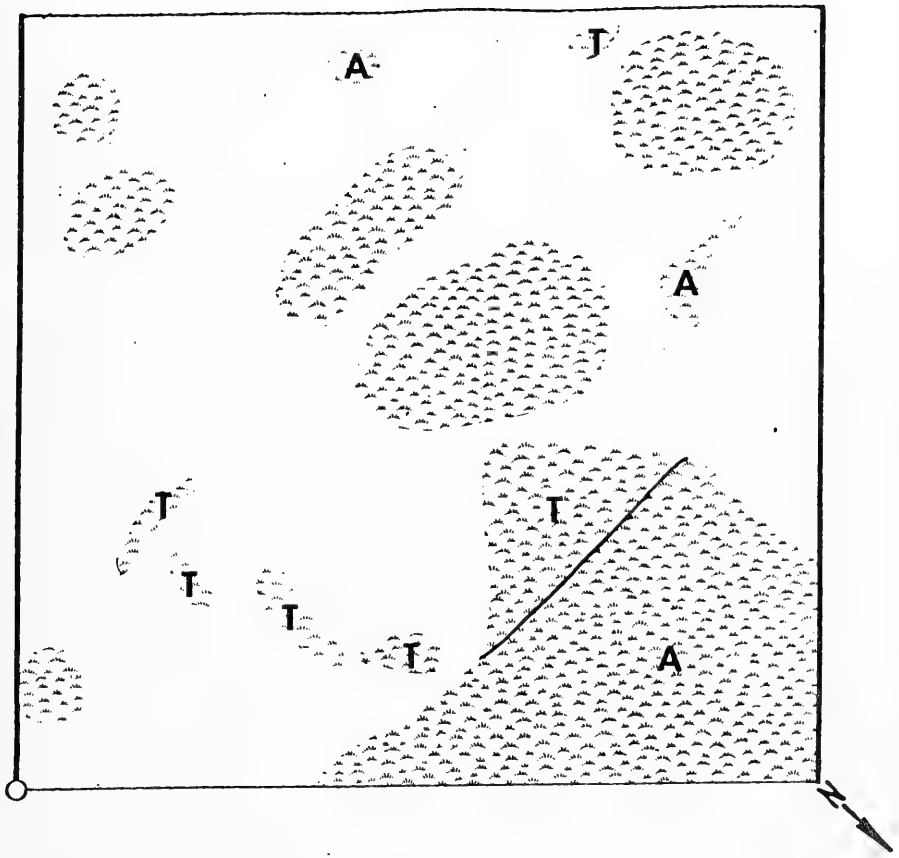


Figure C-11. Low dune grass community permanent quadrat 3 (Levy, 1976).



A *Ammophila breviligulata*

Panicum virgatum

T *Triplasis purpurea*

Erigeron canadensis var. *pusillus*

Total ground cover - 30 percent

Figure C-12. Low dune grass community permanent quadrat 3.

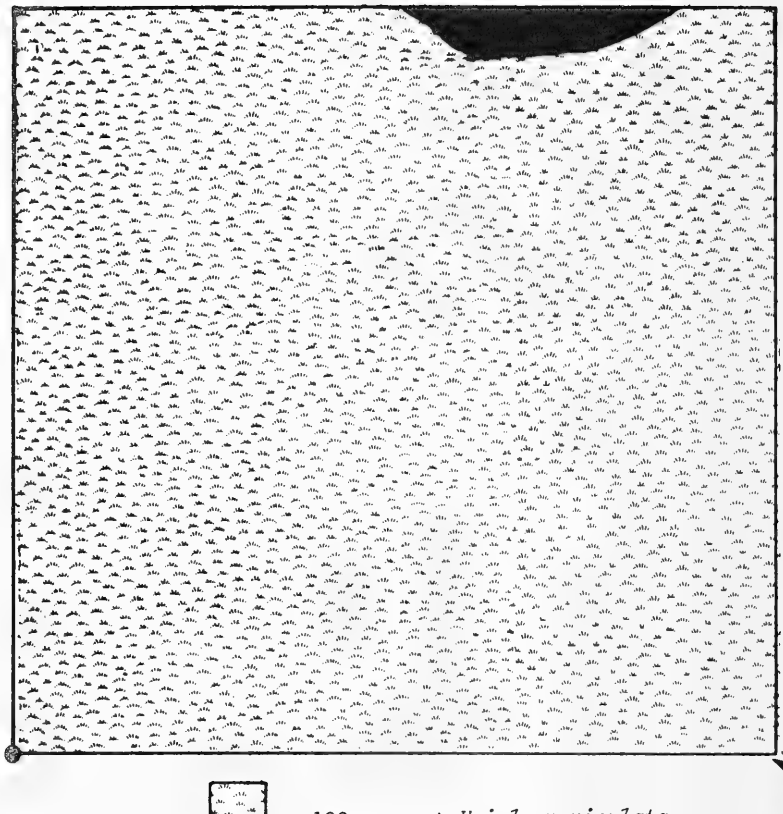
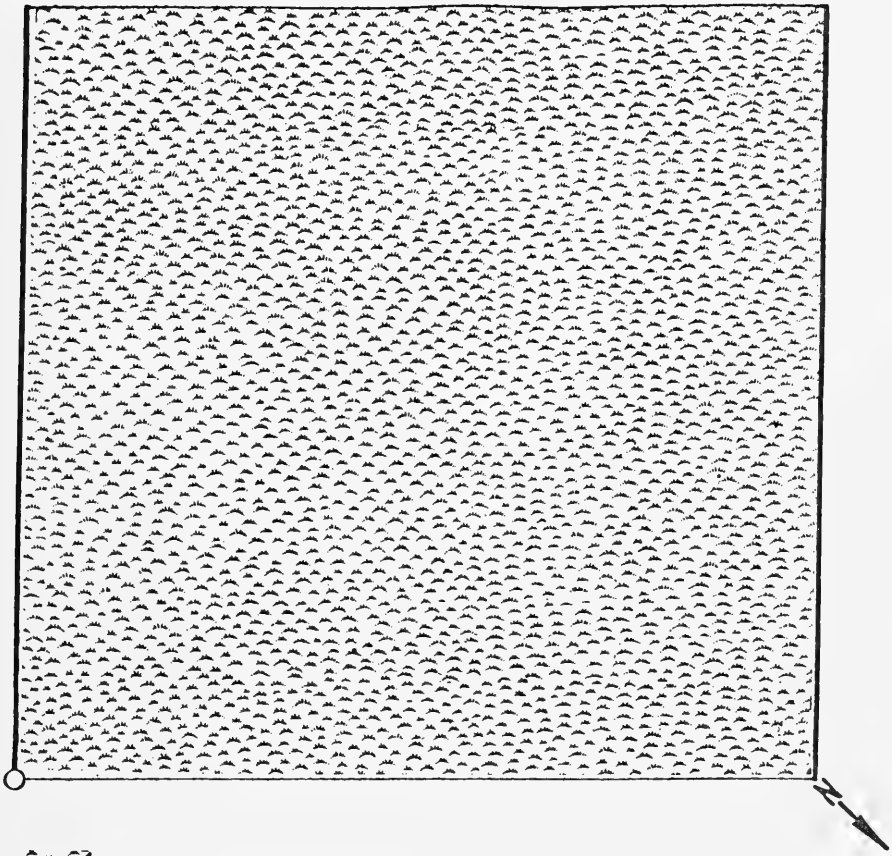


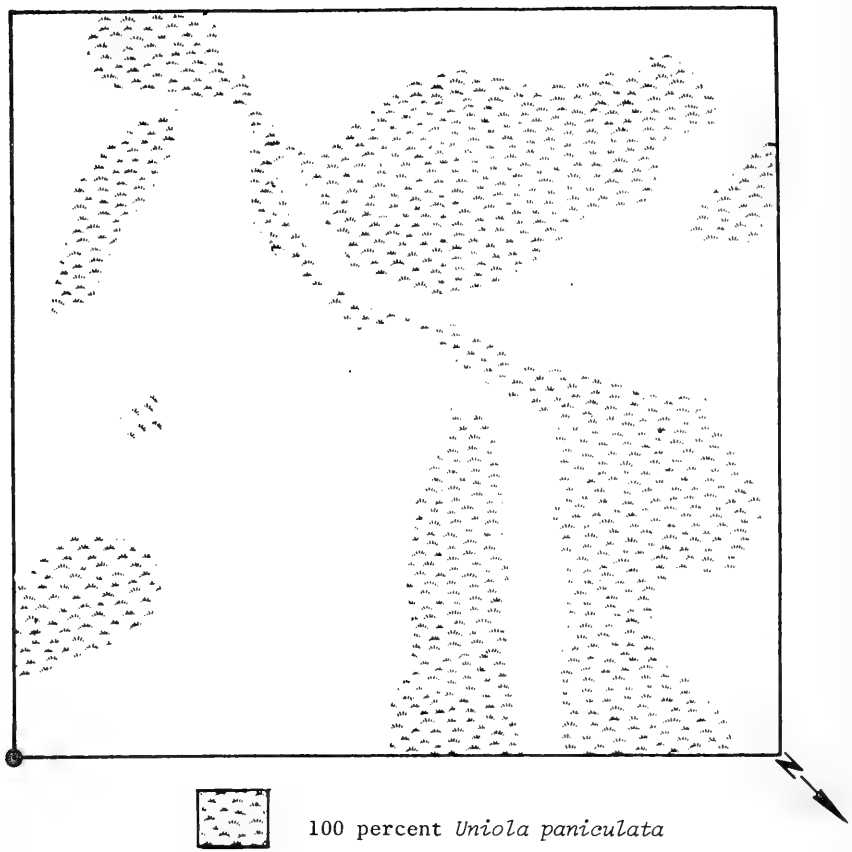
Figure C-13. Oceanside intershrub community permanent quadrat 1 (Levy, 1976).



90 percent *Panicum amarum*
10 percent *Spartina patens*

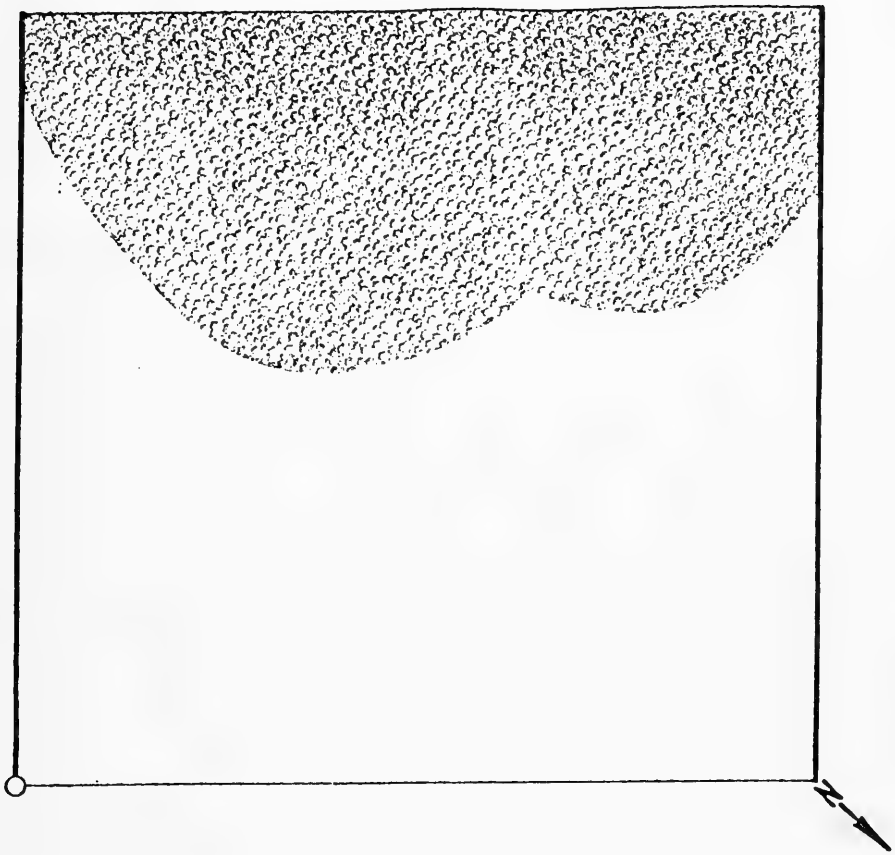
Total ground cover - 75 percent

Figure C-14. Oceanside intershrub community permanent quadrat 1.



Total ground cover - 40 percent

Figure C-15. Oceanside intershrub community permanent quadrat 2 (Levy, 1976).

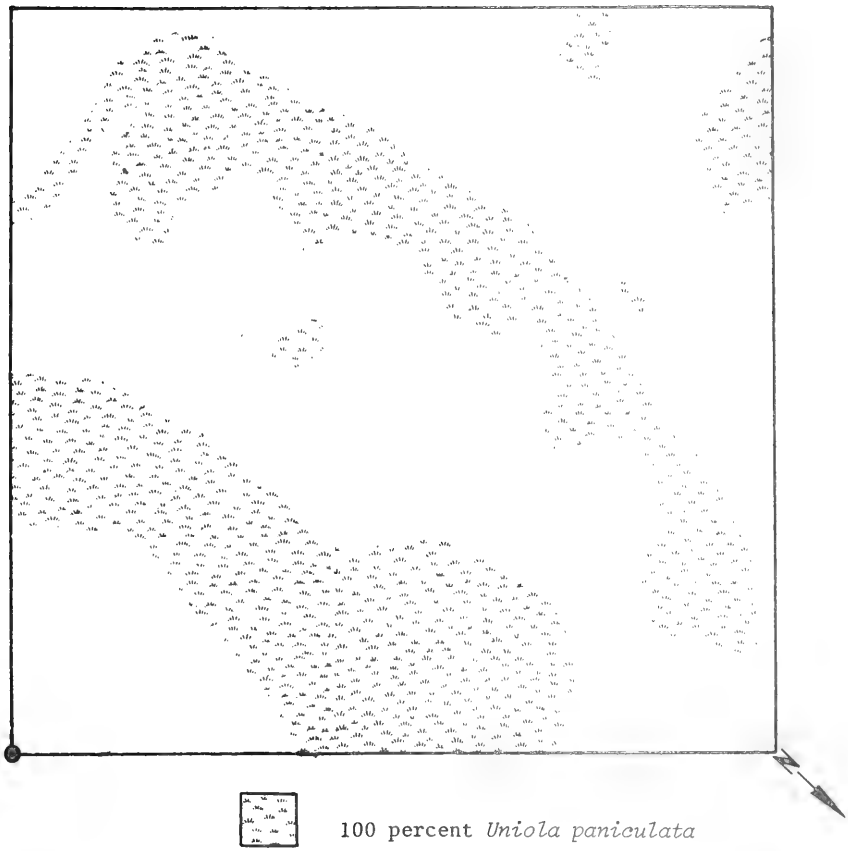


Myrica cerifera

40 percent *Eragrostis elliottii*
20 percent *Heterotheca gossypina*
20 percent *Solidago sempervirens*
20 percent *Uniola paniculata*

Total ground cover - 55 percent

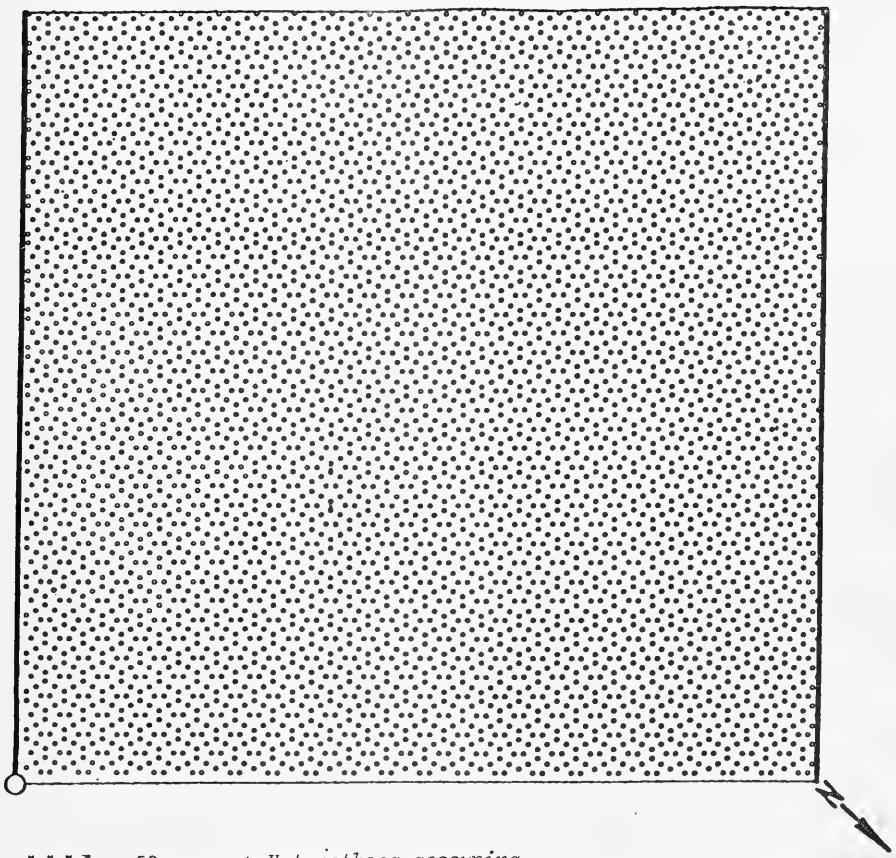
Figure C-16. Oceanside intershrub community permanent quadrat 2.



100 percent *Uniola paniculata*

Total ground cover - 40 percent

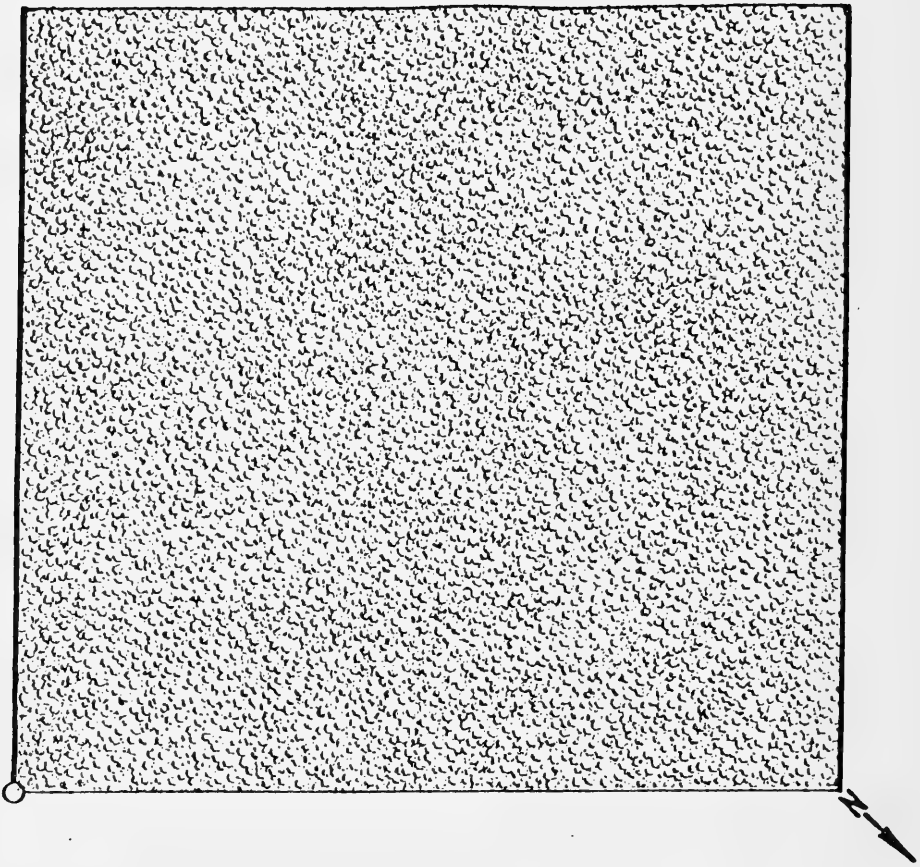
Figure C-17. Oceanside intershrub community permanent quadrat 3 (Levy, 1976).



50 percent *Heterotheca gossypina*
30 percent *Triplasis purpurea*
15 percent *Uniola paniculata*
5 percent *Cyperus haspan*

Total ground cover - 45 percent

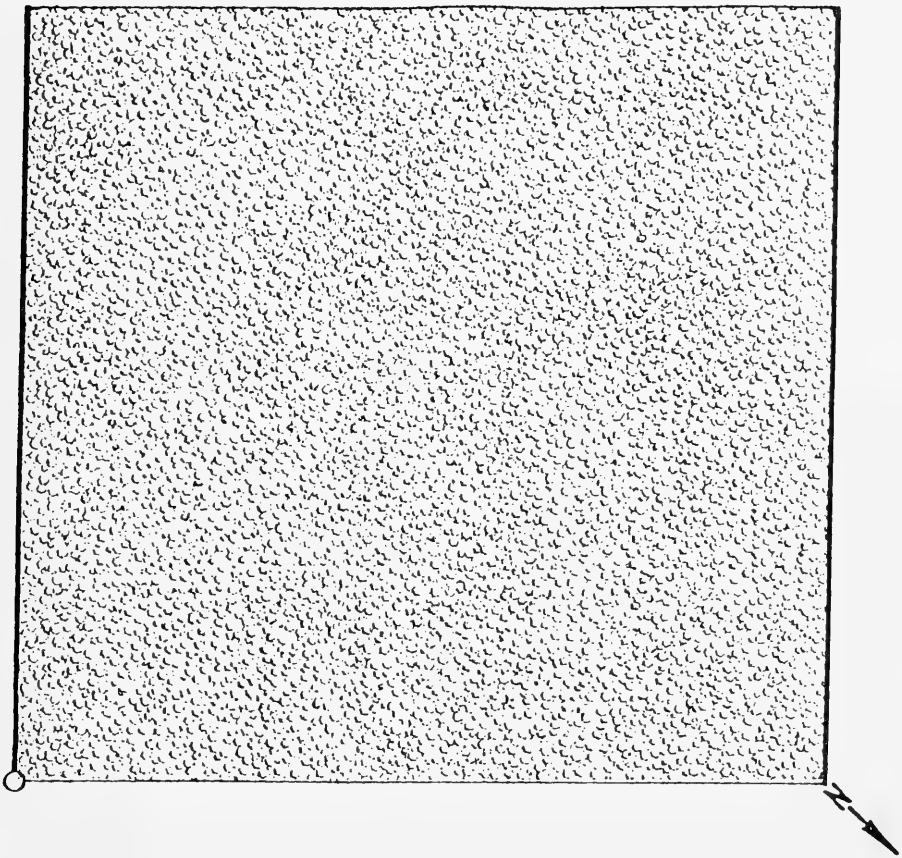
Figure C-18. Oceanside intershrub community permanent quadrat 3.



Myrica pensylvanica

Total crown cover - 100 percent

Figure C-19. Oceanside shrub community permanent quadrat 1 (Levy, 1976).

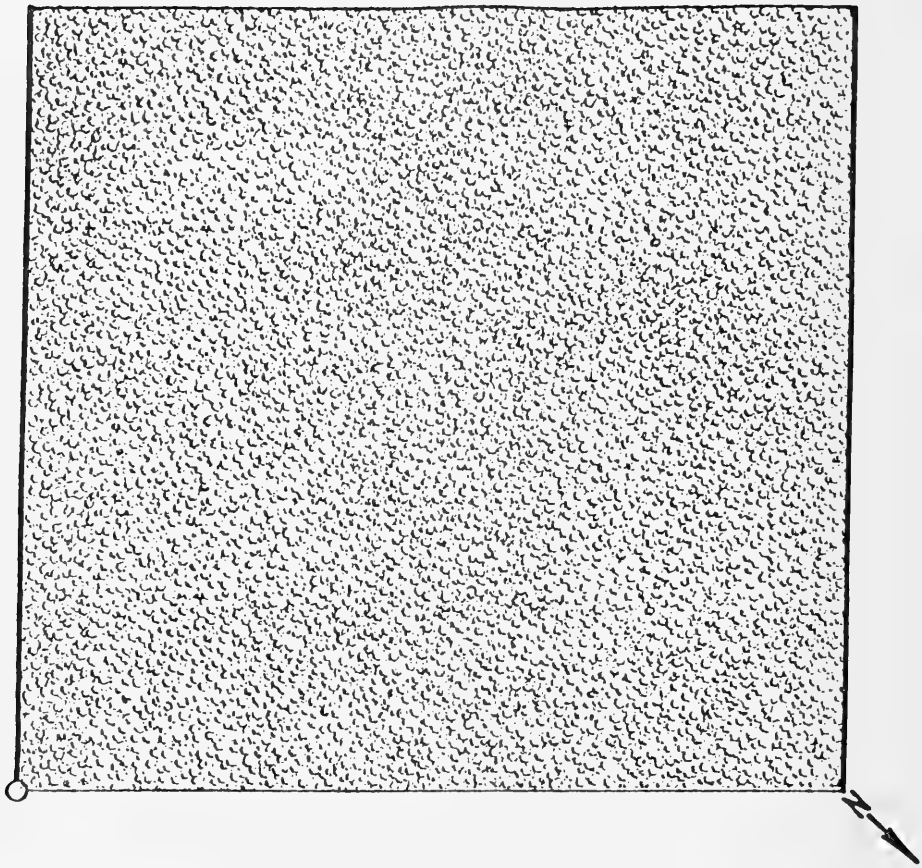


Myrica cerifera

Total crown cover - 98 percent

Total ground cover - 1 percent

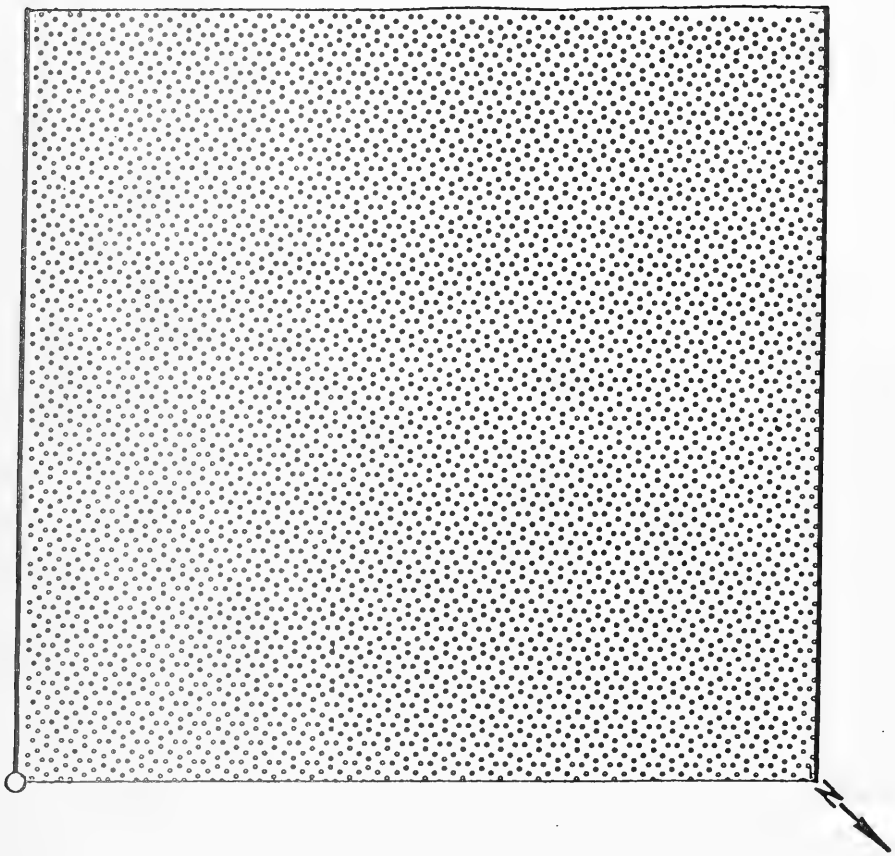
Figure C-20. Oceanside shrub community permanent quadrat 1.



Myrica pensylvanica

Total crown cover - 100 percent

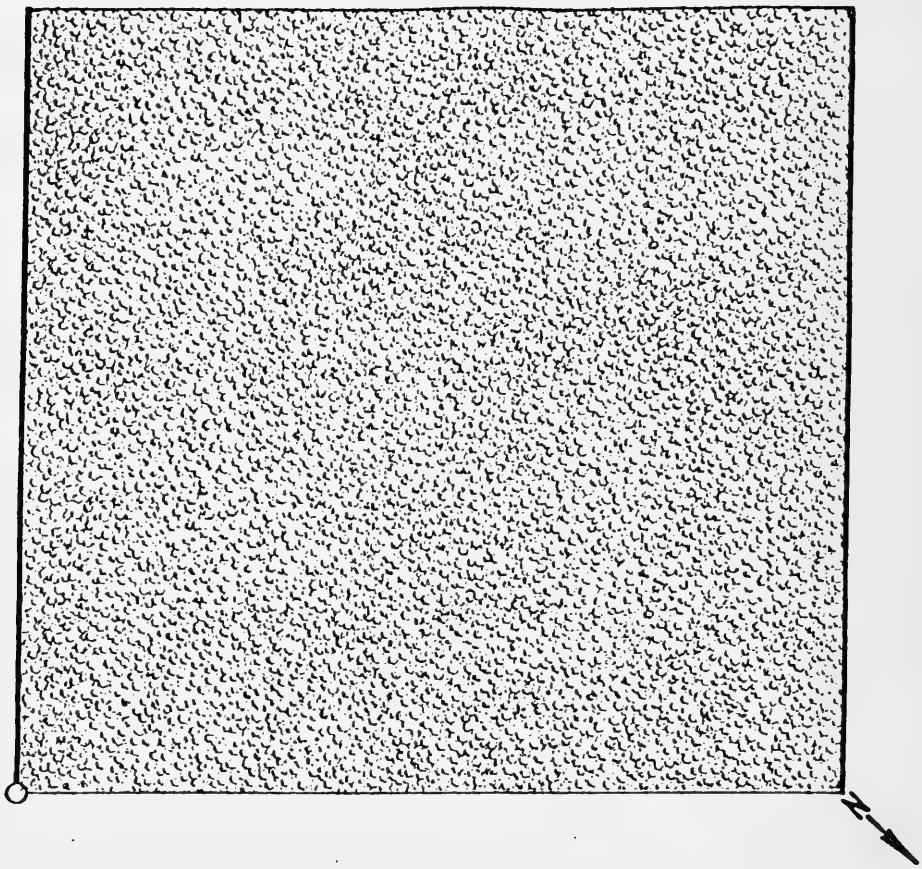
Figure C-21. Oceanside shrub community permanent quadrat 2 (Levy, 1976).



40 percent *Heterotheca gossypina*
25 percent *Triplasis purpurea*
25 percent *Uniola paniculata*
10 percent *Cyperus haspan*

Total ground cover - 50 percent

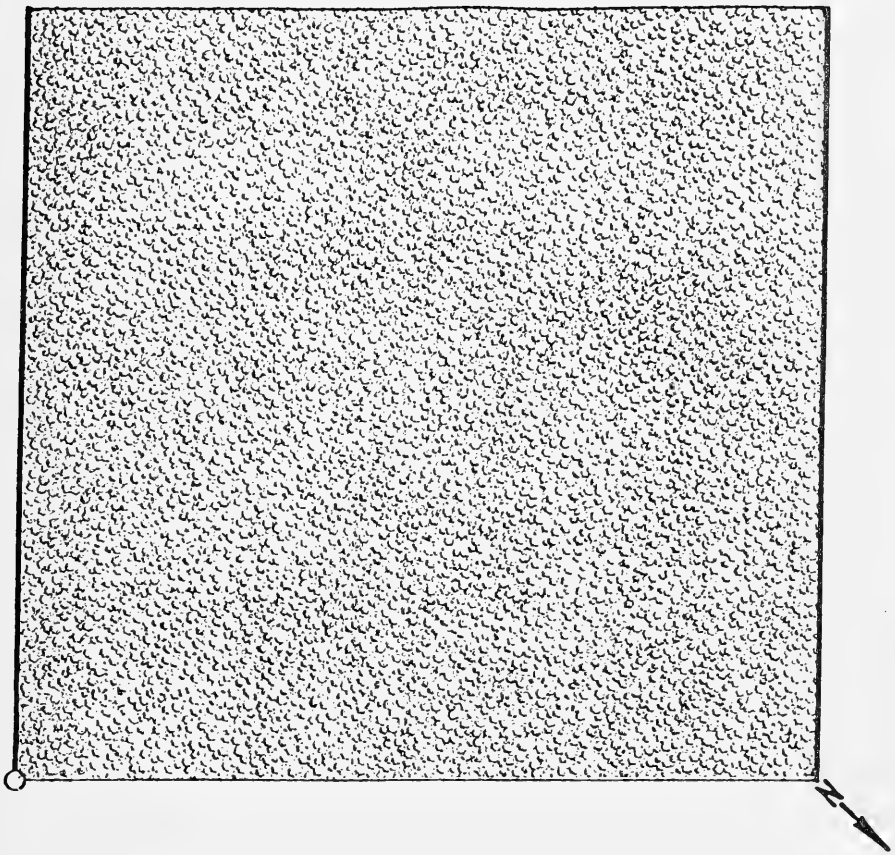
Figure C-22. Oceanside shrub community permanent quadrat 2.



Myrica pensylvanica

Total crown cover - 100 percent

Figure C-23. Oceanside shrub community permanent quadrat 3 (Levy, 1976).

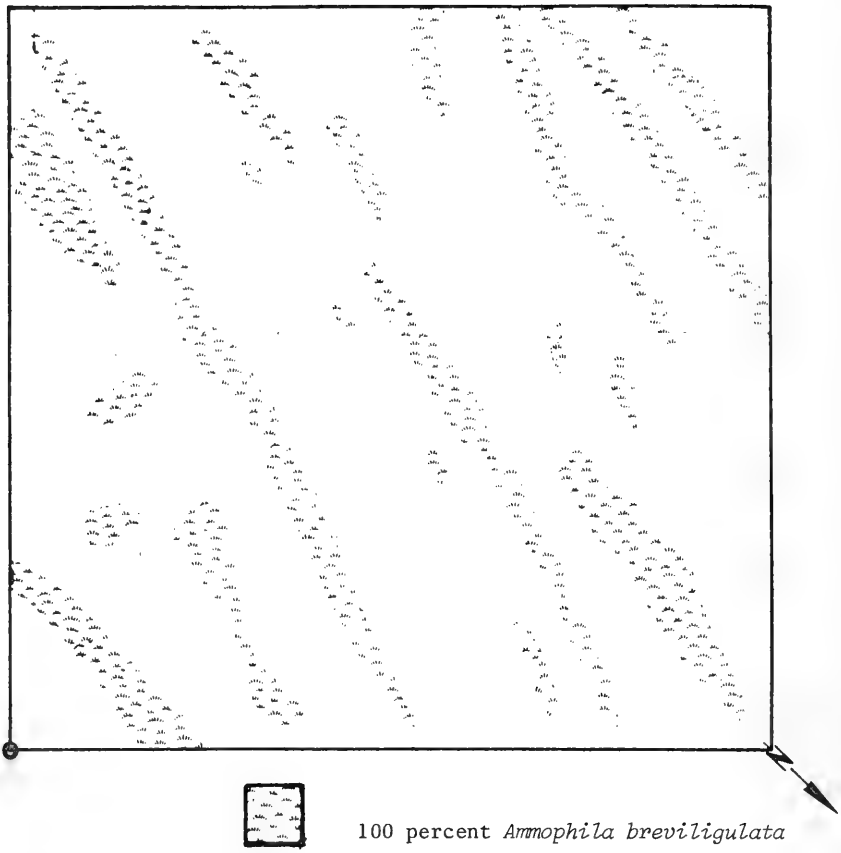


Myrica cerifera

Total crown cover - 98 percent

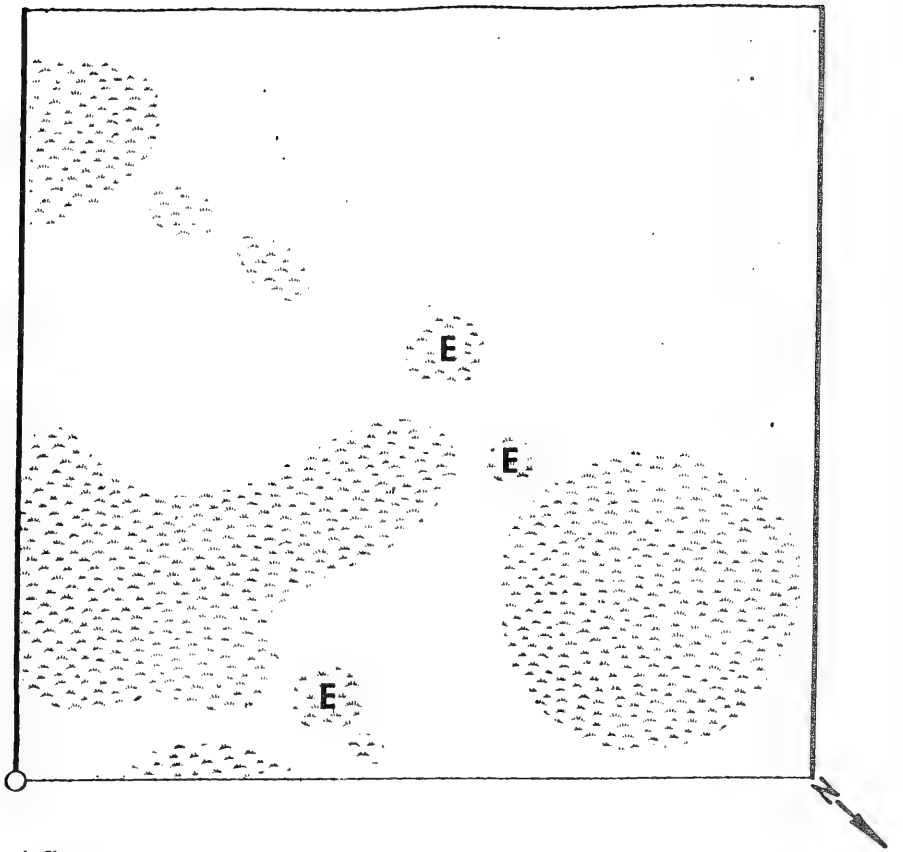
Total ground cover - 5 percent

Figure C-24. Oceanside shrub community permanent quadrat 3.



Total ground cover - 30 percent

Figure C-25. Planted American beachgrass community permanent quadrat 1 (Levy, 1976).



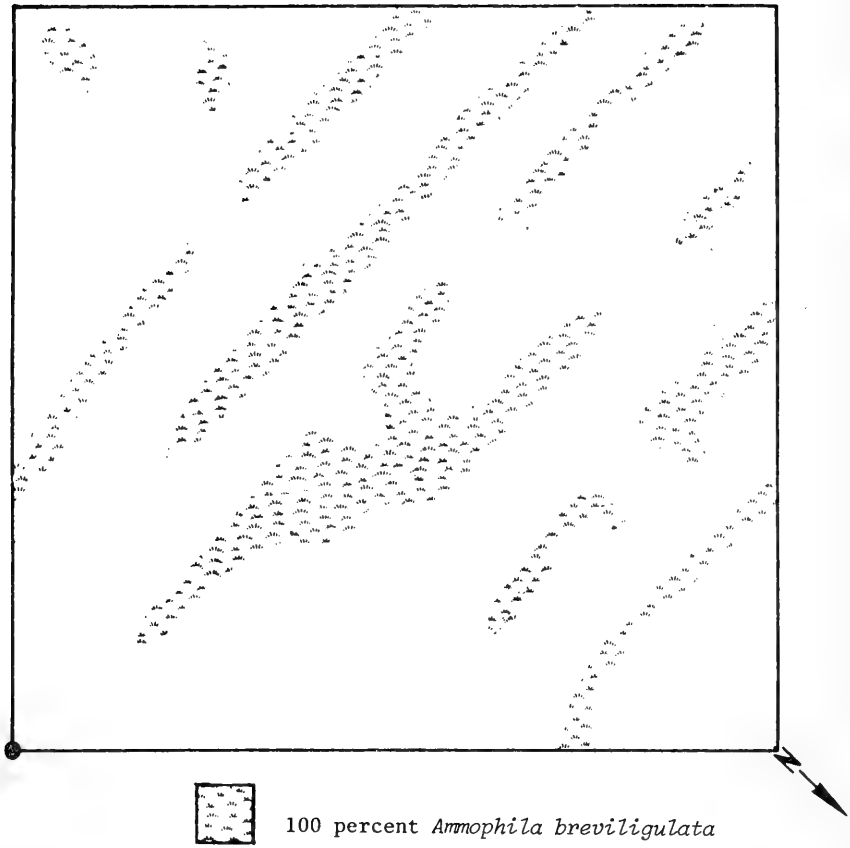
E — *Eragrostis elliottii*

Panicum virgatum

Erigeron canadensis var. *pusillus*

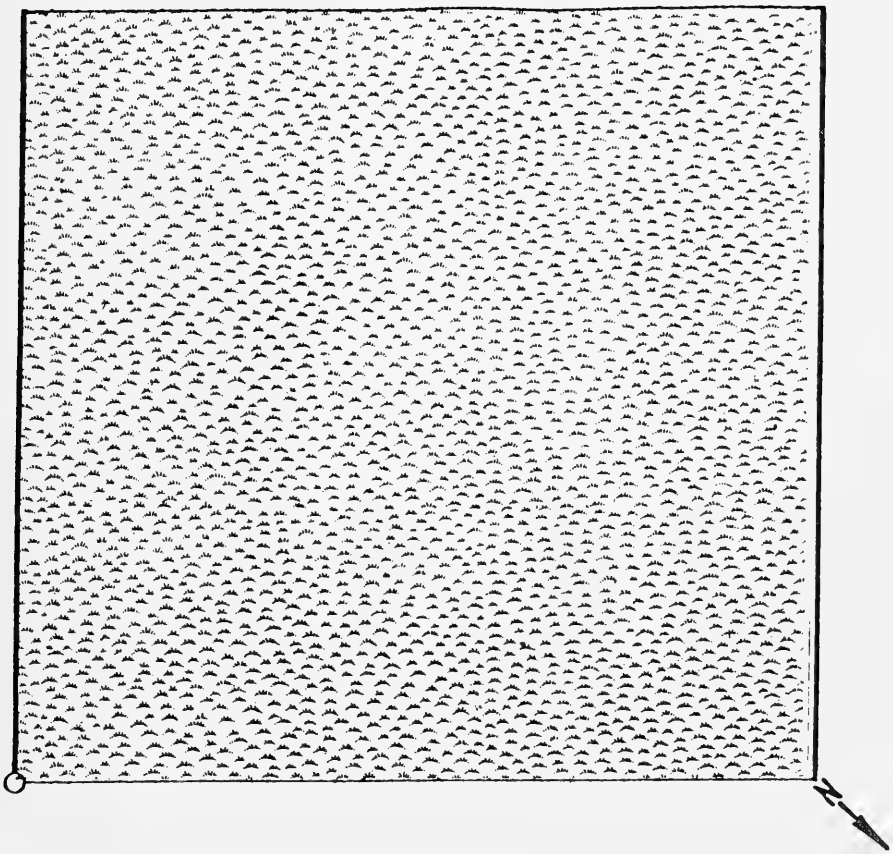
Total ground cover - 20 percent

Figure C-26. Planted American beachgrass community permanent quadrat 1.



Total ground cover - 30 percent

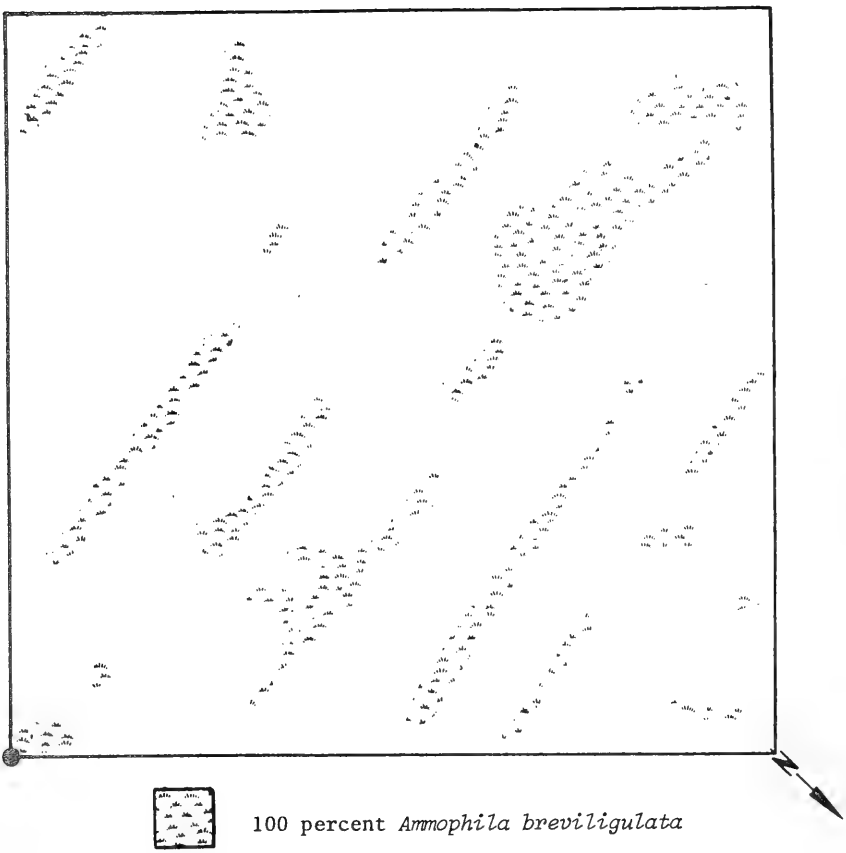
Figure C-27. Planted American beachgrass community permanent quadrat 2 (Levy, 1976).



95 percent *Triplasis purpurea*
5 percent *Diodia virginica*

Total ground cover - 20 percent

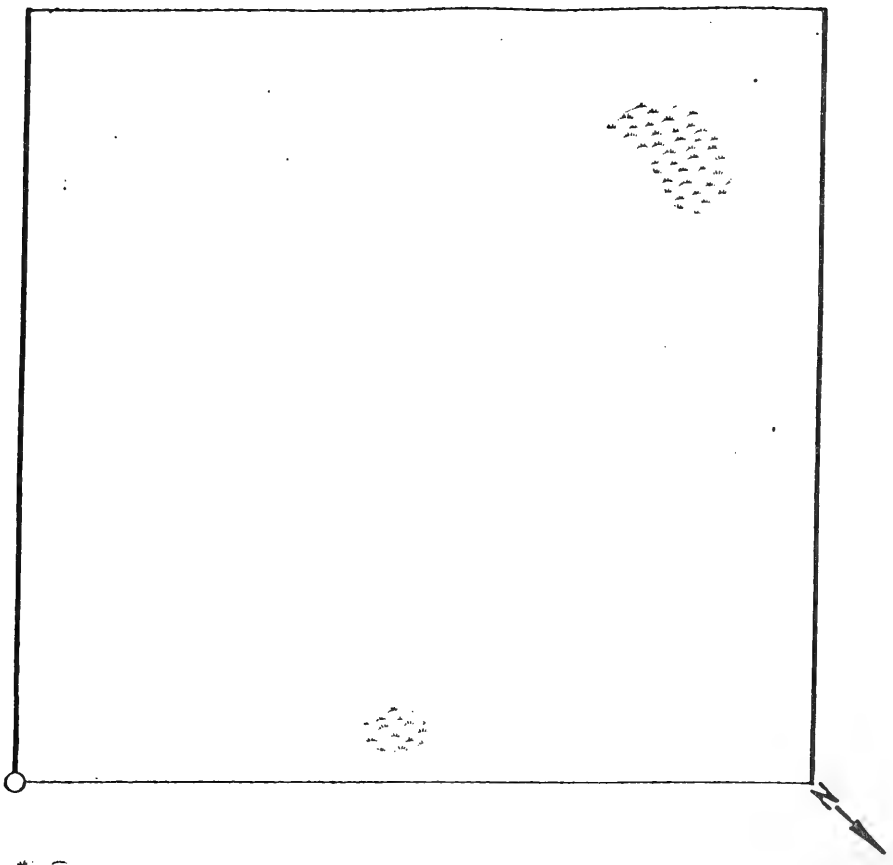
Figure C-28. Planted American beachgrass community permanent quadrat 2.



100 percent *Ammophila breviligulata*

Total ground cover - 20 percent

Figure C-29. Planted American beachgrass community permanent quadrat 3 (Levy, 1976).

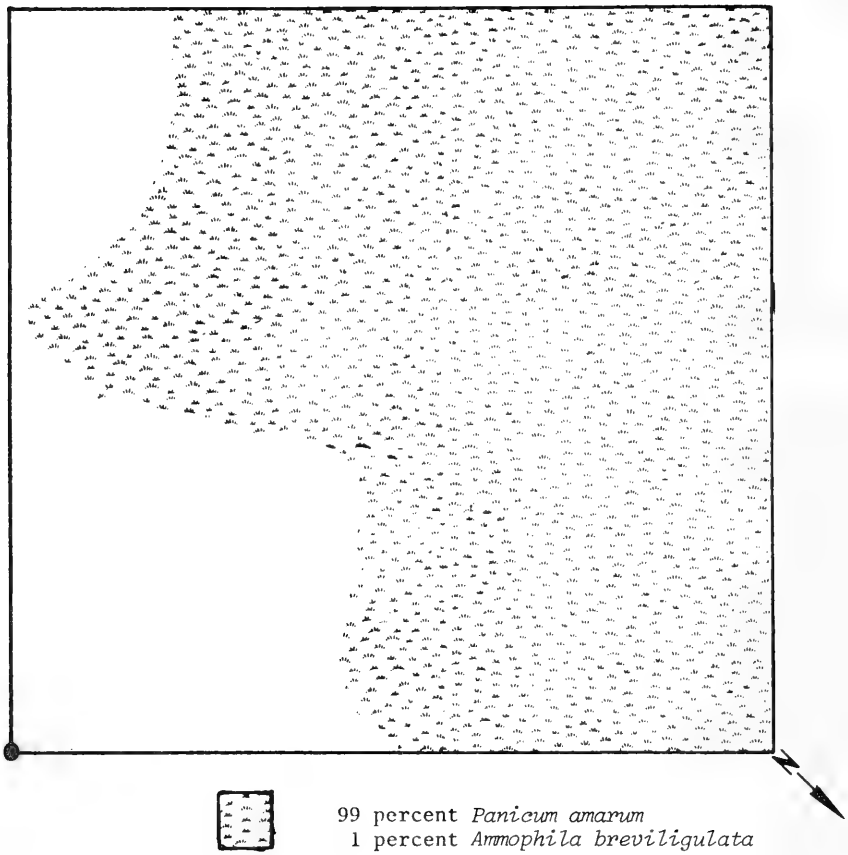


Panicum virgatum

50 percent *Cenchrus tribuloides*
50 percent *Triplasis purpurea*

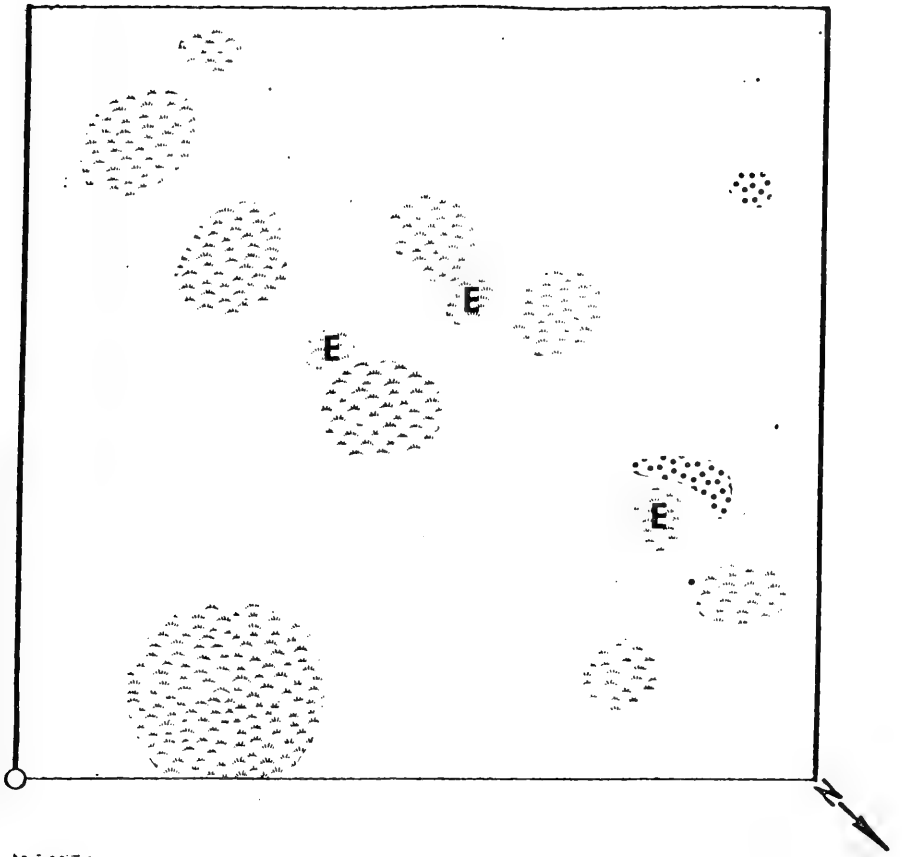
Total ground cover - 10 percent

Figure C-30. Planted American beachgrass community permanent quadrat 3.



Total ground cover - 45 percent

Figure C-31. Planted bitter panicum community permanent quadrat 1 (Levy, 1976).



Heterotheca gossypina

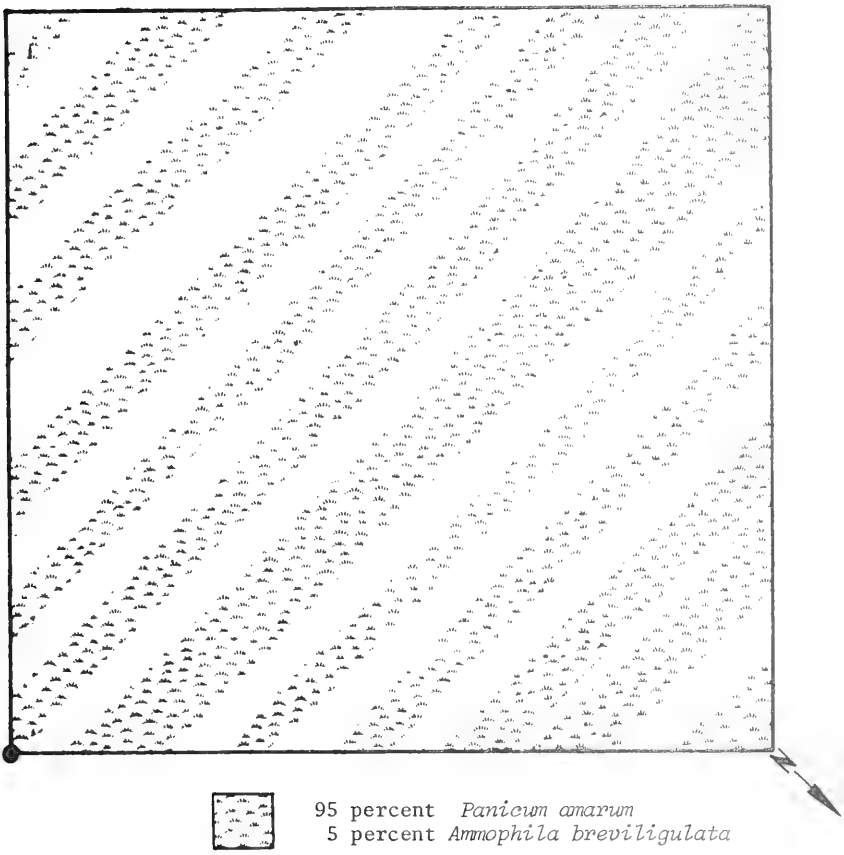
Eragrostis elliottii

Panicum virgatum

50 percent *Erigeron canadensis* var. *pusillus*
50 percent *Panicum amarum*

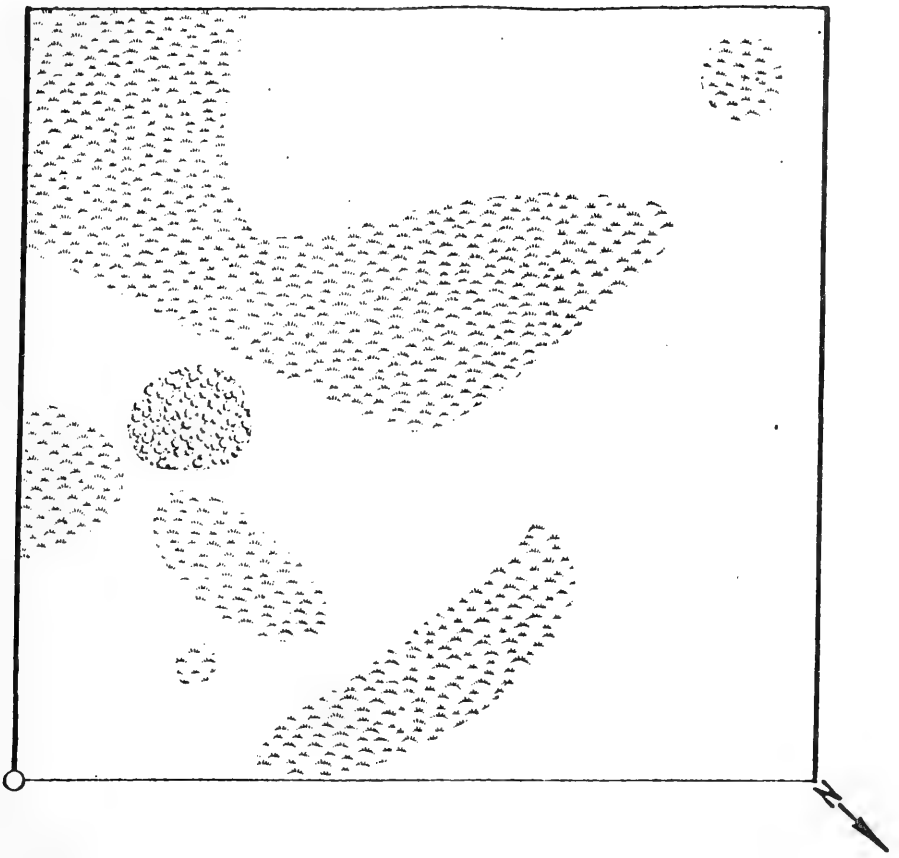
Total ground cover - 15 percent

Figure C-32. Planted bitter panicum community permanent quadrat 1.



Total ground cover - 35 percent

Figure C-33. Planted bitter panicum community permanent quadrat 2 (Levy, 1976).



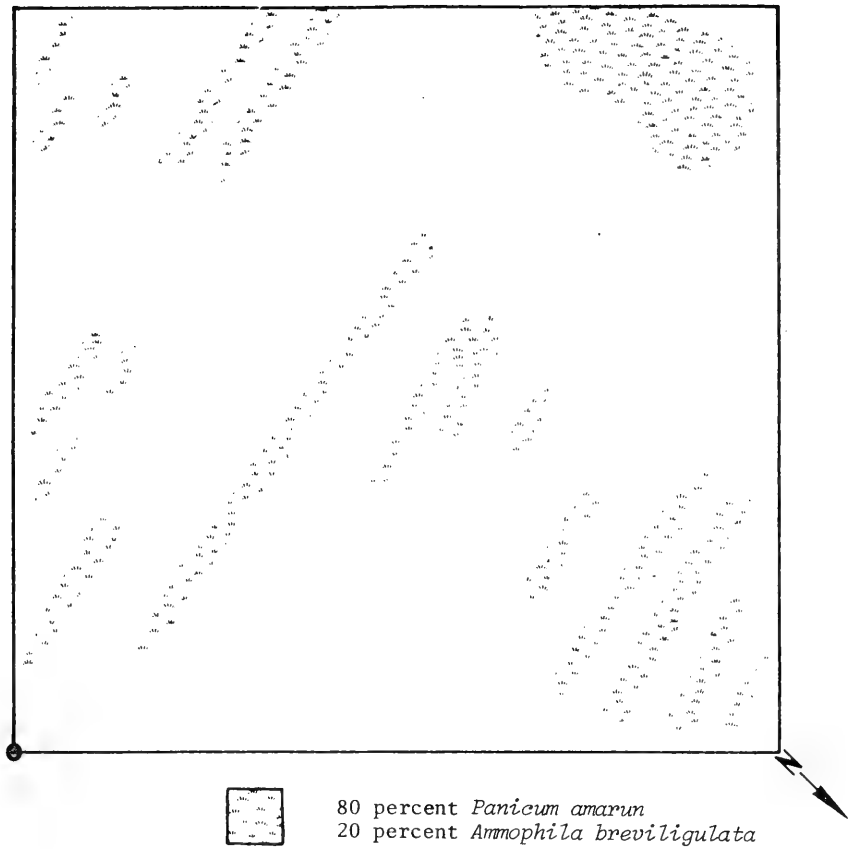
Myrica cerifera

Panicum virgatum

90 percent *Carex alata*
10 percent *Erigeron canadensis* var. *pusillus*

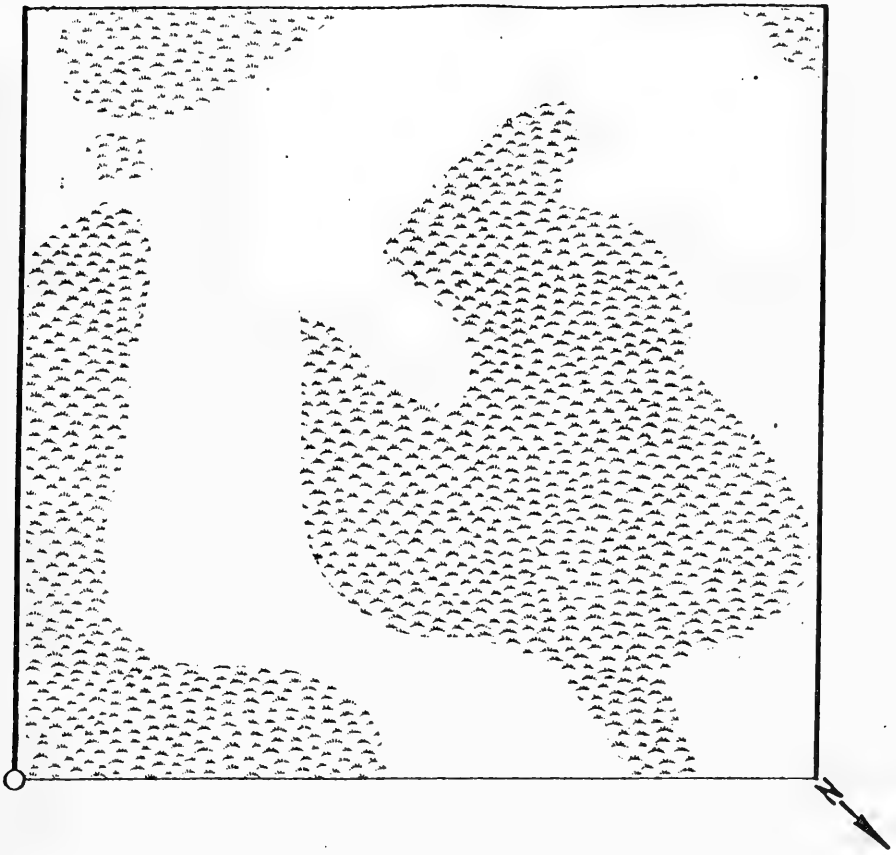
Total ground cover - 30 percent

Figure C-34. Planted bitter panicum community permanent quadrat 2.



Total ground cover - 10 percent

Figure C-35. Planted bitter panicum community permanent quadrat 3 (Levy, 1976).

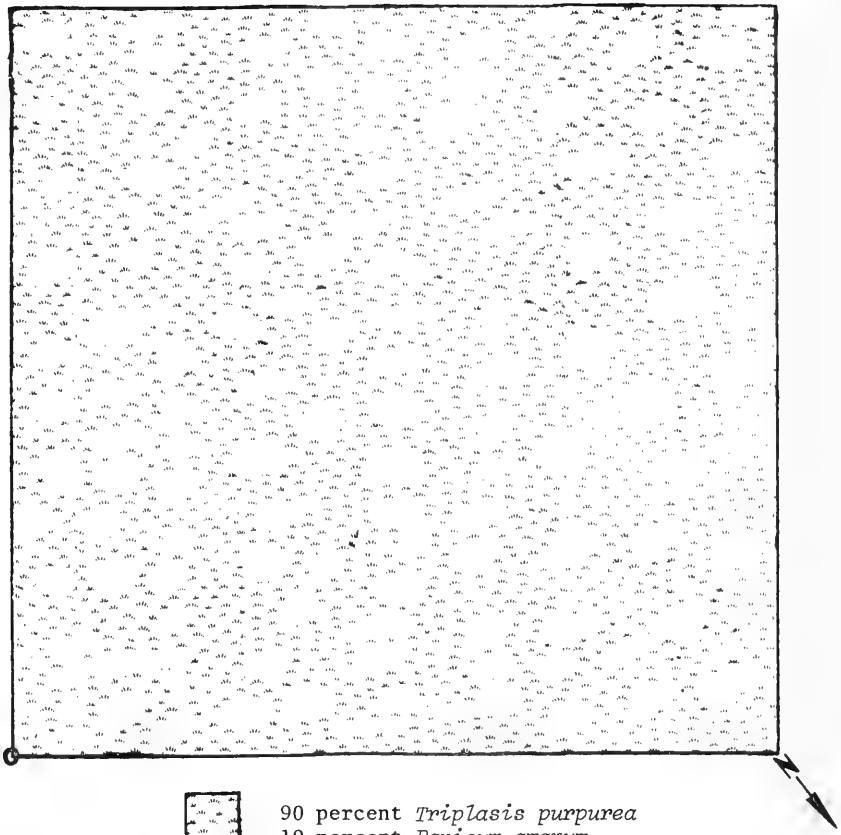


Panicum virgatum

50 percent *Carex alata*
30 percent *Ammophila breviligulata*
20 percent *Erigeron canadensis* var. *pusillus*

Total ground cover - 35 percent

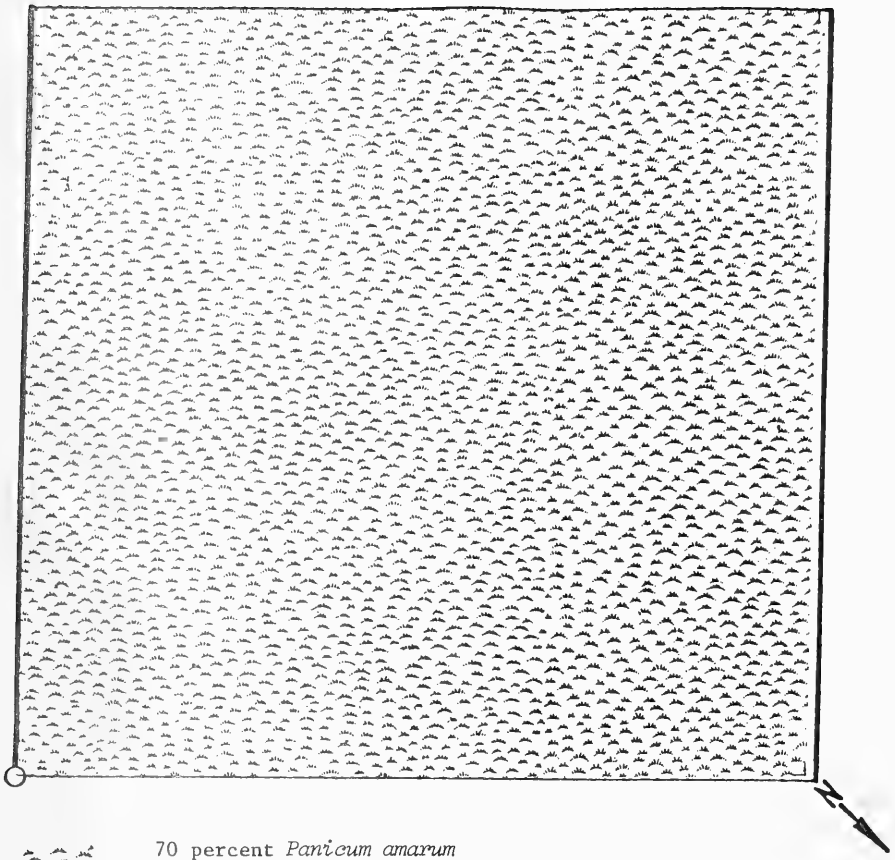
Figure C-36. Planted bitter panicum community permanent quadrat 3.



90 percent *Triplasis purpurea*
10 percent *Panicum amarum*

Total ground cover - 70 percent

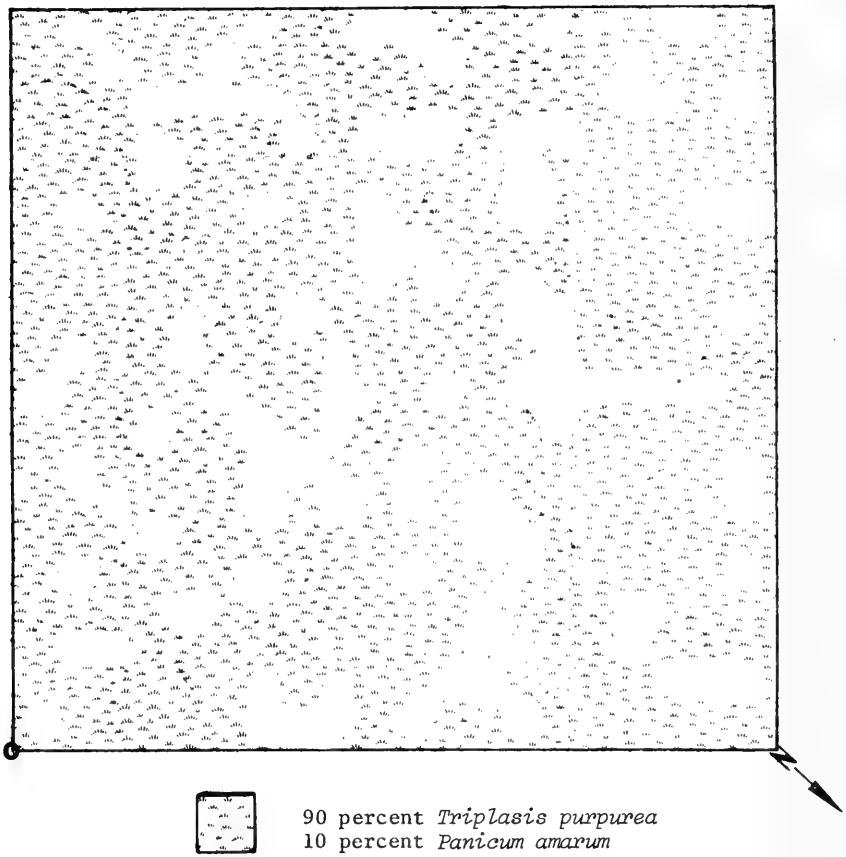
Figure C-37. Sandgrass-buttonweed community permanent quadrat 1 (Levy, 1976).



70 percent *Panicum amarum*
25 percent *Erigeron canadensis* var. *pusillus*
5 percent *Eragrostis elliottii*

Total ground cover - 25 percent

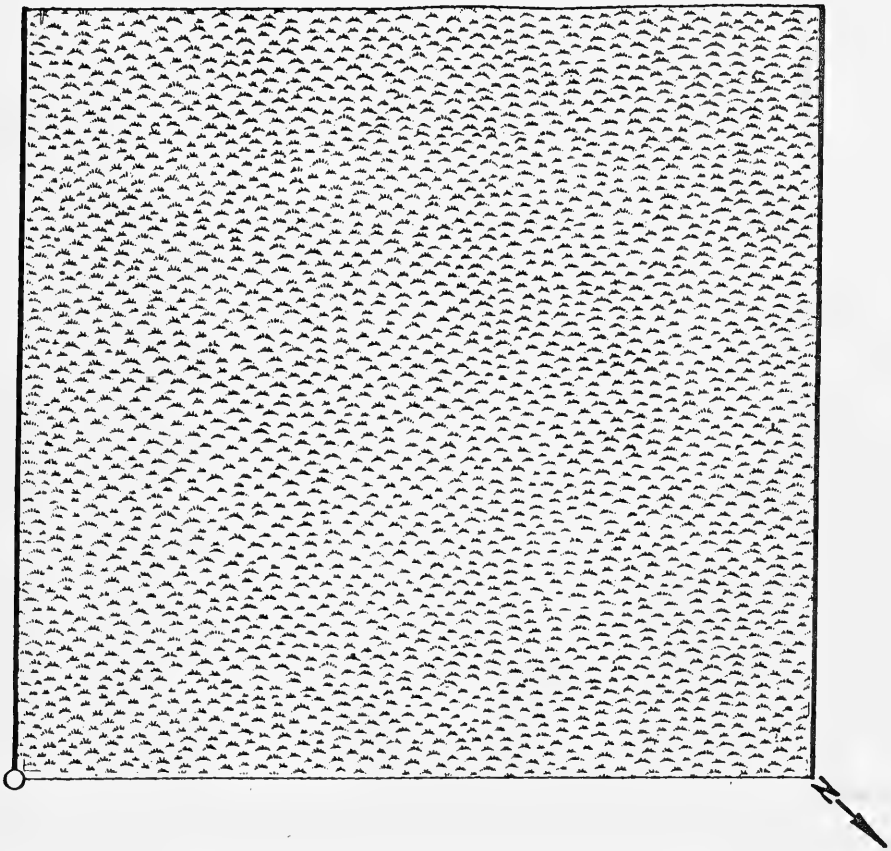
Figure C-38. Sandgrass-buttonweed community permanent quadrat 1.



90 percent *Triplasis purpurea*
10 percent *Panicum amarum*

Total ground cover - 75 percent

Figure C-39. Sandgrass-buttonweed community permanent quadrat 2 (Levy, 1976).



60 percent *Panicum amarum*
40 percent *Erigeron canadensis* var. *pusillus*

Total ground cover - 90 percent

Figure C-40. Sandgrass-buttonweed community permanent quadrat 2.

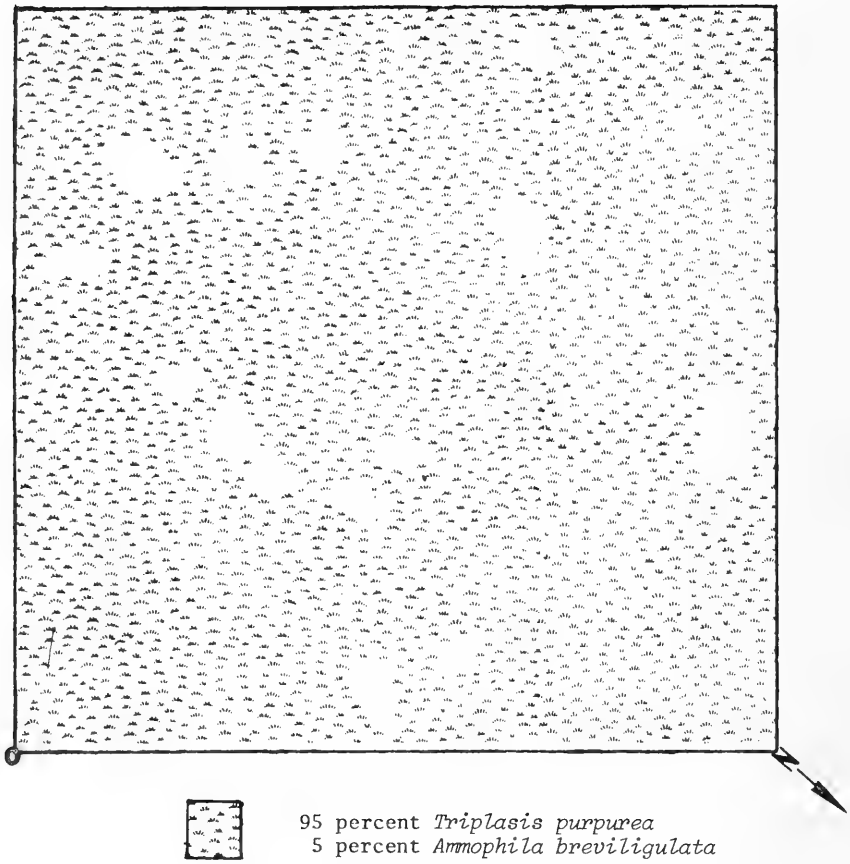
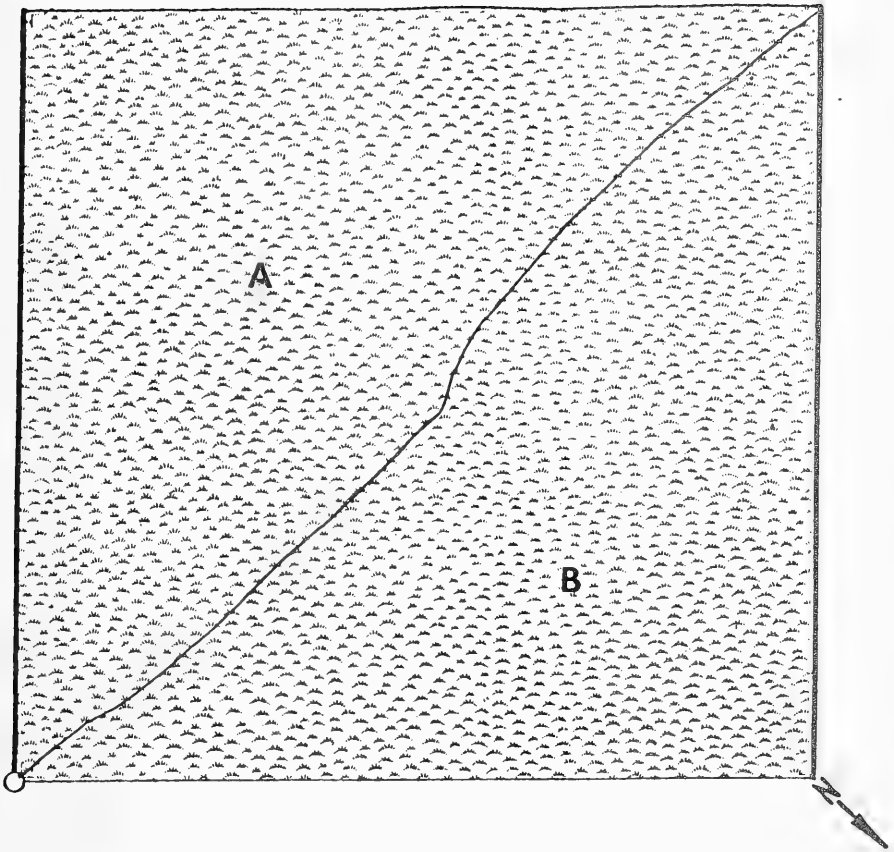


Figure C-41. Sandgrass-buttonweed community permanent quadrat 3 (Levy, 1976).



A
50 percent *Erigeron canadensis* var. *pusillus*
30 percent *Panicum amarum*
10 percent *Ammophila breviligulata*
10 percent *Eragrostis elliottii*

B
30 percent *Eragrostis elliottii*
30 percent *Erigeron canadensis* var. *pusillus*
25 percent *Ammophila breviligulata*
15 percent *Panicum amarum*

Total ground cover - 35 percent

Figure C-42. Sandgrass-buttonweed community permanent quadrat 3.

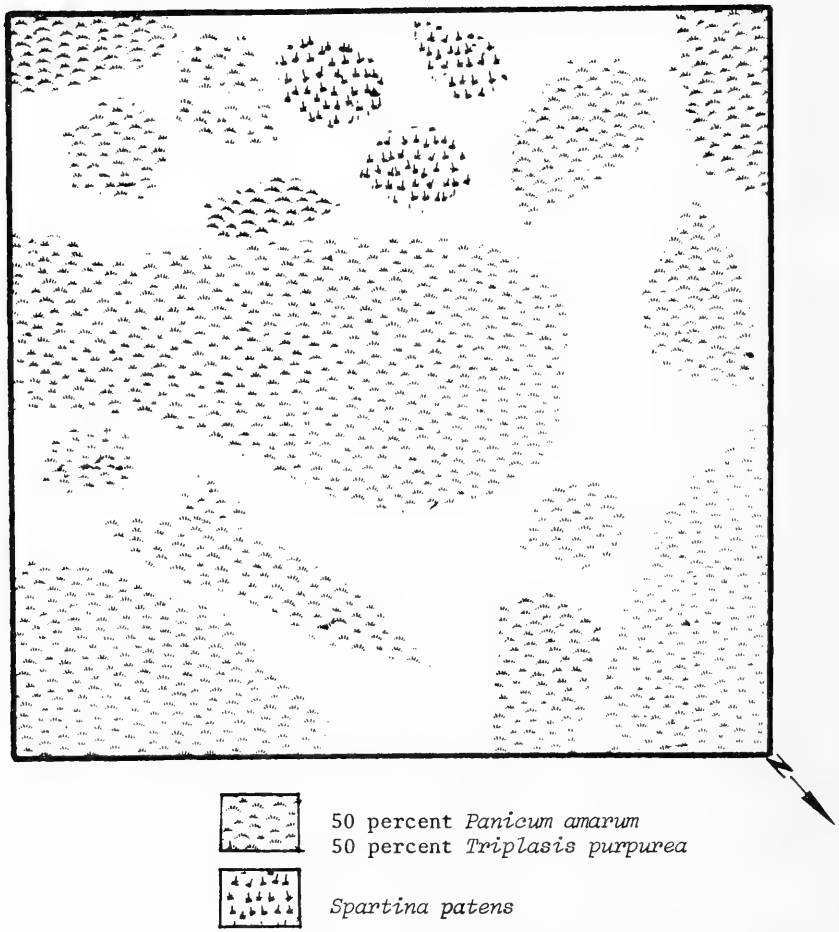
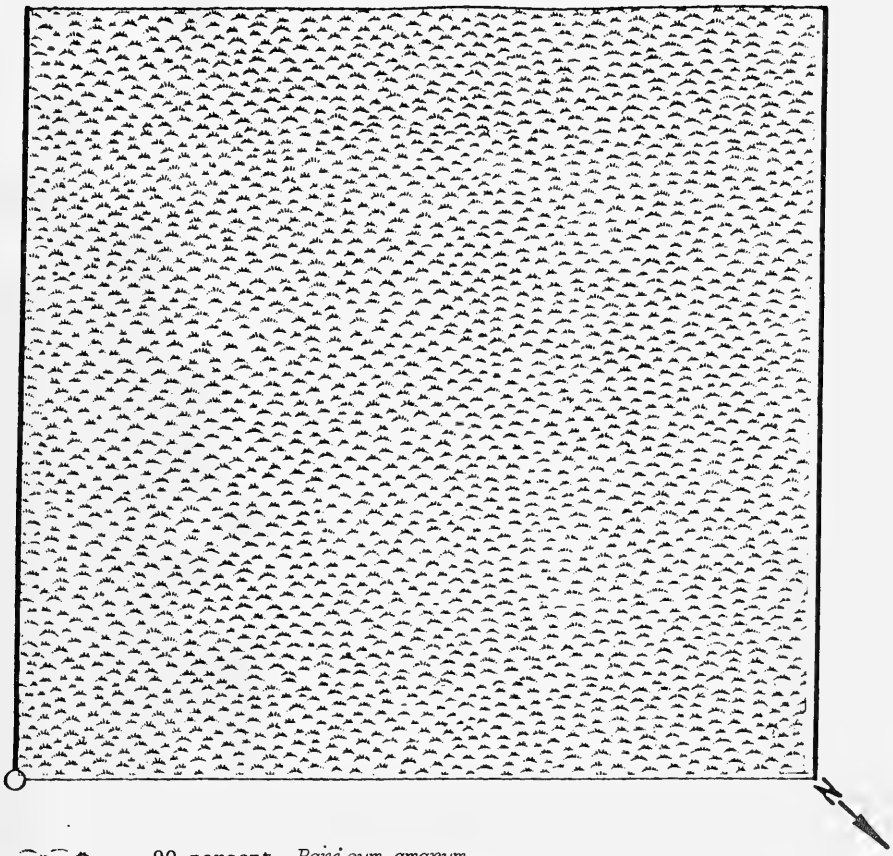


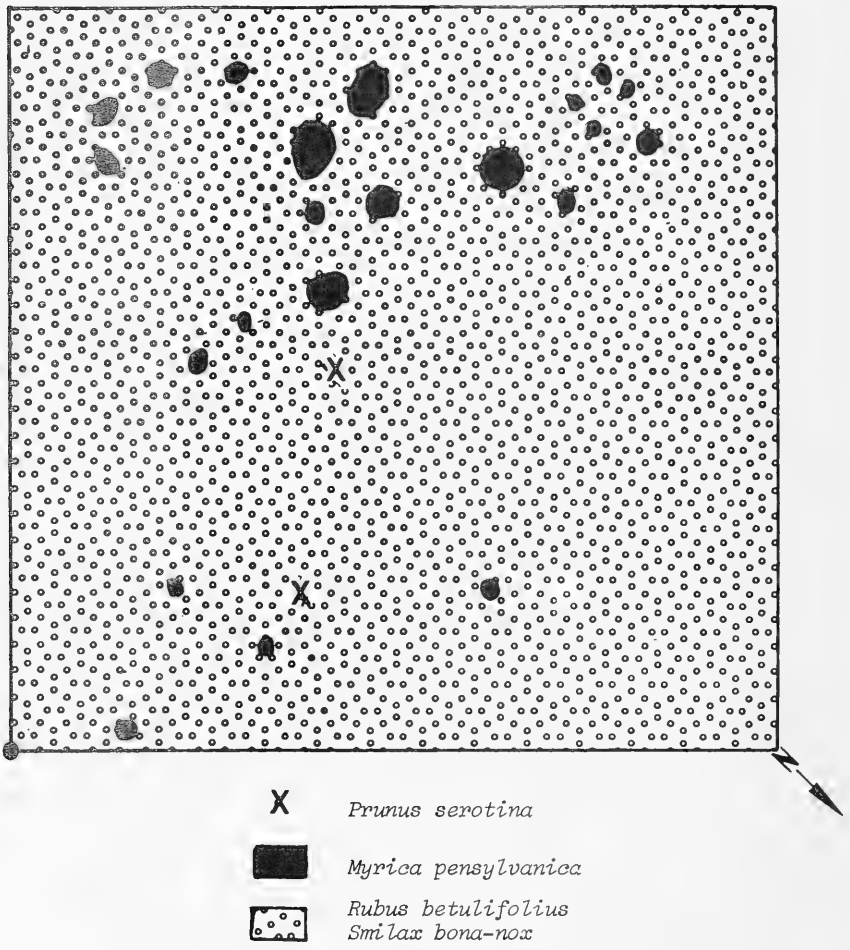
Figure C-43. Spurge-sandgrass community permanent quadrat (Levy, 1976).



90 percent *Panicum amarum*
8 percent *Spartina patens*
1 percent *Erigeron canadensis* var. *pusillus*
1 percent *Triplasis purpurea*

Total ground cover - 80 percent

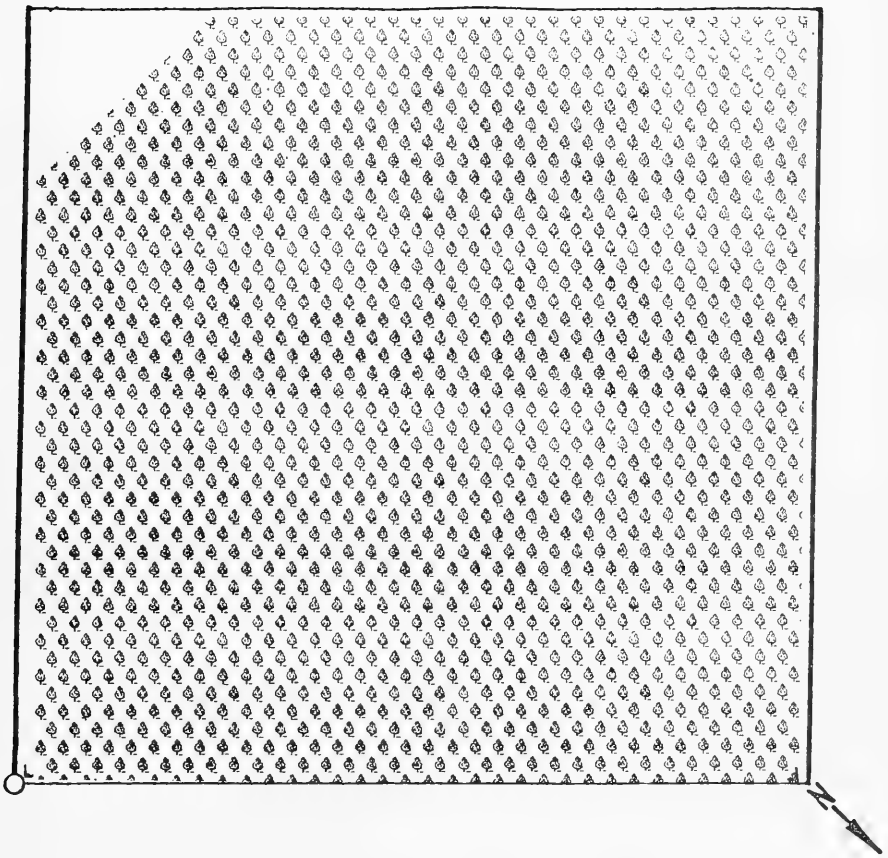
Figure C-44. Spurge-sandgrass community permanent quadrat.



Total crown cover - 95 percent

Total ground cover - 15 percent

Figure C-45. Sound-side shrub community permanent quadrat 1 (Levy, 1976).

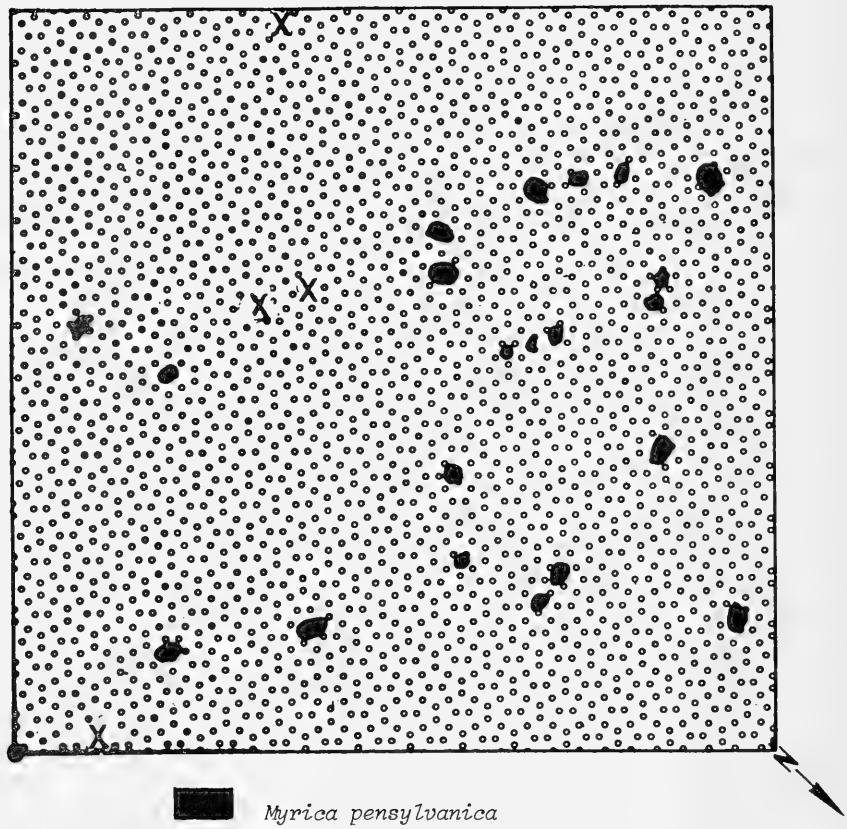


55 percent *Prunus serotina*
45 percent *Myrica cerifera*

Total crown cover - 65 percent

Total ground cover - 15 percent

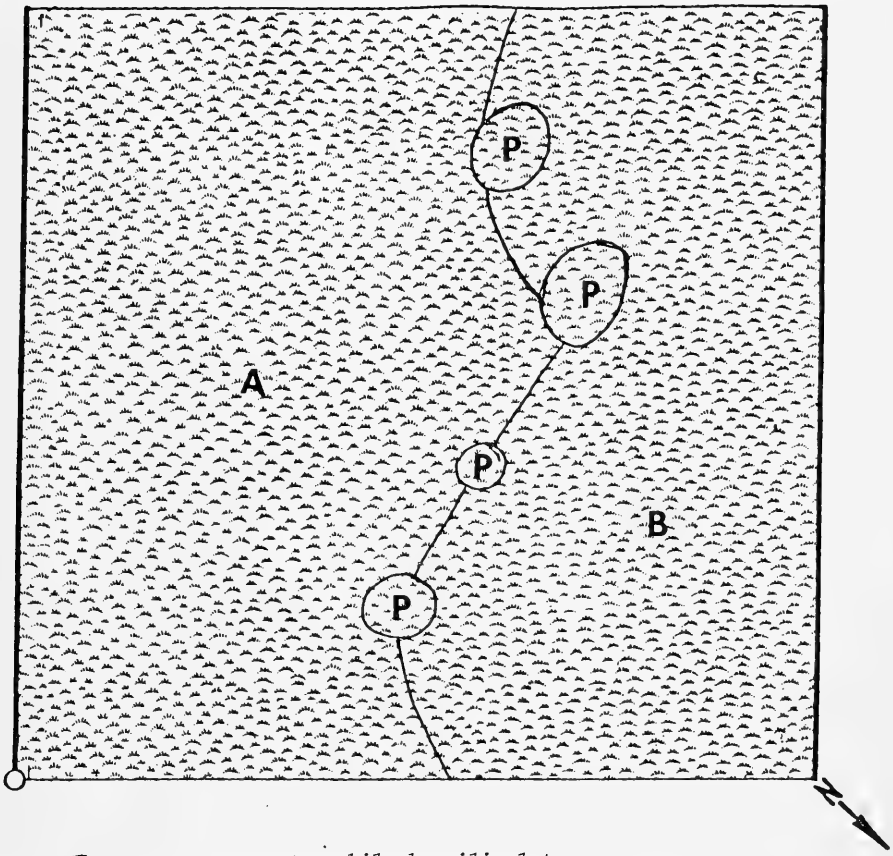
Figure C-46. Sound-side shrub community permanent quadrat 1.



Total crown cover - 95 percent

Total ground cover - 10 percent

Figure C-47. Sound-side shrub community permanent quadrat 2 (Levy, 1976).



A
40 percent *Ammophila breviligulata*
30 percent *Erigeron canadensis* var. *pusillus*
20 percent *Heterotheca gossypina*
10 percent *Smilax bona-nox*

B
35 percent *Panicum fusiforme*
30 percent *Cassia nictitans*
25 percent *Ammophila breviligulata*
10 percent *Erigeron canadensis* var. *pusillus*

P
Panicum virgatum

Total ground cover - 25 percent

Figure C-48. Sound-side shrub community permanent quadrat 2.

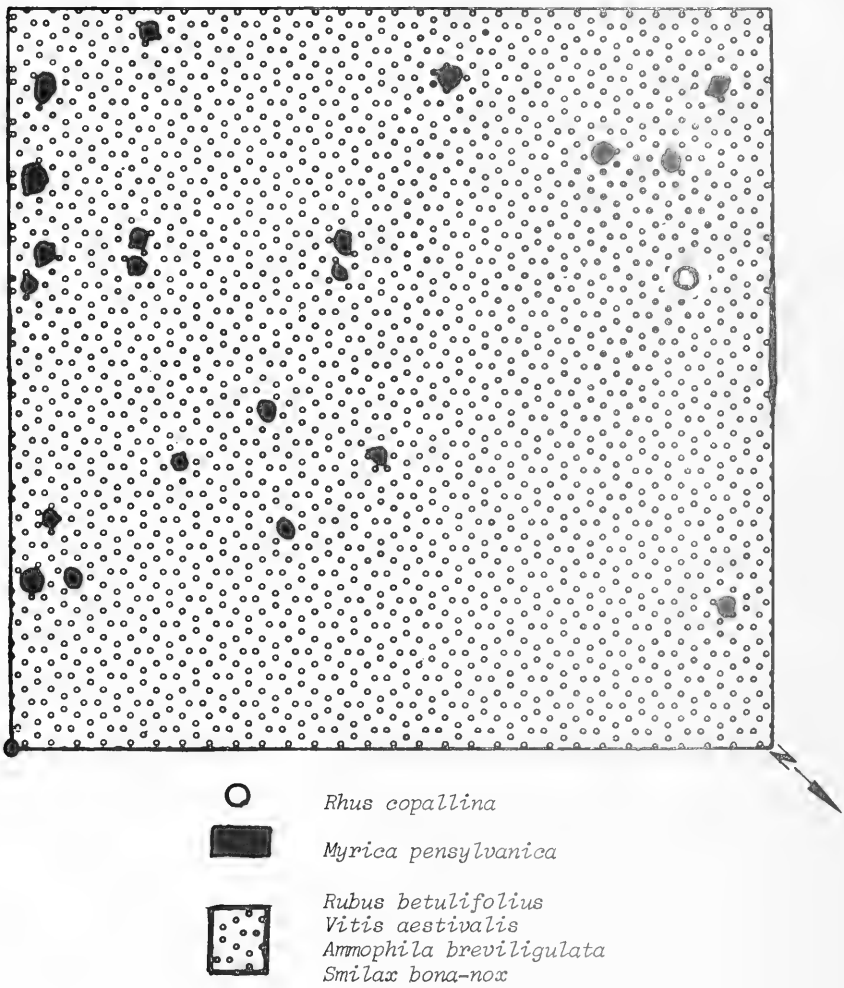
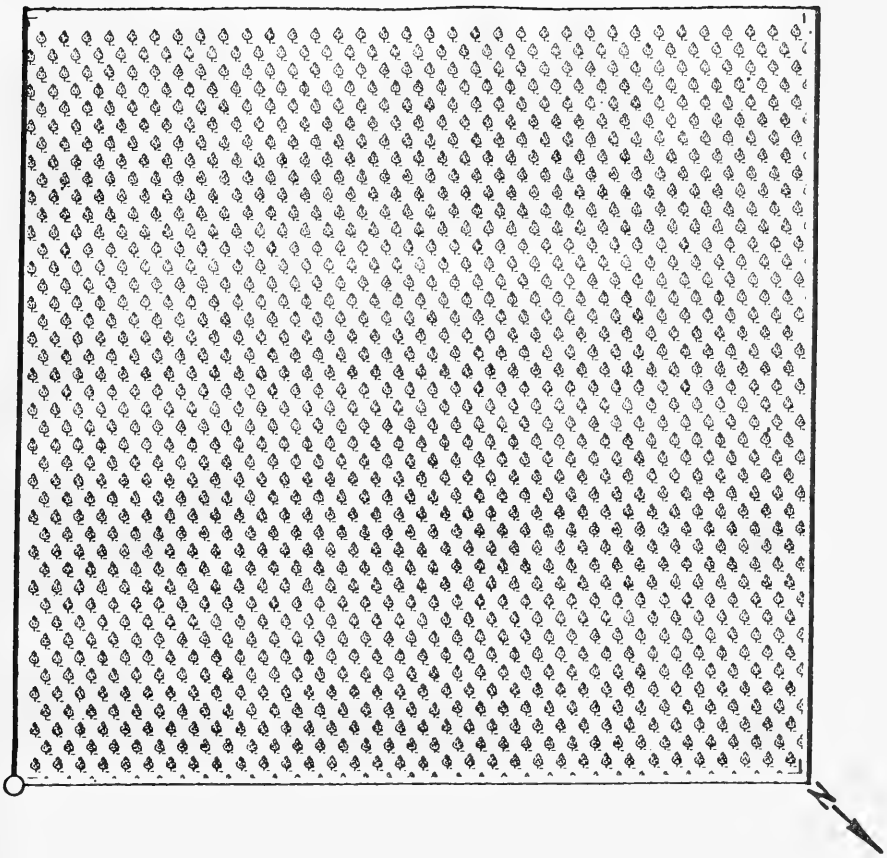


Figure C-49. Sound-side shrub community permanent quadrat 3 (Levy, 1976).



80 percent *Myrica cerifera*
20 percent *Prunus serotina*

Total crown cover - 55 percent

Total ground cover - 5 percent

Figure C-50. Sound-side shrub community permanent quadrat 3.

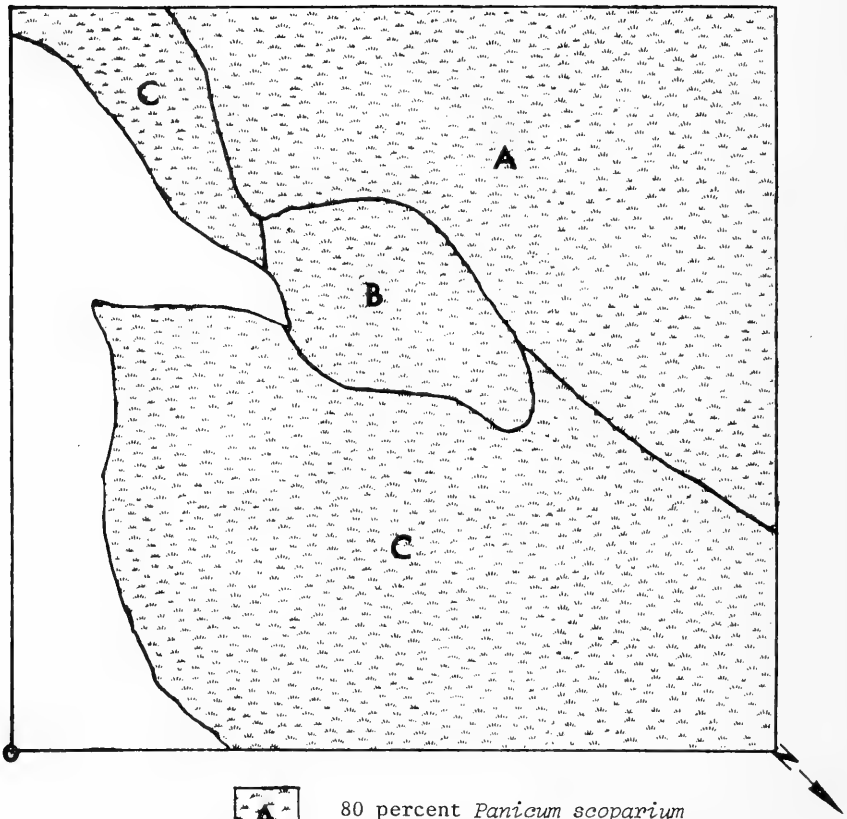
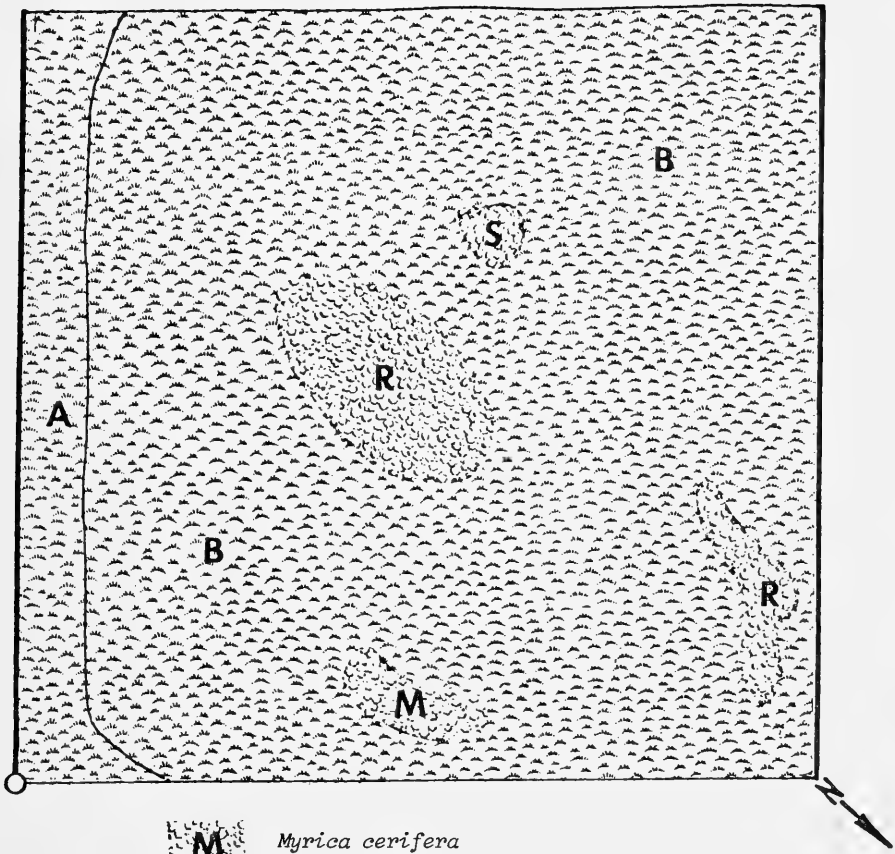


Figure C-51. Sound-side disturbed community permanent quadrat 1 (Levy, 1976).



M *Myrica cerifera*

R *Rhus copallina*

S *Smilax bona-nox*

A
35 percent *Ammophila breviligulata*
35 percent *Monarda punctata*
30 percent *Panicum fusiforme*

B
60 percent *Ammophila breviligulata*
35 percent *Spartina patens*
3 percent *Rubus betulifolia*
2 percent *Panicum fusiforme*

Total ground cover - 55 percent

Figure C-52. Sound-side disturbed community permanent quadrat 1.

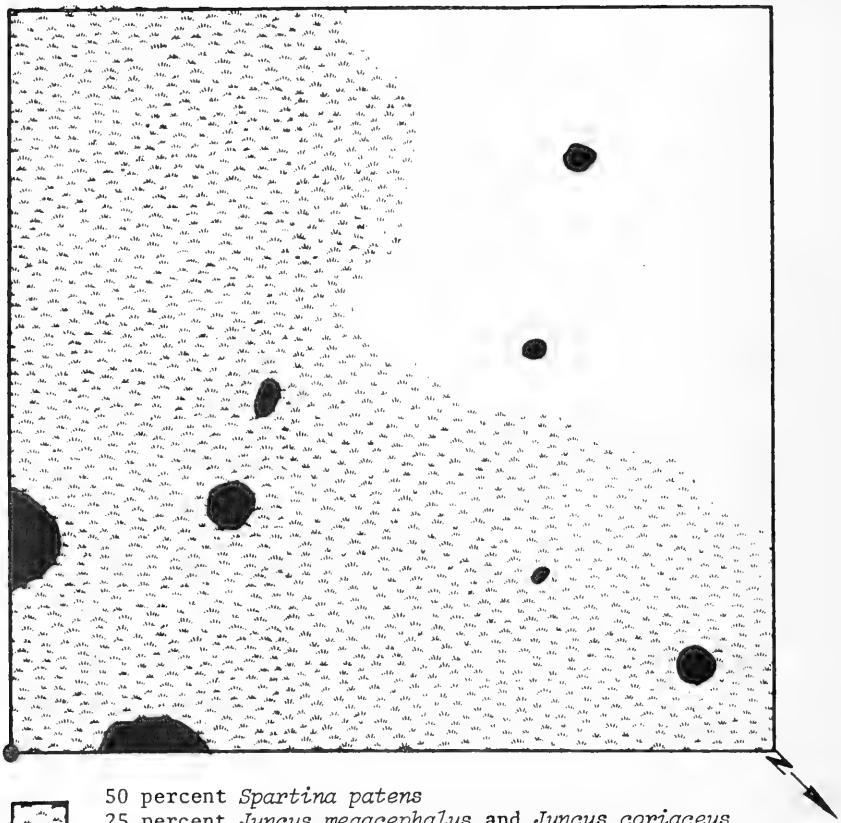
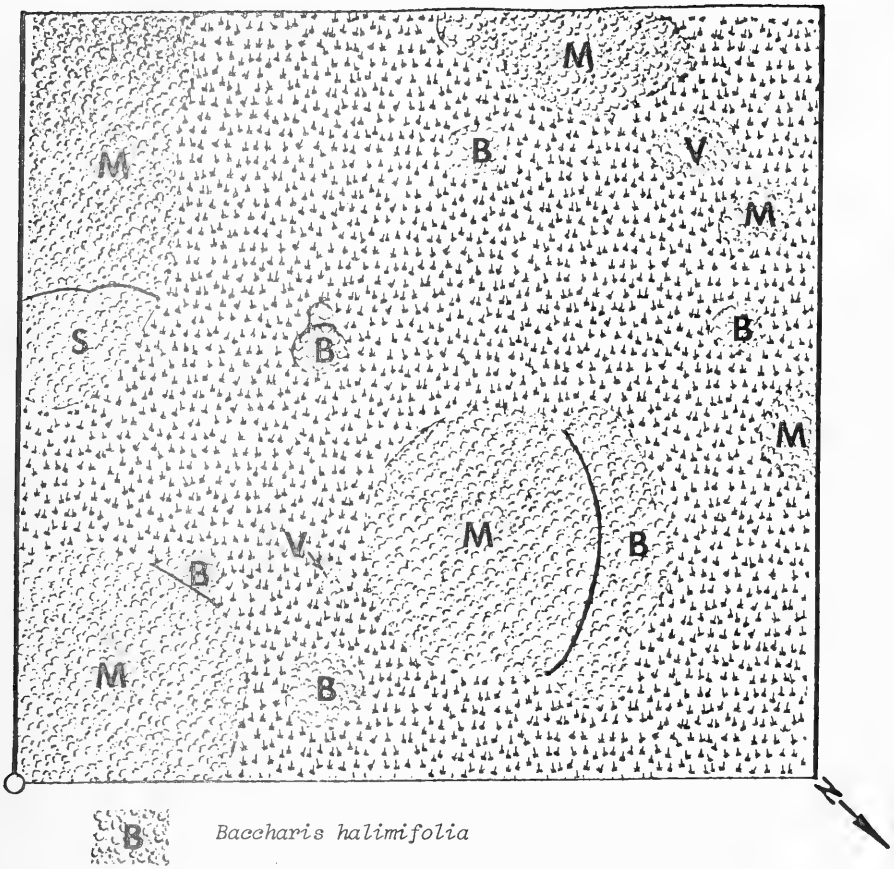


Figure C-53. Sound-side disturbed community permanent quadrat 2 (Levy, 1976).



B *Baccharis halimifolia*

M *Myrica cerifera*

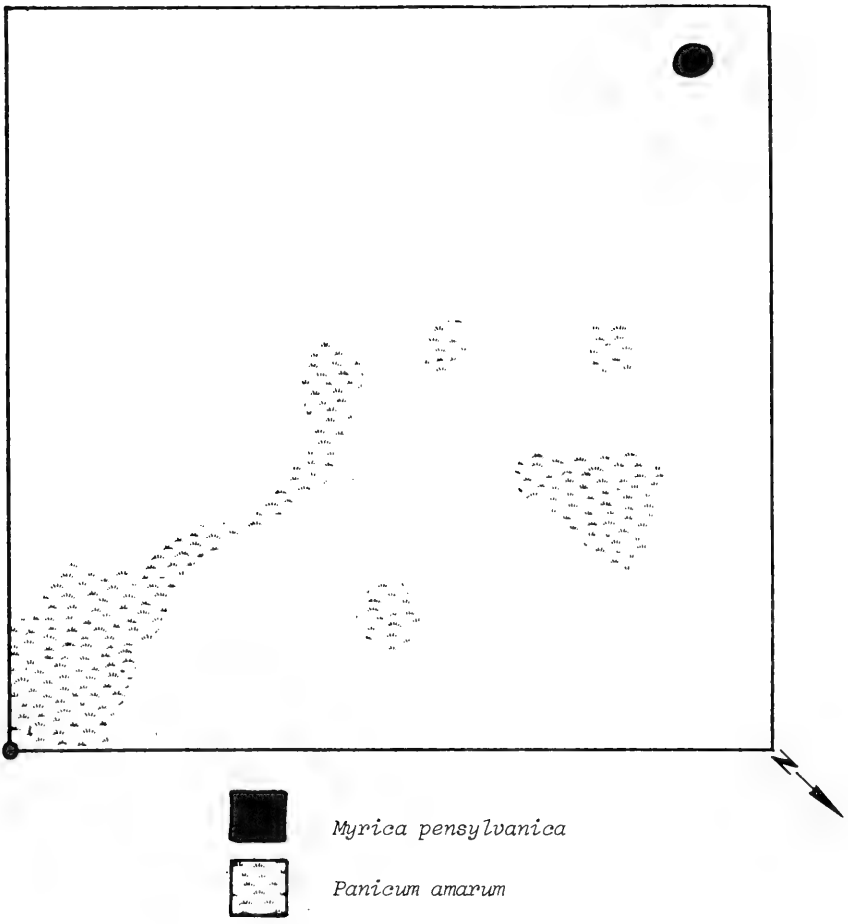
S *Salix nigra*

V *Vaccinium corymbossum*

60 percent *Spartina patens*
30 percent *Panicum fusiforme*
5 percent *Andropogon virginicus*
5 percent *Juncus coreaceous*

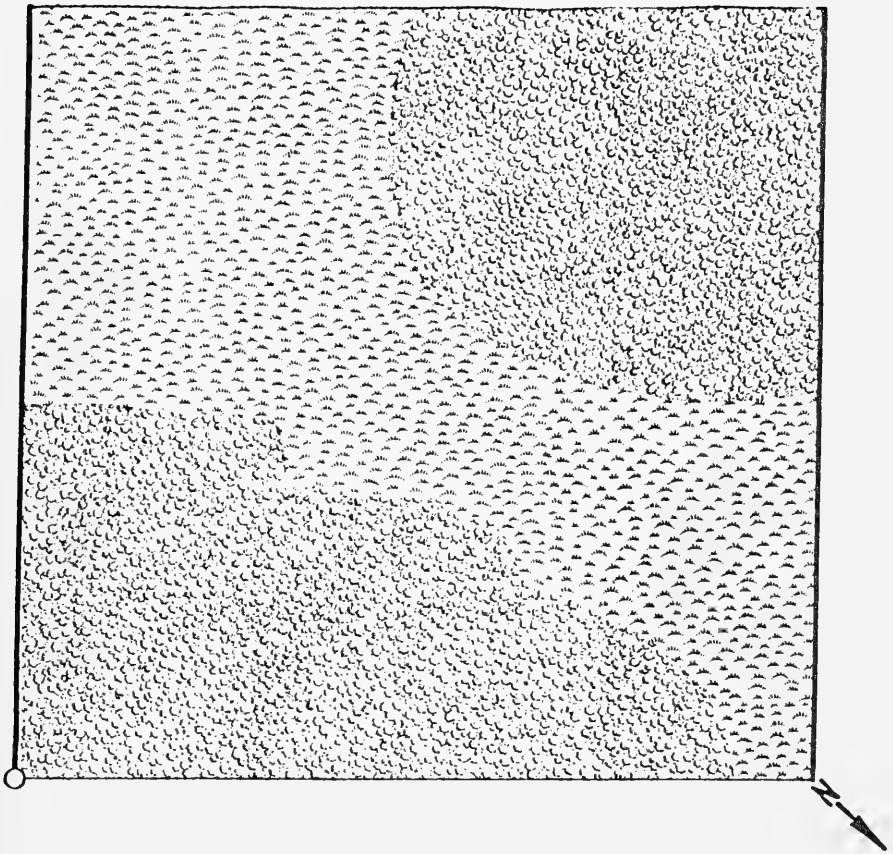
Total crown cover - 30 percent
Total ground cover -80 percent

Figure C-54. Sound-side disturbed community permanent quadrat 2.



Total ground cover - 10 percent

Figure C-55. Sound-side disturbed community permanent quadrat 3 (Levy, 1976).



35 percent *Monarda punctata*
35 percent *Solidago sempervirens*
15 percent *Ambrosia artimisifolia*
15 percent *Oenothera humifusa*

Myrica cerifera

Total crown cover - 70 percent

Total ground cover - 75 percent

Figure C-56. Sound-side disturbed community permanent quadrat 3.

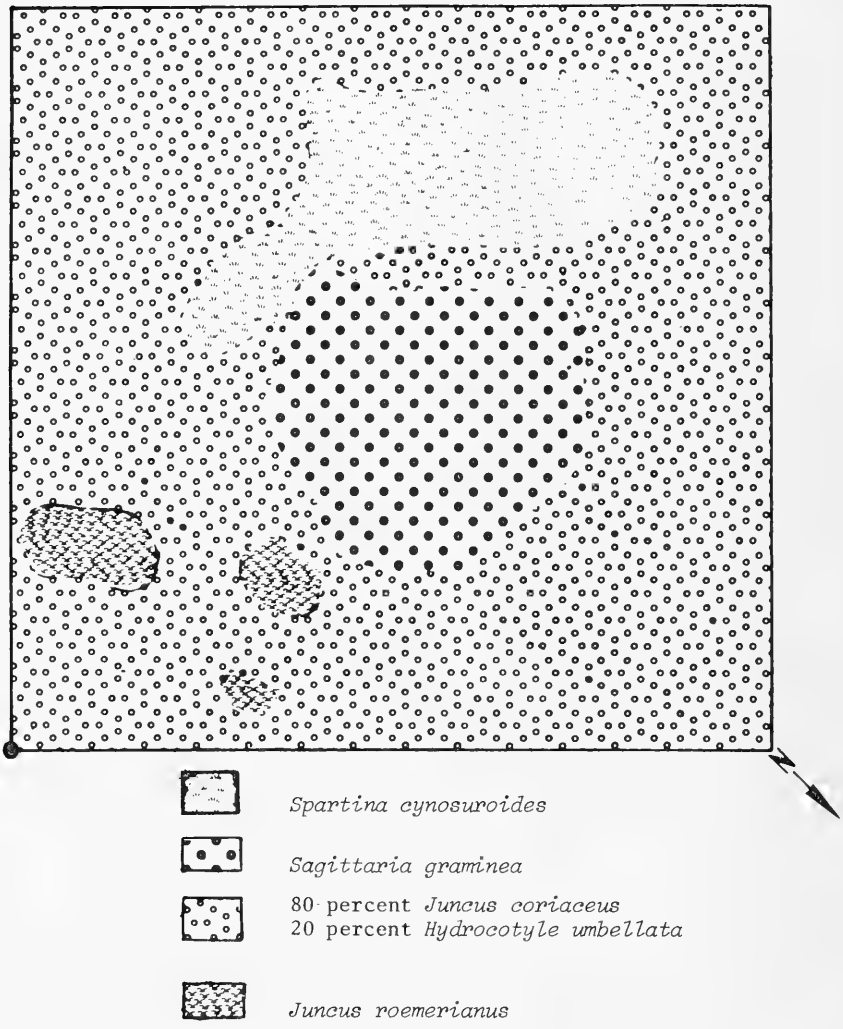
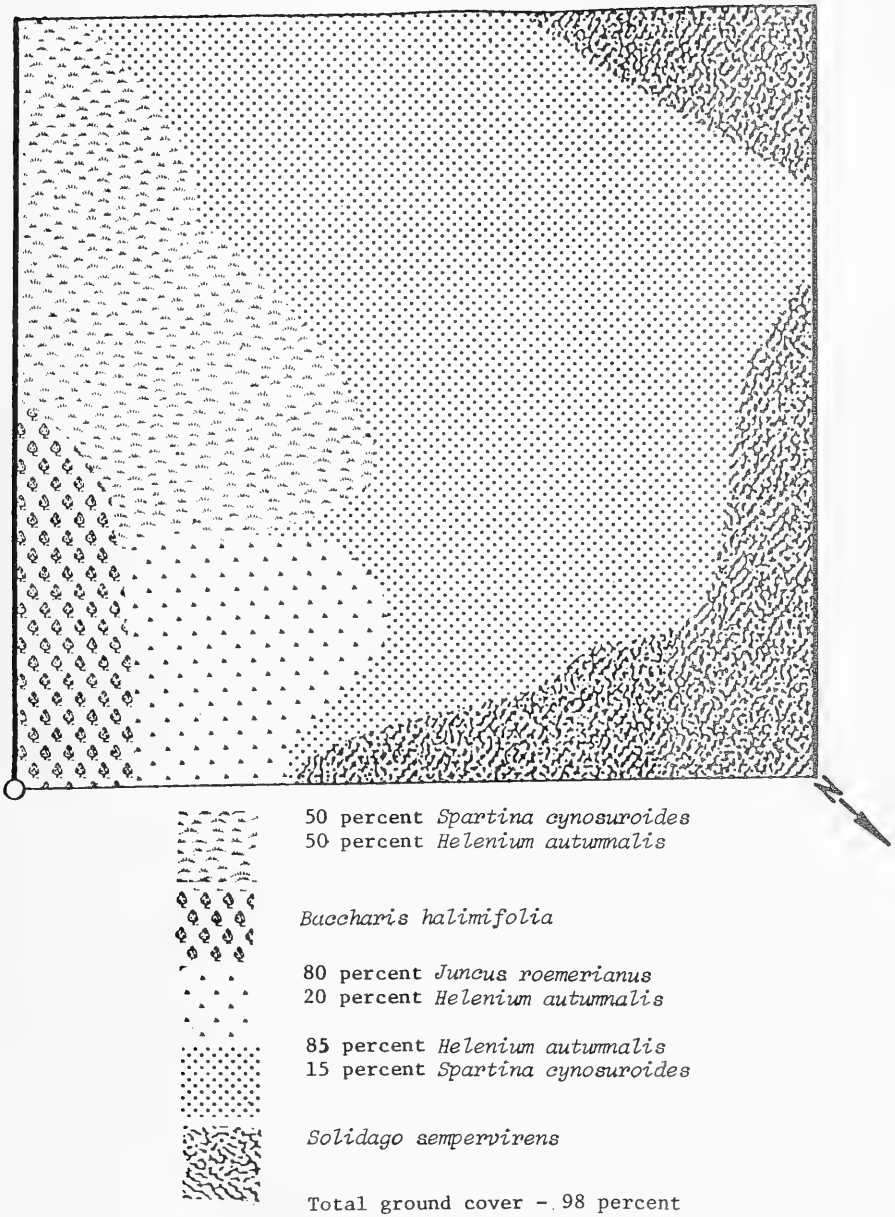


Figure C-57. Wetlands community permanent quadrat (Levy, 1976).



50 percent *Spartina cynosuroides*
50 percent *Helenium autumnalis*

Baccharis halimifolia

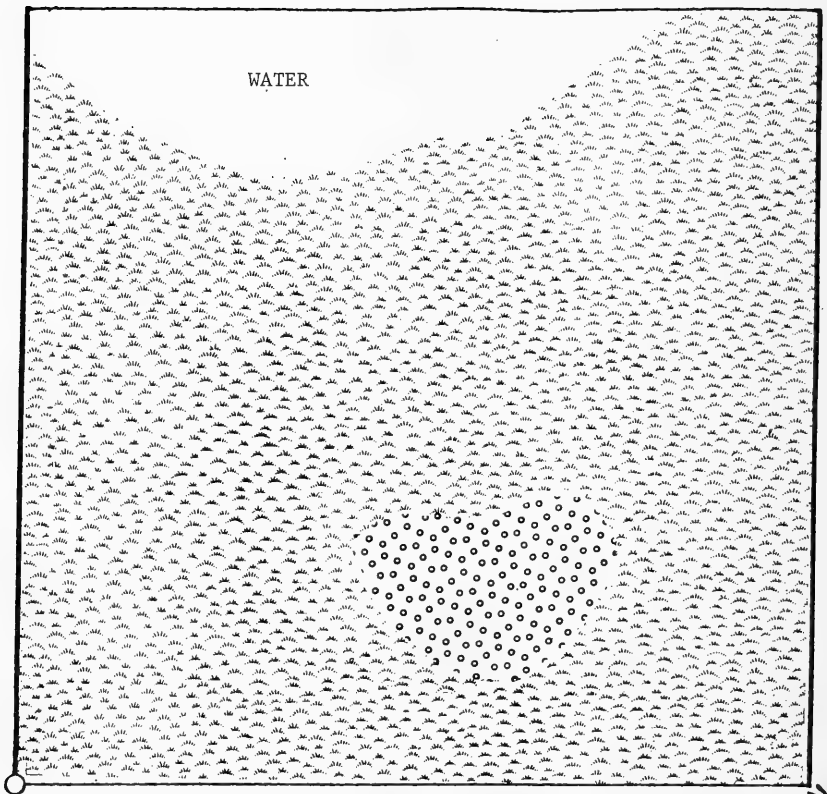
80 percent *Juncus roemerianus*
20 percent *Helenium autumnalis*

85 percent *Helenium autumnalis*
15 percent *Spartina cynosuroides*

Solidago sempervirens

Total ground cover - 98 percent

Figure C-58. Wetlands community permanent quadrat.

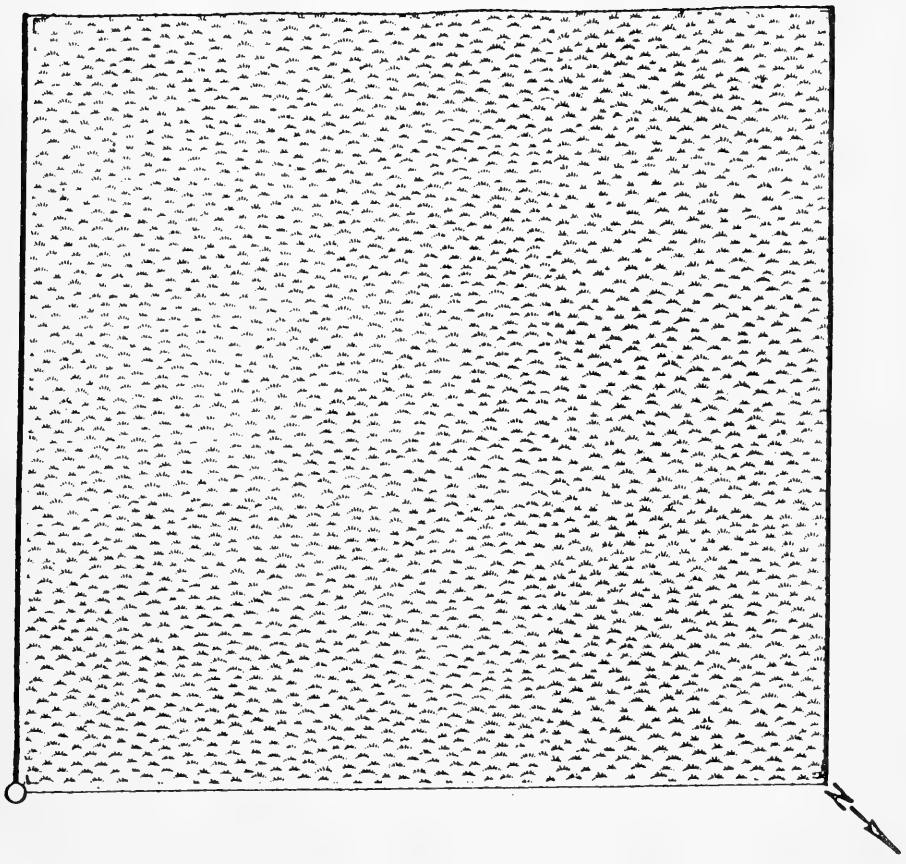


95 percent *Scirpus americanus*
4 percent *Sagittaria falcata*
1 percent *Spartina alterniflora*

Sagittaria falcata

Total ground cover - 85 percent

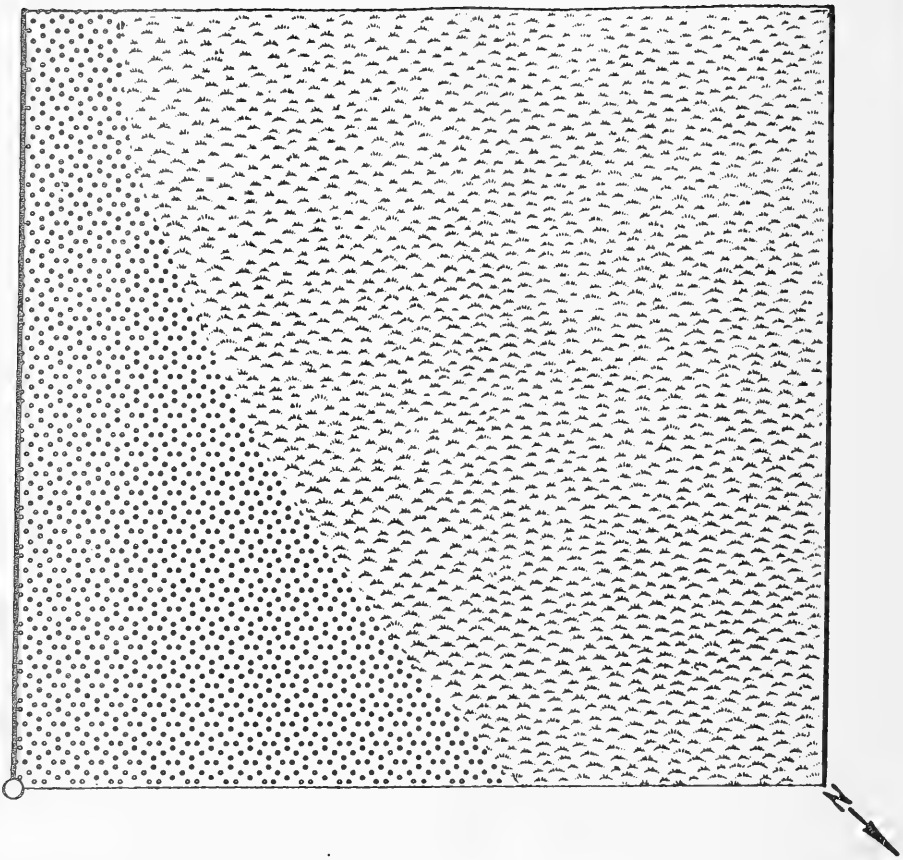
Figure C-59. Bulrush wetland community permanent quadrat.



Phragmites communis

Total ground cover - 60 percent

Figure C-60. **Reed** wetland **community** permanent quadrat.

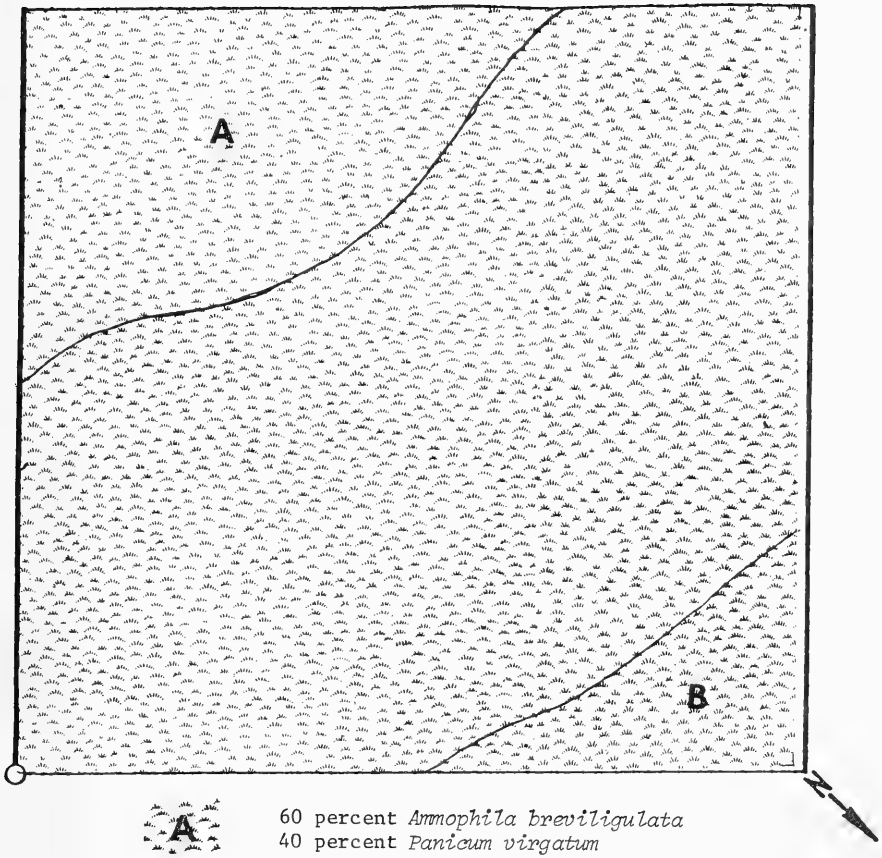


80 percent *Triplasis purpurea*
20 percent *Croton glandulosus* var. *septentrionalis*

30 percent *Croton glandulosus* var. *septentrionalis*
30 percent *Heterotheca gossypina*
20 percent *Triplasis purpurea*
20 percent *Ambrosia artemisifolia*

Total ground cover - 30 percent

Figure C-61. Sound-side disturbed-herbaceous community permanent quadrat.



A

60 percent *Ammophila breviligulata*
40 percent *Panicum virgatum*

B

90 percent *Triplasis purpurea*
10 percent *Cenchrus tribuloides*

35 percent *Triplasis purpurea*
35 percent *Cenchrus tribuloides*
20 percent *Erigeron canadensis* var. *pusillus*
10 percent *Ammophila breviligulata*

Total ground cover - 35 percent

Figure C-62. Roadside disturbed community permanent quadrat.

Harris, Richard L.

Reevaluation of vegetational characteristics at the CERC Field Research Facility, Duck, North Carolina / by Richard L. Harris, Gerald F. Levy...[et al.]--Fort Belvoir, Va. : U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Springfield Va. : available from NTIS, 1983.

[127] p. : ill. ; 28 cm.--(Miscellaneous report / Coastal Engineering Research Center ; no. 83-4)

Cover title.

"March 1983."

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1. Coastal dunes. 2. Field Research Facility. 3. Marshes. 4. Plant communities. 5. Vegetation. I. Title. II. Levy, Gerald F. III. Coastal Engineering Research Center (U.S.). IV. Series: Miscellaneous report (Coastal Engineering Research Center (U.S.)); no. 83-4.

TC203 .U581mr no. 83-4 627

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