

DREDGED MATERIAL RESEARCH PROGRAM



TECHNICAL REPORT D-77-38

HABITAT DEVELOPMENT FIELD INVESTIGATIONS, MILLER SANDS MARSH AND UPLAND HABITAT DEVELOPMENT SITE COLUMBIA RIVER, OREGON

APPENDIX F: POSTPROPAGATION ASSESSMENT OF WILDLIFE RESOURCES ON DREDGED MATERIAL

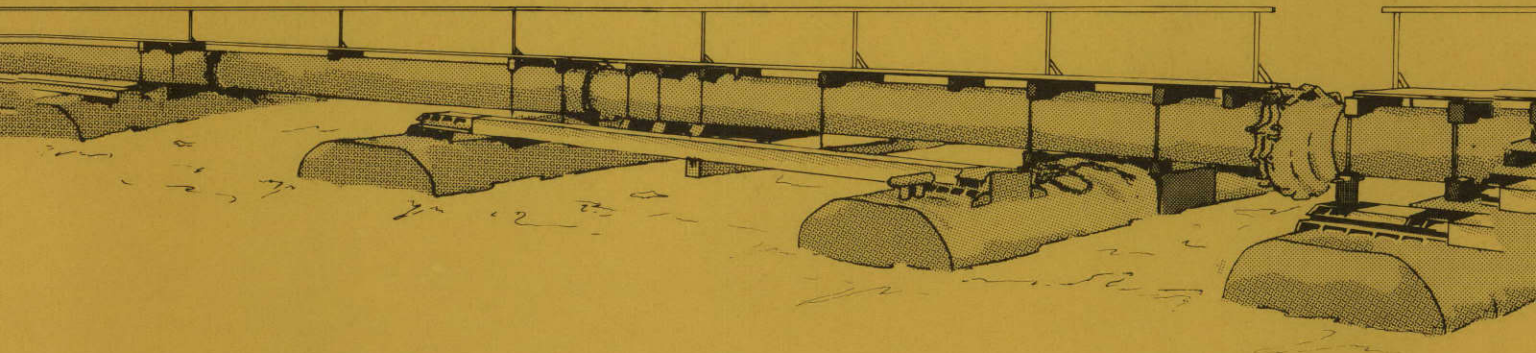
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HABITAT DEVELOPMENT FIELD INVESTIGATIONS, MILLER SANDS
MARSH AND UPLAND HABITAT DEVELOPMENT
SITE, COLUMBIA RIVER, OREGON

Appendix A: Inventory and Assessment of Predisposal Physical and Chemical Conditions

Appendix B: Inventory and Assessment of Predisposal and Postdisposal Aquatic Habitats

Appendix C: Inventory and Assessment of Prepropagation Terrestrial Resources on Dredged
Material

Appendix D: Propagation of Vascular Plants on Dredged Material in Wetland and Upland Habitats

Appendix E: Postpropagation Assessment of Botanical and Soil Resources on Dredged Material

Appendix F: Postpropagation Assessment of Wildlife Resources on Dredged Material

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15 June 1978

SUBJECT: Transmittal of Technical Report D-77-38, Appendix F

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of Work Unit 4B05I regarding postpropagation wildlife use of the Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. This work unit was conducted as part of Task 4B (Terrestrial Habitat Development) of the Corps of Engineers' Dredged Material Research Program. Task 4B was part of the Habitat Development Project and had as its objective the development and application of habitat management methodologies on upland disposal areas for the purpose of planned habitat creation, reclamation, and mitigation.
2. This report, "Appendix F: Postpropagation Assessment of Wildlife Resources on Dredged Material," is one of six contractor-prepared appendices published relative to the Waterways Experiment Station Technical Report D-77-38, entitled "Habitat Development Field Investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon; Summary Report" (4B05M). The appendices provide technical background and supporting data and may or may not represent discrete research products. Appendices that are largely data tabulations or that clearly have only site-specific relevance are published as microfiche; those with more general application are published as printed reports.
3. The purpose of this report (4B05I) was to document the wildlife use of Miller Sands Island after the implementation of habitat development activities. There was no dramatic wildlife response to any of the habitat development efforts; however, greater animal density and diversity were observed on several areas. Animal use may increase as the plant communities mature.
4. Data from this report are best interpreted in the context of the series of 13 work units that were conducted at Miller Sands (4B05A-N) and are synthesized in that site's summary report (4B05M).

A handwritten signature in cursive script, reading "John L. Cannon", is positioned above the typed name.

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Columbia River Marshes Terrestrial habitats Dredged material Miller Sands Island Waste disposal sites Field investigations Plants (Botany) Wildlife Habitats Plant populations Wildlife habitats Islands (Landforms) | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Wildlife response to plant propagation on a dredged material island in the lower Columbia River (Miller Sands Marsh and Upland Habitat Development Site) was assessed from July 1976 through August 1977. Plantings were done in late summer and fall of 1976. Data on birds, mammals, and terrestrial macroinvertebrates were collected, analyzed, and compared with data from other regions of the United States. Six habitat types were examined: natural beach, marsh, <p style="text-align: right;">(Continued)</p> | | |

20. ABSTRACT (Continued).

upland, and tree-shrub; planted marsh; and planted upland.

The planted marsh was used by fewer bird species than was a reference marsh; however, a trend developed near the end of the study which indicated that use of both will eventually be similar. Upland plantings apparently increased the number of species which used adjacent upland areas, as well as the diversity. Waterfowl fed and nested in the upland plantings, preferring a barley/bentgrass/red clover mix for feeding and a reed canary grass/red fescue/hairy vetch mix for nesting.

Very few small mammals were trapped, but it appeared that the Townsend's vole population increased in the upland canary grass/fescue/vetch mix. Macro-invertebrate populations increased on the upland.

Plantings did not have dramatic effects on the populations which were monitored. Avian density and diversity were mostly unaffected. But in some instances, the number and type of species changed in response to the plantings.

SUMMARY

The Environmental Laboratory of the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, conducted marsh and upland habitat development research on Miller Sands, Oregon, a dredged material island, located between river miles 23 and 25 on the Columbia River. This project was part of the Dredged Material Research Program.

The purpose of the study reported herein was to determine the effects of habitat development on bird, mammal, and macroinvertebrate populations on Miller Sands. Data collected on this study site were compared with data from other regions of the United States.

Bird, mammal, and macroinvertebrate populations were monitored from July 1976 through August 1977. Avian populations were censused twice each month, mammal populations were censused once every three months, and macroinvertebrate populations were censused once every two months.

Bird density, bird species diversity and number of species were monitored on 15 study areas. The study areas were located to provide data by which the effects of marsh and upland plantings on bird populations were tested.

Six areas were monitored by live-trapping to determine the effects of plantings on small mammal populations. Three planted upland areas were monitored to determine which combination of planted species had the greatest effect on small mammal populations; a reference area was also monitored to determine the overall effects of the plantings. Inventory trapping with snaptraps was also conducted in areas where small mammal sign was observed.

Macroinvertebrate populations were monitored by collecting along seven 300 x 1-m transects. The transects were arranged so data could be compared between planted and reference areas.

The planted marsh was used by fewer bird species than were the reference beach and marsh areas; however, a trend developed near the end of the study which indicated that the number of species utilizing

the planted marsh eventually would resemble the number of species which used natural marshes.

The upland planting apparently increased the number of species which utilized the upland area adjacent to the planted area. The upland planting also may have increased the bird species diversity on all of the near-planted habitats. No differences in bird species diversity were detected between pairs of near and away-from-planted areas; however, when all near-planted areas were compared to away-from-planted areas, diversity was higher on near-planted areas.

Waterfowl used the planted upland more than they used reference upland areas. Canada and snow geese preferred the upland area planted with barley. Mallards utilized the area which contained hairy vetch, reed canarygrass, and creeping red fescue for nesting more than other planted upland areas but not as much as natural tree-shrub areas.

Tree-shrub areas were ecologically the oldest habitats on Miller Sands and supported the highest bird density and species diversity. Beach and marsh areas supported the greatest number of species; these areas were ecologically the youngest.

Very few mammals were live-trapped and no density estimates were determined. However, observations and snap-trapping information indicated that the Townsend's vole population increased on the upland area planted with hairy vetch, reed canarygrass, and creeping red fescue.

The marsh planting increased the macroinvertebrate populations utilizing the area. No macroinvertebrates were captured on the reference beach areas; a few macroinvertebrates were captured in the planted marsh area after vegetation developed.

Macroinvertebrate biomass was lower on the planted upland than on the reference upland. Low biomass on the planted upland was probably related to the preparation for planting rather than the planting itself; macroinvertebrate biomass increased as vegetation developed on the area.

Plantings did not have dramatic effects on the populations which were monitored. Avian population parameters such as density and diversity were usually unaffected; however, in some instances, the number and type of species changed in response to the plantings.

PREFACE

This is a report of research conducted by the Department of Fisheries and Wildlife, Oregon State University (OSU), for the U.S. Army Engineer Waterways Experiment Station (WES) through contract DACW57-76-C-0180. The study is part of the Dredged Material Research Program (DMRP), Habitat Development Project (HDP). The DMRP is sponsored by the Office, Chief of Engineers, and is assigned to the WES Environmental Laboratory (EL).

The report is composed of two parts: the main text and Appendices A'-D', which provide the density of each bird species (determined by three techniques), the location of all the nests which were located, a list of all animals observed on Miller Sands, Oregon, and a list of the common and scientific names of all plants and animals referred to in the text, respectively. Common names of plants and animals are used throughout the text.

The project, A Post-propagation Evaluation of Wildlife Resources at the Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon, was conducted by Dr. John A. Crawford of OSU; Mr. Daniel K. Edwards served as research assistant throughout the study. Mr. Hollis Allen and Ms. Jean Hunt of WES served as technical contract managers. Dr. Jack Lattin, Ms. Barbara Gillmour, and Mr. Barry Frost of the Department of Entomology, Oregon State University, aided in identification of macroinvertebrates collected during the study.

Director of WES during this study was COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown. Chief of EL was Dr. John Harrison. Manager of the HDP was Dr. H. K. Smith.

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Conversion Factors, U.S. Customary to Metric (SI) and Metric (SI) to
 U.S. Customary Units of Measurement

Units of measurement in this report can be converted as follows:

| <u>Multiply</u> | <u>By</u> | <u>To Obtain</u> |
|--------------------------------------|-----------|----------------------|
| <u>U.S. Customary to Metric (SI)</u> | | |
| inches | 2.54 | centimeters |
| feet | 0.3048 | meters |
| miles (U.S. Statute) | 1.609344 | kilometers |
| acres | 0.4046856 | hectares |
| <u>Metric (SI) to U.S. Customary</u> | | |
| centimeters | 0.3937 | inches |
| meters | 3.2808 | feet |
| kilometers | 0.6214 | miles (U.S. Statute) |
| hectares | 2.471 | acres |

A POST-PROPAGATION EVALUATION OF WILDLIFE RESOURCES AT THE
MILLER SANDS MARSH AND UPLAND HABITAT DEVELOPMENT SITE,
COLUMBIA RIVER, OREGON

PART I: INTRODUCTION

Objectives

1. Objectives of this study were to determine effects of plantings in marsh and upland habitats on bird, small mammal and macroinvertebrate populations; to determine bird density and species diversity among different life-forms of vegetation on a dredged material island; to determine avian nest density and success in planted and control habitats; and to evaluate habitat damage by animals.

Birds

2. A review of the literature yielded several studies that indicated relationships between plant and avian succession on dredged material islands. Soos and Parnell (1975) determined the relationships between age of dredged material islands and the stages of avian (based on breeding birds) and plant succession in North Carolina. Carlson (1972) worked on dredged material islands along the west coast of Florida and identified four avian habitats; shore areas and sand bars, barren xeric areas, shrubby areas and mangrove and Australian pine (Casuarina equisetifolia) zones. The Coastal Zone Resources Corporation (1977) conducted plant and animal successional studies on five dredged material sites in the United States: Nott Island, Connecticut; Hillsborough Bay Islands, Florida; High Island, Texas; Whiskey Point Pilot Channel dredging site, Louisiana; and Mott Island, Oregon. The complexity of the vegetative and avian communities increased with the age of the site.

3. Mott Island, Oregon is located 14.5 km southwest of Miller Sands, the study area for this report. Hypothetical patterns of plant and avian succession for Mott Island were proposed by the Coastal Zone Resources Corporation (1977). Three patterns of vegetative

succession were proposed, all of which proceeded through various grass and shrub stages and culminated in a sitka spruce (Picea sitchensis) community. One exception to this pattern was the probable establishment of a climax willow (Salix spp.) community along the periphery of the island. Four stages of avian succession also were proposed: pioneer species probably colonized Mott Island first and remained until sparsely vegetated areas were eliminated; grassland species of birds probably colonized with the establishment of grassy ground cover; hedgerow-inhabiting species probably established after some of the vegetation reached a shrub and short tree stage; and woodland species probably inhabited the island as stands of mature trees developed.

4. Sixty percent of the bird species inhabiting Mott Island in 1974 were hedgerow and forest-edge species; 33 percent were woodland-inhabiting species. The high percentage of hedgerow, forest-edge, and woodland species inhabiting Mott Island corresponded closely with vegetative succession which seemed to be approaching the brush and early woodland stages (Coastal Zone Resources Corporation 1977).

5. Woodward-Clyde Consultants (1978) sampled five habitats on Miller Sands to determine which supported the greatest bird species diversity (BSD). BSD was greatest in a tree-shrub association dominated by alder (Alnus spp.), cottonwood (Populus spp.), willow, shrubs, sedges and grasses followed by intertidal marsh which was dominated by spikerush (Eleocharis palustris), Lyngby's sedge (Carex lyngbyei) and tufted hairgrass (Deschampsia cespitosa). The BSD continued to decline in the willow shrub association (dominated by several species of willows and other shrubs), an upland area dominated by horsetail (Equisetum spp. and numerous grasses), and a sandspit (little or no vegetation). The high BSD of the tree-shrub area was attributed to the degree of vegetative stratification of this habitat type. Intertidal marsh supported the second highest BSD. Intertidal marsh was considered the most diverse plant community on nearby Mott Island (Coastal Zone Resources Corporation 1977) which may account for

the high BSD observed in the marsh habitat.

6. Many studies on natural islands were concerned with colonization rates and dealt almost exclusively with breeding bird populations. Theoretically, islands were colonized only by bird species whose habitat requirements were satisfied, even though other species reached the islands (Crowell 1963). Species inhabiting islands often utilized habitats which were not used by the same species on the mainland (Crowell 1963, Diamond 1970a, 1970b). Habitat expansion was probably due to lack of competitors, which allowed island inhabitants to utilize habitats for which they were outcompeted in mainland situations.

7. MacArthur and Wilson (1963) proposed the equilibrium theory of island biogeography (i.e. the number of species inhabiting an island was a function of immigration and extinction rates which were related to the area of the island and its distance from the colonizing source). Islands farther from a colonization source would, all other factors being equal, have fewer species than would islands nearer the source. Also the number of species on large islands would decrease faster with distance from a colonization source than would the number of species inhabiting small islands. Grant (1966a) concluded that there were less congeners in the Tres Marias Islands, 80.6 km from the Mexico mainland, than on the same sized tracts of land on the mainland. The difference was attributed to the concept that island habitats are usually not of sufficient complexity to support very similar species. Grant (1966a) also noted that the proportion of congeneric species to total species increased with island size. Preston (1962) theorized that the number of congeners on an island followed a conical (logarithmic) distribution (i.e. islands supported the predicted number of congeneric species for their area). More congeners existed on mainland plots than on islands of equal area because the number of congeners on a mainland plot corresponded to the total area of the contiguous mainland habitat rather than the area of the plot; the number of congeners on an island corresponded to the area of the

island. Greenwood (1968) considered that data from Grant (1966a) to follow a logarithmic distribution; he concluded the number of congeners on Tres Marias was very close to the number predicted by the logarithmic distribution.

8. Powers (1972, 1976) believed the relationship between island area and number of bird species was indirect on the California Islands; the number of bird species inhabiting an island was better accounted for by the number of native plant species present, elevational gradient, and an isolation factor. The number of plant species was closely related to island area (Powers 1972, 1976). Habitat availability was more important in determining the number of bird species inhabiting an island than was island area on dredged material islands in Hillsborough Bay, Florida (Coastal Zone Resources Corporation 1977).

9. Diamond (1970a, 1970b) determined that total bird densities in comparable habitats on islands of the New Guinea region were linear or supralinear functions of species diversity (number of species). In the New Guinea area, average density per species did not increase and often decreased on islands; total density was as much as nine times higher on New Guinea than on adjacent islands. Crowell (1963) compared total bird densities between Bermuda and the North American mainland and found little difference. Total bird density on Maria Magdalena, in the Tres Marias Islands, was higher than the total bird density on the Mexican mainland (Grant 1966b). MacArthur et al. (1972) compared total breeding bird densities between Puercos and the Panamanian mainland; island densities were from 20-40 percent higher than mainland densities. MacArthur et al. (1972) concluded that factors such as dispersal ability of the species, habitat type, and size, location, and history of an island determined the relationship between bird density on an island and on the mainland in similar habitat.

10. Numerous studies focused on relationships among plant succession, bird density, and BSD in natural mainland communities. Johnston and Odum (1956) determined that breeding bird density

increased with complexity of the vegetative community on the Georgia Piedmont. Plant succession on the Piedmont was from cultivated or abandoned fields to a mature hardwood forest. The trend toward increased bird density with increased age of the plant community was interrupted during an early coniferous stage; increased bird density was again noted with the coming of the late sub-climax (development of a hardwood understory) and early climax stages. The number of species inhabiting each seral stage paralleled changes in density in response to ecological age of the environment, except little increase in the number of species was noted beyond the 60-year-old pine stage. Hooper et al. (1973) found similar results in the eastern United States; a positive linear relationship existed between the amount of understory and the breeding bird density. Shugart and James (1973) found that bird densities increased with ecological age in northwestern Arkansas where there were three basic successional stages; fields dominated by grasses and forbs, fields dominated by shrubs and shade intolerant trees, and forests. Karr (1968) noted a general increase in bird density with an increase in ecological age (from bare ground to bottomland forest) in east central Illinois. His study also noted higher densities than did other studies in similar habitats; the higher densities were attributed to the ridge-and-valley topography (decreased the frequency of interaction between pairs), an increased land surface per unit area (decreased horizontal territory size), and the presence of ponds (increased patchiness of the habitat).

11. MacArthur (1964) and MacArthur et al. (1966) found a significant positive linear relationship between breeding BSD and the diversity of three foliage layers in homogenous habitat in hardwood forests in the eastern United States. However, all types of foliage were not of equal value to birds. Recher (1969) determined that the relationship between BSD and the diversity of foliage layers in five Australian habitats fit the same regression equation that MacArthur (1964) derived for similar habitats in North America. MacArthur et al. (1966) determined that the habitat of birds in

Puerto Rico was divided into two layers rather than the three layers used by birds in the eastern United States; whereas, the habitat of Panamanian birds was divided into four layers. He concluded that the BSD of an area was related closely to the number of vegetative layers which the birds utilized.

12. Cody (1966) found the number of species and BSD were consistent among grasslands in North, Central, and South America and Europe. He theorized the number of species supported by a habitat depended on the structural complexity of the habitat and the degree of specialization of the species inhabiting it. Thus, there is a maximum number of species which a habitat can support, and if two physically similar habitats are saturated, they will support similar numbers of species. Karr (1968) found significant linear relationships between BSD and the diversity of foliage layers, the natural logarithm of the percent vegetation cover, and the existence energy requirements of the avian community. He concluded that BSD and energy requirements were related to habitat structure.

13. Willson (1974) theorized that the nonlinear relationship between BSD and the sum of the percent vegetation cover for all vegetation layers was more biologically meaningful than the relationship between BSD and diversity of foliage layers. The relationship noted between BSD and the diversity of foliage layers did not take into account the order in which layers of vegetation became available to birds. He concluded that the initial addition of trees to the vegetative structure was extremely important to the addition of new bird species to the system. The increase in the number of bird species theoretically was due to increased environmental patchiness on a three-dimensional basis rather than an increased productivity of resources.

14. Several studies dealt with BSD and bird densities relationships with succession at times other than the breeding season. Johnston and Odum (1956) found that grassland and pine forest bird densities were higher during the winter than during the breeding season; relative densities were less in the mature oak-hickory forest in winter

than during the breeding season.

15. Kricher (1972, 1973, 1975), working on the New Jersey Piedmont, compared BSD among summer and winter bird populations in three stages of old field succession: herbaceous field (2-3 years), cedar field (30 years), and near climax oak-hickory forest. The oak-hickory forest and cedar field supported significantly higher BSD in the summer of 1968 than did the herbaceous field; no significant difference was detected between the oak forest and the cedar field. In 1969 the BSD was significantly higher in the oak-hickory field than in the cedar field which had significantly higher BSD than the herbaceous field. He found that BSD was significantly higher in the oak-hickory forest than in the cedar field during the winters of 1968 and 1969. He also found that BSD in the herbaceous and cedar fields varied more with respect to season than did BSD in the oak-hickory forest. Thus, he concluded that the oak-hickory was the most stable ecosystem. The results of Kricher (1973, 1973, 1975) supported the theory that greater stability is present in later successional stages (Margalef 1963).

16. Anderson (1970) worked in Oregon and found that BSD was highest during late spring and early summer in Oregon white oak (Quercus garryana), Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla). Anderson (1972) determined that BSD and density were highest in the Oregon white oak stage, the ecologically youngest stage. Similar results were observed in Georgia by Johnston and Odum (1956). Such results were in contrast to the theory that species diversity increased with ecological age (Margalef 1963); if total ecosystem diversity rather than BSD had been measured, the results possibly may not have been contradictory.

17. Several studies compared the equitability component (J') of the Shannon-Weaver formula among different habitat types and found that J' was relatively constant and the species richness component (S) accounted for most of the variability in BSD; however, only birds nesting in a particular habitat were considered (MacArthur and MacArthur 1961, Karr 1968, and Recher 1969). Contrariwise, Kricher

(1972) considered all of the birds which utilized a habitat and concluded that both the magnitude and variability of J' were greatly influenced in the herbaceous field habitat by non-nesting species. J' in the cedar field and oak forest was more stable than in the herbaceous field but did vary from season to season. He concluded that the ecological importance of J' was increased when all of the birds which utilized a habitat were considered, especially in ecosystems in the early stages of succession.

Mammals

18. Carlson (1972) concluded that mammal use of dredged material islands in Sarasota Bay, Florida, was minimal but that density and species diversity were highest on islands with well developed areas of Australian pine and mangroves. Six small islands in Hillsborough Bay, Florida, supported low-density mammal populations; a single small mammal was trapped on one of the islands and desiccated mammal droppings were observed on other islands (Coastal Zone Resources Corporation 1977). The Coastal Zone Resources Corporation (1977) also conducted other studies concerning small mammal populations on dredged material at Nott Island, Connecticut; Whiskey Bay Pilot Channel site in Louisiana; High Island, Texas; and Mott Island, Oregon.

19. The Coastal Zone Resources Corporation (1977) reported three species of mammals which inhabited Mott Island: nutria (Myocaster coypus), mule deer (Odocoileus hemionus) and an unidentified mole. Townsend's voles (Microtus townsendii) probably inhabited the island but were not confirmed. Nutria were the most abundant mammals on Mott Island.

20. Woodward-Clyde Consultants (1977) reported six species of mammals on Miller Sands: Norway rat (Rattus norvegicus), Townsend's vole, Trowbridge's shrew (Sorex trowbridgii), deer mouse (Peromyscus maniculatus), nutria, and harbor seal (Phoca vitulina).

21. A number of studies concerned mammal populations on natural islands. Brown (1971) compared boreal mammal populations of mountain-top islands in the Great Basin with mainland populations in the Sierra Nevada and Rocky Mountains. His results showed that island

area was a good predictor of the number of mammal species present. No relationship was detected between the distance from a faunal source and the number of species present on a particular island. Brown (1971) concluded that the immigration rate was low and did not equal the extinction rate; he reasoned that boreal mammals of the Great Basin islands were relics from the last ice age.

22. Webb (1965) in New York observed that the number of species was lower on islands than on the mainland but that island size did not affect diversity. McPherson and Krull (1972) studied islands in an Illinois reservoir and concluded that even though the largest island in their study did not support the highest mammal diversity, diversity generally increased with island size. Distance from the mainland seemed to have little effect on the mammals present on isolated islands. In both Brown (1971) and McPherson and Krull (1972), some species of mammals were considered relics from past land bridges to the mainland.

23. Mammals on islands in Maine often expanded their habitat range relative to their range on the mainland (Manville 1951, Crowell 1973). Meadow voles (Microtus pennsylvanicus), primarily inhabitants of fields and grasslands, occupied forests on islands in both studies. Cameron (1959) found beavers (Castor canadensis) in atypical habitat on islands in the Gulf of St. Lawrence; these animals often moved back into atypical habitat after they were captured and placed in what seemed typical mainland habitat. Crowell (1963) offered the lack of competitors as a reason for the expansion of certain mammal populations into atypical habitat on islands; Grant (1971) determined that high population densities in the meadow vole caused these animals to utilize atypical habitat.

24. Various studies were concerned with the vehicles of dispersal utilized by mammals in insular colonization. Manville (1942) stated that proximity to the mainland and frequent ice bridges eliminated any physical barrier to mammals on Mount Desert Island, Maine. Manville (1964) concluded that 6 miles (9.6 km) of salt water were somewhat of a barrier in the case of Isle au Haut, Maine; only 2 of 16 prevalent

mainland mammals were found on the island. McCabe and Cowan (1945) believed that log rafts caused by land slides were a viable mechanism by which mammals dispersed from the British Columbia mainland to off-shore islands. Accidental introduction of deer mice by Indian visitors also was considered a possibility. Beer et al. (1954) reported that ice bridges were the most common means of immigration to islands in Basswood Lake, Minnesota. Crowell (1973) felt it was possible for meadow voles to swim water barriers up to 1 km in width in the Bay of Maine, whereas deer mice depended on drift and ice bridges. Ten juvenile or subadult white-footed mice (Peromyscus leucopus), from natural island populations in Ontario, Canada, swam to other islands or the mainland; the longest swim was approximately 125 m (Sheppe 1965). Mice which were introduced to new islands often abandoned these islands by swimming. One swam 233 m to return to its original island. Sheppe (1965) established that mice could orient toward land while swimming; all mice released within 53 m of shore swam toward land; however, mice released at distances greater than 300 m swam aimlessly. Some mice swam for as long as 30 minutes without becoming exhausted.

25. Hirth (1959) compared small mammal populations in old field areas from pioneer stages through forest stages. White-footed mice occurred in pioneer, mid-seral, and forest stages at a ratio of 2:4:3, respectively; the ratio for short-tailed shrews (Blarina brevicauda) was 2:5:3. McPherson and Krull (1972) believed that mammalian succession progressed from the prairie vole (Microtus ochrogaster) to the short-tailed shrew on islands in Crab Orchard Lake, a man-made reservoir in southern Illinois; plant succession was from old field to forest. Goertz (1959, 1964) found that three species of voles in Oregon had definite habitat associations: Townsend's vole (riparian habitat), Oregon vole (Microtus oregoni) (Douglas fir), and gray-tailed vole (Microtus montanus canicaudus) (cropland).

Macroinvertebrates

26. Relatively little work has been done concerning

macroinvertebrates on islands. Carlson (1972) collected 53 families of arthropods from dredged material islands off the gulf coast of Florida; arthropods were the most diverse faunal group inhabiting the island. Manville (1951) reported 15 species of spiders and 59 species of insects from a natural island in Michigan; all of the flora and fauna of the island were considered destroyed by a severe fire 39 years prior to the study. Weissman and Rentz (1976) concluded that the number of grasshopper species on the California Channel islands was best explained by maximum island elevation and area. Simberloff and Wilson (1969) reported that by 250 days after defaunation, species number and composition of terrestrial arthropods were similar to those of untreated islands on all but the most remote of six small Florida islands. Psocoptera were among the first colonizers; one to four species were usually observed during each census after the second month subsequent to defaunation. Results showed that ants were numerically and energetically the most important animals on the island. They also displayed the most orderly pattern of colonization. Data indicated that ability of ants to colonize increasingly smaller islands paralleled closely the ability to colonize increasingly distant ones; i.e. only Crematogaster ashmeadii was found on distant and extremely small islands, Crematogaster and Pseudomyrmex elongatus were both found on slightly larger and closer islands, and Crematogaster, Pseudomyrmex, and several other species were found on islands nearer still as well as on slightly larger islands.

Significance of Research

27. Because of dwindling numbers of many wild species in portions of North America, it is essential to determine methods for maintaining or enhancing wildlife populations and habitat. Intensive human use of the land is causing the disappearance of much wildlife habitat; thus, the creation of new areas capable of supporting wild populations is of increasing importance. Islands formed from dredged material are one source of such areas. This research provided an

estimate of the wildlife use of several seral stages on a dredged material island, and elucidated the effects of habitat planting on wildlife populations. These data provide a framework for future management on similar, dredged material islands.

PART II: DESCRIPTION OF STUDY AREA

28. The study site, Miller Sands, was located at a dredged material island located between river miles 22 and 25 in the Columbia River, Clatsop County, Oregon. Deposition of dredged material on the site was initiated in 1932 and has occurred periodically to maintain the shipping channel. Deposition of dredged material has resulted in an island-marsh complex approximately 228 ha in size.

29. The climate of the area, Pacific Northwest Maritime, is characterized by wet winters and dry summers (U.S. Army Engineer District, Portland 1975). The average maximum and minimum temperatures for Astoria, 19 km west of Miller Sands, during the period 1956 through 1965, were 14.6°C and 6.3°C respectively (Pacific Northwest River Basin Commission and Meteorology Commission 1969).

30. Annual precipitation for Astoria averaged 127.5 cm per year about 1 to 2 percent of which was snow (Pacific Northwest River Basin Commission and Meteorology Commission 1969; U. S. Army Engineer District, Portland 1975).

31. The soil on Miller Sands was classified as clean, fine sand with 10 percent of the particles finer than 0.1mm in diameter (U.S. Army Engineer District, Portland 1975). Organic materials in the form of logs and wood chips occurred on some areas on the island and the sand spit.

32. The Miller Sands complex consisted of three land types: the island (approximately 150 ha) deposited in the 1930's, the sand spit (approximately 53 ha) deposited in 1974, and a marsh (approximately 25 ha). The vegetation was categorized into four habitat types on a life-form basis (Figure 1): beach characterized by little or no vegetation; marsh, characterized by tufted hairgrass, spikerush, and Lyngby's sedge; upland, characterized by horsetail and grasses; and tree-shrub characterized by willow, black cottonwood (Populus trichocarpa), and alder. The island exhibited all four habitat types; the spit exhibited marsh and beach; and the marsh exhibited only marsh. These habitat types probably represented several seral

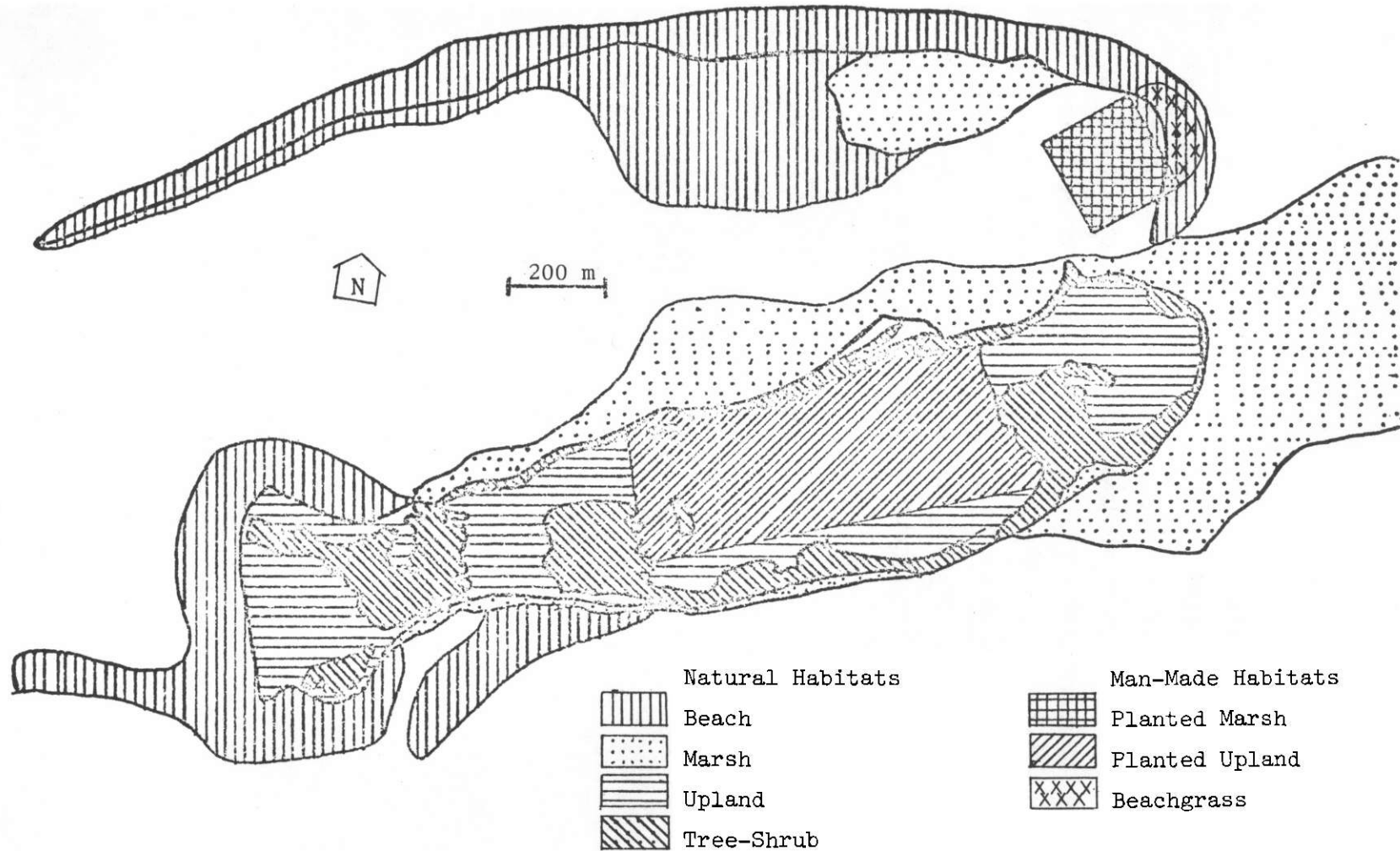


Figure 1. Location of Habitat Types on Miller Sands, Oregon (For Explanation of Habitats See Text).

stages on Miller Sands.

33. Two man-made habitats, a planted marsh and a planted upland, were constructed during the summer of 1976. The planted marsh was composed of plots of tufted hairgrass, slough sedge (Carex obnupta), and unplanted plots. Beachgrass (Ammophila arenaria) was planted on the spit to aid in stabilizing the marsh. The planted upland was divided into three meadows; meadow 3 was composed of a mixture of Reed canary grass (Phalaris arundinacea), creeping red fescue (Festuca rubra) and hairy vetch (Vicia villosa); meadow 2 of Hannchen barley (Hordeum vulgare), bentgrass (Agrostis oregonensis), and red clover (Trifolium pratense); and meadow 1 of alta fescue (Festuca elatior), tall wheat grass (Agropyron elongatum), and white clover (Trifolium repens).

PART III: METHODS
Division of Study Area

34. Fifteen areas (Table 1 and Figure 2) were established to appraise the effects of habitat manipulation on avian populations and to determine which habitats exhibited the greatest bird density and BSD.

35. Areas IUPP and IUP were used as controls for the manipulated area IUPPL. Data from IUPPL and IUPP were compared to determine if significant differences among avian populations resulted from manipulation. The following comparisons were made to determine the effects of manipulation on nearby habitats: IUPP to IUP, ITSP to ITS, IBIP to IBI, and IMAP to IMA.

36. Area SBI was used as the control to determine the effects of the planted marsh (SBIPL). No near-planted and away-from-planted comparisons were made regarding intertidal beaches, due to the lack of near-planted beach. Areas SMAP and SMA were compared to determine the effects of a planted marsh on nearby natural marsh; SMAP and SMA were also compared with SBIPL to determine differences among natural and planted marshes. SBE and MMA were used in over-all comparisons of marsh and beach habitats.

37. Data from areas adjacent to manipulated areas were pooled and compared with pooled data from away-from-planted areas to determine if any subtle effects which were not indicated by direct comparisons could be detected. Data from all areas were compared to determine which areas supported the greatest bird density and BSD.

Avian Data Collection and Analysis

38. Three techniques were used to estimate bird density on each study area. Results of the transect method (Emlen 1971), the fixed plot technique (Bond 1957 and Anderson 1971, 1972) and the variable plot technique (Personal Communication, June 1976, R. T. Reynolds,

Table 1

Study Area Titles and Description for Miller Sands

| <u>Study Area</u> | <u>Description</u> |
|-------------------|--|
| IUPPL | Planted upland |
| IUPP | Meadow area adjacent to planted upland |
| IUP | Meadow area away-from-planted upland |
| ITSP | Island tree-shrub area adjacent to planted upland |
| ITS | Island tree-shrub area away-from-planted upland |
| IMAP | Island marsh adjacent to planted upland |
| IMA | Island marsh away-from-planted upland |
| MMA | Large marsh complex |
| IBIP | Island intertidal beach adjacent to planted upland |
| IBI | Island intertidal beach away-from-planted upland |
| SBIPL | Spit planted marsh |
| SBI | Reference area for planted marsh |
| SBE | Below intertidal zone |
| SMAP | Spit marsh adjacent to planted marsh |
| SMA | Spit marsh away-from-planted marsh |

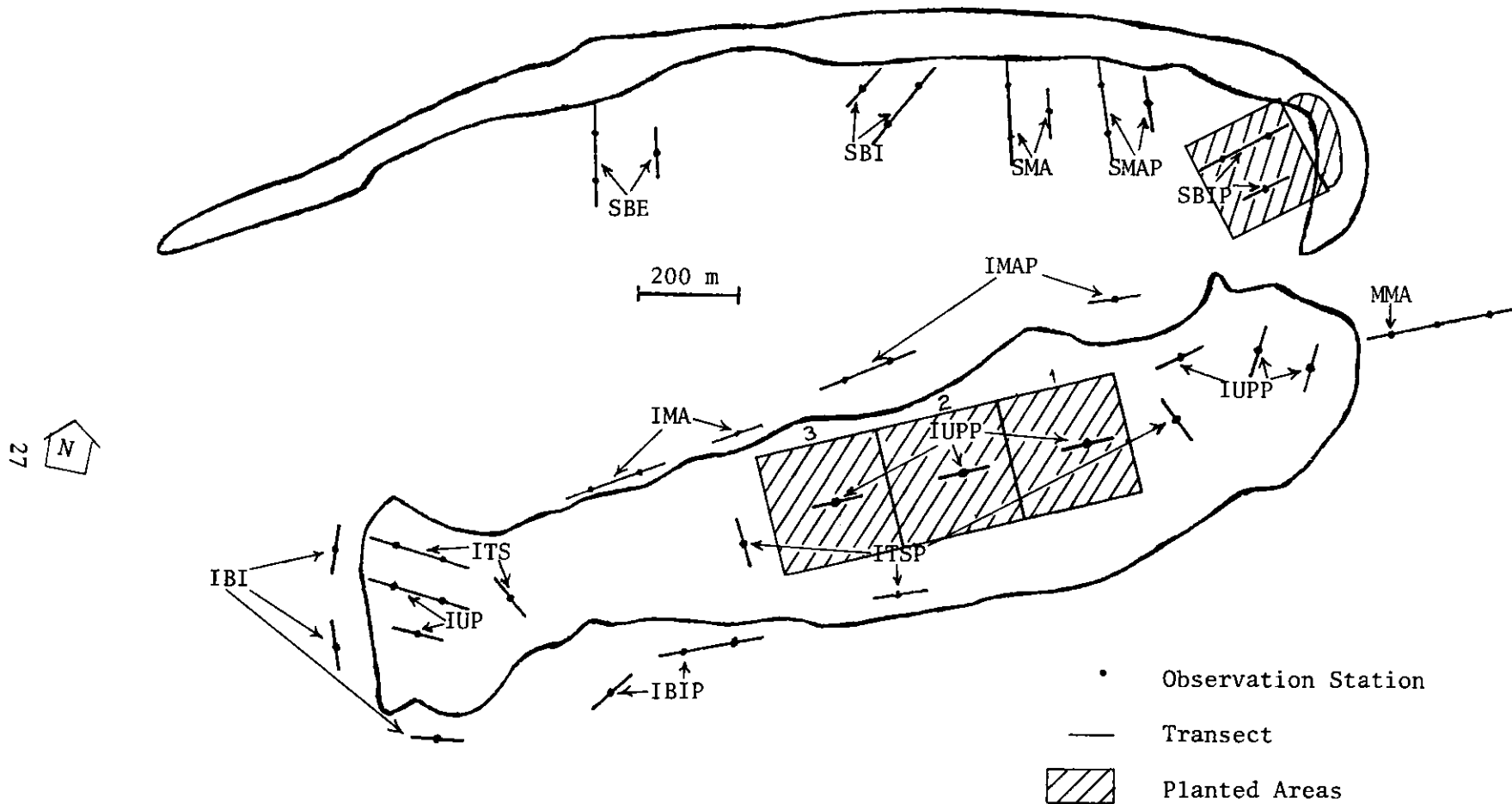


Figure 2. Location of Transects on Miller Sands, Oregon
 (For an Explanation of Transects See Text and Table 1).

Oregon State University, Corvallis) were compared (Appendix A'). The results and conclusions in this report were based on data collected with the variable plot technique.

39. A 100 m by 300 m transect, divided into three 100 m by 100 m subsamples, was established in each of 15 study areas; three observation stations: 50 m, 150 m, and 250 m from the beginning of each transect were also established. Data were collected along each transect twice monthly between sunrise and 2.5 hr after sunrise; three study areas were sampled each day. The altitude of flying birds was recorded as low (0-40 m) and high (above 40 m). The space 0-40 m was considered the approximate space between the lowest point on the area at low tide and the top of the tallest tree. All birds observed within the 0-40 m space were considered as utilizing the area and were included in the analysis. Birds above 40 m were not included in the analysis unless they demonstrated use of the area (i.e. circling, foraging etc.). Birds which entered the area after sampling had begun were considered in the analysis. Data used for analysis by the fixed and variable plot techniques were collected simultaneously.

40. Birds were identified and their lateral distances from the belt transect line recorded; birds over 50 m on either side of the transect line were not recorded. Transect data were recorded along 50 m of a subsample, then ten minutes were spent recording data from an observation station, at the end of which the transect subsample was completed. No bird more than 50 m ahead or behind the observer along a transect was recorded. As the observer moved along the transect the distance at which birds were identified steadily decreased from 50 m to 0 m; the distance behind the observer increased from 0-50 m.

41. Density estimates of bird populations from transect counts were based on the determination of the coefficient of detectability (C.D.) which is an estimate of the proportion of the total population of a species in an area which was detected (Emlen 1971). The C.D. for a species was determined by plotting all of the observations

within each of five 10 m lateral bands along each side of all transects within a particular habitat. The inflection point of the curve, after it began to fall in respect to increasing distance, was considered the point beyond which 100 percent of the individuals of a particular species was no longer detected. The C.D. was calculated by the following formula:

$$C.D. = \frac{b}{a} \text{ where } a = 10(Z) \text{ and } Z = \frac{x}{y}$$

(x was the number of birds observed between zero and the inflection point, y was the number of bands between zero and the inflection point, Z was the mean number of birds per band, 10 was the total number of lateral bands, a was the expected number of birds within 50 m on each side of the transect line, and b was the actual number of birds observed within 50 m on either side of the transect line). The C.D. was divided into the number of individuals of each species on each study area to obtain the transect density estimates for each species.

42. The fixed plot technique (Bond 1957) and Anderson (1971, 1972) involved data collected during a 10 minute period at each of the observation stations. All birds recorded within a 56.4 m radius (1 ha area) of the observer were considered in the analysis.

43. Density estimates for each species were derived from data collected with the fixed plot technique by dividing the total number of individuals recorded for a species by three (the number of hectares sampled).

44. The variable plot technique (Personal Communication, June 1976, R. T. Reynolds) also involved data collected during a 10 minute period at observation stations. The distance from the observer and species of bird were recorded as distant on a particular study area as the bird could be identified.

45. Avian density estimates from the variable plot technique (Personal Communication, June 1976, R. T. Reynolds) were derived from all data (including that used in the fixed plot technique) collected on observation stations by the formula:

$$\text{Density (birds/ha)} = \frac{10,000\text{m}^2/\text{ha}}{3\pi r^2} \times N$$

(N = number of individuals within a species, r = 100 percent detection distance for the species and 3 = the number of areas sampled to distance r). The 100 percent detection distance was that distance at which the density of a species within concentric 10 m bands radiating from the observer decreased to less than one-half the density of the preceding band.

46. The communication theory of species diversity (Shannon and Weaver 1949),

$$H = -\sum_{i=1}^s P_i \log_e P_i$$

where s is the number of species and p is the proportion of the total number of individuals belonging to the ith species, was used to calculate BSD for each study area.

47. The Shannon-Weaver diversity index was divided into its two components for the analysis: the species richness component (number of species) and the equitability component (J' where $J = \frac{H'}{H'_{\max}}$ and H'_{\max} is \log_e of the total number of species and H' is the Shannon-Weaver value).

48. A droppings-count index was used during January and February to differentiate use of upland areas (IUPPL No. 1, IUPPL No. 2, IUPPL No. 3, and IUPP) by Canada and snow geese. Ten 1 m^2 samples were taken on each of three successive days during each sample period.

49. All data were analyzed by analysis-of-variance or paired-t-test techniques; means were separated by Least Significant Difference analysis if significant F-values were obtained from analysis-of-variance tests (Snedecor and Cochran 1967). Fiducial limits for statistical analysis of all tests were set at the 95 percent confidence level.

Nest Searches

50. Two nest searches in July and one in August were conducted during 1976. The entire island and spit were searched during each nest search. Upland, marsh, and beach areas were traversed by several observers spaced approximately 30 m apart to flush nesting

birds. Observers maintained approximately 10 m spacings while tree-shrub areas were searched. Nests were identified to species with the aid of a nest key (Stevenson 1942); the number of eggs, young, and success of each nest were recorded when possible.

51. Two nest searches per month were conducted from April through July in 1977. Three 1 ha plots were dragged with a 30 m long rope in each study area (IUPPL, IUPP, and IUP). Three 1 ha plots were walked in study areas ITSP and ITS; observers maintained approximately 10 m spacings. The spit was walked in a criss-cross manner during each nest search. Nest searches were not conducted in marsh areas because these were totally inundated on the average of once each day. Fluctuations were of a magnitude too severe even for birds that built floating nests.

Small Mammal Populations

52. Small mammal populations were censused every three months with 7.62 cm x 7.62 cm x 25.4 cm Tomahawk live-traps set for seven nights. In July 1976, 49-trap mammal grids were set on areas IUPPL No. 1, IUPPL No. 2, IUPPL No. 3, and IUPP and in August 1976, 48-trap grids were set on areas SBE, SMA and SBIPL. Seven-trap grids were set on areas IUPPL No. 1, IUPPL No. 2, IUPPL No. 3, IUPP, SBE, SMA, and SBIPL in October 1976 and January 1977. In April and July 1977, 49-trap grids were set on areas IUPPL No. 1, IUPPL No. 2, IUPPL No. 3, and IUPP and a 24-trap grid was set on area SBIPL. Trapping on areas SBE and SMA was terminated after January 1977 due to problems with high tides and a paucity of evidence of small mammals in these areas. Twenty-eight rat traps were set subjectively in upland and tree-shrub habitats during October 1976 and January 1977 and 51-trap and 46-trap, mixed trap-lines (mouse-trap, rat-trap, and live-trap) were set in April and July 1977, respectively, to inventory small mammals inhabiting Miller Sands. Inventory trapping was done for six nights each period.

Macroinvertebrate Insect Populations

53. Macroinvertebrate populations were monitored every two months except during the period December 1976 through April 1977; insect standing crop estimates for each area were made from data collected along 300 m x 1 m transects in areas IUPPL, IUPP, IMAP, SBE, SMAP, and SBIPL. Insects were collected with a sweep-net and identified to the lowest possible taxa.

Animal Damage and Human Disturbance

54. Damage by animals and humans was assessed when it was noted or reported by other contractors. An attempt was made to identify the organisms responsible for damage by observing damage areas and searching for tracks, droppings, and other signs.

PART IV: RESULTS

Avian Censuses

Marsh planting

55. The number of species recorded, bird density, and BSD of each area were compared among study areas SBIPL, SBE, and SBI to determine the effects of planting marsh vegetation on a beach (Table 2). The mean number of species recorded on SBIPL (8.43) was significantly lower than the mean number of species recorded on SBE (10.79) or SBI (10.93). No significant difference occurred between the number of species recorded on SBE and SBI (Table 2). No significant differences in bird density and BSD were detected among the study areas (Tables 3 and 4).

56. Study areas SBIPL, SMAP, SMA, and MMA were compared to determine the effects of plantings on an adjacent natural marsh and to compare the planted marsh with natural marshes. The mean number of species recorded on SBIPL (8.43) was significantly lower than the mean number of species recorded on SMA (10.50) and MMA (13.07); the number of species recorded on SMAP (9.50) was not significantly different from that recorded on SMA. The number of species recorded on MMA was significantly different from those recorded on SMAP and SMA. BSD on MMA (1.65) was significantly higher than BSD on SBIPL (0.91), SMAP (1.03), and SMA (1.14); no significant differences in BSD were detected among SBIPL, SMAP, and SMA (Table 3). No significant differences were detected in bird density among SBIPL (11.70), SMAP (11.53), SMA (12.63), and MMA (7.82) (Table 4).

57. Densities of four species of birds (mallard (Anas platyrhynchos), western gull (Larus occidentalis), California gull (Larus californicus), and common crow (Corvus brachyrhynchos) were compared among areas SBIPL, SBI, and SBE and areas SBIPL, SMAP, and SMA to determine the effects of marsh plantings on common species. No significant differences were detected.

Table 2
Number of Species Recorded on Each Study Area on Miller Sands, from July 1976 through August 1977

| Month | Study Area | | | | | | | | | | | | | | |
|---------------------|-----------------|----------------|----------------|----------------|-----------------|-----------------|----------------|-----------------|-----------------|-------|----------------|----------------|-------|-------|-------|
| | IUPPL | IUPP | IUP | ITSP | ITS | IMAP | IMA | SMAP | SMA | MMA | IBIP | IBI | SBIPL | SBI | SBE |
| July | 11 ^a | 7 ^a | 7 ^a | 7 ^a | 11 ^a | 10 ^a | 8 ^a | 8 ^a | 9 ^a | 9 | 4 ^a | 7 ^a | 9 | 9 | 8 |
| August | 8 ^a | 9 ^a | 9 ^a | 8 ^a | 8 ^a | 7 ^a | 8 ^a | 11 ^a | 13 ^a | 11 | 6 ^a | 8 ^a | 7 | 8 | 10 |
| September | 13 | 7 | 3 | 4 | 5 | 10 | 12 | 8 | 11 | 12 | 6 | 12 | 7 | 12 | 13 |
| October | 4 | 11 | 4 | 4 | 6 | 12 | 14 | 8 | 10 | 14 | 9 | 11 | 7 | 13 | 11 |
| November | 9 | 5 | 4 | 5 | 5 | 15 | 12 | 7 | 9 | 12 | 8 | 13 | 5 | 12 | 12 |
| December | 3 | 4 | 2 | 7 | 7 | 12 | 7 | 3 | 10 | 16 | 8 | 10 | 6 | 10 | 8 |
| January | 7 | 5 | 2 | 8 | 6 | 9 | 7 | 11 | 10 | 10 | 13 | 12 | 3 | 10 | 9 |
| February | 3 | 4 | 4 | 9 | 6 | 10 | 9 | 6 | 12 | 14 | 13 | 10 | 6 | 9 | 11 |
| March | 3 | 6 | 5 | 9 | 11 | 10 | 10 | 10 | 9 | 12 | 14 | 12 | 8 | 10 | 11 |
| April | 8 | 10 | 7 | 10 | 11 | 11 | 15 | 15 | 11 | 18 | 7 | 12 | 12 | 12 | 14 |
| May | 10 | 11 | 11 | 9 | 9 | 10 | 12 | 10 | 10 | 17 | 11 | 13 | 11 | 15 | 10 |
| June | 7 | 11 | 5 | 10 | 8 | 9 | 12 | 11 | 11 | 10 | 5 | 8 | 13 | 9 | 10 |
| July | 10 | 11 | 6 | 6 | 7 | 9 | 13 | 11 | 10 | 12 | 8 | 8 | 10 | 10 | 10 |
| August | 9 | 10 | 7 | 7 | 6 | 11 | 11 | 14 | 13 | 16 | 9 | 11 | 14 | 14 | 14 |
| Mean B ^b | 9.50 | 8.00 | 8.00 | 7.50 | 9.50 | 8.50 | 8.00 | 9.50 | 11.00 | - | 5 | 7.50 | - | - | - |
| Mean A ^c | 7.17 | 7.92 | 5.00 | 7.33 | 7.25 | 10.67 | 11.17 | 9.50 | 10.50 | 13.07 | 9.25 | 11.00 | 8.43 | 10.93 | 10.79 |

^a Data used for before-planting calculations related to upland plantings.

^b Mean of before-planting data.

^c Mean of after-planting data.

Table 3

Bird Species Diversity Recorded on Each Study Area on Miller Sands, from July 1976 through August 1977

| Month | Study Area | | | | | | | | | | | | | | |
|---------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------|-------------------|-------------------|-------|------|------|
| | IUPPL | IUPP | IUP | ITSP | ITS | IMAP | IMA | SMAP | SMA | MMA | IBIP | IBI | SBIPL | SBI | SBE |
| July | 1.74 ^a | 1.20 ^a | 1.23 ^a | 1.59 ^a | 1.83 ^a | 1.13 ^a | 1.53 ^a | 1.58 ^a | 1.38 ^a | 1.27 | 0.67 ^a | 1.15 ^a | 0.41 | 0.68 | 0.53 |
| August | 1.59 ^a | 1.49 ^a | 1.24 ^a | 1.57 ^a | 1.67 ^a | 0.99 ^a | 0.63 ^a | 1.91 ^a | 1.84 ^a | 1.68 | 0.57 ^a | 1.07 ^a | 0.52 | 0.97 | 1.17 |
| September | 1.64 | 1.17 | 0.68 | 1.22 | 0.97 | 1.51 | 1.09 | 1.05 | 1.46 | 1.91 | 0.94 | 0.83 | 1.38 | 1.15 | 1.80 |
| October | 1.01 | 1.94 | 1.12 | 0.86 | 1.35 | 2.15 | 0.54 | 1.34 | 1.10 | 1.79 | 1.87 | 1.93 | 1.50 | 1.23 | 0.60 |
| November | 1.39 | 0.59 | 1.12 | 1.13 | 1.08 | 1.90 | 1.48 | 0.65 | 0.36 | 1.81 | 1.75 | 1.38 | 0.38 | 1.63 | 1.05 |
| December | 0.79 | 0.57 | 0.64 | 1.31 | 1.48 | 0.72 | 0.26 | 0.31 | 0.86 | 0.80 | 1.34 | 0.60 | 0.63 | 0.56 | 0.96 |
| January | 1.63 | 0.88 | 0.13 | 1.34 | 1.49 | 0.77 | 1.07 | 0.97 | 1.50 | 1.16 | 1.61 | 1.62 | 0.05 | 0.73 | 1.15 |
| February | 0.29 | 0.81 | 1.24 | 1.83 | 1.60 | 1.61 | 0.55 | 1.73 | 1.12 | 1.76 | 1.81 | 1.86 | 0.39 | 1.32 | 1.90 |
| March | 1.00 | 1.41 | 1.50 | 1.72 | 1.91 | 1.76 | 1.81 | 0.46 | 1.57 | 2.03 | 2.50 | 0.84 | 1.25 | 1.27 | 1.14 |
| April | 1.30 | 1.97 | 1.02 | 1.67 | 1.95 | 0.90 | 1.36 | 0.87 | 1.34 | 1.54 | 1.16 | 1.14 | 1.44 | 0.89 | 0.95 |
| May | 1.19 | 2.14 | 1.26 | 1.95 | 1.85 | 0.86 | 0.80 | 1.12 | 0.85 | 1.95 | 0.57 | 0.51 | 0.73 | 1.02 | 0.60 |
| June | 0.96 | 2.06 | 0.77 | 1.92 | 1.82 | 1.18 | 2.13 | 1.38 | 1.62 | 2.01 | 1.36 | 1.39 | 1.86 | 1.35 | 1.71 |
| July | 1.55 | 1.85 | 1.18 | 1.63 | 1.84 | 1.17 | 0.99 | 1.58 | 1.30 | 1.43 | 1.33 | 1.40 | 0.95 | 0.92 | 1.13 |
| August | 0.72 | 1.12 | 1.08 | 1.68 | 1.45 | 1.18 | 0.64 | 0.89 | 0.62 | 1.91 | 1.79 | 1.87 | 1.19 | 0.72 | 1.65 |
| Mean B ^b | 1.67 | 1.35 | 1.24 | 1.58 | 1.75 | 1.06 | 1.08 | 1.75 | 1.61 | - | 0.62 | 1.11 | - | - | - |
| Mean A ^c | 1.12 | 1.38 | 0.98 | 1.52 | 1.57 | 1.31 | 1.06 | 1.03 | 1.14 | 1.65 | 1.50 | 1.28 | 0.91 | 1.03 | 1.17 |

^a Data used for before-planting calculations related to the upland plantings.

^b Mean of before-planting data.

^c Mean of after-planting data.

Table 4

Bird Density Recorded on Each Study Area on Miller Sands, July 1976 through August 1977

| Month | Study Area | | | | | | | | | | | | | | |
|---------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|-------------------|-------|-------|-------|-------------------|-------------------|-------|-------|-------|
| | IUPPL | IUPP | IUP | ITSP | ITS | IMAP | IMA | SMAP | SMA | MMA | IBIP | IBI | SBIPL | SBI | SBE |
| July | 8.51 ^a | 1.99 ^a | 3.14 ^a | 12.86 ^a | 24.84 ^a | 16.08 ^a | 6.11 ^a | 7.23 | 6.53 | 4.02 | 0.64 ^a | 1.29 ^a | 31.43 | 23.75 | 10.01 |
| August | 20.50 ^a | 5.92 ^a | 2.01 ^a | 9.35 ^a | 8.19 ^a | 2.39 ^a | 5.02 ^a | 10.67 | 11.35 | 3.14 | 1.24 ^a | 1.25 ^a | 9.47 | 7.07 | 6.33 |
| September | 3.25 | 2.75 | 3.65 | 2.42 | 5.05 | 3.12 | 3.73 | 5.04 | 3.78 | 3.19 | 4.28 | 8.63 | 2.62 | 8.52 | 6.11 |
| October | 1.93 | 1.51 | 0.84 | 11.90 | 19.31 | 1.86 | 9.52 | 1.56 | 10.45 | 2.18 | 0.42 | 1.38 | 1.02 | 8.26 | 6.36 |
| November | 2.32 | 5.90 | 1.18 | 14.92 | 5.71 | 1.09 | 1.86 | 11.51 | 18.22 | 6.36 | 0.61 | 2.45 | 11.20 | 3.32 | 11.02 |
| December | 0.75 | 1.64 | 0.06 | 27.37 | 10.79 | 2.42 | 8.97 | 1.53 | 3.36 | 12.06 | 1.93 | 13.67 | 3.11 | 14.25 | 2.06 |
| January | 0.68 | 2.38 | 1.71 | 15.16 | 6.86 | 8.96 | 1.72 | 1.78 | 2.12 | 6.71 | 3.65 | 0.92 | 4.80 | 11.30 | 1.07 |
| February | 0.30 | 0.44 | 0.24 | 13.03 | 7.47 | 1.14 | 6.06 | 0.37 | 19.56 | 2.17 | 4.24 | 3.88 | 2.59 | 8.20 | 1.39 |
| March | 0.33 | 0.42 | 0.21 | 7.01 | 13.07 | 1.74 | 2.70 | 17.34 | 1.06 | 5.44 | 0.75 | 7.93 | 3.26 | 6.92 | 9.16 |
| April | 3.84 | 2.32 | 1.10 | 11.11 | 19.28 | 10.05 | 13.90 | 31.80 | 10.10 | 23.82 | 1.28 | 5.86 | 4.85 | 34.74 | 23.72 |
| May | 3.89 | 2.87 | 9.88 | 11.81 | 8.37 | 15.77 | 16.79 | 9.50 | 14.00 | 11.10 | 9.43 | 14.59 | 4.61 | 10.45 | 10.53 |
| June | 3.19 | 4.40 | 2.54 | 10.79 | 8.70 | 4.24 | 1.82 | 7.40 | 13.81 | 2.78 | 1.06 | 4.78 | 7.92 | 4.59 | 2.54 |
| July | 10.97 | 2.51 | 4.78 | 11.34 | 30.60 | 15.84 | 8.13 | 23.71 | 19.59 | 15.13 | 2.48 | 1.33 | 38.24 | 29.95 | 14.08 |
| August | 20.02 | 10.62 | 2.63 | 4.45 | 7.58 | 14.96 | 56.20 | 31.97 | 42.82 | 11.31 | 1.05 | 2.10 | 38.66 | 52.31 | 11.45 |
| Mean B ^b | 14.51 | 3.96 | 2.58 | 11.11 | 16.52 | 9.24 | 5.57 | - | - | - | 0.94 | 1.27 | - | - | - |
| Mean A ^c | 4.29 | 3.15 | 2.40 | 11.78 | 11.90 | 6.77 | 10.95 | 11.53 | 12.63 | 7.82 | 2.60 | 5.63 | 11.70 | 15.97 | 8.27 |

^a Data used for before-planting calculations related to upland plantings.^b Mean of before-planting data.^c Mean of after-planting data.

Upland planting

58. No significant differences in number of species, BSD or bird density were detected among areas IUPPL No. 1, IUPPL No. 2, and IUPPL No. 3 (Tables 5, 6, and 7) before or after upland plantings.

59. Two months of before-planting data were compared among IUPPL, IUPP, and IUP; no significant differences in number of species, BSD, or bird density were detected. After-planting data indicated that the number of species was significantly higher on IUPP (7.92) than on IUP (5.00); however, IUPP was not significantly different from IUPPL (7.17) nor was IUPPL significantly different from IUP (Table 2). No significant differences in BSD and bird density were detected among IUPPL, IUPP, and IUP (Tables 3 and 4) after planting.

60. Bird density was significantly higher on IBI (5.63 birds/ha) than on IBIP (2.4 birds/ha) (Table 4). No significant differences in the number of species and BSD were detected between IBIP and IBI (Tables 2 and 3).

61. No significant differences in number of species, BSD, or bird density were observed between IMAP and IMA, nor between ITSP and ITS (Tables 2, 3, and 4).

62. BSD was significantly higher in the near-planted areas (IUPP, IBIP, IMAP, and ITSP) (1.43) than in the away-from-planted areas (IUP, IBI, IMA, and ITS) (1.22). No significant differences in number of species and bird density were detected between near-planted and away-from-planted areas.

63. Densities of the four most common species which occurred in the uplands (mallard, common crow, starling (*Sturnus vulgaris*) and savannah sparrow (*Passerculus sandwichensis*) were compared among IUPPL, IUPP, and IUP. The transformation, $\sqrt{x + 1}$, where x = density (Snedecor and Cochran 1967:325) was used to adjust the data to fit a normal distribution. Common crows were significantly more abundant on IUPPL (0.14 crows/ha) and IUPP (0.13 crows/ha) than on IUP (0.01 crows/ha) (Table 8). No significant differences in densities of mallards, starlings, and savannah sparrows were detected among IUPPL, IUPP, and IUP. Densities of four common species (common

Table 5
 Number of Bird Species Recorded by Subsample in IUPPL,
Miller Sands, July 1976 - August 1977

| <u>Month</u> | <u>Study Area</u> | | |
|---------------------|--------------------|--------------------|--------------------|
| | <u>IUPPL No. 3</u> | <u>IUPPL No. 2</u> | <u>IUPPL No. 1</u> |
| July | 6 ^a | 6 ^a | 7 ^a |
| August | 4 ^a | 3 ^a | 6 ^a |
| September | 7 | 7 | 6 |
| October | 1 | 3 | 4 |
| November | 4 | 5 | 3 |
| December | 1 | 2 | 2 |
| January | 4 | 5 | 2 |
| February | 0 | 2 | 1 |
| March | 2 | 2 | 0 |
| April | 4 | 6 | 5 |
| May | 6 | 2 | 7 |
| June | 4 | 3 | 5 |
| July | 9 | 5 | 4 |
| August | 3 | 6 | 5 |
| Mean B ^b | 5 | 4.5 | 6.5 |
| Mean A ^c | 3.75 | 4.00 | 3.67 |

^a Data used for before-planting calculations related to the upland plantings.

^b Mean of before-planting data.

^c Mean of after-planting data.

Table 6

Bird Species Diversity by Subsample in IUPPL, Miller Sands,
July 1976 - July 1977

| <u>Month</u> | <u>Study Area</u> | | |
|---------------------|--------------------|--------------------|--------------------|
| | <u>IUPPL No. 3</u> | <u>IUPPL No. 2</u> | <u>IUPPL No. 1</u> |
| July | 1.36 ^a | 1.60 ^a | 1.22 ^a |
| August | 0.86 ^a | 1.02 ^a | 1.28 ^a |
| September | 1.38 | 1.18 | 0.99 |
| October | 0 | 0.43 | 0.88 |
| November | 0.99 | 1.20 | 0.40 |
| December | 0 | 0.25 | 0.44 |
| January | 1.08 | 1.42 | 0.65 |
| February | - ^d | 0.11 | 0 |
| March | 0.35 | 0.65 | - ^d |
| April | 0.89 | 1.36 | 0.78 |
| May | 1.30 | 0.16 | 1.15 |
| June | 1.15 | 0.42 | 0.66 |
| July | 1.50 | 0.99 | 1.07 |
| August | 0.26 | 0.78 | 0.76 |
| Mean B ^b | 1.11 | 1.31 | 1.25 |
| Mean A ^c | 0.81 | 0.75 | 0.71 |

^a Data used for before-planting calculations related to the upland plantings.

^b Mean of before-planting data.

^c Mean of after-planting data.

^d In instances when no birds were recorded on a study area, the BSD is undefined.

Table 7
Bird Densities by Subsample in IUPPL, Miller Sands,
July 1976 - August 1977

| <u>Month</u> | <u>Study Area</u> | | |
|---------------------|--------------------|--------------------|--------------------|
| | <u>IUPPL No. 3</u> | <u>IUPPL No. 2</u> | <u>IUPPL No. 1</u> |
| July | 8.33 ^a | 8.34 ^a | 7.88 ^a |
| August | 22.24 ^a | 18.00 ^a | 19.72 ^a |
| September | 4.85 | 5.10 | 3.82 |
| October | 0.41 | 1.69 | 3.68 |
| November | 1.04 | 2.10 | 4.01 |
| December | 0.02 | 1.29 | 0.88 |
| January | 0.68 | 1.07 | 0.23 |
| February | 0 | 0.85 | 0.03 |
| March | 0.54 | 0.39 | 0 |
| April | 2.06 | 1.63 | 8.11 |
| May | 4.41 | 2.82 | 4.46 |
| June | 3.12 | 2.91 | 4.30 |
| July | 7.29 | 4.42 | 20.01 |
| August | 6.11 | 19.25 | 39.93 |
| Mean B ^b | 15.29 | 13.17 | 13.80 |
| Mean A ^c | 2.54 | 3.63 | 7.46 |

^a Data used for before-planting calculations related to the upland plantings.

^b Mean of before-planting data.

^c Mean of after-planting data.

Table 8

Common Crow Densities in Upland Study Areas, Miller Sands,
July 1976 - August 1977

| <u>Month</u> | <u>Study Area</u> | | |
|---------------------|-------------------|-------------------|-------------------|
| | <u>IUPPL</u> | <u>IUPP</u> | <u>IUP</u> |
| July | 0 ^a | 1.20 ^a | 0.14 ^a |
| August | 0.07 ^a | 0.02 ^a | 0 ^a |
| September | 0.27 | 0 | 0 |
| October | 0.43 | 0.02 | 0 |
| November | 0.03 | 0 | 0 |
| December | 0.03 | 0 | 0 |
| January | 0.10 | 0.02 | 0 |
| February | 0.01 | 0.06 | 0 |
| March | 0.12 | 0.03 | 0.02 |
| April | 0.24 | 0.15 | 0.01 |
| May | 0.07 | 0.19 | 0.02 |
| June | 0.03 | 0.42 | 0.04 |
| July | 0.29 | 0.41 | 0.03 |
| August | 0.04 | 0.29 | 0.03 |
| Mean B ^b | 0.04 | 0.61 | 0.07 |
| Mean A ^c | 0.14 | 0.13 | 0.01 |

^a Data used in before-planting calculations.

^b Mean of before-planting data.

^c Mean of after-planting data.

crow, blackcapped chickadee (Parus atricappillus), Bewick's wren (Thryomanes bewickii), and song sparrow (Melospiza melodia) were compared between ITSP and ITS; no significant differences were detected. No significant differences in densities of four common species (mallard, western gull, California gull, and common crow) were detected between IMAP and IMA or between IBIP and IBI.

64. Data from the goose-use indices were transformed for analysis by $\sqrt{x + 1}$: where x = number of droppings per 1-m^2 sample. The index showed that IUPPL No. 2 received significantly greater use by Canada geese (Branta canadensis) and snow geese (Chen caerulescens) than did IUPPL No. 1, IUPPL No. 3, and IUPP during all four sample periods (Table 9). Goose use on IUPPL No. 1 was significantly greater than on IUPPL No. 3 and IUPP during all sample periods (Table 9). Goose use on IUPPL No. 3 was significantly greater than on IUPP during the first January and second February sample periods; goose use on IUPPL No. 3 and IUPP was not significantly different during the second January and first February sample periods (Table 9).

65. Number of species, BSD, and bird density were compared among near-planted habitats (ITSP, IUPP, IBIP, and IMAP). The number of species was significantly higher on IMAP (10.67) than on ITSP (7.33) or IUPP (7.92); IMAP was not significantly different from IBIP (9.25) (Table 2). No significant difference in number of species was detected among ITSP, IUPP, and IBIP (Table 2). No significant differences were detected in BSD among ITSP (1.52), IUPP (1.38), IBIP (1.50), and IMAP (1.31) (Table 3). Bird density was significantly higher on ITSP (11.78 birds/ha) than on IMAP (6.77 birds/ha), IUPP (3.15 birds/ha), or IBIP (2.60 birds/ha) (Table 4). Bird density was significantly greater on IMAP than on IUPP or IBIP; no significant difference was observed between IUPP and IBIP (Table 4).

66. Number of species, BSD, and bird density were compared among away-from-planted habitats (ITS, IUP, IBI, and IMA). The number of species was significantly higher on IMA (11.17 birds/ha) and IBI (11.00 birds/ha) than it was on ITS (7.25 birds/ha) and

Table 9
Index to Goose Use (Droppings/m²), Miller Sands, January and February 1977

| IUPPL No. 1 | | IUPPL No. 2 | | IUPPL No. 3 | | IUPP | |
|-------------|----------|-------------|----------|-------------|----------|---------|----------|
| January | February | January | February | January | February | January | February |
| 1 2 | 1 2 | 1 2 | 1 2 | 1 2 | 1 2 | 1 2 | 1 2 |
| 2 1 | 0 0 | 15 21 | 11 8 | 7 10 | 1 9 | 0 0 | 0 0 |
| 2 1 | 1 0 | 12 15 | 6 5 | 6 5 | 4 7 | 0 0 | 0 0 |
| 0 0 | 0 1 | 7 12 | 1 3 | 11 2 | 0 6 | 0 0 | 0 0 |
| 0 2 | 3 0 | 2 3 | 2 4 | 5 6 | 1 3 | 0 0 | 0 0 |
| 2 0 | 0 2 | 3 4 | 2 1 | 2 4 | 5 2 | 0 0 | 0 0 |
| 4 1 | 0 1 | 1 16 | 6 13 | 3 1 | 3 6 | 0 0 | 0 0 |
| 1 1 | 0 3 | 0 9 | 11 17 | 7 0 | 4 2 | 0 0 | 0 0 |
| 0 0 | 0 0 | 2 6 | 3 11 | 4 5 | 8 6 | 0 0 | 0 0 |
| 0 1 | 0 0 | 1 4 | 2 4 | 0 3 | 3 13 | 0 0 | 0 0 |
| 5 0 | 1 0 | 21 4 | 4 5 | 10 3 | 4 9 | 0 0 | 0 0 |
| 1 3 | 0 2 | 17 12 | 10 12 | 4 0 | 1 2 | 0 0 | 0 0 |
| 0 1 | 3 0 | 2 15 | 17 6 | 6 2 | 2 1 | 0 0 | 0 0 |
| 1 0 | 0 0 | 4 10 | 23 12 | 3 2 | 1 0 | 0 0 | 0 0 |
| 0 0 | 0 3 | 1 6 | 15 7 | 2 2 | 6 1 | 0 0 | 0 0 |
| 0 1 | 0 1 | 7 2 | 6 10 | 2 3 | 1 2 | 0 0 | 0 0 |
| 1 0 | 0 2 | 1 3 | 10 10 | 2 7 | 4 1 | 0 0 | 0 0 |
| 1 0 | 0 4 | 3 5 | 4 15 | 3 14 | 2 0 | 0 0 | 0 0 |
| 1 0 | 0 0 | 0 2 | 7 4 | 3 7 | 3 0 | 0 0 | 0 0 |
| 2 2 | 0 2 | 12 7 | 14 1 | 1 3 | 0 1 | 0 0 | 0 0 |
| 0 4 | 0 0 | 14 11 | 6 10 | 4 3 | 2 1 | 0 0 | 0 0 |
| 1 1 | 2 4 | 13 31 | 19 17 | 1 3 | 12 3 | 0 0 | 0 0 |
| 0 3 | 1 0 | 7 18 | 1 22 | 3 2 | 4 0 | 0 0 | 0 0 |
| 1 0 | 1 2 | 5 12 | 2 14 | 5 1 | 24 3 | 0 0 | 0 0 |
| 1 0 | 2 1 | 8 6 | 10 20 | 2 0 | 6 2 | 0 0 | 0 0 |
| 2 0 | 0 5 | 7 14 | 5 10 | 4 3 | 1 3 | 0 0 | 0 0 |
| 4 0 | 1 1 | 10 3 | 9 15 | 7 3 | 8 3 | 0 0 | 0 0 |
| 0 3 | 0 3 | 7 11 | 8 14 | 0 5 | 2 6 | 0 0 | 0 0 |
| 1 2 | 1 2 | 8 14 | 5 8 | 0 4 | 4 2 | 0 0 | 0 0 |
| 0 6 | 1 4 | 1 9 | 6 22 | 1 1 | 8 7 | 0 0 | 0 0 |
| 3 0 | 2 6 | 10 0 | 4 25 | 3 3 | 4 1 | 0 0 | 0 0 |

Mean
1.20 1.10 0.63 1.63 6.70 9.50 7.63 10.83 3.70 3.50 4.27 3.40 0 0 0 0

IUP (5.00 birds/ha); IMA was not significantly different from IBI (Table 2). The number of species on ITS was significantly greater than on IUP (Table 2). BSD was significantly greater on ITS (1.57) than on IBI (1.28), IMA (1.06), or IUP (0.98); BSD among IBI, IMA, and IUP was not significantly different (Table 3). Bird density was significantly higher on ITS (11.90 birds/ha) than it was on IBI (5.63 birds/ha) and IUP (2.40 birds/ha); bird density was not significantly different between ITS and IMA (10.95 birds/ha) (Table 4). IMA had a significantly higher bird density than IUP but was not significantly different from IBI; bird density on IBI was not significantly different from that observed on IUP (Table 4).

67. J' values were compared among away-from-planted (ITS, IMA, IBI, and IUP) and near-planted (ITSP, IMAP, IBIP, and IUPP) study areas. The mean J' for ITS (0.80) was significantly higher than the mean J' for IUP (0.65), IBI (0.54), or IMA (0.45). Mean J' was significantly higher on IUP than on IMA; mean J' was not significantly different on IUP than on IBI nor was IBI different from IMA. Mean J' for ITSP (0.78) was higher than for IMAP (0.55), but was not significantly different from IUPP (0.66) or IBIP (0.65), nor was IMAP different from IUPP or IBIP.

Nest Searches

Marshes 1976

68. No nests were found in any of the marshes during the 1976 nest searches.

Upland and associated habitats, 1976

69. Sixty-seven common crow nests, two willow flycatcher (Empidonax trailii) nests, and one nest each for American robin (Turdus migratorius), song sparrow, and savannah sparrow were found during three nest searches in 1976 (Table 10). One willow flycatcher nest which contained four eggs in July and three nestlings in August was the only active nest found in 1976 (for nest location see Appendix B).

Table 10

Bird Nesting Activity on Miller Sands, July 1976 - August 1976

| <u>Habitat</u> | <u>Species</u> | <u>No. of Nests</u> | <u>No. of Active Nests</u> | <u>No. Young</u> |
|----------------|-------------------|-------------------------|------------------------------------|----------------------|
| Tree-shrub | Common crow | 67 | 0 | 0 |
| | Willow flycatcher | 2 | 1 | 3 |
| Scot's broom | American robin | 1 | 0 | 0 |
| | Song sparrow | 1 | 0 | 0 |
| Upland | Savannah sparrow | 1 | 0 | 0 |

Table 11
Bird Nesting Activity on Miller Sands,
April 1977 - July 1977^a

| <u>Habitat</u> | <u>Size in ha</u> | <u>Bird Species</u> | <u>Number of Nests</u> | | <u>Average Nest Success</u> | <u>Nest Density Nests/ha</u> | |
|----------------|-----------------------|-----------------------|------------------------|-----------------|---------------------------------|----------------------------------|-----------------|
| | | | <u>Active</u> | <u>Inactive</u> | | <u>Active</u> | <u>Inactive</u> |
| IUPPL | 3 | Mallard | 2 | | 0 | 0.67 | 0 |
| Total | 3 | | 2 | | 0 | 0.67 | |
| <hr/> | | | | | | | |
| IUPP | 3 | White-crowned sparrow | 1 | | 0 | 0.33 | 0 |
| Total | 3 | | 1 | | 0 | 0.33 | |
| <hr/> | | | | | | | |
| ITSP | 2.5 | Common crow | 12 | 20 | 3.2 young | 4.80 | 8.00 |
| | | Unknown | 0 | 11 | - | 0 | 4.40 |
| | | Mallard | 4 | 0 | 0.75 young | 1.60 | 0 |
| | | American robin | 0 | 1 | - | 0 | 0.40 |
| | | Swainson's thrush | 2 | 0 | Undetermined | 0.80 | 0 |
| | | Song sparrow | 1 | 0 | Undetermined | 0.40 | 0 |
| Total | 2.5 | | 19 | 32 | 1.98 | 7.60 | 12.80 |
| <hr/> | | | | | | | |
| ITS | 2 | Common crow | 10 | 19 | 3.13 | 5.00 | 9.50 |
| | | Unknown | 0 | 5 | - | 0 | 2.50 |
| | | Mallard | 5 | 0 | 5.20 | 2.50 | 0 |
| | | Song sparrow | 2 | 2 | Undetermined | 1.00 | 1.00 |
| | | American robin | 1 | 1 | Undetermined | 0.50 | 0.50 |
| Total | 2 | | 18 | 27 | 4.17 | 9.00 | 13.50 |

^a No nests were found in IUP or on the spit.

Marshes, 1977

70. Marshes were not searched for nests in 1977 because they were completely inundated daily.

Uplands and associated habitats, 1977

71. Results of the 1977 nest searches indicated that IUPPL supported 0.67 mallard nests/ha; however, no young were known to have hatched from either nest (Table 11). Both nests were located in IUPPL No. 3. Additionally, two mallard nests were located in IUPPL No. 1 but they were not in the nest search area (see Appendix B). One white-crowned sparrow (Zonotrichia leucophrys) nest was found in IUPP (0.33 nests/ha). ITSP supported a total nest density of 7.60 active nests and 12.80 inactive nests/ha; an average of 1.98 young/nest was produced from nests for which nest success was determined (Table 11). ITS supported a total nest density of 9.00 active nests and 13.50 inactive nests/ha. An average of 4.17 young per nest was produced from nests for which nest success was determined (Table 11). No nests were found in IUP or on the spit during 1977.

Small Mammals

72. Seven small mammals were captured by live-trapping between July 1976 and July 1977 (Table 12). Three Townsend's voles and one vagrant shrew (Sorex vagrans) were caught in grid IUPPL No. 3. Three vagrant shrews were trapped in IUPP.

73. Snap-traps were used for a total of 1182 trap-nights in upland and tree-shrub habitats from August 1976 through August 1977. During this time, 65 small mammals were captured (Table 12). All of the Norway rats (20) were captured in the drift zone (logs and other debris) of the tree-shrub habitat. Three vagrant shrews were captured in IUPPL No. 2, and six shrews were caught in the drift zone. Of the 36 Townsend's voles which were captured, 16 were in the tree-shrub community: 11 were found in IUPPL No. 3, and 9 were caught in a small tract of unmanipulated upland habitat between IUPPL No. 3 and ITS No. 1.

Macroinvertebrate Population

74. IUPP supported a significantly higher macroinvertebrate standing crop ($\bar{X} = 1.91 \times 10^{-3} \text{ g/m}^2$) than did SBE ($\bar{X} = 0$), SBIPL ($\bar{X} = 0.010 \times 10^{-3} \text{ g/m}^2$), SMAP ($\bar{X} = 0.363 \times 10^{-3} \text{ g/m}^2$), or IMAP ($\bar{X} = 0.550 \times 10^{-3} \text{ g/m}^2$) but was not significantly different from IUPP ($\bar{X} = 1.15 \times 10^{-3} \text{ g/m}^2$). IUPPL supported a significantly higher macroinvertebrate biomass than did SBE and SBIPL but was not significantly different from SMAP and IMAP (Table 13).

75. The most important groups of macroinvertebrates on a weight basis were: grasshoppers (Acrididae), long-legged flies (Dolichopodidae), anthomyiid flies (Anthomyiidae), and spiders (Aranae) during July 1976; grasshoppers, earwigs (Forficulidae), heleomyzid flies (Heleomyzidae), and spittle bugs (Cercopidae) during September 1976; spiders, leaf beetles (Chrysomelidae), ants (Formicidae), and ichneumon flies (Ichneumonidae) during November 1976; spiders, crane flies (Tipulidae),

Table 12

Numbers of Trap-nights and Captures of Small Mammals, Miller Sands, July 1976-August 1977

| <u>Method</u> | <u>July 1976</u> | <u>August 1976</u> | <u>Number of Individuals</u> | | | <u>July 1977</u> | <u>August 1977</u> |
|----------------------------------|----------------------|------------------------|------------------------------|-------------------------|-----------------------|----------------------|------------------------|
| | | | <u>October 1976</u> | <u>January 1977</u> | <u>April 1977</u> | | |
| Live-trapping (trap nights) | 1372 | 1008 | 343 | 343 | 1540 | 1540 | - |
| Vagrant shrew | 0 | 0 | 0 | 0 | 1 | 3 | - |
| Townsend's vole | 0 | 0 | 0 | 0 | 2 | 1 | - |
| 6 Snap-trapping (trap nights) | - | 108 | 168 | 168 | 318 | 276 | 144 |
| Vagrant shrew | - | 3 | 0 | 0 | 4 | 2 | 0 |
| Townsend's vole | - | 1 | 1 | 0 | 14 | 9 | 11 |
| Norway rat | - | 5 | 5 | 2 | 5 | 3 | 0 |

Table 13
Total Macroinvertebrate Biomass ($\text{g} \times 10^{-3}/\text{m}^2$)
by Time Period and Study Area, Miller Sands,
July 1976 - July 1977

| <u>Study Area</u> | <u>Total Macroinvertebrate Biomass</u> | | | | |
|-------------------|--|------------------|-----------------|------------|-------------|
| | <u>July</u> | <u>September</u> | <u>November</u> | <u>May</u> | <u>July</u> |
| IUPPL | 1.482 | 0.783 | 0 | 0.428 | 3.077 |
| IUPP | 1.236 | 1.603 | 1.351 | 1.665 | 3.698 |
| IMAP | 0.374 | 0.160 | 0.159 | 0.507 | 1.575 |
| SBIPL | 0 | 0 | 0 | 0.032 | 0.019 |
| SMAP | 0.433 | 0.235 | 0.078 | 0.177 | 0.890 |
| SBE | 0 | 0 | 0 | 0 | 0 |

midges (Chironomidae) and ladybird beetles (Coccinellidae) during May 1977; and spiders, ladybird beetles, grasshoppers, and long-legged flies during July 1977.

Animal Damage

Marsh

76. Some cutting of tufted hairgrass and Lyngby's sedge by nutria and muskrats (Ondatra zibethicus) in natural marsh was noted during July and August 1976. Nutria were also responsible for destroying several bulrushes in the intertidal area bordering SBIPL. Grazing on tufted hairgrass in SBIPL was noted during September, October and November of 1976. Nutria and muskrat sign and American wigeon (Anas americana) were observed in SBIPL on several occasions; these animals were probably responsible for the grazing. Grazing of tufted hairgrass by American wigeon and mallards was noted in SBIPL during December 1976 and January 1977. Green-winged teal (Anas carolinensis) and Canada geese were responsible for minor grazing of tufted hairgrass in SBIPL during February 1977. A small amount of grazing of tufted hairgrass by waterfowl and muskrats was noted during May 1977.

Upland

77. Large flocks of common crows, starlings, killdeer (Charadrius vociferus), and water pipits (Anthus spinoletta) were observed feeding in IUPPL soon after it was planted. Newly emerged vegetation in IUPPL (especially IUPPL No. 2 and IUPPL No. 1) was heavily grazed by Canada and snow geese in January 1977 and by Canada geese in February 1977.

78. A mallard nest which contained 11 eggs was destroyed by crows in April 1977. Two mallard nests were completely destroyed and eggs from several other nests were lost to common crows in May 1977; a white-crowned sparrow nest in IUPP and a Swainson's thrush (Catharus ustulata) nest in ITSP were destroyed by common crows in June 1977.

Disturbance by Man

79. Several common flickers (Colaptes auratus) and one great-horned owl (Bubo virginianus) were caught in nutria traps during November 1976 (Personal Communication, November 1976, Jack Rogers, Trapper, Corvallis, Oregon). The owl was released with slightly injured toes on its left foot; all flickers were killed by the traps. Several common flickers were killed in nutria traps (Personal Communication, January 1977, Jack Rogers), and one common snipe and one song sparrow were killed by rat traps during the mammal census in January 1977. Two Canada geese were caught in nutria traps in February 1977; one goose was released with a severely damaged left leg and foot. The other goose was found dead in a trap (Personal Communication, February 1977, David Greer, Western Washington Research Center, Puyallup). One common crow, one hen mallard, and one muskrat were killed by nutria traps in March 1977 (Personal Communication, March 1977, Jack Rogers). One Canada goose, two hen mallards, and one common snipe (Capello gallinago) were caught in nutria traps in April 1977; the goose and the snipe were dead. The mallards were released; both birds were missing one leg (Jack Rogers, April 1977). Mark Hirschberger (Personal Communication, April 1977, Oregon State University, Corvallis) also reported a song sparrow which was killed by a rat trap during the April 1977 mammal census. Two hen mallards were flushed by a dog which accompanied some visitors to the island in April. A mallard nest in IUPPL No. 3 was abandoned, possibly due to human disturbance associated with nest searching during June 1977.

PART V: DISCUSSION

Birds

Marsh plantings

80. Comparison of SBE and SBI with SBIPL indicated that planting marsh vegetation decreased the number of species utilizing SBIPL. However, the planting apparently had little effect on the BSD or the bird density of SBIPL. The results also indicated that significantly fewer species utilized SBIPL than SMA and MMA; however, the number of species utilizing SBIPL was not significantly different from the number using SMAP. Thus, the marsh planting seemingly decreased the number of species utilizing SMAP. However, SMAP was not used by significantly fewer species than was SMA. Thus, the difference detected between SBIPL and SMA was probably not caused by the marsh planting. During the last 6 months of the study, the number of species in SBIPL corresponded closely to the number of species recorded on SMAP and SMA (Table 2). If this trend continued, since BSD and bird density were not significantly different among SBIPL, SMAP, and SMA, the avian community in SBIPL would eventually be similar to SMAP and SMA.

81. MMA exhibited significantly more species and higher BSD than did SMAP, SMA, and SBIPL; these differences were probably due to the larger size of MMA and the fact that it was interspersed with small mudflats and tide channels which did not occur in SMAP and SMA.

82. Fewer species used SBIPL than SBI and SBE; nevertheless, BSD and bird density were not different among the areas. However, species composition was somewhat different. For example, cinnamon teal (Anas cyanoptera) were observed in marsh habitats and not in beach habitats; whereas, sanderlings (Calidris alba) and semipalmated plovers (Charadrius semipalmatus) were much more abundant in beach areas. Parameters of the avian community such as BSD and density provided only partial information to appraise the effects of the

plantings. Thus, future marsh establishment may not alter BSD and density, but the type and number of species may be changed.

Upland plantings

83. Since so little data were available for before-planting analysis only gross differences could have been detected. Thus, the fact that IUPPL No. 1 supported significantly higher ($P \leq 0.10$) bird density than did IUPPL No. 3 or IUPPL No. 2 cannot be unequivocally attributed to the planting. However, vegetation was still green on IUPPL No. 1 (IUPPL No. 2 and IUPPL No. 3 had turned brown) during July and August 1977 and may have supported higher insect populations, which could have accounted for the trend toward higher bird density on IUPPL No. 1; large numbers of tree swallows and barn swallows fed in IUPPL No. 1 during July and August 1977.

84. No significant differences in number of species, BSD, or bird density were detected among IUPPL, IUPP, and IUP before IUPPL was planted. However, data indicated that IUPP was utilized by significantly more species than was IUP after IUPPL was planted; IUP was not significantly different from IUPPL nor was IUPPL significantly different from IUPP. The higher number of species which used IUPP over IUP may have been a result of the planting on IUPPL.

The more frequent observation of water pipits in IUPP than in IUP was possibly due to the close proximity of IUPP to IUPPL. Water pipits were often observed feeding in IUPPL and most of the observations of water pipits on IUPP were birds flying low over the area. Robbins et al. (1966) noted water pipits were common in plowed fields during winter throughout North America. White-crowned sparrows were more common in IUPP than in IUP which is hard to explain. Petersen (1961) considered the white-crowned sparrow a shrub-inhabiting species. IUPP did not appear more shrubby than IUP but a small clump of sitka spruce was located within IUPP; white-crowned sparrows were often observed in the clump of spruce.

85. IUPPL received more use by waterfowl than did IUPP and IUP. Snow and Canada geese in January and February 1977 utilized IUPPL significantly more than IUPP, geese preferring short green grass over

other types of vegetation. Many grass species emerged in IUPPL during January and February. Geese also utilized IUPPL No. 2 significantly more than IUPPL No. 1 and IUPPL No. 1 significantly more than IUPPL No. 3. Less use may have occurred in IUPPL No. 3 because this area was dominated by hairy vetch which may be a less preferred food item to geese than grasses. Two trailers were also parked on the edge of IUPPL No. 3 which may have caused geese to avoid the area. IUPPL No. 2 was the most open area with trees on two sides rather than three which may account for geese using that area more than IUPPL No. 1. IUPPL No. 2 also contained barley which was possibly a preferred food item for geese (Martin et al. 1961, and Personal Communication, 22 September 1977, Robert L. Jarvis, Assistant Professor of Wildlife Ecology, Department of Fisheries and Wildlife, Oregon State University, Corvallis). No mallard nests were found in IUPP or IUP but five were located in IUPPL. Two were in vetch (one in IUPPL No. 1 and one in IUPPL No. 3), one in Scot's broom, one in a grassy area in IUPPL No. 1 and the other in beach grass on the north border of IUPPL No. 3. IUPPL did not support as many mallard nests as tree-shrub areas.

86. The most common species inhabiting near-planted and away-from planted areas were for the most part unaffected by the plantings. However, the common crow attained significantly higher density on IUPPL and IUPP than on IUP. The planting seemingly provided more food for common crows; they were often observed feeding in IUPPL and IUPP but seldom in IUP.

87. Number of species, BSD, and bird density were not significantly different between ITSP and ITS, and IMAP and IMA. IBIP supported significantly lower bird density than did IBI, probably due to the small size of IBIP and not an effect of planting IUPPL. The planting may have had a subtle effect on BSD, since BSD was significantly higher in near-planted habitats than in away-from-planted habitats.

88. Differences in number of species, BSD and bird density among near-planted habitats (IBIP, IMAP, IUPP and ITSP) and

differences among away-from-planted habitats (IBI, IMA, IUP, and ITS) probably reflect natural succession on Miller Sands. Marsh and beach areas supported significantly more species than tree-shrub areas but the away-from-planted tree-shrub area supported significantly higher BSD than away-from-planted marsh and beach areas. ITSP did not support a higher BSD than did IMA and IBIP which was probably due to higher overall BSD displayed by near-planted areas. More species were observed in marsh and beach areas than in tree-shrub areas but higher BSD was observed in the away-from-planted tree-shrub area than in marsh and beach areas; this can be explained on the basis of equitability. ITS had a significantly higher J' than did either IMA or IBI which indicates that individuals were more evenly apportioned among the species making up the tree-shrub community than were the individuals making up the marsh and beach communities. Kricher (1972) concluded that low and variable J' was an indicator of early successional stages on the New Jersey Piedmont. Large flocks of waterfowl, gulls, shorebirds, and swallows were often observed in this study feeding in beach and marsh areas and probably accounted for low values of J' .

89. In view of increasing BSD and J' with ecological age, it appeared that succession on Miller Sands was from beach and/or marsh to upland to tree-shrub. Margalef (1963) theorized that species diversity increased with the age of the ecosystem and then tapered-off in the late climax stage. Kricher (1973) in New Jersey and Johnson and Odum (1956) in Georgia observed that BSD increased with ecological age but the trend was interrupted by a drop in BSD during early sub-climax stages. Increased BSD was again noted with the coming of the early climax stage. Karr (1968) observed BSD on strip-mined land in Illinois increased with ecological age and tapered off in the climax. Anderson (1972) found BSD was higher in Oregon white-oak forests than in Douglas fir and western hemlock forests. BSD did increase slightly from the Douglas fir to western hemlock stage; Oregon white-oak forest was the earliest of the three seral stages (Franklin and Dyrness 1969). Anderson (1972) did not consider succession from bare ground to climax; therefore, the high BSD of the Oregon white-oak forest may have been

similar to the results of Kricher (1973) and Johnston and Odum (1956). Sitka spruce and western hemlock were proposed as possible climaxes for Mott Island (Coastal Zone Resources Corporation 1977) which is approximately 14.5 km southwest of Miller Sands. Since no drop in BSD was noted during intermediate seral stages on Miller Sands it appeared that vegetation on Miller Sands may not have reached climax; both sitka spruce and western hemlock are present on Miller Sands and may eventually be climaxes.

90. A general increase in bird density with ecological age was observed by Karr (1968) in Illinois, Odum (1950) in North Carolina, Johnston and Odum (1956) in Georgia, and Shugart and James (1973) in Arkansas. Karr (1968) observed a decline in bird density in the last forest stage; Shugart and James (1973) noted a continuous increase in density with ecological age. Bird density on Miller Sands fluctuated among early and intermediate stages but increased in the later (tree-shrub) stage.

91. Average BSD (1.86) for April, May, and June 1977 for the tree-shrub areas on Miller Sands was slightly lower than average BSD (2.11) calculated for the same three months of 1975 from data presented by Woodward-Clyde Consultants (1978). BSD on Miller Sands was low compared to BSD in many other areas; Karr (1968) found breeding BSD in Illinois was 3.31 in bottomland forest, whereas breeding BSD in tree-shrub areas on Miller Sands was 1.83. Average annual BSD, calculated from Anderson (1970), for an Oregon white-oak forest was 2.74 compared to 1.53 the mean annual BSD for tree-shrub areas on Miller Sands. Emlen (1972) determined BSD was 1.99 for a grass forb prairie in southern Texas; upland BSD, based on the mean values of all upland study areas on Miller Sands was 1.19. BSD for Miller Sands was similar to data from the New Jersey Piedmont; Kricher (1972) observed BSD of 0.88, 1.52, and 1.84 in herbaceous field, cedar field, and oak forest, respectively (BSD figures are means calculated from Kricher's data).

92. The Miller Sands complex bird densities were similar to many other areas. Mott Island supported breeding bird densities of

1528 birds/km² (calculated from breeding pairs/ 100 acres) (Coastal Zone Resources Corporation 1977). Tree-shrub areas on Miller Sands supported 1400 birds/km² during the breeding season. Anderson (1970) observed 1359 birds/km² during the breeding season in Oregon white-oak stands. Kendeigh (1944) found bird densities between 948-1422 birds/km² during the breeding season in eastern deciduous forests. Karr (1968) determined that bird densities during the spring and summer were 355 birds/km² in bottomland forests and 812 birds/km² for upland maple-oak forest. Bird densities were slightly higher between river miles 12-79 of the Columbia River than on Miller Sands; densities were 3486 birds/km², 2770 birds/km², 3615 birds/km², and 3303 birds/km² in large willow, cottonwood, tidal shrub-willow, and cottonwood-willow habitats, respectively (Oregon Cooperative Wildlife Research Unit 1976). Tree-shrub areas on Miller Sands supported an average of 1212 birds/km². Emlen (1972) observed 858 birds/km² in oak woodland and 1395 birds/km² in river forests in southern Texas during the winter; winter bird density in tree-shrub habitats on Miller Sands was 1345 birds/km².

93. In general, Miller Sands showed a BSD lower than in other areas and bird densities similar to densities recorded in other areas. Miller Sands is approximately 45 years old which makes it a relatively young ecological system. With time and the development of older ecological stages, Miller Sands will probably support avian populations similar to other areas in the lower Columbia River region. Thus, dredged material seemingly provides relatively good habitat for birds in the lower Columbia River region.

Nest Searches

Marshes

94. No nests were found in marshes in 1976 and marshes were not searched for nests in 1977 because of complete inundation at least daily. Even birds which build floating nests probably could not have nested due to extreme water fluctuation.

Uplands and associated habitats

95. More mallards utilized IUPPL No. 3 for nesting than other planted or natural upland areas, although tree-shrub areas seemingly were preferred. Mallard nest density in IUPPL No. 3 was 0.67 nests/ha, contrasted to an average of 2.05 nests/ha were found in tree-shrub areas. Common crows were the most common nesters on Miller Sands (Appendix B). Crow nest density on Miller Sands averaged 4.90 active nests/ha which was greater than the 2.12 nests/ha observed on Mott Island, Oregon (Coastal Zone Resources Corporation 1977). Swainson's thrush, song sparrow, American robin, white-crowned sparrow, and Bewick's wren (no Bewick's wren nests were located in nest search areas) were other species which nested on Miller Sands. All of these species nested on the ground, in bushes, and/or in small trees or in holes (Bewick's wren). Peterson (1969) described nesting habitat of the above species as intermediate successional stages. It is possible that more species and higher nest densities may develop if a denser shrub understory and patches of coniferous vegetation develop on Miller Sands.

Small Mammals

96. Townsend's voles and vagrant shrews were the only mammals caught in livetraps on Miller Sands. All of the Townsend's voles were caught within a Scot's broom patch in IUPPL No. 3 after it was planted. Townsend's vole populations probably increased on IUPPL No. 3 after the planting; numerous microtine runways were observed in this area and all Townsend's voles were captured in snap-traps in August 1977. The increased population may have been a response to increased cover provided by the hairy vetch. Goertz (1959, 1964) found that Townsend's voles preferred to inhabit lush growths of grasses and sedges along streams and in lowland areas but they occurred in dry areas if sufficient cover was present. Even though no density estimates were determined, Townsend's voles were probably one of the

most abundant small mammals on Miller Sands; 36 Townsend's voles were caught in snap-traps. Density of Townsend's voles was not estimated for two reasons: very few runways were observed within IUPPL No. 3, IUPPL No. 1, and IUPP (which indicated very low density) and Townsend's voles are extremely difficult to live-trap (Maser 1968, and Personal Communication, June 1976, B. J. Verts, Professor of Wildlife Ecology, Oregon State University, Corvallis).

Norway rats were also abundant on Miller Sands; 20 Norway rats were caught in snap-traps and at least 125 Norway rats were caught in nutria traps (Personal Communication, December 1977, Jack Rogers). Very little sign of Norway rats was observed within the live-trapping areas; numerous burrows and trails were observed in the tree-shrub and drift areas bordering Miller Sands. Norway rats are also difficult to live-trap (Lores et al. 1971 and Taylor et al. 1974). Nutria were abundant on Miller Sands at the beginning of the study but had nearly been eliminated by trapping (professional trapper) by the end of the study. A small colony of muskrats inhabited a log pile near SBIPL and also was nearly eliminated by trapping. Harbor seals and California sea lions (Zalophus californianus) were observed in the surrounding waters of Miller Sands and were reported by commercial fishermen to rest on the spit. (For a list of mammals observed on Miller Sands see Appendix C').

97. The insular theory of biogeography (MacArthur and Wilson 1963) probably applied more to mammals on Miller Sands than it did to the avifauna. Trowbridge shrew and deer mouse were two species reported as inhabiting Miller Sands (Woodward-Clyde Consultants 1978), however neither species was captured during the present study. These species may have been extirpated during the time interval between the studies. Vagrant shrew was observed during the present study and may have been a species which established on Miller Sands between the studies. Due to the currents and rough water conditions present in the Miller Sands area, Norway rat, vagrant shrew, and Townsend's vole probably reached Miller Sands by rafting. Norway rats also may have reached the island as a result of human activity; several plantings

and numerous dredging operations were done on Miller Sands and may have resulted in the establishment of the Norway rat population. Nutria, muskrats, harbor seals, and California sea lions are capable swimmers and it is unlikely that the water surrounding Miller Sands would create a barrier for them.

Macroinvertebrate Populations

Marsh plantings

98. Statistically, there was no significant difference among macroinvertebrate populations on SBE, SBIPL, and SMAP; however, no macroinvertebrates were found on SBE during the study (Table 13), and only small numbers were collected on SBIPL in May and July 1977, after some planted marsh vegetation became established. Thus, planting marsh vegetation on a beach area brought about very small insect populations on SBIPL.

Upland plantings

99. IUPP supported significantly higher macroinvertebrate populations than did IUPPL. However, IUPPL supported a small macroinvertebrate population during July and September of 1976 and May of 1977; IUPPL was plowed and planted in September and October 1976 and vegetation was just beginning to grow on IUPPL in May 1977. Thus the low macroinvertebrate population observed on IUPPL from September 1976 through May 1977 was probably due to the lack of vegetation which resulted from plowing and planting the area. The increased biomass of insects on IUPPL in July 1977 may have reflected results of the planting. Macroinvertebrates biomass was extremely low in all habitats sampled on Miller Sands.

Animal Damage

Marsh

100. Animal damage was minimal in the marsh area. Even though some of the tufted hairgrass clumps in SBIPL were heavily grazed by waterfowl in winter 1976, the plants grew vigorously in the summer of 1977. Muskrats and nutria had little effect on any of the marsh areas. However, any damage which muskrats and nutria may have done was eliminated by the near total eradication of these mammals from Miller Sands by the nutria trapper.

Upland

101. Animal damage to upland areas was also minimal. If any detectable damage occurred it was probably in the form of seed loss; large flocks of common crows and starlings were observed feeding in IUPPL daily after it was planted.

Disturbance by Man

102. All disturbance to wildlife by man was associated with trapping and other research activities carried out on Miller Sands during the course of the study. The ultimate effects of the human disturbance were probably minimal. For example, the nutria population was practically eliminated, but in light of dense nutria populations near Miller Sands, within a short time nutria will probably become as prevalent on Miller Sands as they were before the trapping period. The island was visited by very few people not associated with the research project during the course of the study; such visits probably had little effect on the wildlife on Miller Sands. The paucity of human use of the island may have been due to the research project and the fact that all of Miller Sands except MMA was closed to hunting. Signs of hunting in past years when the area was open were observed and more people may have visited the island during that period.

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APPENDIXES

Appendix A': Estimates of Bird Density by Transect, Station, and Variable Plot Methods by Study Area on Miller Sands, Oregon, July 1976-August 1977.

Appendix B': Location of Bird Nests Found on Miller Sands, Oregon, During Summer of 1976 and Spring and Summer of 1977

Appendix C': List of all Animals Observed on Miller Sands, Oregon, July 1976-August 1977.

Appendix D': List of Common and Scientific Names of Plants and Animals Mentioned in this Report.

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Crawford, John A

Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon; Appendix F: Postpropagation assessment of wildlife resources on dredged material / by John A. Crawford, Daniel K. Edwards, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

68, [123] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-38, Appendix F.

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW57-76-C-0180 (DMRP Work Unit No. 4B051)

Appendixes A'-D' on microfiche in pocket.

Literature cited: p. 63-67.

1. Columbia River. 2. Dredged material. 3. Field investigations. 4. Habitats. 5. Islands (Landforms). 6. Marshes.

(Continued on next card)

Crawford, John A

Habitat development field investigations, Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon: Appendix F: Postpropagation assessment of wildlife resources on dredged material ... 1978. (Card 2)

7. Miller Sands Island. 8. Plants (Botany). 9. Plant populations. 10. Terrestrial habitats. 11. Waste disposal sites. 12. Wildlife. 13. Wildlife habitats. I. Edwards, Daniel K., joint author. II. Oregon. State University, Corvallis. Dept. of Fisheries and Wildlife. III. United States. Army. Corps of Engineers. IV. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-38, Appendix F.

TA7.W34 no.D-77-38 Appendix F

TECHNICAL REPORT D-77-38, HABITAT DEVELOPMENT FIELD INVESTIGATIONS,
MILLER SANDS MARSH AND UPLAND HABITAT DEVELOPMENT SITE, COLUMBIA
RIVER, OREGON; APPENDIX F: POSTPROPAGATION ASSESSMENT OF WILDLIFE
RESOURCES ON DREDGED MATERIAL.

APPENDIX A': ESTIMATES OF BIRD DENSITY

APPENDIX B': LOCATION OF BIRD NESTS FOUND

APPENDIX C': LIST OF ALL ANIMALS OBSERVED

APPENDIX D': LIST OF COMMON AND SCIENTIFIC NAMES OF PLANTS AND ANIMALS

DREDGED MATERIAL RESEARCH PROGRAM



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