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 E: POSTPROPAGATION ASSESSMENT OF BOTANICAL AND SOIL RESOURCES ON DREDGED MATERIAL

by

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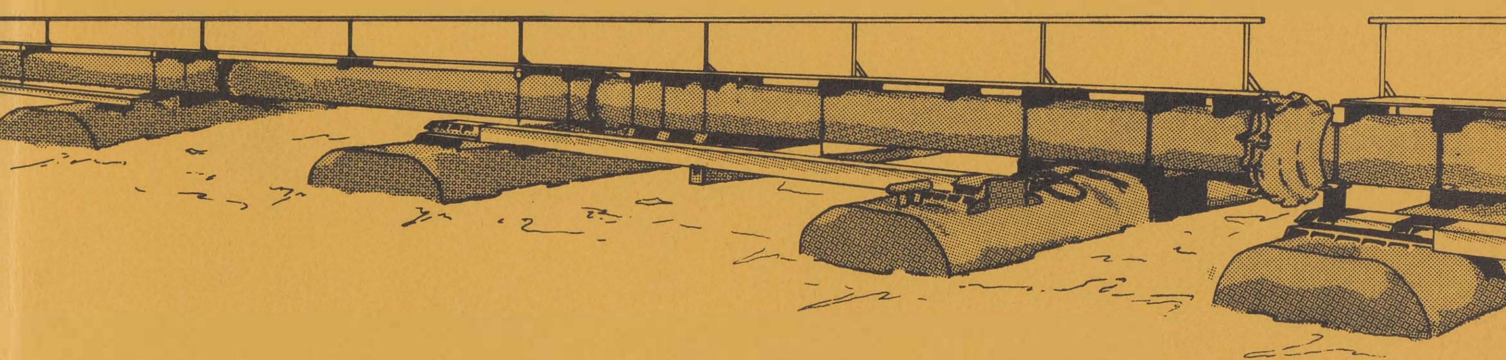
August 1978
Final Report



Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Under Contract No. DACW57-76-C-0195
(DMRP Work Unit No. 4B05K)

Monitored by Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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

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Appendix F: Postpropagation Assessment of Wildlife Resources on Dredged Material

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
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IN REPLY REFER TO: WESEV

30 September 1978

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

TO: All Report Recipients

1. The technical report transmitted herewith represents the results of Work Unit 4B05K regarding the postpropagation assessment of botanical and soil resources at the Miller Sands Marsh and Upland Habitat Development Site, Columbia River, Oregon. This work unit was conducted as part of the Habitat Development Project (HDP) of the Dredged Material Research Program. The HDP had as its main objectives the development of wetland and upland habitats on dredged material and the evaluation of the impact of disposal on wetland sites.

2. This report, "Appendix E: Postpropagation Assessment of Botanical and Soil 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 to the summary report are studies that 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 were published as microfiche; those with more general application were published as printed reports.

3. The purpose of this study was to evaluate the establishment of upland and marsh plants at Miller Sands and to interpret these data in light of soil treatments and modifications. Marsh plants established from sprigs were generally successful, particularly in the upper two-thirds of the tidal range. Establishment of marsh plants from seeds was much less successful. Upland propagation of legumes and grasses from seed was successful. The marsh habitats are expected to be maintenance free; however, the perpetuation of the upland habitats would require periodic maintenance. Marsh plant establishment was not influenced by fertilization, whereas fertilization had a pronounced beneficial impact on upland plantings.

WESEV 30 September 1978

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

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-L and N), and are summarized in that site's summary report (4B05M).

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

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Technical Report D-77-38	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) HABITAT DEVELOPMENT FIELD INVESTIGATIONS, MILLER SANDS MARSH AND UPLAND HABITAT DEVELOPMENT SITE, COLUMBIA RIVER, OREGON; APPENDIX E: POSTPROPAGATION ASSESSMENT OF BOTANICAL AND SOIL RESOURCES ON DREDGED MATERIAL		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Paul E. Heilman David M. Greer Stanton E. Brauen Aaron S. Baker		8. CONTRACT OR GRANT NUMBER(s) Contract No. DACW57-76-C-0195
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State University Pullman, Wash. 99163		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DMRP Work Unit No. 4B05K
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U. S. Army Washington, D. C. 20314		12. REPORT DATE August 1978 13. NUMBER OF PAGES 393
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U. S. Army Engineer Waterways Experiment Station Environmental Laboratory P. O. Box 631, Vicksburg, Miss. 39180		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Columbia River	Marshes
Dredged material	Miller Sands Island
Field investigations	Plants (Botany)
Habitat development	Soil analysis
Habitats	Vegetation establishment
Marsh development	Waste disposal sites

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the study area, methods, and results of habitat development experiments conducted at Miller Sands, a dredged material disposal site near the mouth of the Columbia River. The study consisted of investigations and experimental plantings on the older upland portion of the island and on the more recently constructed spit and marsh area. Soil analyses showed relatively uniform soil conditions with sand texture on both experimental sites. However, at the low elevation on the spit, silt and clay contents were higher than elsewhere. The soil was also very low in organic matter and nitrogen but had relatively high base status and pH, with the upland being about pH 6 and the marsh soils about pH 7. The phosphorus level was also relatively high, being above soil phosphorus levels found in adjacent natural soils. Although marsh soils were somewhat less oxidized at lower elevations, the soil was

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Unclassified

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20. ABSTRACT (Continued).

relatively well aerated and contained no sulfides or nitrites. There was some nitrate present on the upland, but prior to fertilization nitrate levels were very low in the marsh.

Soil samples taken in the marsh in September 1976 after the first season's growth of propagated plants and the first application of the split fertilizer treatments showed significantly increased levels of ammonium and potassium and a reduction in soil pH corresponding to treatment rates. Available phosphorus determined by the oxalate method of extraction was not related to fertilizer treatment.

Samples taken in June 1977 showed some increases in fertility probably as a result of the second fertilizer treatment on the split application plots, but, by August 1977, fertility levels had declined and showed little relationship to fertilizer treatment. A significant reduction in available N and exchangeable K due to uptake by plants was noted on the transplant plots, especially in the 1977 samples. This reduction represented a significant depletion in fertility status, particularly at the upper elevations in the marsh, and will likely result in lower vigor and productivity by these transplants in the future.

Fertility levels in unvegetated areas of the marsh and sandspit showed comparable conditions to those in the marsh monotypic plot area. Considerably higher values were noted in the marsh reference area for total Kjeldahl nitrogen, organic carbon, and cation exchange capacity. In contrast, levels of available nutrients were lower in the marsh reference area, presumably as a result of uptake by the heavy vegetative cover.

Results of treatment in the marsh on plant growth and survival showed significant effects of elevation (tier), with almost no plants of Deschampsia cespitosa or Carex obnupta surviving in the lower tier, which corresponded to elevations lower than 2.13 ft above mean lower low water. Aerial biomass production at the end of the second growing season was 1356 kg/ha for D. cespitosa and 547 kg/ha for C. obnupta. This compares to a mean biomass of 6157 kg/ha in the marsh reference area and to 379 kg/ha in the unvegetated intertidal area at elevations similar to the vegetative zone in the monotypic plot area. Fertilization significantly increased growth, seed production, and biomass of D. cespitosa but had no effect on C. obnupta. No seed was produced by C. obnupta, but considerable seed was produced by D. cespitosa, particularly in the upper tier.

Soil samples were collected from the upland monotypic plots in June and August 1977. Fertilization had a significant effect on fertility status of the soil, but the effects were relatively minor by August. In contrast to the June samples, soil pH and moisture content were more closely related to fertilizer treatment in the August samples, with increased fertilization causing a significant reduction in both properties.

Good plant growth was obtained with most species planted on the upland considering the late date of establishment in the fall of 1976. Hairy vetch showed particularly good early growth, but many plants died before maturity due to spring black stem disease. Fertilization was necessary for the establishment of most species even though competition from invading grasses greatly increased with application of fertilizer. Barley, red clover, white clover, and bentgrass produced flowers after the first year of growth, but seed production was poor. The likelihood of success in establishing these plants on dredged material cannot be determined without future monitoring.

Aerial biomass production in the upland meadows significantly increased due to planting and fertilization. Increased production of invading grasses such as rat-tail fescue and common velvetgrass and elimination of moss followed application of fertilizer on the upland meadows. Only barley and hairy vetch contributed major portions of the biomass in the planted meadows.

Appendix A' presents the data supplement for the study.

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SUMMARY

Miller Sands, a dredged material study site, is located 38.6 km from the mouth of the Columbia River. Experiments at Miller Sands were conducted at two areas--the older upland portion of the island and on the newer spit area, an actively used disposal site.

The marsh experiment employed two marsh species propagated by seeding and transplanting and unplanted control plots. Five fertilizer treatments were used with a series of treatments located at each of the three elevation levels in the marsh. Another planting of marsh species was made around the edge of the main study area. The sandspit above tidal influence was planted with European beachgrass (*Ammophilia arenaria*).

The upland study consisted of three monotypic plot experiments involving a total of nine planted grass and legume species plus unplanted controls. The plots were planted and treated with three different fertilizer rates. In addition, the same nine species were planted on three larger areas, designated as nesting meadows, with three species, consisting of two grasses and one legume, being used on each of the three meadows.

Cages to exclude wildlife were placed on experimental plantings and in unplanted reference areas of the upland and marsh. Plant growth and production were determined on these areas. Vegetation in the monotypic plots of both areas was monitored periodically. Samples of the plants were collected at the end of the first growing season and at the conclusion of the second growing season. Soils were sampled initially in both monotypic plot areas and periodically in each plot after the plots were planted and fertilized. Caged areas were also sampled at the conclusion of the study.

Results of the initial soil sampling showed that the soils were relatively uniform on the monotypic plot areas. However, elevation had a pronounced effect on soil properties. At lower elevations in the marsh, silt and clay contents were higher and the sand was somewhat finer. Material on both locations was very low in organic matter and

nitrogen but had relatively high base status considering the sandy nature of the soil. Soil pH on the upland area was about 6 and on the marsh area about 7. The phosphorus status of both locations was also high being somewhat above adjacent soils. Marsh soils were relatively well oxidized even at low elevations and no sulfides or nitrites were present. Nitrate was present on the upland but there was little evidence of nitrate in the marsh. In the marsh, exchangeable ammonium and other factors of fertility status were considerably higher at lower than at upper elevations.

Fertility status of the marsh plot area was significantly related to sampling date, fertilizer treatment, and the presence of vegetation. Phosphorus determined by the oxalate method of extraction, was not related to fertilizer treatment or presence of transplants. Effects of fertilization on soils declined with time except for increases in June 1977 probably as a result of the second split application of fertilizer. Presence of transplants on the plots significantly reduced available nitrogen and exchangeable potassium. The greatest decline in fertility was at the upper elevation plots and suggests a potential reduction in vigor and productivity of transplants at this elevation in the future.

If elevation differences were considered, it appeared that other unvegetated areas of the marsh and sandspit had comparable soil to that in the monotypic plot area. However, the marsh reference area contained higher organic matter levels with higher Kjeldahl N, organic carbon, and cation exchange capacity. However, available nutrient status in the reference marsh area was lower than elsewhere, presumably as a result of plant uptake by the relatively dense vegetation that was present in that area.

Good results were obtained in establishing vegetative cover in the marsh using transplants of both tufted hairgrass (Deschampsia cespitosa) and slough sedge (Carex obnupta). Almost no plants were established by seeding although many seedlings of tufted hairgrass emerged. However, because of the late seeding (August 1976) the plants did not become well established and most failed to survive the first winter. Consequently, these plots were reseeded in May 1977, and with the earlier seeding, the tufted hairgrass plants entered the winter of 1977 with a better chance of survival because of larger size. Tufted hairgrass showed a significant response to the fertilizer with the 610-kg rate of 10-10-10 applied in fall and spring giving best results. Slough sedge showed no response to fertilizer.

Elevation (tier) was very important in determining survival of transplants; almost no plants of either species survived below about 67.1 cm above mean lower low water.

Soil samples from the upland plots showed increased fertility levels as a result of fertilization with the increase being most pronounced in the June 1977 samples. By August 1977, it was indicated that fertility levels were little influenced by fertilization. Moisture content and pH were found to be significantly reduced. Nitrification of ammonium N and raised salt levels appear to somewhat be responsible for reduced pH while increased plant growth on fertilized plots probably resulted in greater soil moisture.

Overall response of seedlings to fertilizer in the upland plantings varied with species, but fertilization was considered essential for seedling success. Dense vegetative cover was established in monotypic plots of the upland when fertilizer was applied but much of the cover in the tall wheatgrass (*Agropyron elongatum*), tall fescue (*Festuca elatior*), and Oregon bentgrass (*Agrostis oregonensis*) plots was comprised of invading plants. Good stands of white clover (*Trifolium repens*), red clover (*Trifolium pratense*), barley (*Hordeum vulgare* L.), and hairy vetch (*Vicia villosa* L.) were established in the fertilized plots. Seeding of creeping red fescue (*Festuca rubra* L.) and reed canarygrass (*Phalaris arundinacea* L.) was unsuccessful due to a mistake in the amount of seed applied to the plots.

Changes in the plant composition of the meadow areas following fertilization and planting included increased production of grasses, elimination of moss, reduction of broadleaf importance, and significant increases of vegetative cover and biomass production. These changes were largely due to invader success with only barley, red clover, and hairy vetch of the seeded species comprising substantial portions of the vegetative structure in the meadow areas.

PREFACE

Monitoring of soils and botanical aspects at the Miller Sands habitat development site was performed by Washington State University (WSU) personnel located at Western Washington Research & Extension Center in Puyallup and at the main campus in Pullman, Wash. The work was conducted under Contract No. DACW57-76-C-0195 through the U. S. Army Engineer District, Portland, with the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. The study was conducted as part of the Dredged Material Research Program sponsored by the Office, Chief of Engineers, U. S. Army, and monitored by the Environmental Laboratory (EL), WES. The study began in June 1976 and continued through 15 January 1978. Contracting Officer's representative for the Portland District was Mr. Adam B. Mello.

The principal investigator for WSU was Dr. Paul E. Heilman. The report was written by Dr. Paul E. Heilman, Forest Scientist, Puyallup; Mr. David M. Greer, Research Technician, Puyallup; Dr. Stanton E. Brauen, Associate Agronomist, Puyallup, and Dr. Aaron S. Baker, Soil Scientist, Puyallup.

Acknowledgement of assistance with the field work on the project is also given to Messrs. Dave Siburg and Rick Brauen; Mesdames Robin Farrar, and Annette Summerhill. Thanks are expressed to Mr. Wilbur Ternyik of the Wave Beachgrass Nursery and his employees for their efforts particularly with the excellent planting of the marsh plots. Data processing and statistical services by Mr. Robert Knox, Mr. Larry Lang, and Dr. Tom Russell are deeply appreciated. Gratitude is extended to Dr. Amy Jean Gilmartin and the rest of the herbarium staff at WSU for their assistance with the plant identification. Appreciation is also given to Messrs. Robert Watson, John Coykendall, and Al Halfmoon of the Lewis and Clark National Wildlife Refuge for their assistance with the project, particularly for the use of the garage and dock facilities. Dr. Charles Meslow, Oregon Cooperative Wildlife Research Unit, and Dr. John Crawford and Mr. Dan Edwards, Department of Fisheries and Wildlife, Oregon State University, are thanked for the rental of the boat that was used in this project and other assistance.

Thanks are made also to Ms. Doreen Flippo for her typing of the manuscript and to Ms. Louise Knoblauch and Ms. Doris Schneider for their accounting and budgetary help on the project.

The site and contract were initially managed by Dr. J. Scott Boyce until taken over by Mr. Ellis J. Clairain, Jr., both of the Habitat Development Project (HDP), WES. The study was under the supervision of Dr. Hanley K. Smith, Project Manager, HDP, and under the general supervision of Dr. John Harrison, Chief, EL.

Commander and Director of WES during the preparation of this report was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

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

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

Multiply	By	To Obtain
feet	0.3048	metres
pounds per acre	1.121	kilograms per hectare

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

APPENDIX E: POSTPROPAGATION ASSESSMENT OF BOTANICAL AND SOIL RESOURCES ON DREDGED MATERIAL

PART I: INTRODUCTION

1. This report presents results of a study conducted by Washington State University (WSU) under contract with the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. This study was part of the Dredged Material Research Program (DMRP) Habitat Development Project, a research project to develop wildlife and fisheries habitat on dredged material. Habitat development is one aspect of the DMRP, which is designed to examine environmental aspects of dredged material disposal and to develop improved methods for the disposal and managed use of this material.

2. Studies on habitat development are being conducted at eight locations across the nation. The study site in the Pacific Northwest is located at Miller Sands, a dredged material disposal site in the lower Columbia River near Astoria, Oregon.

Preliminary Studies

3. A preliminary study of transplanting of several marsh species was made on the spit area of Miller Sands during 1975 (Ternyik 1976). Species tested in this study were common spike-rush (*Eleocharis palustris*), Baltic rush (*Juncus balticus*), soft rush (*J. effusus*), tule (*Scirpus validus*), Lyngby's sedge (*Carex lyngbyei*), and tufted hairgrass (*Deschampsia cespitosa*). The experiment contained both fertilized and unfertilized plots. Fertilizer was applied between three to four weeks after planting in May 1976 at the rate of 100 kg of 11-55-0 per hectare.

The most promising species was tufted hairgrass with Lyngby's sedge and soft rush also showing potential for such plantings. These three species were also considered desirable because transplants are readily available in marshes of the area. Results showed relatively little effect of fertilizer for most plants examined. However, fertilizer was reported to be essential for establishment of Lyngby's sedge.

4. Flora and fauna at Miller Sands were described in a study conducted in 1975 under contract with the Corps of Engineers (Woodward-Clyde Consultants 1978). A review of the pertinent literature was also included in the report. Thirty-nine families and 123 species of plants were identified in the various terrestial and aquatic habitats on the island during the study. Fauna on the island was largely comprised of avifauna with 65 different species of birds observed during the study. Six species of mammals were located but these were generally few in number with the exception of nutria (Myocastor coypus). Potential problems with nutria activities in the marsh and upland areas were discussed.

Description of the Area

Miller Sands

5. Miller Sands was first used for dredged material disposal in 1931 (U. S. Army Corps of Engineers 1976). It is located between river km 35 and 40 on the Columbia River (Figure 1) within the Lewis and Clark National Wildlife Refuge. Miller Sands consists of the main island, which was used for disposal from 1932 to 1934, and a spit which is currently an active disposal site (Figures 2 and 3). The island and the spit are separated by a narrow, shallow channel and together form a U-shape with the open end pointing downriver. The fringe of trees and woody vegetation on the main island can be seen in Figure 2 along with the relatively unvegetated spit. The marsh study area is in the enclosed lagoon on the inside of the "U", and the upland study area is in the light-colored central meadow region of the main island (Figure 2).

Climate

6. Climate of the Lower Columbia River area is characterized by mild temperatures, wet winters, and fairly dry summers. Data from the National Oceanic and Atmospheric Administration (NOAA) (1976) show the following for the Astoria Airport. Mean temperature for August, the hottest month, is 15.7°C with the average daily maximum for August being 20.2°C and the average August daily minimum 11.2°C. Mean temperature for January, the coldest month, is 4.8°C with the average daily maximum for January being 8.1°C and the average daily minimum 2.3°C. Mean annual precipitation in Astoria is 168.5 cm. The driest month is July with an average of 2.4 cm, and the wettest month is December with an average of 26.8 cm. The growing season, which is the frost-free period, averages about 250 days.

Hydrology

7. Peak flows of the Columbia River occur during the months of April, May, and June as a result of spring runoff from melting snow (U. S. Army Engineer District, Portland 1975). Stream gradient is low in the Lower Columbia from Bonneville Dam to the Pacific Ocean. The width of the floodplain in this region of the river varies from between 3.2 to 9.7 km. Tidal influence is considerable at Miller Sands with the average range in water level due to tide being about 2.43 m, with storms also significantly affecting water levels. River flow is reversed on the incoming tide, with upriver flow observed as far upstream as river km 85 (Peloquin et al. 1976). However, salt water from the ocean seldom extends as far upriver as Miller Sands.

Water quality

8. Generally the Columbia River water is of high quality. Periodic water samples are taken at several stations along the river with the nearest station to Miller Sands being Harrington Point, river km 37. Data for the stations are available from the Environmental Protection Agency (Peloquin et al. 1976).

Soils

9. Miller Sands is composed mostly of sandy dredged material with analysis of samples collected in this study from the main island

and spit showing 90 to 99 percent sand. Considerable driftwood is present, especially on the main island, and organic material in the form of peat also occurs in scattered locations on the island and the spit (Figure 4).

Vegetation

10. The marshland portion of Miller Sands is dominated by tufted hairgrass and Lyngby's sedge, with common spike-rush at lower elevations. The main island is surrounded with a fringe of willows (Salix species), cottonwood (Populus tricocarpa), and red alder (Alnus rubra). The open meadows in the central portions of the main island are dominated by common scouring rush (Equisetum hyemale) and common velvetgrass (Holcus lanatus). A complete list of the plant and algae species observed on Miller Sands is included in Appendix A' (Table A1 and Table A2).

PART II: DESCRIPTION OF THE STUDIES

11. The two main study areas in this project were those centered around the marsh and those involved in the upland meadow area of the main island.

Objectives

12. The purpose of the plant and soil monitoring aspects of the Miller Sands study was to evaluate establishment of marsh and upland plant cover on the area. The objectives were:

- a. Determine survival and productivity of planted species in the marsh and on the upland.
- b. Determine the relationship of site and soil properties, fertilizer treatment, and nutrient content to performance of these species.
- c. Compare productivity of planted and fertilized species with natural marsh and upland vegetation.
- d. Determine grazing preferences and the effect of animal pressures on plant performance through use of animal closures.

Marsh and Sandspit Study Area

13. The marsh study area shown in Figure 5 consists of the marshland monotypic plot study; an intertidal mixture area where five species were planted in rows across the elevational range; a reference marsh, which is a naturally vegetated marsh area; an unvegetated intertidal area; and the area of the spit above the normal tidal influence that was planted to European beachgrass (*Amophilia arenaria*).

Monotypic plot study

14. Preparation of the plot area. The site for this study was constructed in July 1975 by personnel of the Portland District according to specifications written by WES. Approximately 237,000 m^3 of dredged material were deposited on the spit in early July 1975. After deposition, site development consisted of grading the dredged material on the

sandspit into an even prescribed slope with bulldozers.

15. Experimental design. Fertilizer, species, and propagation treatments are shown in Table 1. The monotypic plot study consisted of three experiments, one in each elevation tier. Mean elevations of the tiers measured above mean lower low water (mllw) were 42.6, 112.8, and 185.9 cm for the lower, middle, and upper tiers, respectively. Each experiment was designed as a randomized complete block with a factorial array of 30 treatments assigned at random to each of three replicates. The treatment array consisted of two planted marsh species and an unplanted treatment, two methods of propagation, and five fertilizer treatments.

16. Plot description and planting. Transplants and seeds of tufted hairgrass were collected from marsh areas adjacent to Miller Sands with transplants and seeds of slough sedge (*Carex obnupta*) collected along the coastal estuaries of the Oregon coast near Florence. Seed collection and planting were done under separate contract by the Wave Beach Grass Nursery, Florence, Oregon. Individual plots were 11.9 by 14.2 m in size with an unplanted buffer area 1 m wide separating the plots. Fertilizer was broadcast on the transplanted, seeded, and control plots and raked in during the weeks of 18 July and 25 July 1976. Tufted hairgrass and slough sedge transplants were planted during the first 3 weeks of July 1976. A spacing of 0.5 by 0.5 m separated each of the 594 plants in each plot. Slough sedge was seeded on 29 July 1976 and tufted hairgrass was seeded on 24-26 August 1976. Spring planting of these seeds was intended but seeds were unavailable prior to the above planting dates. Seed was broadcast on the plots and raked in with garden rakes. Presumably because of the late seeding, the plants did not attain sufficient growth to survive the winter. For this reason these plots were seeded again during the week of 9 May 1977 with rate and planting methods the same as before. Fertilizer was again applied to the seeded plots at the time of seeding and at the same rates as initially.

17. Monitoring of vegetation. Transplant biomass and root:shoot ratios were determined at the time of planting on a sample of

20 transplants of each species (Table 2). After planting, three 1- by 3-m sampling quadrats were randomly established in each plot. Ten plants were selected from the sampling quadrats on each transplant plot according to a predetermined pattern that specified three plants from the first and second quadrats and four from the third. The growth and development of the transplants were documented on a monthly basis throughout the duration of the study by observing these 10 plants. When any of the 10 plants died, replacements were randomly selected from within the quadrat, tagged, and subsequently monitored. At the peak of the growing season, the 10 plants from each plot were removed for destructive sampling. Peak of the growing season was defined as that period of time in the phenological stage of the plant population where the majority of the fruiting structures reached a midpoint between immaturity and maturity. All plant shoots of tufted hairgrass were clipped at the root crown and roots and below-ground stems were carefully removed and washed clean of inorganic material. Only the shoots of slough sedge were collected for destructive sampling due to the difficulty of removing the root system from the substrate. However, considerable time and care was expended to harvest one intact plant, thought to be representative, from each plot to help assess root:shoot ratios of this species. All samples were dried to a constant weight at 83°C before weighing, and an average biomass value was calculated for each study plot. Seed present at the time of harvest was threshed and weighed. Tufted hairgrass was harvested on 4 August 1977 and slough sedge was harvested during the week of 23 August 1977. The latter date did not reflect the peak of the growing season for slough sedge but was harvested at that date due to time schedules of the contractor.

18. Seedling counts were made several times a week for the first month following seed application. Growth and survival data were collected three times during the following month and later counts were made at monthly intervals through November 1977.

19. Four tufted hairgrass plants were randomly selected and clipped at ground level from the transplant plots in the upper and middle elevations of the study site on 8 June 1977 for foliar analysis.

The four plants were composited and values of percent nitrogen, phosphorus, and potassium in the leaf parts were determined for each plot. Subsequent growth and development of the clipped plants were monitored every other week through 1 September 1977.

20. The cover parameter was used to monitor plant growth and plant invasion and to observe the development (succession) of the marsh. Estimates of percent cover of the propagated species located in the three quadrats of each plot were made at monthly intervals in the marsh study area. The guided estimate scale used for cover estimation followed that developed by Phillips (1959) and was as follows: <1.0 percent, 1.0 to 9.9 percent, 10 to 24.9 percent, 25 to 49.9 percent, 50 to 74.9 percent, and 75 to 100 percent. The midpoints of these classes were used to determine average values of foliage cover for each plot. Statistical analysis of the percent foliage cover for each propagated plot in all marshland quadrats was performed at the end of the 1977 growing season. Cover ratings were made for the total foliage in each quadrat for the 1976 season due to the "new" nature of the planted marsh. Better familiarity with the identification of aquatic plants and the increased number and diversity of plants invading the marsh plots as the year progressed facilitated the estimation of percent cover for each individual species of plant in the marsh quadrats for the 1977 season.

Intertidal mixture plantings

21. The intertidal mixture plantings were located adjacent to the west and east boundaries of the monotypic plot area (Figure 5). Transplants of Lyngby's sedge, slough sedge, tufted hairgrass, tule, and soft rush were planted in rows traversing the three elevation tiers of the marsh. Seeds of the respective transplant species plus broadleaf arrowhead (*Sagittaria latifolia*) were similarily planted and all rows and individual plants within rows were spaced 0.5 m apart. A few transplants of water foxtail (*Alopecurus geniculatus*), yellow flag (*Iris pseudocorus*), and water plantain (*Alisma plantago-aquatica*) were planted in the upper regions of the intertidal areas. Initial transplant weights and measures of slough sedge, Lyngby's sedge, soft rush

and tufted hairgrass are shown in Table 2. Three 1- by 6-m cages were constructed perpendicular to the rows in each intertidal area and situated within the three elevation tiers. Each cage and adjacent quadrat contained 24 plants that were monitored during the spring and summer months for growth and development. On 23 August 1977, surviving transplants were carefully removed with roots intact and clipped at the root crown; both shoots and roots were thoroughly washed before drying to a constant weight at 83°C. Morphological characteristics of these plants were measured in August 1977.

Marsh reference area

22. Just west of the marsh plot area is a naturally established marsh. Six cages (3 by 3 m) were placed at three elevation levels in the marsh. A pair of square-metre subplots within each of the caged and adjacent quadrat areas were clipped for aboveground biomass determination at the end of the 1976 and 1977 growing seasons. All plants were sorted into separate species and washed clean of inorganic material before drying at 83°C. Additional quadrats were established in August 1977 to better sample the marsh vegetation. Twenty 1-m^2 quadrats were used to estimate cover and twenty 0.5-m^2 plots were clipped to estimate biomass. A grid method of locating quadrats, using compass lines and paces, was employed to sample the entire vertical range of the marsh.

23. The clipped samples were sorted into separate species and dried at 83°C to a constant weight. Average biomass measures were calculated for each species and transect level. Relative dominance, relative frequency, and importance values were calculated from data obtained from these wetland quadrats. These formulas are defined by Phillips (1959, p 43) as follows:

$$\text{Relative Dominance} = \frac{\text{total percent cover of species i}}{\text{total percent cover of all species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{number of points of occurrence of species i}}{\text{number of points of occurrence of all species}} \times 100$$

$$\text{Importance Value} = \text{Relative Frequency} + \text{Relative Dominance}$$

Unvegetated intertidal area

24. An unvegetated area on the sandspit adjacent to the east boundary of the monotypic plots was studied using six 3- by 3-m cages (Figure 5). Sampling of this area was conducted in a manner similar to that described for the marsh reference area. Biomass of the invading plants located in the caged and adjacent outside areas (quadrats) was determined at the end of the 1976 and 1977 growing seasons. Twenty independent cover and clip-plot quadrats were established along four transect lines in the area and sampled at the end of the 1977 growing season. Importance values and weight of individual species were calculated for each quadrat and average biomass measures were determined for each transect level.

Sandspit above tidal influence

25. European beachgrass was planted on 26 January 1977 on the sandspit located just north of the monotypic plot area (Figure 5). These transplants were placed at a spacing 0.5 by 0.5 m. Nitrogen fertilizer was applied in the form of ammonium sulfate at the rate of 224 kg/ha on 29 January and 27 April 1977. A similar and adjacent planting of European beachgrass was made on 1 May 1977 with the same spacing as the first. It was fertilized right after planting with ammonium sulfate at the rate of 448 kg/ha. The planting of European beachgrass was protected from blowing sand by lath fencing. Eighteen designated plants in each of three caged and adjacent uncaged areas (3 by 3 m) of the first planted beachgrass area were monitored for growth and survival during the summer months (June to August) of 1977. Aboveground biomass values were determined for this species by clipping the shoots of these plants at the end of the 1977 sampling period (24 August). Due to the limited population size of the newer planting 10 plants were selected at random for root:shoot ratio determination while 18 plants were chosen from the older planting.

Upland Study Area

26. The upland study area occupied most of the major meadow on

the main island (Figure 6). The study area consisted of three large nesting meadows,* each planted with a different grass-legume mixture; a series of monotypic plots corresponding to each of the three nesting meadows and containing those species present in the respective nesting meadow; and a natural meadow reference area (unplowed).

Meadows and monotypic plots

27. Site preparation. The topography of the meadow area is flat to gently rolling. Dominant vegetation in the upland area included common scouring rush, common velvetgrass, various lichens and two mosses (*Polytrichum juniperinum* and *Rhacomitrium heterostrichum*). To prepare a seedbed and reduce competition it was necessary to remove existing meadow vegetation cover. This was accomplished by repeated disking and in some areas, where the vegetation was particularly dense, a moldboard plow was used to turn under the material.

28. Experimental design. A description of the fertilizer treatments used in the monotypic plots is shown in Table 3. The area of each nesting meadow was approximately six hectares. The monotypic plots measured 13.0 by 17.5 m and treatments were replicated three times at each nesting meadow. Species and varieties and their germination and seeding rates for the upland experiments are shown in Table 4.

29. Planting and fertilizing. The Wave Beach Grass Nursery, Florence, OR was contracted for seeding and fertilizing the upland areas. A tractor-mounted cyclone fertilizer spreader was used to fertilize the nesting meadows and a hand-held model was used to fertilize the monotypic plots. The same equipment used for fertilizing was used in seeding the respective areas. A cultipacker was then used to pack the seedbed and cover both the seed and fertilizer. Date of planting for the upland monotypic plots and nesting meadows was 27 September to 2 October 1976. The spring application of fertilizer was applied on 13 May 1977.

30. Monitoring of vegetation. After planting the monotypic plots, three 1- by 3-m sampling quadrats were randomly established in

* Meadows were developed to attract ground-nesting birds.

each plot. The variables of plant density and percent cover were measured on the basis of these quadrats. Plant counts were made three times weekly during the month of October 1976, two counts were made in November and subsequent counts were made at monthly intervals. Twenty-seven subsamples of 0.01 m^2 each were used to derive numbers of plants per square metre for each plot. Initially, it was impossible to distinguish between many seeded grass species and invader grass species. However, beginning in late November, emerging seeded species were counted separately from emerging invaders and in January 1977 ten individual plants of the seeded species were selected and identified in each plot and tagged with 8-cm snap-on stem tags or wire-tie plastic tags. Stake flags identified individual plants that were still too small to physically retain a tag. The variables of plant height, stems per plant, seed production, plant vigor, and phenological characteristics were monitored on the basis of these tagged plants throughout the duration of the study. The difficulty of separating and identifying individual plants prompted the termination of the collection of measurements in May 1977.

31. At the peak of the growing season the tagged plants from each plot were removed for destructive sampling. Any seed present at the time of harvest was threshed and weighed. Harvest of the upland area occurred during the week of 11 July 1977. Importance values were calculated for individual species of plants in the monotypic plots at the time of harvest. Additional sampling at the peak of the growing season included the clipping of five random quadrats, each measuring 20 by 50 cm, from each monotypic plot. Each sample was separated into the following categories: seeded species, common velvetgrass, rat-tail fescue (Festuca myuros), and "all others." All samples were dried at 83°C to a constant weight before weighing. Mean biomass values were determined for each treatment and plant group.

32. Nesting meadows were monitored using animal exclosures (cages) and randomly located quadrats. Growth and development of the seeded species were monitored on a monthly basis during the spring and summer months of 1977 by measuring seven selected plants of each species.

The sample size generally reflected greater than 30 percent of the seeded plants present in the quadrats. Outside and adjacent to the cages similar plots were established and plants tagged. Three of these caged-quadrat pairs were established on each nesting meadow. Estimates of percent cover of the seeded species located in the study plots were initiated in January 1977 and continued at monthly intervals throughout the remainder of the study. All tagged plants were carefully removed with roots intact during the week of 11 July 1977. End-of-season biomass measures were calculated by clipping four randomly located quadrats (20 by 50 cm) in each of the caged and uncaged areas. Additional information on meadow plant composition was acquired at the end of the 1977 growing season by biomass measures of 20 random quadrats (20 by 50 cm) and from estimates of percent cover of plant species located in 20 random 1-sq m plots. Quadrat size and number of plots needed for adequate sampling of the nesting meadows were determined by the criterion that a standard error no greater than 10 percent of the mean dry weight of the dominant species occurred. The method of locating the quadrat plots was similar to the technique used for sampling the marsh reference area.

Meadow reference area

33. Three caged-quadrat pairs were established in a natural meadow (unplowed) located adjacent to the nesting meadow area. End-of-season biomass values were determined for each caged and uncaged area by clipping two 1-m^2 quadrats in 1976 and four 0.1-m^2 quadrats in 1977. Samples were divided into groups of common velvetgrass, rat-tail fescue, scouring rush, stream lupine (Lupinus rivularis), and "all others." Random plots located throughout the reference meadow were sampled in a manner similar to that employed in the nesting meadows.

Monitoring of Soils and Analysis of Soil and Plant Material

Soil sampling

34. The initial samples were used to characterize the soil

material before experimental treatments were imposed. Posttreatment samples were used to monitor changes during the course of the studies. Samples were collected 30 cm deep and divided into two sections: 0-15 cm and 15-30 cm. Cores 2.2 cm in diameter were taken using an Oakfield soil sampler. After collection, the cores were thoroughly mixed and subsamples placed in Whirl-Pak plastic bags. These were immediately placed in an ice chest with dry-ice until it was possible to transfer them to a -10°C cold storage room.

35. Initial samples were taken from each replicate block in the marsh studies and upland meadow on 12 June 1976 and 27 June 1976, respectively. This generated 18 samples from each study (3 replications × 3 elevations × 2 depths (0-15 cm and 15-30 cm) = 18, and 3 replications × 3 meadows × 2 depths = 18). Each sample was a composite of 12 evenly spaced cores.

36. Posttreatment samples were collected on the following dates:

a. Marsh plots: 9 September 1976, 7 June 1977, and 8 August 1977.

b. Upland plots: 8 June 1977 and 27 July 1977.

c. Cages: 23 August 1977.

37. A single sample was procured from every plot in the upland meadow and marsh areas, as well as from the inside and outside quadrats of the caged areas on each of the above dates. A sample was a composite of 9 cores taken from the quadrats in the plots or cage areas.

Soil analysis methods*

38. Particle size. A sample was air-dried and sieved through a 2-mm sieve to determine the gravel (>2 mm) fraction. The percentages of sand, silt, and clay were based on the mineral soil (free of organic matter) that passed a 2-mm sieve.

39. For analysis, a 15-g sample of soil particles <2 mm in size was saturated with Na** by serial centrifuge washings with 1 N NaOAc

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* Many of these methods have no single reference but are methods that have been developed by A. S. Baker and associates over a period of 19 years. Where no reference is given the method is described.

** The names of chemical symbols are given in Table A3.

followed by serial centrifuge washings with 80 percent methanol. The soil was then quantitatively transferred to a tared beaker, dried at 105°C, and weighed. It was then treated with serial aliquots of H_2O_2 and heated (70° to 80°C) until a total of 50 ml of 30 percent H_2O_2 had been added. The soil sample was oven-dried (105°C) again and the weight loss recorded as H_2O_2-oxidizable organic matter. The soil was dispersed by boiling in 50 ml of 2 percent Na_2CO_3 for 30 min. It was then washed through a 300-mesh (50 μ) screen using distilled water. Exactly 1 ℓ of the washings was collected in a cylinder. The sand fraction retained on the screen was dried and transferred to the top of a set of nested sieves which were agitated mechanically for 3 min. The various size fractions of sand were determined by weighing. The clay and silt fractions were determined on the suspension in the cylinder by the pipette method (Day 1965).

40. Organic carbon. Organic carbon was determined using the Wakeley-Black method described by Allison (1965, sections 90-3.2.1 and 90-3.2.2) using the following modifications. Diphenylamine (1 g in 100 ml concentrated H_2SO_4) was used as the titration indicator and 5 g of NaF was added prior to titration to improve detection of the end point.

41. Soil pH. Soil pH was determined on samples immediately after thawing on a 1:1 (weight/volume) ratio of soil to distilled water. The measurement was made using a glass electrode and a calomel reference electrode. Additional soil pH measurements were performed in situ at the same times and locations that Eh determinations were made in the marsh plots. An Orion model 407 A portable pH meter was used for measurement of soil pH. The electrodes were inserted directly into the moist marsh soil. When the soil was too dry for good electrical contact, distilled water was added to saturate the soil.

42. Soil Eh (redox potential). The Eh measurements were determined in situ on the marsh plots. For this purpose, bright platinum electrodes were standardized in a stirred saturated solution of quinhydrone at pH 7.0 using a saturated calomel electrode as the reference cell. The same cells were used with a Beckman model N portable pH meter for field measurements. The measured Eh values were corrected for

deviations of the platinum electrode from the theoretical values and were reported relative to the standard hydrogen electrode. Although soil temperature and pH measurements were made at the same location and time as the Eh measurements, the latter were not adjusted for temperature or pH.

43. Moisture content. Immediately upon thawing, the soil was mixed and between 60 and 70 g transferred to a tared weighing can and dried at 105°C overnight to determine moisture content.

44. Conductivity. The soil that was dried for the moisture determination was transferred to a beaker and sufficient distilled water was added from a burette to completely saturate the soil. A second addition of water was made that was equivalent to that required to saturate the soil. The soil-water mixture was stirred several times over a 30-min period and then sufficient solution for the measurement was filtered off. Conductivity measurements were corrected for temperature (to 25°C) and multiplied by two to adjust the reading to that of a saturation extract. The change in the activity coefficient is negligible for a 1:1 dilution of salt solutions at the concentration found in these samples.

45. Exchangeable ammonium and soluble nitrate. Both forms of nitrogen were extracted with a 2 N KCl solution and determined by the MgO-Devarda alloy method of Bremner (1965, sections 84-3.3.1 to 84-3.3.2). These were run on wet samples immediately after thawing.

46. Kjeldahl nitrogen. This form of nitrogen was determined by a micro-Kjeldahl method. A 2-g sample of air-dried soil was digested in 5 ml of concentrated H_2SO_4, 3 g K_2SO_4, and a single selenium granule. The digestion was continued for 30 min after clearing. The NH_3 was steam distilled into a 2 percent H_3BO_3 solution and titrated with 0.01 N HCl.

47. Phosphorus in upland samples. Air-dried soils were extracted with Bray's acid fluoride solution (0.03 N NH_4F and 0.025 N HCl) (Bray No. 1). The soil-to-solution ratio was 1:7 (weight/volume). The soil was shaken for 1 min before filtration. The phosphorus was determined

colorimetrically by the molybdenum blue-ascorbic acid method using H_3BO_3 to prevent interference by fluoride (John 1970).

48. Phosphorus in marsh samples. Air-dried samples were extracted with a modified Tamm reagent (0.1 N oxalic acid and 0.2 N ammonium oxalate, pH 3.5) using a 1:20 (weight/volume) ratio of soil to solution and a 2-hr shaking. The extract was diluted 1:10 with distilled water and phosphorus determined by the method of Owens et al. (1977).

49. Exchangeable cations. The procedure used was developed in the WSU laboratory. Analyses were run on air-dried samples because a comparison of wet (recently thawed) and air-dried samples indicated that drying had no effect on exchangeable cation values. Tests also indicated that there was no free $CaCO_3$ in these soils and thus no correction was necessary for the solubility of this mineral in NH_4OAc.

50. For extraction, fiberglass filter pads were seated in small Gooch crucibles. Two grams of air-dried soil were transferred to the crucibles; these were then inserted in the top of 50-ml plastic centrifuge tubes. The soil was leached serially with five 5-ml aliquots of neutral N NH_4OAc using centrifugation to force the solution through the soil. The NH_4OAc extract was analyzed for sodium and potassium by emission flame photometry and for calcium and magnesium by atomic absorption.

51. Cation exchange capacity. Using the same Gooch crucible and centrifuge system as above, 2 g of soil were saturated with calcium by leaching with five 5-ml aliquots of neutral N $Ca(OAc)_2$ and then with five 5-ml aliquots of neutral 0.01 N $Ca(OAc)_2$. After the last filtration, the crucible was weighed to determine the excess 0.01 N $Ca(OAc)_2$ remaining in the soil. The calcium was leached from the soil with five 5-ml aliquots of neutral N NH_4OAc. The NH_4OAc extract was analyzed for calcium by atomic absorption. The cation exchange capacity was calculated by the amount of Ca extracted by ammonium acetate minus the excess 0.01 N $Ca(OAc)_2$ remaining after the last saturation step.

52. Nitrite-N. Nitrite was not detected in any of the samples from the marsh. Absence of nitrite was affirmed by the sulfanilic acid

and α-naphthylamine spot test (Feigl 1954), which can detect 0.05 μg/ml of nitrite-N.

53. Sulfide. Sulfide was not detected in samples from the marsh even at low elevations where iron sulfide is most likely to occur. This was affirmed by the method of Goldhaber (1974).

Plant analysis methods

54. Plant sample preparation. Plant samples from the marsh required considerable washing to remove silt and sand, especially from crowns and roots. Samples were oven-dried (65°C) to determine dry weights and then were ground to pass a 20-mesh screen.

55. Kjeldahl nitrogen. This was run by a macro-Kjeldahl procedure using 300 mg of plant tissue in 15 ml of concentrated H_2SO_4, 8.5 g of K_2SO_4, and a selenium granule. Samples were digested for 30 min after clearing. The NH_3 was distilled into 4 percent H_3BO_3 and was titrated with standard acid.

56. Total phosphorus and potassium. Plant samples were ashed by heating in a muffle furnace at 550°C for 4 hr. The ash was treated with 5 N HNO_3, dried at 100°C, and returned to the muffle furnace at 400°C for 15 min. The ash was then treated with 6 N HCl, dried at 100°C to dehydrate silica, and the salts dissolved in 0.1 N HCl. The latter solution was analyzed for potassium by emission flame photometry and for phosphorus by the vanadomolybdate method (Kitson and Mellon 1944).

PART III: RESULTS AND DISCUSSION

57. This part of the report is divided into three main sections: (a) meteorological information which pertains to both the marsh study area and the upland study area, (b) the results of the marsh study, and (c) the results of the upland study.

Meteorological Information

Climatic conditions

58. Data collected at the National Weather Service Office at Clatsop County Airport, Astoria, Oregon (NOAA 1976 and 1977) was selected to represent long-term normal climatological conditions of the area (Table 5) and monthly means for the period June 1976 to July 1977 (Table 6). The collection point for this data was about 20.1 km WSW of Miller Sands. Winter temperatures measured at Miller Sands average about 1.1°C warmer than at Astoria (daily maximum +1.7°C, daily minimum 0.6°C). Summer temperatures at Miller Sands are about 1.9°C warmer (daily maximum +1.5°C, daily minimum +0.4°C). Rainfall for the two areas was not compared.

59. The weather during the period of the study was not normal being both warmer and especially drier than usual. During the period June through September 1976, all months except June were above normal in temperature with September temperatures averaging 1.3°C above normal. However, rainfall during this period was about normal, but beginning in September and until July 1977 rainfall was considerably below normal. The cumulative deficit for September 1976 to January 1977 was 50.3 cm. The cumulative deficit for 1977 up to August was 18.5 cm. Only March 1977 and May 1977 rainfall exceeded normal.

60. Temperatures the last three months of 1976 slightly exceeded normal whereas in 1977 monthly normal temperatures were exceeded in February, March, April, and June.

61. Although this abnormal weather undoubtedly influenced growth and development of vegetation at Miller Sands, the effects on vegetation

were not nearly as great as in drier habitats in the Pacific Northwest. In fact, weather during the fall of 1976 following seeding of the upland meadows and plots was more favorable for growth than would normally be expected. Rainfall was adequate for early germination and the greater than normal clear weather resulted in good plant growth and development. In addition, leaching of fertilizer was undoubtedly much less than would have occurred in a normal rainfall year. Thus, up to the 1977 growing season, the effects of the abnormal year were favorable for the upland plantings.

62. Because of limited retention of moisture in sand, winter storage of moisture in the profile has little influence at this site. Thus, the moisture deficits of importance to the upland vegetation were those in June and July of 1977 when rainfall was about one-half of normal. As a consequence, soil moisture became limiting sooner than normal and growth was probably reduced, especially of the later maturing species including tall wheatgrass (Agropyron elongatum), Oregon bentgrass (Agrostis oregonensis), white clover (Trifolium repens), and red clover (T. pratense).

63. The marsh vegetation was relatively unaffected by the drier weather even though river flow was reduced. Water levels appeared to be about normal except that the usual high water period in the spring caused by snow melt did not occur.

64. The weather pattern of this period included frequent strong east winds in the Columbia River Gorge especially from November 1976 through February 1977. These winds caused considerable sand movement from the sandspit onto the upper elevation plots because the east legs of the sand fence were not constructed until late in January 1977. Sand movement stopped after the sand fence was completed and the beachgrass was planted.

Nutrient input in rainfall

65. Rainfall was collected for analysis at Miller Sands during the period of the study. However, analyses were not made on the rainfall because conditions of collection did not give reliably uncontaminated samples. During the summer months when daily servicing was

possible, there was little rainfall. In winter months, service was infrequent. Consequently samples were almost always contaminated by insects and/or bird droppings, the latter despite the special bird repelling design of the collector.

66. For this reason, this study relied on data reported by Ellsworth and Moodie (1964) to estimate nutrient inputs at Miller Sands (Table 7). Their report gives data for a location near Long Beach, Washington, a point 22 miles WNW of Miller Sands. Very likely, the marine influence is less at Miller Sands with Na, Mg, and Cl being lower because of the nearness to the ocean of Long Beach and the relatively localized effect of storms on the distribution of these ions. However, these data likely approximate the input of other elements at Miller Sands.

67. Data in Table 7 show relatively large inputs of the nutrient elements K, Ca, Mg, and SO_4-S. Inputs of these elements are significant in terms of annual uptake by plants, but they are probably less than leaching losses since the natural soils of this area are relatively low in these elements. Deficiencies of these elements do not occur in natural vegetation of the area, but for maximum growth, cultivated plants of the area require fertilization with these nutrients. The relatively high input of SO_4-S is surprising since most atmospheric S originates with industrial activity and from vulcanism, both of which have little influence in this location.

68. Inputs for NH_4-N are very low compared to both plant needs and leaching losses. These low levels are typical of coastal locations with onshore movement of oceanic air masses.

Marsh and Sandspit Studies

69. This section covers results of the marsh soil and plant investigations in relation to the marsh monotypic plot experiment, intertidal mixture plantings, marsh and unvegetated intertidal reference areas, and the European beachgrass plantings.

Topography of the marsh plots

70. Computer-generated contour maps of the monotypic plot area were prepared and supplied by WES. These maps are drawn with 0.15 m contour intervals and show the normal topography on July 1976, November 1976, and April 1977. These maps are included in Appendix A' (Figures A1-A3). It should be noted that three plots in the SE corner were not utilized because of encroachment of the primary flow channel of the lagoon into this area.

71. Average elevations at the beginning of the experiment are shown in Table 8. Analysis of variance showed significant differences in elevation between tiers and replications and a significant interaction between replications and tiers. Replication number one was higher than the other two replications in the upper and middle tiers, but lowest in the low tier whereas replication number three was lowest in the upper two tiers and highest in the low tier. At the middle elevation, replication three was particularly low (94.5 vs 128.0 and 115.8 cm).

72. Average elevations for the treatments over the course of the experiment are shown in Figure 7.

Elevation changes over time

73. The factors causing significant elevation changes in the marsh were deposition of windblown sand on vegetated upper tier plots, channeling by draining water during ebb tides, and sedimentation on vegetated and lower tier plots (Figure 8). Unfortunately, the measurements of elevation were not very sensitive to the first two of the above conditions.

74. The sand was blown onto the plots from the sandspit area in the fall of 1976 prior to planting of the European beachgrass and placement in January 1977 of the last part of the sand fence. This sand was deposited mostly on the transplant plots which were the only ones with significant vegetative cover. Accumulations varied from 0 to 26 cm (Table 9) and occurred at the centers of these plots with rather abrupt boundaries in accumulation at the edge of the planted areas. Since the stakes used to assess elevation changes were located in the unplanted

borders, the data on elevation do not reflect this sand deposition. Nevertheless, much of the sand accumulation was still evident on these plots in October 1977 (Figure 9).

75. Channeling is not indicated by the elevation stake measurements because of the localized nature of these features. These channels are continuing to enlarge and are developing into the major topographic features of the plot area (Figure 10). At the upper elevation these channels, while not as pronounced as at lower elevations, were influenced in their locations by the sand deposition referred to above (Figure 9). For this reason, their location is related in places to plot treatment. At lower elevations their location is not influenced by plot treatment since there is almost no vegetation remaining on the lower plots. Some of the channeling at low elevations has followed in the bulldozer tracks made during preparation of the area. These tracks were still evident in places in October 1977 (Figure 11). Sedimentation in the lower and middle elevations appears to have been about 3 cm deep (Figure 8). Some of this material originated from the deposition of dredged material on the spit and in the lagoon in July 1975. The channeling described above is likely also contributing sediment at these elevations. At the upper elevation sand appears to be shifting from the unvegetated to the vegetated plots (Figures 8 and 9).

Initial properties
of the marsh substrate

76. Tests of the marsh substrate were made initially on the monotypic plot area prior to planting and subsequently on the marsh plots and in the reference areas. The initial data and results from the fall 1976 sampling of the marsh plots are reported in the following paragraphs.

77. Particle size distribution. Results of textural analysis of marsh soil samples are shown in Table 10. Surface samples from the low elevation contain greater quantities of silt and clay (means of 5.46 and 2.50 percent) than the middle (means of 1.77 and 0.87 percent) or the upper elevation (means of 0.86 and 0.66 percent). At the low elevation, fine sand was the major sand fraction while at the middle and upper

elevations medium sand was the major fraction. Thus soil at the low elevation appears to be finer in texture than at the upper elevations.

a. Surface samples were higher in silt and clay at the lower elevation. At the other two elevations, silt and clay contents were similar for both depths.

b. Within each elevation there appeared to be slight differences in texture between replications but on the average across all elevations, replications were similar.

c. Textural class of all samples was sand according to the particle-size classification system of the U. S. Department of Agriculture. With the exception of the differences mentioned above in relation to elevation and depth, the marsh area is uniform in soil texture.

78. Soil temperature. Soil temperatures shown in Table 11 indicate very little differences among elevations and replications at the time of sampling. Temperatures of the soil taken at that time probably reflect the river water temperature and thus would be expected to be uniform.

79. Chemical properties. All parameters described in the soil analysis methods section were run on the initial samples and on those collected at the end of the 1977 growing season with fewer parameters examined for the other sample times. These data are shown in Table 11. Organic carbon was quite low in the marsh soils, but was appreciably higher at the low elevation than at the other two elevations. The low elevation surface samples averaged 0.260 percent organic carbon; the middle 0.089 percent, and the high elevation 0.046. Some differences between replications were evident with replication 1 being lower in organic carbon than the others, particularly at the low elevation.

80. Soil pH was around 7 in all samples reflecting the neutral to basic reaction of the river water. Soil pH values showed significant differences due to elevation with low elevations averaging pH 6.7 in surface soils, middle averaging 6.9, and high 7.3. Subsurface samples were somewhat lower in pH than the surface.

81. Soil Eh or redox potential varied with elevation and sampling depth. Values were lowest at the low elevation and at the lower soil depths. However, even at the low elevations in the marsh, the substrate

appeared to be relatively well aerated.

82. Conductivity of marsh soils was low, reflecting the low salt content of the river water. The low elevation surface samples were highest in conductivity being 0.51 μmhos/cm, middle 0.32, and upper 0.22. Subsurface samples were lower in conductivity than surface samples.

83. Cation exchange capacity of the surface marsh soils varied with elevation being 6.24 meq/100 g in the low elevation, 3.79 in the middle, and 3.01 at the high elevation. The same trend was evident for subsurface samples. These differences in cation exchange capacity appear to correspond to the differences in content of clay and organic matter.

84. Exchangeable potassium was low in the marsh surface averaging 0.15 meq/100 g in the low elevation and slightly less in the upper two elevations. There was little effect of depth on soil potassium.

85. Exchangeable calcium and magnesium of the surface samples were fairly high and corresponded to cation exchange capacity being highest in the low elevation and lowest at the high elevation. Subsurface samples were only slightly lower in calcium and magnesium than surface samples.

86. Exchangeable sodium was uniform throughout the area with little variation due to either elevation or soil depth. Mean values varied between 0.035 and 0.041 meq/100 g of soil.

87. Kjeldahl nitrogen was low in all soils, but was extremely low in high elevation surface samples, which had only 0.003 percent nitrogen. Middle elevation had somewhat more, and low elevation averaged 0.015 percent nitrogen. Subsurface samples were slightly lower. These low levels indicate low nitrogen reserves in this material and a likely need for nitrogen fertilization especially at the high elevation.

88. Ammonium nitrogen varied from a high of 6.41 ppm at the low elevation to 2.24 ppm in the middle elevation and 0 at the high elevation. Subsurface samples had similar values. Ammonium levels are fairly high at low elevation but a need for nitrogen fertilization for

plants probably exists at the high elevation.

89. Nitrate nitrogen showed an opposite pattern to ammonium. Low elevation samples had no nitrate nitrogen while there was a little present in the middle samples and the high elevation samples averaged 0.49 ppm nitrate nitrogen. Results for nitrate nitrogen were quite variable, but this is not surprising in view of the low values encountered. Low nitrate values would be expected since this ion is readily leached or removed from sandy substrate by water although denitrification is also likely a factor in causing low nitrate levels especially at low elevations where Eh values are lowest.

90. Phosphorus values were very high in the marsh surface samples and averaged 282 ppm in the low elevation, 198 at the middle elevation, and 165 at the high elevation. Values in the sursurface samples were similar to surface values and to each other although replication 1 was generally lower than the others. These high levels indicate high phosphorus content in the dredged material since it is very unlikely that this area had been fertilized prior to sampling.

91. No nitrate or sulfide was detected in any of the marsh samples.

Substrate properties in the marsh experiment

92. Effects of treatments. Mean values for soil properties for all treatments and elevations in the marsh experiment are presented in Tables A4-A26 in Appendix A'. Average pH on the plots was 6.92 in the September 1976 samples, 7.03 in the June 1977 samples, and 7.11 in the August 1977 samples (Table 12). The increase in pH of the marsh substrate probably reflects an increase in the pH of the Columbia River water which in turn may be associated with the unusually low river flow during the year of drought. According to Analysis of Variance (ANOVA) there were significant differences in pH that were related to tier, replication, and fertilizer treatment. The effects of tier and fertilizer were significant at all three sampling dates with similar patterns being shown. Substrate pH increased with elevation in the marsh and it decreased as a result of fertilizer treatment. However, little

importance should probably be given to these differences since they are minor relative to nutrient availability and effects on plant growth.

93. Exchangeable potassium values were similar to initial values and averaged 0.135 in the September 1976 sampling, 0.151 in the June 1977 sampling and 0.128 in the August 1977 sampling (Table 13). ANOVA showed significant differences due to tier, replication, the interaction of tier and replication, and to fertilizer treatment. Highest levels occurred at the low elevation and in Replication III although, in the latter case, the difference was significant only at the September 1976 sampling date. Exchangeable potassium corresponded closely to fertilizer treatment. For instance, at the September 1976 sampling, the F0 treatment showed 0.113 meq K/100 g, the F1 and F4, which had received the same amount of fertilizer at that time, had 0.137 and 0.134 meq K/100 g respectively, and F2, which was the highest treatment at that time, had 0.160 meq K/100 g.

94. Phosphorus (oxalate extraction) in the marsh was significantly related to tier at all three sampling times, to replication in the June sampling time, and to the interaction of tier and replication in the August sampling time (Table 14). Phosphorus was highest at the low elevation and in Replication III. Only in August did the values for phosphorus correspond to fertilizer treatments. In the September 1976 samples, available P did not seem to be sensitive to P fertilizer application. By August 1977, values had decreased considerably but there appeared to be a relationship of P values to fertilizer treatment.

95. Ammonium N was relatively constant during the course of this experiment averaging 8-10 ppm at the three sampling dates (Table 15). Ammonium levels decreased with elevation but the differences were significant only in the 1977 samples. Ammonium N corresponded closely to fertilizer treatments in the September 1976 samples but by August 1977, the differences between fertilizer treatments were not significant. However, the values remained substantially above those that were found in the initial samples.

96. Kjeldahl N appeared to remain constant at about 0.01 percent

N throughout the experiment (Table 16). ANOVA showed significant differences between elevations in all three sampling times and between replications and fertilizers at the September sampling only. As with potassium and ammonium N, the Kjeldahl N values appeared to be related to fertilizer treatment and like ammonium N, the differences were no longer significant by August 1977. Highest values occurred at low elevation and in Replication III.

97. Differences in nitrate N were not as significantly related to elevation, replication, and fertilizer as other soil chemical properties (Table 17). However, the pattern of distribution appears to be opposite to that of the other nutrients. For instance, nitrate is lowest at the low elevation and highest at the upper elevation and is lowest in Replication III. Also, there was no relationship of nitrate to fertilizer treatment in the September 1976 sampling but in August 1977 there appears to be a close relationship. Nitrate levels in 1977 appeared to have increased somewhat over the 1976 values, which in turn were above initial levels, particularly at the lower elevation.

98. Organic carbon determinations were run at the end of the experiment in August 1977 and showed significant relationship to elevation, to the interaction of replication and elevation, and to fertilizer treatment (Table 18). Highest values occurred at low elevation and lowest values at the upper elevation. An increase over the initial values is apparent at the low elevation but no change occurred at the other two elevations.

99. Cation exchange capacity was also determined on the August 1977 samples. Values corresponded to those determined in the initial samples with highest values for exchange capacity occurring at the low elevation (Table 19).

100. Moisture level at time of sampling is shown in Table 20. As would be expected, moisture contents of the low elevation samples were higher than those from the upper elevation. With Replication III being lower in elevation, it was also higher in moisture content. Fertilizer treatment was not related to moisture content.

101. Effect of plants on fertility levels. Levels of available

nitrogen and exchangeable potassium were influenced by the presence of plants in the marsh (Tables 21, 22 and 23). The greatest differences were observed in the two 1977 sampling periods, however ammonium levels in the September 1976 sampling period were significantly reduced on transplant plots as compared to the unplanted plots in the upper elevation and in the mean for the three elevations (Table 21). No plants were present in low elevation plots after the winter of 1976-77 because of mortality on these plots. Consequently there were no significant differences in nitrogen and potassium levels in the 1977 samples at the low elevation.

102. Depletion of nutrients on the transplant plots is likely the result of nutrient uptake by the plants. Status of nitrogen (considering both ammonium and nitrate nitrogen levels) and potassium was lowest on the upper elevation plots. It was on these plots where differences between transplant and unplanted plots were greatest and in all cases the differences were significant. Depletion of available nutrients following only one full season of growth suggests that fertility is likely to somewhat limit growth of transplants in the future, at least at upper elevations.

103. Fertility status of phosphorus as measured by the oxalate method of extracting available phosphorus was not significantly related to the presence of plants on the plots. It is not known whether other methods of extracting available phosphorus might have been sensitive to plant uptake as was noted with nitrogen and potassium.

104. <u>Changes in the fertility levels in the marsh over the course of the experiment.</u> The relationship of fertility status to sampling date and elevation is shown in Table 24. Average ammonium nitrogen levels in samples from both periods in 1977 were significantly below values that were found in the August 1976 sampling. The most pronounced drop in ammonium levels occurred in the soil from the upper elevation plots. This probably results from the lower total nitrogen levels and lower cation cxchange capacity in the more sandy upper elevation soil.

105. Nitrates showed an opposite pattern to that observed with

ammonium. Average levels in 1977 increased significantly over those that were present in 1976 probably as a result of nitrification of the ammonium added in the fertilizer. The greatest increase occurred at the upper elevation and is in keeping with results showing low nitrification at lower elevations in the marsh.

106. Phosphorus status, as measured by the oxalate extraction procedure, was significantly different for all three sampling dates. August 1976 samples were highest and June 1977 samples were lowest. Similar relationships were evident at upper elevations but at low elevations, there was no significant difference in phosphorus level between the three sampling periods.

107. Average values for exchangeable potassium were highest in June 1977 samples and lowest in August of that year. Values for June 1977 were highest in all three elevations of the marsh. Elevated levels in June are probably the result of the spring fertilization that was done on these split fertilizer application plots with the increased values of those particular plots being high enough to significantly affect the overall averages in the samples collected at that time.

108. The drop in nitrogen fertility status (mostly ammonium nitrogen) and the decline in exchangeable potassium was most evident in the upper elevation plots. This is further evidence for the likely drop in productivity of plants growing at upper elevations.

109. Over a longer period, the presence of vegetation will likely cause increases in sedimentation and increased organic matter content of the substrate, and in association with this, fertility of the substrate is likely to increase.

Substrate properties in the intertidal mixture plantings

110. Chemical properties in the intertidal area are shown in Table 25. No significant difference was found between samples collected on the inside of the cages and those collected on the outside.

111. The relationship of fertility levels to elevation that was observed in the marsh monotypic plots is also seen in these samples. However, it should be noted that lower, middle, and upper elevation in

the intertidal area does not correspond exactly to low, middle, and upper elevation tiers in the marsh experiment since lower and middle elevation samples in the intertidal areas are taken at somewhat higher elevations than in the marsh experimental area (Table 25). Thus, mean values for properties that decrease in value with higher elevation are likely to be somewhat lower in the intertidal area than in the marsh plot area. For example Kjeldahl nitrogen in the intertidal area averages 0.007 percent N compared to a mean of 0.011 percent Kjeldahl N in the marsh plot area (Table 16). Similarly, ammonium nitrogen, phosphorus, exchangeable potassium, percent moisture, organic carbon, and cation exchange capacity all average less in the intertidal area than in the monotypic plots. On the other hand, those properties which are highest in upper elevation, namely nitrate nitrogen and pH, average higher in the intertidal area. Other than the effect of differences in elevation, it would appear that the fertility levels in the marsh experiment and in the intertidal area are comparable.

Substrate properties
<u>in the marsh reference area</u>

112. Chemical properties in the substrate of the established marsh, referred to as the marsh reference area, are shown in Table 26. Elevations in this area correspond to those in the planted area and thus direct comparisons can be made between the two. The average value in the marsh reference area for Kjeldahl nitrogen is almost three times greater than in the intertidal area. In contrast to both the intertidal mixture plantings and the marsh monotypic plot areas, there appears to be little effect of elevation on Kjeldahl nitrogen in the reference marsh. The highest value actually was obtained at the upper elevation (Table 26). Available forms of nutrients in the established marsh, namely ammonium and nitrate nitrogen and exchangeable potassium, are lower than in the intertidal mixture area (Table 25). This pattern is similar to that observed in the marsh monotypic plots where the presence of plants apparently caused significant reduction in the soil nutrient levels (Tables 21, 22 and 23). In addition to Kjeldahl nitrogen, higher values occurred in the marsh reference area for phosphorus, moisture,

organic carbon, and cation exchange capacity.

Substrate properties in the unvegetated intertidal area

113. Chemical properties for this area are shown in Table 27. Average elevations are lower in this area than in the reference marsh or the intertidal mixture planting area. Consequently these values may be more comparable to the marsh monotypic plot values as indeed is the case with Kjeldahl and ammonium nitrogen, phosphorus, exchangeable K, pH, and cation exchange capacity. However, moisture content and organic carbon are lower in the unvegetated reference area than in the marsh monotypic plot area.

Substrate properties in the European beachgrass plantings

114. Chemical properties in this area are presented in Table 28. Despite the difference in fertilization history no significant differences are observed in fertility levels or other soil properties between areas A and B. Ammonium nitrogen is considerably higher in this area than in all but the low elevation samples from the marsh. Otherwise, values in the European beachgrass area are comparable to those found for upper elevations in the marsh study areas except for the reference marsh. Moisture content is, of course, an exception since this area is well above the influence of inundation and moisture can become very limiting.

115. High ammonium levels indicate retention of ammonium from the fertilizer. This is in contrast to the pattern of fairly rapid depletion or conversion to other forms in the marsh monotypic plots that were subject to inundation.

Results of the marsh experiments on plants

116. Marsh cover. The average percent cover for each propagule-type and species with respect to fertilizer application and elevation for September 1976 is shown in Table 29. The percent cover values of the upper tier were consistently larger than those of the middle and lower tiers. The low values recorded in the lower tier reflected poor

vigor of transplants, failure of seedling emergence, and insignificant establishment of invading plants in that tier.

117. The percent cover of slough sedge seeded plots was not significantly different from the percent cover of the tufted hairgrass seeded plots in September 1976. Similarly, no significant difference was observed between the percent cover of the transplant plots of the two transplant species. Transplanted plots had significantly more cover than the seeded plots and unplanted plots (Table 30). Seedlings emerging in the seeded plots were not well established and had not obtained sufficient growth at the time of sampling to reflect high values of percent cover. Plants invading the unplanted plots were few in number and reflected an average cover value similar to that of the seeded plots (Table 30).

118. No significant percent cover differences were observed between fertilizer application rates of either species for the 1976 sampling date. Cover classes were broad and unless fertilizer dramatically influenced plant growth, no fertilizer effects were expected to be recorded using this parameter in the short time the seedlings and transplants had been growing.

119. Table 30 presents cover values of the three replications. The larger cover value associated with replication 3 is probably due to significantly higher nutrient levels in that replication.

120. Figures 12 and 13 show the seasonal cover values of the transplant species. Vegetative die-back of tufted hairgrass transplants commenced in September 1976 and reflected decreases in percent cover values through the subsequent months until April, when vegetative regrowth commenced. Larger cover values were recorded in August 1977 for the upper and middle tiers of tufted hairgrass on transplant plots than were recorded in September 1976. The values of the lower tier reflected low survival of transplants (Table 31).

121. Loss of foliage by slough sedge on transplant plots continued through December 1977 and regrowth commenced in January. Cover values of slough sedge transplants were similar in September 1976 and August 1977 in the upper tier. Greater cover values were recorded in

1977 than in 1976 for transplants in the middle tier and the cover values of the lower tier reflected poor survival (Table 31).

122. Table 32 shows the percent cover of the transplant species in August 1977. The largest cover values of tufted hairgrass transplants were recorded in the upper tier but these were not significantly greater than those recorded in the middle tier. The percent cover values of the upper and middle tiers were significantly greater than the cover values of the lower tier.

123. Response to fertilizer application was apparent in tufted hairgrass transplants. Cover values of plants growing in the F3 plots were significantly higher than cover values of the unfertilized plots in the middle and upper tiers. The general response of fertilizer indicated that the split applications of fertilizer (F3 and F4) significantly increased the foliage cover of tufted hairgrass transplants over those plants receiving only one fertilizer application and no fertilizer.

124. The largest cover values of slough sedge transplants were recorded in the middle tier during the August 1977 sampling date and the smallest values were recorded in the lower tier of the marsh but differences between tiers were not significant.

125. Percent cover of slough sedge transplants did not differ significantly between fertilizer treatments.

126. Table 33 shows the percent cover of the seeded species in August 1977. Values of percent cover of tufted hairgrass seedlings were recorded in the upper two tiers of the marsh. No seedlings emerged in the lower tier but differences in cover of the seedlings were not significant between tiers. No slough sedge seedlings were observed in the lower middle tiers and a cover value of less than 0.1 percent was recorded for slough sedge seedlings in the upper tier. No significant differences of percent cover between fertilizer treatments were apparent with either species.

127. Cover values of planted and invader plants with respect to elevation, propagule-type, and fertilizer treatment are shown in Appendix A' (Tables A27-A31). This information indicates that plant invasion of the marsh area was greatest in the upper two tiers and

provides useful information on the tolerance range (cm above mllw) of hydrophytes occurring in a freshwater tidal marsh.

128. Evaluation of survival of transplants. Surviving transplants of tufted hairgrass and slough sedge were counted in July 1977, one year following planting. Each transplanted plot contained upwards to 594 plants (100 percent survival) and percent survival was calculated for each species with respect to fertilizer treatment and tier.

a. Tufted hairgrass. Survival of tufted hairgrass transplants one year following transplanting was very high in the two upper tiers (Table 33), which corresponded to elevations greater than 91 cm above mllw (Figure 7). Only 22 percent of the transplants survived below this range.

Overall survival of transplants in the upper tier was 96 percent. Sand accumulation within the upper tier plots in the fall and winter of 1976 (Table 9) apparently had no detrimental effects on the survival of tufted hairgrass.

Survival in the middle tier averaged 80 percent and appeared to be related to plot elevation. The two lowest elevation plots in the middle tier had the lowest survival. These were Replication 3, application F1, and Replication 2, application F2 with 16 and 19 percent survival, respectively (Table 31). Elevations of these plots were 63 cm and 94 cm with the average elevation of the middle tier being 127 cm above mean lower low water.

Fertilizer treatment did not affect survival of tufted hairgrass in any of the tiers (Table 33). Significantly more transplants survived in the upper two tiers than in the lower tier. Figure 14 shows a tufted hairgrass transplant plot in the upper tier at the end of the 1977 growing season. Environmental conditions at the lower tier differed from those of the middle and upper tiers primarily in degree of submergence and sedimentation. The latter coated the plants and substrate with fine-textured material and probably reduced photosynthesis by these plants. Water depth and its relationship to photosynthesis and survival of aquatic plants has been extensively discussed in the literature (Dabbs 1971, Hinde 1954, Humm 1956, Meyer et al. 1943, Meyer and Heritage 1941, Palmisano and Newsom 1968, Robel 1961, Robel 1962, Schmid 1965, Spence and Chrystal 1970a, Spence and Chrystal 1970b, Spence et al. 1971, Walker and Coupland 1968) and is likely the primary cause of the poor survival of tufted hairgrass transplants at this elevation. Differences in average substrate texture (Table 10) and nutrient availability (Tables 13 and 17) did not appear to be limiting factors for survival in the lower tier.

b. Slough sedge. The percent survival of slough sedge transplants at each elevational tier is shown in Table 34. Similar to the survival of tufted hairgrass, transplants of slough sedge survived best in the two upper tiers which corresponded to elevations of greater than 75 cm above mllw (Figure 7). Less than 8 percent of the transplants survived below this range.

Figure 15 shows a typical slough sedge transplant plot in the upper elevation in October 1977. Overall survival of slough sedge transplants in the upper tier was 80 percent. The lower survival of F2 plots was a result of heavy sand accumulation during fall and early winter (Table 9).

Survival of slough sedge transplants in the middle tier averaged 69 percent. Differences in elevations within the tier as opposed to fertilizer rates influenced survival of the transplants. Plots without fertilizer (FO) had the highest survival (89 percent), and plots with high fertilizer application (F4) resulted in a low survival of 47 percent. The elevational position of these plots is shown in Figure 7. The FO plots, on the average, were nearly 30 cm higher in elevation than those of the F4 plots. Sand deposition was slight at this elevation and was not considered as a factor of survival in this tier. Fertilizer did not affect survival at any of the three elevations (Table 34).

Significantly more slough sedge transplants survived in the upper tiers than in the lower tier. Factors responsible for the failure of slough sedge to survive at the lower tier were discussed earlier in reference to tufted hairgrass transplants.

129. Effect of fertilization and tier on tufted hairgrass transplants.

a. Characteristics of plants in 1976. Growth patterns of tufted hairgrass plants on transplant plots from August 1976 to September 1977 are shown in Figures 16 and 17. Average heights of tufted hairgrass plants on transplant plots were 30 cm in the middle tier, 22 cm in the upper tier, and 17 cm in the lower tier by the end of the 1976 growing season (Table 35). These differences were not significant at the 0.05 level.

Response to fertilizer was apparent in the upper and lower tiers during the 1976 sampling period (Table 35). Application of 1220 kg/ha (F4) significantly increased growth of tufted hairgrass plants on transplant plots in the lower tier and 610 kg/ha significantly increased growth in the upper tier. Plant heights were less on FO treated plots than on fertilized plots at the end of the 1976 growing season (Table 35). The overall effect of fertilizer indicated that application of 610 kg/ha significantly increased growth of the transplants.

Effect of tier and fertilizer on the number of leaves per plant of tufted hairgrass transplants at the end of the 1976 growing season is shown in Table 36. With this species of grass, stems other than culms are not evident and therefore number of stems and number of leaves were considered equivalent. Transplants growing in the lower tier averaged four leaves per plant while the middle and upper tiers averaged 14 and 16, respectively. The differences were not significant at the 0.05 level.

Nonfertilized plants (FO) had significantly fewer leaves per plant than those receiving fertilizer at the time of the 1976 sampling date. Similar growth responses of plants were shown by the F1, F2, and F3 application rates, but plants growing in the F4 plots produced fewer leaves per plant than the other fertilizer treatments according to the Duncans Multiple Range Test (DMRT). The F4 plots tended to be positioned in the lower regions of the two upper tiers relative to the other fertilized plots (Figure 7) and this elevation difference may have been enough to affect the growth of the transplants.

Significant differences of average weights per plant were observed between the three tiers in 1976 (Table 37). Transplants in the upper tier averaged 4.93 g per plant while the plants in the middle tier averaged 3.51 g and 1.74 g in the lower tier. These differences were significant between the upper and lower tiers.

b. <u>Characteristics of plants in 1977.</u> A die-back of shoot material commenced in September 1976, and by January 1977 few green leaves were evident on most tufted hairgrass plants (Figure 18). Vegetative regrowth began in March and maximum growth was reached during the month of August 1977 (Figures 16 and 17). Investigations of tufted hairgrass in 1977 included harvesting of plants during the summer and at the end of the growing season.

Four tufted hairgrass plants were clipped at ground level from each transplant plot located in the middle and upper tiers on 8 June 1977. The information collected on these plants is summarized in Tables 38, 39 and 40. Plants in the upper tier averaged 42 stems per plant while those in the middle tier averaged 33 stems per plant but these differences were not significant. Plants receiving fertilizer had significantly more stems per plant than unfertilized plants.

Inflorescences were beginning to develop at this time and tufted hairgrass growing in the upper tier averaged nearly five flowering heads per plant as compared to one per plant in the middle tier. These differences were not significant at the 0.05 level. Plants fertilized once with 2440 kg/ha (F2) and twice with 610 kg/ha (F3) produced significantly more flowering heads per plant than the unfertilized plants.

Shoot weights averaged 16.57 grams in the upper tier and 8.12 grams in the middle tier in June 1977. Fertilizer significantly increased biomass production in the F2, F3, and F4 plots as compared to FO plots.

Figures 19 and 20 depict the growth of the clipped plants during the summer months of 1977. New growth averaged 30 cm in the upper tier and 31 cm in the middle tier by August. Significant differences in plant height were not observed between treatments. Stems per plant averaged 25 in the upper tier and 27 in the middle tier and differences between treatments were not apparent in August. These findings suggest that little residual fertilizer was available for plants by this time since growth differences (height, stems per plant) between treatments were not observed in the clipped plants (refer to section on shoot analysis of marsh plants).

Anthesis of tufted hairgrass plants on transplant plots initiated in the upper tier in late June 1977 but was not evident in the middle tier until early July 1977. Development proceeded quickly and by mid-July all flowers were open in both tiers. Figure 21 shows that more flowering plants were produced in the upper tier than plants in the middle tier, and that development of flowering heads proceeded at a faster rate in the upper tier. Few plants produced flowering heads in the lower tier. Plants averaged 2.60 grams of seed per plant in the upper tier as compared to 0.68 grams per plant in the middle tier at the end of the 1977 growing season (Table 41), but this difference was not significant.

End-of-season sampling during August 1977 showed tufted hairgrass plants on transplant plots tended to be taller (55 cm) in the upper elevation. Plants in the middle tier averaged 46 cm and the size differences between the two tiers were not significantly different according to to ANOVA (Table 42). Plants in the lower tier died during the winter. Low levels of light intensity have been found to limit growth of tufted hairgrass (Tieszen and Bonde 1967) and the longer submergence of transplants located in the lower tier may have prevented these plants from obtaining sufficient light to carry on photosynthesis. The higher average heights of plants seen at the upper elevation indicate favorable conditions of that tier.

Significant differences in plant growth were evident between treatments at the end of the 1977 growing season (Table 42). Plants fertilized twice at the rate of 610 kg/ha in the summer (1976) and spring (1977) (F3) grew to an average height of 59 cm which was significantly taller than plants growing in the F0 and F1 plots.

Stems per plant averaged 45 in the middle and 45 in the upper tier at the end of the 1977 growing season (Table 41). The average number of stems per plant differed significantly between fertilizer rates according to ANOVA and DMRT. Table 42 shows that F0 plots averaged less stems per plant than those plants receiving fertilizer. Plants growing in the F3 plots produced the greatest number of stems with 62 per plant. These plants had significantly more stems per plant than those growing in the F0 and F1 plots.

At the end of the 1977 growing season tufted hairgrass plants on transplant plots averaged 54.30 grams per plant in the upper tier and 36.95 grams in the middle tier (Table 41) but these differences were not significant. The 1977 values represent more than a ten-fold increase over the 1976 values.

The low survival of tufted hairgrass transplants in the lower tier (7 percent) suggests unfavorable conditions of that tier. Larger biomass values (Table 41) and growth values (Table 42) observed in the upper tier as compared to the middle tier suggest better plant performance of tufted hairgrass as elevation above mllw increases.

Plants growing in the F3 plots consistently showed the highest averages with significantly greater shoot weights than all other treatments, greater seed weights than F0 and F1 plants, and greater total weight values than F0 and F1 plants (Table 41). In all instances the lowest values were obtained in the unfertilized plots.

130. Effect of fertilization and tier on slough sedge transplants.

a. Characteristics of plants in 1976. Growth patterns of slough sedge from August 1976 to September 1976 are shown in Figures 22 and 23. Average heights of slough sedge transplants were 17.0 cm in the marsh monotypic plots at the end of the 1976 growing season (Table 43). Plant height of slough sedge was significantly greater in the middle tier than the upper and lower tiers. Similar to the tufted hairgrass transplants, slough sedge plants were smaller in the lower tier.

Plants were significantly taller in the F4 plots than in the F3 and F2 plots at the time of the 1976 sampling date (Table 43). Nonfertilized plants (F0) produced leaf lengths similar to the F4 plants. These responses do not appear to be fertilizer related but in rhizonomous plants such as slough sedge, growth cannot always be monitored on the basis of leaf length. Measurements of growth and expansion of the root system might have been a more reliable index of plant growth and response to fertilizer application for this species.

The average number of stems per plant was significantly greater in the upper tier as compared with the middle and lower tiers at the end of the 1976 growing season (Table 44). The increased amount of foliage may be directly correlated with increasing exposure to light and to the firmness of the substrate. The loose sand in the upper tier probably facilitated growth of the rhizomes beneath the surface layer.

No fertilizer response of increased number of stems was evident between treatments in 1976 (Table 44) but unfertilized plants tended to average less stems per plant than fertilized plants.

According to both ANOVA and DMRT, there was no effect of fertilizer or tier on average weight values of slough sedge plants at the time of the 1976 sampling date (Table 45). The average weight of a slough sedge plant in 1976 was 4.77 grams.

b. Characteristics of plants in 1977. Die-back of slough sedge began in September 1976 and continued through February 1977. Spring growth started in early March and final sampling of this species was completed in late August 1977. However, the August sampling date does not reflect end-of-growing season values since slough sedge continued to grow through November 1977.

Values for plant size on the slough sedge plants on the transplanted plots for August 1977 are shown in Table 46. Plant height averaged 39 cm in the middle tier and 28 cm in the upper tier, but these differences were not significant at the 0.05 level. All transplants died during the winter in the lower tier. Because slough sedge has seldom been studied it was difficult to know the reason for its poor performance in the lower tier. Since slough sedge responded in a manner similar to that of tufted hairgrass, it might be assumed that the same environmental factors (submergence, light intensity) influenced growth and survival of this species.

ANOVA and DMRT showed no effect due to fertilizer on the size of slough sedge plants on the transplanted plots at the August 1977 sampling date (Table 46). Plants growing in the F4 plots were the smallest (29 cm) while F2 plants were the largest, averaging 38 cm. Similar results were found with the length of the slough sedge roots with F4 plants showing the smallest values and F2 plants showing the largest values (Table 46). These differences of root length between fertilizer treatments were not significant at the 0.05 level.

Plants averaged five stems per plant in the middle and upper tiers at the time of the 1977 harvest (Table 46). Fertilizer had no effect on stem production of slough sedge and plants on transplant plots averaged five stems per plant in 1977. This is an overall increase of three stems per plant over the 1976 values.

Plants harvested in 1977 averaged 14.49 g per plant in the middle tier and 11.85 g in the upper tier but these differences were not significant (Table 47). These 1977 values represent a 2.64-fold increase over the 1976 values.

131. <u>Shoot nutrient information.</u>

<u>a.</u> <u>Tufted hairgrass.</u> Nitrogen levels were highest in the June 1977 samples with an average of 1.55 percent N (Table 48). Values were lowest in the August 1977 samples with an average of 0.77 percent N. Plants from the upper elevation were lowest in nitrogen content but the differences due to elevation were not significant at any of the sampling dates. Significant differences due to fertilizer were evident in September 1976 and June 1977 samples but only in the September samples did the values closely reflect fertilizer treatment. We could find no data in the literature on nutrient concentration in tufted hairgrass plants from a marsh habitat. However, seasonal patterns of N, P, K, and Mg in tufted hairgrass in upland situation were

investigated by Davy and Taylor (1975). Average value for tops in the three areas they investigated was between 1.5 and 2.0 percent at the first of May and about 1.0 percent at the first of September. Based on this information, it would appear that the 1.03 percent N in marsh unfertilized plant tops in September 1976 was about average for the species and that 1.62 percent N in the F2 plants represented a significant increase. Values for N content at this time may have correlated with yield in the next season, but additional fertilizer was given in April to the F3 and F4 treatments. Concentration of nitrogen in the plants in June did not reflect fertilizer treatment except that the highest value, 1.73 percent N was found in the F4 treated plants. In August, fertilizer treatments giving the highest yields, F2 and F3, showed lowest nitrogen concentrations but the differences between fertilizer treatments were not significant.

Concentration of phosphrous in tufted hairgrass plants is shown in Table 49. Levels averaged about 0.20 percent P in September 1976 and June 1977. These equal the maximums reported by Davy and Taylor (1975) for tufted hairgrass on three upland sites. By August 1977, phosphorus in the plants dropped to about 0.10 percent, a drop that corresponds to the findings of Davy and Taylor, but still somewhat above their average values for August.

Upper elevation plants were lowest in P concentration, but the differences were significant only in the September 1976 sampling period. P levels appeared to correspond to fertilizer treatment but the differences were not significant except in August 1977.

Potassium concentration averaged about 1.2 percent in September 1976, 1.4 percent in June 1977, and 0.7 percent in August 1977 (Table 50). The September 1976 values correspond to those found by Davy and Taylor (1975) but the other values from the monotypic plot experiment are considerably less than the reported values. Davy and Taylor showed maximum values in tufted hairgrass plants on three sites averaged above 2.0 percent K. Elevation appeared to have no significant relation to K concentrations. Fertilization was significantly related to K concentration except for the August 1977 samples. Concentration of K in September 1976 corresponded to fertilizer treatment but in June 1977 the values did not reflect treatment.

Content of nutrients in tufted hairgrass plants was most closely related to fertilizer treatment in the

September 1976 samples. Uptake of nutrients by the plants at this stage was probably limited because of relatively undeveloped root systems and thus closely reflected fertilizer treatments. The relative lack of influence of the split applications on nutrient levels in June 1977 samples may indicate that the plants by this time were able to obtain relatively more nutrients from the substrate because of larger root systems. Thus the split application of fertilizer represented a relatively small percentage of nutrients available and taken up by the plants at this time.

By the end of the experiment concentration on fertilized plots became similar to those on control plots. Very likely the extra nutrients from the fertilizer were depleted causing the nutrient contents of the plants to decline.

Comparisons of the percentage nutrient values with the mean dry weights of the shoots show that the inorganic nutrient resources were diluted with increasing dry matter.

Nitrogen uptake in shoot parts of tufted hairgrass was highly variable between fertilizer treatments in September 1976 (Table 48). Differences in uptake of N in September 1976 were not significant in the lower tier where inundation was more prolonged.

The June 1977 uptake of N represented more than a fourfold increase over the values recorded in 1976. Rapid growth of leaf and culm parts was occurring at the time of the June sampling. Plants fertilized with split applications (F3, F4) show the largest uptake values but no significant differences were obtained between fertilizer treatments and tiers.

The large uptake recorded in August 1977 reflects increased weights of plants over the previous sampling dates. Uptake of N was greatest in plants fertilized with split applications (F3, F4) with the F3 plants absorbing significantly more nitrogen than unfertilized plants and those plants fertilized only once.

Uptake of phosphorus followed a pattern similar to the uptake of nitrogen (Table 49). Less phosphorus was incorporated in the shoots of tufted hairgrass in 1976 when the plants were young and small as compared to shoots collected in June 1977 when the plants were rapidly growing and August 1977 when the plants had obtained maximum growth. Phosphorus absorption was the greatest in plants located in the F3 and F4 plots in 1977. Significantly higher uptake values of P were recorded in the F3 plots than in the other fertilized and unfertilized plots in August 1977. All fertilized plants incorporated significantly more P in shoot parts than the unfertilized plants.

Values of K uptake were similar to the values of N uptake at all three sampling dates and were generally greater in the larger and more vigorous plants (Table 50). A high mean value of 411 mg of K per plant was recorded in the F3 plots in August 1977 and this was significantly more uptake of potassium than plants growing in the other plots. The low average value of 99 mg of K per plant recorded in the F0 plots was significantly less than the values recorded from the fertilized plots.

b. Slough sedge. Nitrogen levels in samples collected in September 1976 and August 1977 are shown in Table 51. Nitrogen averaged 0.89 percent in the September 1976 samples and 1.58 percent in the August 1977 samples. No information was available in the literature on nutrient content of slough sedge. Values for six other species of sedge were reported by Gorham (1953). Samples from these species were collected in mid-season and varied from 1.42 to 2.32 percent N. Thus the samples of slough sedge from Miller Sands that were taken in 1977 were comparable to the results of Gorham (1953).

No significant differences were evident in nitrogen content in relationship to elevation at either sampling date. Significant differences due to fertilizer were evident in the September 1976 samples with the unfertilized (F0) samples averaging 0.75 percent N and samples from the F2 plots with 1.01 percent N (Table 51).

It is not known why the values for September 1976 were depressed. However, uptake of nitrogen by these recently transplanted plants, might have been low because of limited root systems.

The only value for phosphorus content of Carex sp. found in the literature was for beaked sedge (Carex rostrata) and was 0.078 percent P before fertilization and 0.055 percent P after fertilization (Caines 1958). These samples were collected in August only 14 days apart and no explanation is given for the drop in P concentration following fertilization with phosphorus. Concentration of P in slough sedge in this study is considerably above the data reported by Caines (1958), particularly in the August 1977 samples. These high P levels probably reflect the high soil P status at Miller Sands.

Elevation showed a significant effect on P values in September 1976 with plants from the upper elevation having significantly lower phosphorus concentrations than from the other two elevations. However, no significant difference between elevations was evident in the August 1977 samples.

Potassium concentration in slough sedge is shown in Table 53. Values averaged 0.63 percent K in September 1976 and 1.29 percent K in August 1977. No data on potassium concentration for sedge species was found in the literature.

No significant differences were observed in potassium concentration due to elevation. Fertilization also had no effect on potassium values in slough sedge for either sampling period.

The nutritional status of sedge plants appeared to be abnormally low in September following transplanting. This may indicate a poorly developed root system at this time which could limit uptake of nutrients. By August 1977 nutrient levels were almost double those in the previous sampling.

In September 1976 the levels of both nitrogen and phosphorus were significantly related to fertilizer treatment. The split fertilizer treatments, F3 and F4, were also higher in nitrogen and phosphorus in August 1977 than other treatments, but the differences were not significant. Thus for nitrogen and phosphorus at least, results from Miller Sands contradict those reported by Caines (1958), but here slough sedge was fertilized with N, P, and K compared with phosphorus alone, which also was applied to the waters in his study, not to the substrate as in our marsh experiment.

Table 51 summarizes the uptake of nitrogen by slough sedge plants in September 1976 and August 1977. The amount of N absorbed by the shoots in 1976 averaged 34 mg per plant. No significant differences of N uptake were observed between the three elevation tiers or between fertilizer treatments in the lower and middle tiers in September 1976. Findings in the upper tier showed significantly more uptake of nitrogen in shoot parts of the F3 plants than in the FO and F4 plants. These results were reflected in the size and nutrient concentration differences of the plants with F3 plants averaging the largest shoot weights (Table 45), FO plants averaging the smallest percentage values (Table 51), and F4 plants averaging the smallest shoot weights (Table 45). The overall effect of fertilizer on nitrogen uptake showed F2 plants with significantly more nitrogen in the shoot parts than F0 and F4 plants. These findings largely reflect percentage differences of nitrogen in the shoot parts, which show F0 plants with the smallest values (0.75 percent) and F2 plants with the largest values (0.01 percent) (Table 51). However, the low value of N uptake recorded for the F4 plants reflects the significantly smaller size of these plants (Table 45).

The values recorded in August 1977 showed an overall increase of N uptake of 74 percent over the September 1976 values. The greater amount of uptake in 1977 reflected increased weights of plants over the previous year and the development of larger root systems (Tables 45 and 47). The August 1977 results showed an average N uptake of 154 mg per plant in the middle tier and 111 mg in the upper tier (Table 51), but these differences were not significant at the 0.05 level. No differences of N uptake between fertilizer treatments were evident in August 1977, but unfertilized plants averaged substantially less N uptake than fertilized plants.

Uptake values of phosphorus in shoot parts of slough sedge in September 1976 and August 1977 are shown in Table 52. Uptake of P in 1976 averaged 4 mg/plant with significantly more P uptake in the middle tier than in the lower and upper tiers. The values recorded for P uptake were apparently influenced by both shoot weight and phosphorus concentration (percent) in the shoots. No difference of P uptake was observed between fertilizer treatments in the lower tier in 1976 but findings in the middle and upper tiers closely reflected the patterns observed in these tiers for N uptake.

Uptake of P in August 1977 showed an overall increase of five-fold over the values recorded in Septemer 1976. Greater amounts of P were incorporated in the shoots of plants in the middle tier (23 mg/plant) as compared to the upper tier (16 mg/plant) (Table 52), but these differences were not significant at the 0.05 level. No significant differences of P uptake were observed between fertilized and unfertilized plants but the latter averaged less P uptake than fertilized plants.

The results for potassium uptake in shoot parts of slough sedge are summarized in Table 53. Uptake of K closely reflected the pattern of uptake observed with nitrogen in 1976. The overall uptake of K in September 1976 averaged 24 mg/plant with plants in the middle tier averaging the largest uptake value of 29 mg/plant. Uptake of K was the greatest in the largest fertilized plants (F2), but as found with N and P uptake, values of K uptake were less in the FO plants due to lower concentration of this nutrient in the shoot parts rather than differences of shoot weight.

Results of the August 1977 sampling show a 78 percent increase of K uptake over the values recorded in September 1976. These increases reflect the increase nutrients as plants increase in size. No significant differences of K uptake were observed between tiers or fertilizer treatments in 1977. Uptake was generally greater in the middle tier and F2 plots where the plants obtained the greatest amount of shoot biomass (Table 47).

132. Effect of fertilization and tier on seeded species. Slough sedge and tufted hairgrass seeds were planted in the marsh plots in May 1977. This planting was a follow-up on the previous summer plantings when establishment of these species by seeding proved unsuccessful. The earlier planting date of the seeds in 1977 was expected to enhance the chances of seedlings becoming established prior to the winter months.

133. Figure 24 shows the density of tufted hairgrass seedlings in each of the study plots during the summer and fall months of 1977. Emergence peaked around 9 June in the upper and middle tiers and density values decreased after that date until late July. After July density of seedlings increased through October in the upper tier and September in the middle tier. The increased number of seedlings in the fall months corresponded to the germination of seeds from adjacent tufted hairgrass plants.

134. Statistical treatment of the data collected in October 1977 (Table 54) showed a significant elevation response with no seedlings in the lower tier and the greatest number of seedlings in the upper tier. Plant numbers were highly variable between plots and no significant differences were observed between fertilizer treatments. Establishment of seedlings was largely influenced by tidal current and wave action which prevented rooting of the young plants in areas of high turbulence. Large numbers of seedlings were observed in areas of algae concentration which provided favorable substrate conditions and a possible

nitrogen source (Figure 25) and in areas around transplant plots where a seed source existed and where the taller plants offered protection from turbulent conditions.

135. The average heights of tufted hairgrass seedlings in October 1977 were 2.24 cm in the middle tier and 5.16 cm in the upper tier (Table 55), but this difference was not significant at the 0.05 level. No significant differences of height were observed between the plants growing in the different treatment plots.

Intertidal Mixture Plantings

136. Characteristics of plants. Performance of species planted along the east and west boundaries of the monotypic plot area are shown in Table 56. Summer growth patterns (stem numbers, height) of these species are shown in Figures A4 and A5. Only those plants located in caged and adjacent uncaged areas were monitored for growth and survival characteristics during the course of the study. Because caged areas did not encompass the entire width of the intertidal mixture plantings, not all species were represented at each of the three elevations. This condition prevented comparisons of water plantain, yellow flag, and tule performances between elevation gradients within the marsh.

137. Plant survival and growth were dependent on a number of variables including sand buildup, wildlife damage, elevation above mllw, and turbulence from waves and tides or a combination of these factors. Caged areas provided protection of soft rush, water plantain, and yellow flag from nutria damage which generally involved uprooting of these plants while feeding on the roots. Roots of tule were also eaten by nutria but a greater percentage of these plants were lost by wave and tidal movements than by animal damage. Grazing of soft rush by waterfowl was evident during the summer months (Figure A4). Both sedges and tufted hairgrass were adversely affected by sand deposition, which occurred during the winter months in both the caged and uncaged areas.

138. Vigor of those plants observed at all three elevation ranges generally decreased as elevation above mllw decreased. This was evident with decreased production of stems, abbreviated seed head development, and reduced dry weight values. No plants survived in the

vicinity of Cage 6 which was 45.7 cm above mllw.

139. Shoot nutrient information. Concentrations of N, P, and K in intertidal plants are shown in Table 57. Differences between species are relatively minor with the average N concentration, for example, varying between about 1.5 and 2.0 percent. Greater variation is shown within species as a result of elevation differences. For instance, Lyngby's sedge had 1.90 percent in the lower elevation and 1.12 percent N in the upper elevation. Lyngby's sedge and slough sedge have about the same nitrogen contents and these values compare with those reported by Gorham (1953). Soft rush was reported by Gorham (1953) to contain 1.05 percent N. Plants of this species from the intertidal area were considerably above that level.

140. Average concentration of phosphorus in the intertidal plants varied between 0.14 for Lyngby's sedge and 0.32 for tule. A decrease in phosphorus with increase in elevation was exhibited by all species but only with Lyngby's sedge was the effect of elevation statistically significant. Plants from the upper elevations contained 0.07 percent phosphorus compared to 0.29 percent in lower elevations (Table 57). Phosphorus levels for soft rush were similar to those reported by Boyd (1970) for that species.

141. Despite the fact that the intertidal mixed plantings area was not fertilized, the area appeared to contain relatively high levels of N, P, and K. (A small amount of slow-release fertilizer was applied to some small plots in the western border of the intertidal mixture in July 1976. However, the fertilizer floated out of the planted areas during the following high tide and therefore, did not influence subsequent N, P, K levels detected.) All plants appeared to contain adequate nitrogen with the possible exception of Lyngby's sedge from the upper elevation. Phosphorus levels appeared high, again with the exception of Lyngby's sedge plants from the upper elevation. Potassium levels also appeared to be adequate in all species.

142. The significant relationship of nutrient levels in Lyngby's sedge to elevation may reflect a sensitivity of this species to nutrient levels in the marsh substrate. These results suggest that Lyngby's

sedge may be more responsive to fertilizer than slough sedge, which showed no growth response to fertilizer in the marsh monotypic experiment.

Marsh biomass production

143. Monotypic plots. Tables 58 and 59 depict average biomass values (kg of dry matter per hectare) of tufted hairgrass and slough sedge, respectively, in August 1977. Values for both the aerial and underground portions of the plants are provided.

144. Biomass production in tufted hairgrass was influenced by fertilizer and elevation. Dry weight values were nearly 1.75 times greater in the upper tier as compared with the middle tier. Production of plant material was negligible in the lower tier. Plots fertilized in the summer of 1976 and spring of 1977 (F3, F4) produced greater amounts of plant material than plots receiving only one fertilizer application (F1, F2) or no fertilizer (FO). Significantly more biomass was produced in the F3 plots than the FO plots.

145. Biomass production of tufted hairgrass represented greater than a four-fold increase over that produced by slough sedge. Response to fertilizer was not apparent with slough sedge and differences of biomass production were minimal between the middle and upper tiers but, as with the tufted hairgrass plots, no plants survived in the lower tier.

146. Marsh reference area. Caged and uncaged quadrats in the marsh reference area were placed within the same elevational boundaries as those areas designated as upper, middle, and lower tiers in the monotypic plot study site. Tables 60 and 61 show the weight of aerial plant material harvested in 1976 and 1977 from the three elevations in the marsh.

147. A noticeable increase of plant material harvested in the lower elevation was apparent between the 1976 and 1977 sampling dates. This may reflect marsh expansion due to a rise in the elevation of the lower portions of the marsh (Johannessen 1964). Biomass production of the middle and upper elevations showed increases over the previous year. Tufted hairgrass and Lyngby's sedge were the dominant plants in these areas with Lyngby's sedge contributing the greatest biomass in the upper

tier (6148 kg/ha) and tufted hairgrass contributing the major portion in the middle tier (3025 kg/ha) at the end of the 1977 growing season (Table 62). Total biomass values of the middle and upper elevations were significantly larger than the biomass of plants in the lower elevation.

148. Unvegetated intertidal area. Tables 63 and 64 show the weight of clipped plants from caged and uncaged quadrat areas located at three elevation levels in the unvegetated intertidal area. Harvest of these plants occurred in August 1977, 40 months after the placement of dredged material in this area.

149. Biomass was the greatest in the upper tier where tufted hairgrass and water smartweed (*Polygonum punctatum*) contributed the major portion of the recorded biomass of 735 kg/ha. The middle elevation averaged 22 kg/ha and the lower tier averaged 11 kg/ha. Nuttall's waterweed (*Elodea nuttalli*) was the only hydrophyte encountered in the lower elevation.

Plant composition of marsh study areas

150. Marsh reference area. The vegetated zone in the marsh reference area ranged between 61 and 213.4 cm above mllw. Numerous microhabitats exist within these boundaries due to occurrence of drainage channels, depressions, and areas of sediment accretion. These topographic features, although often slight, create discontinuity in the marsh vegetative zone.

151. Vegetation of the marsh reference area was investigated by calculating importance and biomass values for individual species of plants. Tables 65 and 66 show the results of the August 1977 sampling.

152. Tufted hairgrass and Lyngby's sedge were the dominant plant species encountered throughout the marsh. These two species occurred in either monotypic stands or in mixed communities and were encountered between 91.4 and 213.4 cm above mllw. Most species of forbs were restricted to the upper reaches of the marsh and seldom were encountered below 121.9 cm above mllw. Water smartweed was especially abundant in this upper range followed in importance by Philadelphia daisy (*Erigeron philadelphicus*), yellow monkey-flower (*Mimulus guttatus*), nodding

beggar's-tick (Bidens cernua), wild carrot (Daucus carota), western dock (Rumex occidentalis), Watson's willow-weed (Epilobium watsonii), and marsh-pepper smartweed (Polygonum hydropiper). Yellow flag was found only along the upper fringes of the marsh regions (152.4-213.4 cm above mllw), but occurred occasionally at lower levels.

153. Rushes occurred in association with the sedge and tufted hairgrass communities. Slender rush (Juncus tenuis) and Baltic rush were the most common rushes in the marsh and less abundant species included tapered rush (Juncus acuminatus), soft rush and painted rush (Juncus oxymeris). Also intermixed with the two dominant species were Olney's bulrush (Scirpus olyneyi) and American bulrush (Scirpus americanus).

154. Most of the smaller hydrophytes occurred in the lower boundaries of the marsh or in isolated depressions or gulleys. These areas were generally devoid of tall vegetation. The combination of greater light availability and good substrate conditions for supporting shallow root systems provided favorable growing conditions for these small plants. Species found in these low levels included lilaeopsis (Lilaeopsis occidentalis), spike rush, water plaintain, spring water-starwort (Callitriche verna), and mudwort (Limosella aquatica) with the latter two being most abundant on silty and muddy substrates.

155. Unvegetated intertidal area. Colonization of bare sandy areas exposed to tidal waters by hydrophytes was monitored in the unvegetated intertidal area adjacent to the marsh monotypic plot study area. Sampling techniques and elevation range of plots were similar to those used in the marsh reference area. Data were collected in August 1977, 40 months following the formation of this area, and are summarized in Tables 67 and 68.

156. Several species had become established in the area but the vegetation was generally sparse. In the middle to upper range of the intertidal area (above 137 cm above mllw) plants were found in more protected areas, away from the vicinity of the cages, where current and wave action was more pronounced.

157. Plants invading the unvegetated intertidal area originated from seeds or rafted plants. Plants emerging from seeds dominated the

vegetative structure of the young marsh and included the following species: yellow monkey-flower, water smartweed, marsh-pepper smartweed, reed canarygrass (Phalaris arundinacea), and tufted hairgrass. The latter was the most abundant species and colonized by both modes of establishment.

158. Rooting of rafted plants was probably the major means of establishment for spike rush and Lyngby's sedge. The former rapidly produced a rhizomonous network of plants and constituted a major portion of the plant structure of the study site. Lyngby's sedge produced creeping rhizomes once it was firmly rooted in the substrate but spread more slowly than spike rush. Only a few plants of Lyngby's sedge were observed in the study area.

159. Most of the smaller hydrophytes were found in the lower boundaries of the plant zone. Conditions at this level provided a substrate suitable for shallow root systems, and a more stable environment without the temperature and soil moisture extremes and turbulent wave action typical of the upper areas where tidal and wave action was more pronounced. Species occupying these regions included lilaeposis, mudwort, water plantain, common American hedge-hyssop (Gratiola neglecta), and spring water starwort.

160. Biomass production of the unvegetated intertidal area averaged 542 kg/ha (Table 68) as compared to 6764 kg/ha (Table 66) in the marsh reference area.

Sandspit above tidal influence

161. Characteristics of plants. Characteristics of two adjacent plantings of European beachgrass are summarized in Table 69. The area planted in January 1977 is referred to as Area A and the area of the May 1977 planting is referred to as Area B. Refer to Figure 5 for the locations of these two plantings. Cages were placed in Area A to provide documentation of animal damage to European beachgrass plants.

162. Figure 26 shows that the variables height, stems per plant, and number of flowering heads differed little between the caged and uncaged plants in Area A. In August 1977, plants averaged 27 stems per plant and length of the shoots averaged 49 cm. (Determined by averaging

means of caged and uncaged values presented in Table 69.) Not all of the plants produced seedheads so a value of less than one seedhead per plant was obtained at the August 1977 sampling.

163. Buildup of blowing sand occurred around the bases of the plants in Area A prior to the planting of European beachgrass in Area B. As a result of this sand buildup, leaf length above ground level was reduced and average lengths of roots were decreased due to the production of small adventitious roots along the nodes of the newly covered stems. Sand buildup was negligible in the May planting and this, along with the spring fertilizer application, may be the reasons plants in this area were significantly taller and had significantly longer roots than the January plants. However, the plants in Area A had significantly more leaves per plant in August than the plants in Area B. The reduced surface area of leaves exposed to sunlight as a result of sand buildup may have been compensated by increased foliage development in plants of Area A. Shoot weight differences between the two areas was not significant at the 0.05 level.

164. Shoot nutrient information. Concentration of N, P, and K in European beachgrass from the sandspit is shown in Table 70. Significant differences were evident between Area A and B with Area B, the May planted area, showing greatest concentration of nitrogen. Significantly higher values for P were also evident in Area B as were values of K; however, the difference in K values was not significant.

165. From this data it is evident that the later planting and fertilization resulted in higher nutrient levels. Very likely leaching of fertilizer was less in the later planting because of the shorter time for leaching to occur. No data were available from the literature showing nutrient levels in European beachgrass.

Upland Studies

Soil particle-size distribution

166. Data on particle size of the upland soils are shown in Table 71. Very little difference was evident between meadows,

replications, or with soil depth. Mean values for silt varied from 0.26 to 0.53 percent. Means for clay content varied from 1.01 to 1.46 percent. No one fraction of sand predominated with coarse, medium, and fine sand fractions being about equal in all but a few of the samples. Thus, the three upland meadow areas appear comparable with respect to soil texture.

Soil chemical properties

167. Initial conditions. Data on the chemical properties of the upland soils are shown in Table 72. Moisture content appeared to be uniform in the meadow area at the time of sampling, averaging 6 to 7 percent in surface soils and slightly over 7 in the subsurface samples. In view of this uniformity, it is unlikely that differences in soil moisture will be a factor affecting the results of the study.

168. Organic carbon was very low in the soils averaging 0.2 to 0.4 percent in surface soils and 0.09 to 0.14 percent in subsurface samples. Meadow II appeared to be significantly lower in organic carbon than the other two meadows. No reason for this difference was evident.

169. Soil pH averaged about 6 in the surface soils and slightly higher in the subsurface soil. No differences between meadows or replications were apparent. Conductivity was very low averaging 0.3 to 0.4 μmhos/cm in the surface samples and about 0.2 in the subsurface samples. No significant differences between meadows or replications were evident. Cation exchange capacity was low, averaging 3.8 to 4.3 meq/100 g in the surface samples and 3.3 to 3.8 in the subsurface samples. Differences between meadows and replications were not evident.

170. Exchangeable potassium averaged between 0.16 and 0.21 meq/100 g in the surface samples, and between 0.11 and 0.17 in the subsurface samples. These values are low according to agricultural standards, but are probably not low enough to cause potassium deficiency in natural vegetation. Meadow II did appear to be slightly lower in K than the other two meadows.

171. Exchangeable calcium was fairly high in this soil in relation to the cation exchange capacity. Calcium varied from 2.2 to 2.7 meq/100 g in the surface and 2.3 to 2.6 in the subsurface samples.

172. Exchangeable magnesium was also fairly high relative to the cation exchange capacity. It averaged about 1 meq/100 g in the surface and about the same in the subsurface with slightly more variability in these samples.

173. Exchangeable sodium was also very uniform. For both depths, the values varied between 0.022 and 0.028 meq/100 g.

174. Kjeldahl nitrogen status of these soils was very low in Meadow II, which is lower than the other two meadows, and contained only 0.009 percent N in the surface soil and 0.004 percent in the subsurface soil. The other two meadows were over twice as high with about 0.021 percent N in the surface and 0.008 percent N in the subsoil samples. The lower N levels in Meadow II correspond with lower organic carbon levels found in this meadow.

175. Ammonium nitrogen was about 3 ppm in the surface soils and around 1.2 to 1.5 ppm in the subsurface samples. Meadow II was not significantly lower in ammonium N as one might expect from the Kjeldahl N values presented above.

176. Nitrate nitrogen was around 1 ppm in surface samples and up to 0.5 ppm in subsurface samples. Meadow II does not appear to be lower in nitrate nitrogen than the other two meadows.

177. Phosphorus levels appeared to be high in the meadow soils compared to expectations, averaging between 7 and 9 ppm in the surface samples and between 5.4 and 6.7 in the subsurface samples. These values are considerably higher than would be found in native unfertilized soils in the area. High levels were also found in the marsh samples and indicate that the dredged material is fairly high in available phosphorus.

178. Effects of experimental treatments. Soil pH averaged 5.85 and 6.00 in the June and August 1977 samples, respectively (Table 73). These values are slightly lower than those found in the initial samples. No significant differences between meadows and fertilizer treatments were evident in the June 1977 samples but in August 1977, significant differences were found. Meadow II was highest and Meadow III was lowest in pH. Fertilization significantly reduced soil pH as a likely result of both the influence of increased salt

levels and nitrification of ammonium nitrogen.

179. Exchangeable potassium averaged 0.175 meq/100 g in June and 0.159 meq/100 g in August (Table 74) with Meadow I significantly higher than the other two meadows at both sampling dates. Fertilization increased exchangeable potassium but the differences were significant only in the June sampling period.

180. Available phosphorus by the dilute acid fluoride method (Bray #1) averaged 6.6 ppm in June and 7.6 in August (Table 75). Thus they correspond to initial values. Meadow I was significantly higher than the other two meadows in the August sampling. Also, fertilization significantly increased phosphorus levels.

181. Ammonium N averaged 0.8 ppm in June and 1.5 ppm in August (Table 76). These values are considerably below the average of about 3 ppm found in the initial samples. The reduction may result from increased plant uptake following the seeding. Highest ammonium values occurred in Meadow III. Fertilization had a significant effect on ammonium N in the soils, with F1 and F2 treatments being significantly greater than the F0 or unfertilized plots.

182. Kjeldahl N averaged about 0.015 percent in both the June and August samplings (Table 77). Meadow II showed significantly lower values in the June samples than those from the other two meadows, a pattern that was apparent in the initial samples as well. Fertilization caused a significant increase in Kjeldahl nitrogen.

183. Nitrate N averaged 0.65 in the June samples and 0.78 in the August samples with Meadow III being higher in nitrate than the other two meadows (Table 78). These values represent slight reductions over those found in the initial samples. Lowest levels of nitrate were found on the unfertilized plots but the difference was significant only in the June samples.

184. Soil moisture averaged about 8 percent in June 1977 and over 17 percent in August 1977 (Table 79). This compares to about 7 percent in the initial soil samples collected in June 1976. Meadow II was significantly higher in moisture than the other two meadows in the August samples. No significant differences due to fertilization

treatment were evident in the June samples but in August, fertilization was significantly related to a decrease in soil moisture probably as a result of greater moisture usage by the more productive, fertilized stands. The increase in August 1977 probably is a reflection of rainfall preceding the August sample period, but may also be due to decreased transpiration of the vegetative cover, which by August was not actively growing and was largely desiccated.

185. Soil carbon was significantly different between meadows with Meadow III being lower than the other two (Table 80). Fertilization also appeared to increase soil carbon with the samples from the unfertilized plots being significantly less than the two fertilized plots. The average value in August 1977 was about 0.23 percent which appears to be somewhat lower than that found in the initial samples.

186. Cation exchange capacity in August 1977 averaged 3.95 meq/100 g (Table 81). This is comparable to the values found in the initial samples. Meadow I was highest in cation exchange capacity. Fertilizer treatment had no significant effect on cation exchange capacity.

187. Fertilizer effects on each species planted in Meadows I, II, and III are presented in Tables 82, 83, and 84, respectively. A more complete description of soil fertility values during the middle and end of the 1977 growing season in the upland monotypic plots is summarized in Appendix A', Tables A35 to A40, and Table A41 shows conditions of the upland meadows in August 1977.

Performance of planted forages in upland monotypic plots

188. Figures 27 to 52 contain the plotted data for plant density, percent cover, percent flowering plants, the plotted tagged plant data for stems per plant, and mean plant height of planted forages in the monotypic plots. Plant performance for forage species in the first year following seeding is dependent upon the degree of establishment the previous season. Because seeding of the upland monotypic plots and upland meadows was made in late September 1976, the plants did not become well established prior to winter. For this reason the data are not representative of plant performances that would be expected in the

first year following seeding from well-established plants. With well-established plants, values for cover, plant height, and stems per plant would be expected to be greater while the plant density values would be lower.

189. Plant biomass, plant cover, and the importance values of planted and invading vegetation in the upland monotypic plots were determined at the end of the 1977 growing season. These data are presented in Tables 85 to 102 and the data are discussed where these results are relevant to the discussion on performance of the seeded species.

190. White clover. Following germination, white clover seedlings develop a short primary stem with several closely spaced internodes. These internodes do not elongate and the leaves become crowded (Spedding and Diekmahns 1972). Primary stolons develop from the axis of these leaves to form a rosette. The white clover plants remained in this rosette condition from November through March and began to increase in primary stolon development in April and May (Figure 29). Primary stolon development was increased by the application of fertilizer at seeding time, but no difference in primary stolon development was observed by increasing the fertilizer level above 224 kg/ha (F1). However, the spring application of fertilizer was not applied until the week of 23 May 1977, which was six days after the period when the greatest number of primary stolons for all treatments was observed. Consequently, the 448 kg/ha (F2) fertilizer rate may have had a different effect on primary stolon numbers had it been applied in early March at the optimum time to affect initial stolon development.

191. Fertilization increased density of white clover plants during the late winter and early spring months (Figure 27). Although adequate numbers of plants necessary for a good stand remained in the unfertilized plantings, there were 25 percent fewer plants within the unfertilized plots as compared to the fertilized plots during the two-month period from December to late February. These unfertilized plants were less vigorous as indicated by smaller plants (Figure 30), and reduced ground cover (Figure 28) from April to July.

192. A significant decrease in average shoot height of white clover plants due to fertilization was observed at the end of the season. Yet the total dry weight biomass per plant was significantly increased due to fertilization with 224 kg/ha (F1) and increasing fertilization beyond 224 kg/ha (F1) did not increase total biomass of tagged plants (Table 82). Ninety-six percent of the increase in tagged plant biomass that was due to application of 224 kg/ha (F1) of fertilizer was the result of increased shoot biomass (Table 82) with only four percent attributable to increased root biomass.

193. The end-of-season total aboveground biomass of white clover and all invading species was significantly increased by fertilization with 448 kg/ha (F2), but a significant total biomass increase was not observed by increasing fertilization from 224 (F1) to 448 kg/ha (F2) (Figure 50 and Table 85). Biomass and cover of common velvetgrass and rat-tail fescue at the end of the season was greatly increased by fertilization at both levels of application (Tables 85 and 88). While little significant increase in white clover biomass due to fertilization was observed in either tagged plant measurements or botanical separations, there was always a numerical increase in biomass weight from fertilized areas compared to nonfertilized areas (Tables 85 and 88). Consequently, white clover establishment was benefited by the application of 224 kg/ha (F1) but establishment was not improved further by the application of 448 kg/ha (F2) fertilizer. Flowering was slightly improved by fertilization (Figure 33).

194. It is very likely that the survival of white clover was higher than would normally be expected because of the mild winter of 1976-77. Percent survival of young white clover plants may be reduced by temperatures below 5°C (Mence 1964) or by repeated frosts. However temperatures this low did not occur during this study.

195. White clover is the most drought susceptible legume used in these evaluations. The mature plant has two root systems, a tap root developed from the primary root, and adventitious roots formed at stolon nodes. The main root mass develops in the upper 10 cm of soil with few roots below 50 cm (Spedding and Diekmahns 1972), which makes the plant

susceptible to drought. The plant's longevity and persistence are determined by moisture stresses of the summer environment and further by competition from associated grasses and invaders. Usually no part of the established white clover plant lives for more than 12 to 24 months. To survive, white clover needs to gain a foothold among invading or competitive species at a time when there are competitive stresses for water, nutrients, and light. Grasses or invaders that are aggressive during May and June will weaken the ability of white clover to persist.

196. Importance value of seeded and invader species (Table 91) shows that the addition of fertilizer at either 224 (F1) or 448 kg/ha (F2) did not change the relative contribution of invading species compared to the contribution of white clover. The spring fertilizer application was made in mid-May, which may have improved the ability of white clover to compete during May and June with the invading grass species. Earlier application of fertilizer in March or April would have encouraged grass invader growth and decreased the competitive level of white clover.

197. Tall wheatgrass. Tall wheatgrass is a tall, coarse, late-maturing bunchgrass. This species is indigenous to the seashores and saline forage areas of southeastern Europe, and is adapted to moist, medium, or heavy soils. Seedlings grow slowly during establishment and plants have a high soil fertility and soil moisture requirement. The fall planting and establishment time greatly influenced the performance of tall wheatgrass in the 1977 observations of the monotypic plots. The grass established slowly and was not strongly winter active. Thus, all plants were small with two or fewer tillers per plant during the winter following seeding (Figure 29). This limited plant growth in the fall and winter and influenced tall wheatgrass response to fertilization treatments.

198. Fertilization at planting time increased competition from aggressive and more winter active grass invaders, such as velvetgrass (Figure 32) resulting in a lower density of tall wheatgrass plants during the winter in fertilized plots compared to nonfertilized plots (Figure 27). During spring months, fertilized tall wheatgrass plants

were more vigorous than nonfertilized plants and averaged almost one more tiller per plant (Figure 29), while in July they were twice as tall as unfertilized plants (Figure 30).

199. Seventy percent of the total density in tall wheatgrass plots (Figures 27 and 31) consisted of invading species. This resulted in tall wheatgrass representing less than 10 percent of the total plant cover at maturity in 1977 (Figures 28 and 32 and Table 88) and placed tall wheatgrass at a competitive disadvantage.

200. The total aboveground biomass in tall wheatgrass plots was significantly increased by the application of 448 kg/ha (F2) of fertilizer (Figure 50). Biomass measurements from the 224 kg/ha (F1) plots were not significantly different from the measurements in nonfertilized areas. Common velvetgrass, rat-tail fescue, stream lupine, and hairgrass (*Aira*) species accounted for 90 percent of the total biomass at the high fertilization level (Tables 85 and 91) while the percentage biomass contributed by invader species was not greatly altered by fertilization (Table 88). Although the percent cover of invading species in the tall wheatgrass plots significantly increased with fertilization, the cover attributed by tall wheatgrass was not altered by fertilization in the first season.

201. The long-term persistence of this species will likely be related to the availability of summer moisture after successful plant establishment. Tall wheatgrass is not highly drought tolerant and the late maturity characteristic of this grass requires some summer moisture to complete seed production which will aid in making it competitive with the invading species and affect its rate of spread.

202. *Tall fescue.* Tall fescue (*Festuca elatior* var. *arundinacea*) is a medium-height, coarse, early-maturing bunchgrass that has wide adaptation in the Pacific Northwest. It is tolerant to poor drainage, particularly in the cool, marine winter weather west of the Cascades. It has a deep root system on well-drained sites and grows well over a wide range of soil pH (Cowan 1966).

203. The density of tall fescue plants was improved by the fall application of 448 kg/ha (F2) of fertilizer, but no observable increase

in tall fescue density was noted at 224 kg/ha (F1) (Figure 27). While no tall fescue cover differences between fertility treatments were noted during the winter and spring months (Figure 28), fertilization increased both density of invaders (Figure 31) and total cover (Figure 32). This increased vegetative growth and total density did not seem to reduce tall fescue density during the spring months to the same extent that vegetation competition reduced tall wheatgrass density (Figure 27).

204. Fertilized tall fescue plants were more vigorous than non-fertilized plants as indicated by 30 to 40 percent taller plants in June (Figure 30) and an average of one tiller more per plant (Figure 29).

205. Although tall fescue was slow to establish and grow, as measured by plant height (Figure 30), and was only slightly improved by fertilizer, the data seemed to indicate that tall fescue was able to compete well without fertilizer until the early summer months without the loss of plant numbers (Figure 27). However, the 448 kg/ha (F2) fertilizer rate increased both the number of established plants (Figure 27) and the average number of tillers per plant as compared to no fertilizer and 224 kg/ha (F1) of fertilizer. This would seem to indicate that fertilizer strengthens the competitive ability of tall fescue by producing larger and more healthy plants.

206. No significant difference in total aboveground biomass was observed between fertilizer treatments in the tall fescue plots although total biomass measurements were numerically higher in the control plots (Figure 50). This result was due to a high level of variability of invading species between replications in this meadow. Table 93 shows the high importance values associated with silver hairgrass (*Aira caryophyllea*), rat-tail fescue, common velvetgrass, stream lupine, black medic (*Medicago lupulina*), vetch sp. (*Vicia* sp), and mouse-ear chickweed (*Cerastium vulgatum*), which accounted for the variation.

207. Control--Meadow I monotypic plots. The percent cover of velvetgrass and rat-tail fescue was increased significantly by the application of fertilizer at 224 (F1) and 448 kg/ha (F2) (Table 88). Likewise, the total aboveground biomass was doubled by both fertilizer treatments (Figure 50). This biomass increase consisted mainly of

seven or eight species, which include silver and early hairgrass (Aira praecox), rat-tail fescue, common velvetgrass, stream lupine, black medic, and perennial mouse-ear chickweed. Of these, common velvetgrass became most aggressive with fertilization (Tables 85, 91, 92, 93, and 94) while rat-tail fescue was also more aggressive but to a lesser extent than common velvetgrass. Generally, the importance of hairgrass species neither increased nor declined due to fertilization while stream lupine, black medic, and mouse-ear chickweed became less competitive as soil fertility was improved.

208. Red clover. Red clover is an early flowering, double-cut variety. It acts mostly as a biennial with some plants persisting as weak perennials depending on the forage harvesting practices applied. The plant is sensitive to low moisture conditions and does not grow vigorously or competitively on light soils of low moisture, low fertility, and acid or poorly drained soils.

209. In this study, red clover plant density during winter was not improved by the addition of fertilizer at planting time (Figure 35). The number of developed leaves of the clover seedling rosette was increased by about one leaf per plant by either fertilization treatment, but no difference was observed between fertilization levels applied (Figure 37). The combination of improved plant density and plant rosette development resulted in a 10 percent increase in clover cover (Figure 36) during the winter and spring months.

210. Red clover growth responded strongly to fertilization during late spring and early summer (Figure 38). Since red clover is known to perform best on fertile soils, this 100 percent increase in growth response to fertilizer on sand was to be expected although a portion of this response may have been due to the timing of the spring application. Fertilizer was applied during the week of 23 May 1977, which just preceded the optimum growth period for an early flowering red clover. This date was too late for the best growth response for grassy invaders and some seeded grasses but may have favored growth of clover. Even so, invaders responded more to fertilization than did red clover.

211. The 448 kg/ha (F2) fertilizer rate had a depressing effect from October to April on the density of plant invaders as compared to the 224 kg/ha (F1) rate (Figure 39). No plant nutrient deficiencies were apparent and the effect was consistent among replications. As with other species studied, fertilization greatly increased the total plot cover (Figure 40), but did not alter the number of different invading species (Figure 42). The majority of total plot cover was attributable to the increases in cover by common velvetgrass, rat-tail fescue, and other invaders (Table 89).

212. The percent of plants flowering increased 70 percent in June due to fertilization (Figure 41). Since the density of red clover plants was not improved by fertilization as in white clover, the application of fertilizer to promote flowering could be critical to the continued persistence of the species at the site. Being a biennial or weak perennial, its continued presence will depend largely on annual seed production or at least periodic seed production. The hard seed characteristic of red clover and other legumes may allow for seed failure in some years without injuring the continuation of the species.

213. Total biomass in red clover plots was increased three-fold over nonfertilized plots by both levels of fertilization (Table 86 and Figure 51). However, biomass production of common velvetgrass, rat-tail fescue, and invader species was increased by fertilization to a greater extent than was red clover biomass (Table 86). Where red clover accounted for 44 percent of the biomass in nonfertilized conditions, it only accounted for 24 percent of the biomass in the highly fertilized plots (F2). Relative to all invading species, red clover accounted for 48 percent of the importance values under no fertilization while it accounted for only 18 percent of the importance values under high fertilization (Table 95). Clearly, the nitrogen response in red clover monotypic plots was greater than that shown by white clover in Meadow I. As measured by end-of-season biomass, grass invaders were benefited more by fertilization than red clover or broadleafed invaders (Table 86). This effect may be partly due to the lower organic carbon level and Kjeldahl nitrogen status of this meadow as compared to Meadow II.

214. Oregon bentgrass. Oregon bentgrass is well adapted to a variety of soils and climatic areas of the Pacific Northwest. It tolerates moist, acid soils and persists well on low fertility sites such as Miller Sands.

215. During the fall and winter, Oregon bentgrass seedlings were very small and could not be distinguished from other grasses except by strong hand lenses. Considerable emergence and establishment occurred in the spring months of late March and April. Oregon bentgrass plants began rapid development in May and responded strongly to fertilizer applications (Figures 36, 37, and 38). Plants fertilized with 224 (F1) and 448 kg/ha (F2) were two and three times as tall as unfertilized Oregon bentgrasses, respectively (Figure 38). Likewise, these two fertilization levels produced Oregon bentgrass plants with two to four times the tumber of tillers of unfertilized plants (Figure 37). Although only one density evaluation was conducted on Oregon bentgrass during the period of these evaluations, it appeared that fertilization at 448 kg/ha (F2) greatly improved seedling density in April (Figure 35). Oregon bentgrass cover was increased 10 percent by fertilization in July, but no significant increase in ground cover was noted before plants began significant development in early summer (Figure 36). Fertilization greatly influenced total plot cover (Figure 40) throughout the year, but did not influence the number of invading species (Figure 42). The increased vegetative cover from invaders did not seem to inhibit establishment of the bentgrass.

216. Fertilization strongly improved Oregon bentgrass cover and invader cover at the end of the season and response was most pronounced at the 448 kg/ha (F2) rate (Table 89). Oregon bentgrass biomass increased from one percent of the total biomass on nonfertilized plots to 12 percent of the total biomass on highly fertilized (F2) plots (Figure 51 and Table 86) while the importance values of Oregon bentgrass increased from 12.14 in the FO plots to 23.97 in the F2 plots (Table 96). The number of plants with flowers increased two-fold and six-fold, respectively, for the 224 (F1) and 448 kg/ha (F2) fertilizer treatments in comparison to nonfertilized Oregon bentgrass (Figure 41).

Oregon bentgrass may be fairly well adapted to this site if some limited N can be provided from a well-adapted N-fixing legume.

217. Barley. Barley (Hordeum vulgare) established well when fertilized with 224 (F1) and 448 kg/ha (F2). The numbers of tillers per plant in February through April was increased by fertilization (Figure 37), but plant height (Figure 38) was not affected by these rates. Barley requires and responds to nitrogen and, from mid-November on, the plants retained a chlorotic appearance typical of N deficiency. On a light sandy soil of this type, this was probably due to the inability of the fertilizer applied to supply sufficient N in the root zone of the small barley plants to promote continued winter development. Consequently, early spring development was minimal due to nutritional stress even in the fertilized plots. Even though there was a spring growth response to both fertilizer levels (Figures 38 and 41), the fertilizer application time was six weeks late for good barley development. As a result, culms were short and seedheads were small and poorly developed in early summer.

218. Like Oregon bentgrass, fertilization greatly improved the establishment and growth of barley. Barley cover was improved 20 percent near the end of the season by F2 fertilization (Figure 36 and Table 89). While barley biomass in the unfertilized plots was 38 percent of the quantity of invader biomass, it was 91 percent of the quantity of invader biomass in the F2 plots (Table 86). Thus, F2 fertilization was highly desirable for barley success at this site.

219. Barley is not expected to persist in this environment, but because it does compete well with invaders, it might be used to provide protection for seeded species during establishment. If used in this manner, the proper balance and timing of fertilizer applications would be needed to provide the best balance of competition for the companion seeding to become established.

220. Control--Meadow II monotypic plots. The total cover and biomass contributed by invader species at the end of the season due to fertilization was generally less in Meadow II than in Meadow I. This may have been caused by greater nutrient and environmental stresses

that were apparent over parts of Meadow II during the first six months following seeding. Generally, common velvetgrass and rat-tail fescue were of increased importance in Meadow II than in Meadow I (Tables 94 and 98).

221. Hairy vetch. Hairy vetch (*Vicia villosa*) is adapted to light sandy as well as heavier soils and has sufficient winter hardiness to withstand winter temperatures at Miller Sands. In comparison to other legumes, it grows earlier in the spring and later in the fall.

222. Hairy vetch establishment in these trials was excellent immediately following seeding and plant density continued to increase until early winter (Figure 43). As plants grew in late winter, plant density counts were discontinued as plots became very lush with hairy vetch growth. Plot cover was significantly increased during the winter by fertilization at 448 kg/ha (F2). This cover increase was primarily due to greater stem development per plant (Figures 44 and 45). Hairy vetch plant height was not greatly improved by fertilization during the winter or early spring months but spring fertilization significantly stimulated stem length of plants fertilized with 224 (F1) and 448 (F2) kg/ha over that of nonfertilized plants (Figure 46).

223. The density of all species in the plots was significantly stimulated by fertilizer throughout the winter and spring months but the final density of all plants in April was similar between treatments (Figure 47). Cover of hairy vetch and total plot cover (includes invaders) was increased by fertilization but by early summer little difference in total plot cover was observable (Figure 48) and the number of invading species was not influenced by fertilization at any time (Figure 49).

224. Hairy vetch biomass at the end of the season was very strongly increased by both fertilization treatments but no difference was observable between the 224 (F1) and the 448 kg/ha (F2) rates (Table 84 and Table 87). This effect was not discernable in hairy vetch cover at the end of the season (Table 90). The significant stimulation of hairy vetch due to fertilization served as a competitive force to limit the importance of common velvetgrass and rat-tail fescue response

to fertilization (Table 99). Total aboveground biomass of the species was significantly improved by fertilization at 448 kg/ha (F2) but not at 224 kg/ha (F1) although total biomass was numerically increased (Figure 52 and Table 87).

225. During mid-spring, spring black stem disease (Ascochyta imperfecta) caused considerable damage to the hairy vetch. This disease is common to susceptible legumes in the Northwest and only a few varities have much resistance. White clover seems to be less susceptible than red clover or vetch to this disease. The high plant density and lush growth in winter may have provided an environment favorable for disease development. Although damage was severe in 1977, only future observations will determine the extent of permanent plant damage caused by the disease.

226. Red fescue. Red fescue (Festuca rubra) did not establish in these trials which apparently was due to ten-fold error in initial seeding rate. This species normally would be expected to be rather persistent on sites with soil and climatic conditions similar to these. However, it would not be expected to be so aggressive as to cause other invaders or seeded species to lack persistence. It is the most widely used grass for conservation and stabilization of slopes and nonstable areas in the Pacific Cascade area.

227. Reed canarygrass. Reed canarygrass (Phalaris arundinaceae) is often difficult or slow to establish even when seedbed conditions or seeding methods are good. The methods used in establishment of these plots were only fair in quality and may have contributed to the failure of the species to establish. Reed canarygrass would not be strongly recommended for stabilization conditions similar to ones at this site unless subsurface moisture was available.

228. Control--Meadow III monotypic plots. Plant populations of invader species were highly variable in Meadow III. The total biomass in the control plots was not significantly increased by fertilizer treatments. However, biomass measurements were numerically higher. Since the red fescue and reed canarygrass seedlings did not become established, these plot areas were in essence controls also. On these

control areas, highly significant increases in biomass resulted from the F2 fertilizer applications (Figure 52). The majority of the biomass increase was attributable to common velvetgrass with little attributable to rat-tail fescue.

229. Summary of performance of planted forages in upland monotypic plots. Three legume species were evaluated for establishment and growth through one season without fertilizer and with 224 (F1) and 448 kg/ha (F2) of fertilizer applied both in the fall (27 September 1976) and in spring (23 May 1977). All the legume species established well with adequate numbers to develop strong stands and all benefited by fertilization at the 448 kg/ha (F2) rate. The legumes perhaps would have been favored even more in comparison to the grass competitors if a lower nitrogen content fertilizer had been used. White clover and red clover did not compete as well as hairy vetch against common velvetgrass, the major invading species, and may have been more competitive against invading grass species if the fertilizer applied had contained half as much nitrogen. Hairy vetch was the most competitive against common velvetgrass and the least competitive was white clover.

230. Of the six grasses included in these evaluations, two, red fescue and reed canarygrass, failed to establish, probably due to seeding errors (Table 4). Barley, an annual grain plant which would not be expected to persist, could be used as a companion crop to aid in establishment of other species. It effectively competed with invader species in these trials. On soils similar to those at Miller Sands, additional N fertilizer would be beneficial for barley both in the fall and in the spring and certainly earlier fertilization in the spring would be encouraged.

231. Tall wheatgrass, tall fescue, and Oregon bentgrass all established in sufficient numbers to develop into adequate cover. These grasses should persist at this site for some time if sufficient legumes are present to provide available nitrogen for grass nutrition. Otherwise, future periodic fertilization would probably be required to maintain adequate grass cover. Preliminary observations indicate that tall fescue and Oregon bentgrass would be somewhat better adapted than

tall wheatgrass. However, if subsoil moisture is adequate to permit the later maturing tall wheatgrass to mature, then it could also be quite persistent on this site. Neither of these three grasses were strongly competitive against the major invader species during the establishment phases but all appeared to benefit from the highest level of fertilization. Some stabilization materials would probably aid in establishment of some species on the upland area.

232. Summary of performance of invader species in upland monotypic plots. Common velvetgrass nearly always increased in importance in relation to other seeded or invader species as a result of fertilization. Usually rat-tail fescue increased in importance when fertilized, but hairgrass spp. were sometimes of less importance depending on the meadow and the species in association with hairgrass spp.

233. Other broadleafed invader species such as black medic, stream lupine, mouse-ear chickweed, and sheep sorrel (*Rumex acetosella* L.) were often decreased in importance when fertilized. Thus, fertilization in most instances worked in favor of the seeded species, but in instances where very heavy densities of common velvetgrass, rat-tail fescue or harigrass spp. were present, fertilization with 224 (F1) or 448 kg/ha (F2) favored the invader species.

Performance of planted forages in upland meadows

234. Individual plants of the seeded species were observed in caged and uncaged (referred to as quadrats) areas in the upland meadows through the spring and summer months of 1977. Figures and tables depicting the growth and morphological characteristics of the plants are included in Appendix A' (Figures A6 to A13 and Tables A32 to A34) and these show that differences in plant performance were minimal between caged and uncaged plants. Individual parameters will not be discussed due to the adequate discussion of these plants included in the previous section. Instead, discussion will be limited to the contribution of the planted species to the plant composition and biomass characteristics of the three meadows and this is included in following sections.

235. Plant composition of meadow areas. Seeds of two grass

species and one legume species were planted in each of the three upland meadows. However, numerous other seeds were present in the soil and these emerged in great quantity along with the planted species. This section describes the plant composition of the upland meadows and a reference, or unplowed and unfertilized area, one year following planting.

a. Reference area. The reference area was representative of the plant communities in the upland study areas prior to planting of the grass legume mixtures. Eighteen plants were identified at the end of the 1977 growing season and frequency of occurrence and importance values of each of these species in this area are shown in Table 103. Common horsetail (Equisetum arvense) and spotted cats-ear (Hypochaeris radicata) were the most abundant species in the area but stream lupine and moss showed the highest importance values due to the more extensive ground cover provided by these plants. Seven species of grass were identified but only common velvet-grass contributed a major portion of plant cover in the reference area.

b. Meadow I. Seeds of white clover, tall wheatgrass, and tall fescue were planted in this meadow. Plant species and associated importance values at the end of the 1977 growing season are shown in Table 104. Invading species dominated the vegetative structure of the meadow. Obvious changes in plant abundance and cover due to the planting and fertilizing of Meadow I included the increased importance of grass and legume species and the virtual elimination of moss. Common velvetgrass and rat-tail fescue dominated the plant structure of Meadow I. Of the three planted species only white clover provided appreciable amounts of ground cover to contribute an important part of the plant community. The low importance values of tall wheatgrass and tall fescue reflected small cover values due to the relative scarcity and compendious development of these plants.

c. Meadow II. Red clover, Oregon bentgrass, and barley were planted in Meadow II. Rat-tail fescue and common velvetgrass dominated the plant community in this meadow and stream lupine continued to be prevalent as shown in Table 105. Barley grew well despite competition from other grasses and comprised a large portion of the plant community. Healthy stands of red clover were evident throughout the meadow making this species an important component of the vegetation. Oregon bentgrass distribution was highly variable throughout the meadow and failed to reflect a high importance value.

d. Meadow III. Hairy vetch, red fescue, and reed canarygrass were planted in Meadow III. Good emergence and growth of hairy vetch made this species the most important component of the vegetation in Meadow III. The apparent suppressing effect of vetch dominance on the emergence and growth of other plant species was reflected in reduced plant variety in that meadow. Heavy growth of hairy vetch discouraged growth of invaders throughout the summer months but at the time of sampling, vetch was dying back permitting rapid growth of common velvetgrass, rat-tail fescue, and other invaders. Table 106 summarizes the importance of the plant species in Meadow III during July 1977. Red fescue failed to emerge and only a few plants of reed canarygrass were observed in the meadow. However seeding rate of these two species was only 10 percent of the rate of other seeded species (Table 4).

236. Biomass production in upland meadows. Clipped quadrat data was obtained in the upland meadows in July 1977 to evaluate herbage production. The date of harvest reflected the apparent maximum standing crop of biomass in the upland areas. The aboveground harvest of the three planted meadows in July 1977 depicts the biomass production of these areas over a period of one year. Herbage production of the reference area reflected productivity of the upland area prior to experimental manipulation.

a. Reference area. Table 107 shows the mean dry weights of plants clipped from caged and uncaged quadrats in 1976. Aerial weights of plants in this area averaged 1130 kg/ha with common horsetail comprising 52 percent of the total herbage production. Common velvetgrass comprised 15 percent of the biomass while the total percentage weight of all the grasses in the reference area averaged 22 percent. Stream lupine was an important component of the reference area with an average overall production of 258 kg of aboveground material per hectare.

Harvest of caged and uncaged quadrats in 1977 showed an increase of biomass production of 72 percent over the previous year (Table 108). Common velvetgrass production nearly doubled and the invader category reflected increased production of stream lupine and common horsetail since the 1976 harvest. Data collected from twenty random plots in addition to the caged and adjacent uncaged area harvest showed an overall biomass production of 3315 kg/ha in the reference (control) area in 1977 (Table 109).

b. Meadow I. Herbage production of plants clipped in caged and adjacent uncaged quadrats in Meadow I at the end of the 1977 growing season is shown in Table 110. Caged areas averaged 4483 kg of plant material per hectare while uncaged areas averaged 3456 kg/ha. These differences were significant at the 0.05 level. Decreased weights of rat-tail fescue in the uncaged areas of pairs two and three possibly reflect intensive grazing pressure of geese in these areas in the winter season. This species of grass comprised 53 percent of the total biomass production in the caged-quadrat areas of Meadow I.

Biomass production of Meadow I averaged 5066 kg/ha in July 1977 (Table 109). This is an increase of 35 percent over the biomass produced in the reference area. Common velvetgrass comprised 50 percent of the herbage production in Meadow I while the combined weights of the planted species only comprised four percent of the total biomass.

c. Meadow II. Table 111 summarizes the biomass production of plants growing in caged and adjacent uncaged areas in Meadow II at the end of the 1977 growing season. Biomass production in the caged areas averaged 4836 kg/ha while the uncaged areas averaged 4995 kg/ha. Canada geese (*Branta canadensis*) grazed extensively on barley and rat-tail fescue during the winter months but no differences of biomass production between the protected (caged) and unprotected areas were observed at the end of the growing season.

Twenty random plots were clipped in the meadow area to assess the overall herbage production of Meadow II and these data were shown in Table 109. The invader category, which was largely comprised of stream lupine, made up 36 percent of the herbage produced in the meadow. Rat-tail fescue was the major grass in the meadow with 1930 kg/ha and barley production averaged 1000 kg/ha. The total amount of biomass production in Meadow II averaged 6163 kg/ha, which was an overall increase of 46 percent of biomass produced in the reference area.

d. Meadow III. Aerial weights of plants in Meadow III were similar between caged and uncaged areas (Table 112). The overall production of biomass in Meadow III averaged 3512 kg/ha with 70 percent comprised of hairy vetch (Table 109). Common velvetgrass and rat-tail fescue averaged 20 percent of the biomass in Meadow III and this is significantly less than in Meadows I and II.

The total amount of biomass produced in this meadow was less than the other two planted meadows but the differences were not significant (Table 109). Meadow II produced the greatest amount of biomass and only this meadow had significantly greater biomass production than the reference area.

237. Uptake and concentration of nutrients in upland monotypic forages. Generally the tissue nutrient concentration values tend to be low for forage tissue (Tables 113, 114, and 115). Also, nutrient concentration of N, P, and K in the aboveground parts did not differ significantly with fertilization treatment. However, species did differ widely in N and P concentration.

238. Tall wheatgrass, Oregon bentgrass, and barley were much lower than other species in percent nitrogen and potassium, while white clover was higher than all other species. Phosphorus tissue concentration did not differ greatly between species but was somewhat lower in barley than in the other species.

239. Generally, for grasses, uptake of nitrogen, phosphorus, and potassium was not significantly different with fertilization treatments but for Oregon bentgrass, nitrogen uptake was significantly increased by fertilization (Tables 116, 117, and 118). For the legumes, uptake of nitrogen, phosphorus, and potassium was increased by fertilizer treatment, but the increases by red clover were not significant.

240. These data indicate that nutritional value of grasses and legumes was not significantly altered by fertilizer treatments and except for the legumes, nutrient uptake was not changed much by fertilization. Both white clover and vetch showed significant increases in nutrient uptake. Competition for nutrients by invading species probably limited nutrient uptake by the planted forages.

241. Information collected on the concentration and uptake of N, P, and K in plants growing in the upland meadow areas is presented in Appendix A' (Tables A42 to A47).

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

242. Results of the study were significant in relationship to establishment and maintenance of vegetation on dredged material from the Lower Columbia River. Successful establishment of marsh vegetation was accomplished through use of transplants with direct seeding being largely unsatisfactory. Tufted hairgrass appears to be well suited for this purpose with excellent survival of transplants obtained when planted at elevations greater than 67 cm above mllw. Furthermore, abundant seed was produced by this species in the second season after establishment resulting in good stands of seedlings on unvegetated areas adjacent to the plots where the surface had been stabilized by algae.

243. Good results were also obtained with the slough sedge transplants. Both species appeared to have similar tolerances to inundation with the same elevation limits for both. No seed was produced by slough sedge although this species has abundant underground stems and appears to develop fairly rapidly by this means.

244. The presence of the transplanted plants provided protection and surface stabilization of the dredged material. With this protection, many other species became established. The algae layer which developed in many places between the transplant plots, also aided in establishing plant seedlings. As a result, rapid development of a complete cover including several species is expected in the future, at least in the area 67 cm above mllw. Species with greater tolerance for inundation such as common spike-rush, lilaeopsis, mudwort, and spring water-starwort are slowly becoming established at elevations below 67 cm above mllw.

245. Fertilization appeared to improve growth and development of tufted hairgrass but was not essential for survival of this species. No fertilizer response was detected with slough sedge. Thus, establishment of these species does not appear to require fertilization. However, at upper elevations, the transplants have significantly depleted

available nutrient levels in the substrate. Consequently, vigor of transplants particularly of tufted hairgrass is likely to be affected. Continued monitoring will be required to determine the effect of depleted nutrient levels at the upper elevations.

246. Satisfactory European beachgrass establishment was obtained in both plantings. The January planting was advantageous since surface stabilization was obtained on the sandspit for a longer period in the winter. However, good growth and better retention of fertilizer was evident for the May planting.

247. The cages showed that there was relatively little damage to the plantings by animal browsing under the conditions and populations that were present during this experiment. Except for loss of certain plant species in the intertidal area, nutria were not a serious problem. Very likely the reduction in nutria populations from the trapping program was responsible for minimizing damage by these animals.

248. Productivity of tufted hairgrass in the monotypic plots greatly exceeded that of slough sedge. Aerial biomass of tufted hairgrass in the marsh reference area (established marsh) at similar elevations exceeded production of tufted hairgrass in the monotypic plots by 29 percent whereas production of Lyngby's sedge in the marsh reference area exceeded aerial biomass of slough sedge by 92 percent. A comparison of the aboveground biomass produced in the monotypic transplant plots with the biomass produced in an unvegetated intertidal area at similar elevations showed biomass productivity can be increased by as much as 72 percent with artificial propagation.

249. Good legume establishment was obtained initially with red clover, white clover, and hairy vetch in the upland plots. Hairy vetch development was most rapid and most winter active of the legumes, but hairy vetch seedlings were severely damaged by spring black stem disease which resulted in a drastic decline in live plants by the end of one year. Future monitoring will be required to determine the extent of damage and evaluate the reoccurrence of disease. White clover and red clover plants were unaffected.

250. Fertilization at the 448 kg/ha rate greatly benefited the

establishment of all species. Generally, the 448 kg/ha rate produced more vigorous and competitive legumes than the 224 kg/ha rate, but all fertilization generated considerable competition from grass invaders.

251. In most instances, common velvetgrass and rat-tail fescue became more important competitors to the seeded species when fertilized but the seeded species did not establish well without fertilization. The competition from invader grasses likely would be much less on recent dredged material which would result in less invader competition at these fertilization levels. Lower nitrogen rates likely would have been more desirable for development of the legume over the invading grasses.

252. Plant flowering and seed production was only slightly influenced by fertilization in the first year due to the small size of the plants. However, few insects necessary for the pollination of legumes and subsequent seed development were noticed on the island. Grass seed production may be improved in subsequent seasons.

253. Tall fescue, Oregon bentgrass and tall wheatgrass were established best in the first year, but success of these plantings in subsequent seasons cannot be assessed without further studies. Red fescue, a species that did not establish strongly in these studies, should receive further consideration.

254. By fall 1977, reinvasion of the meadows by common horsetail was evident, particularly in the areas of the meadow where plant density was lowest. Dense stands of grasses and legumes caused reduction in reinvasion and growth of common horsetail. However, without repeated fertilization, it is unlikely that the density of the grass-legume mixture will be maintained and thus reestablishment of common horsetail can be expected.

255. Benefits to wildlife from the planting in the upland vary with plant species. Hairy vetch benefited the avifauna and small mammals by providing the greatest amount of nesting and escape cover. Little ground cover was provided by the other seeded species, but during the winter of 1977, Canada geese grazed extensively in the upland meadows and food items included tall wheatgrass, tall fescue and barley,

but preferred plants were nonseeded species such as rat-tail fescue. Barley seeds were favorite food items of crows during the summer and fall of 1976.

256. Except for the unfertilized plots, biomass production on the plantings greatly exceeded that in the reference meadow. The greatest aerial biomass production occurred on Meadow II with 6613 kg/ha. Introduction of the legumes will improve the forage quality and quantity of biomass produced on the dredged material. At this time it is not known how well productivity in the meadow area will be maintained, but nutrient levels in this infertile, sandy material obviously limit biomass production.

Recommendations

257. The monotypic plot study in the marsh showed that tufted hairgrass is a desirable species for establishing marsh habitat in an intertidal situation such as that at Miller Sands. Transplanting is a successful method for stand establishment and is recommended but seeding was not successful. Plantings of tufted hairgrass should not be made below 67 cm above mllw. Fertilization is not essential for marsh establishment under these conditions except for upper elevations where it may be required as a postpropagation treatment. Planting of slough sedge is not recommended. A potentially attractive species, which showed promise in the intertidal planting, is soft rush, which survived well when transplanted and has good potential for wildlife usage.

258. Propagation by transplanting appears to be the only feasible method of establishing vegetation in a situation such as at the monotypic plot site. While surrounding marshes can be the source of planting material, consideration should be given to use of nursery-grown transplants where large plantings are proposed.

259. Legumes, with their capability for fixing atmospheric nitrogen, are better suited to infertile soil conditions such as found in the upland. Thus, legumes should be included in any plantings on areas of this type. The duration of this experiment was too short to determine

longevity of legume plantings that were made.

260. Grasses for these conditions should be adapted to low fertility conditions and should not compete too strongly with legumes. Species suitability for forage and cover for wildlife should be considered if this is a goal of the planting.

261. Ratio of nitrogen to phosphorus and potassium in the fertilizer should be reduced to favor clover over grasses to help assure that the legume component can be maintained in the stand.

262. Additional research is needed in the area with a particular need at this time for additional monitoring of the plots and plantings. Without further information regarding the longevity and performance of these species, recommendations made at this time can only be tentative. While the study has shown certain species to be promising and eliminated others from consideration, it has also revealed need for study of still other species, both in the upland and in the marsh.

263. The need for reducing cost of planting in a marsh situation is evident. Propagation with nursery-grown transplant material may be more economical than use of naturally established plants from transplants. Experimental work is needed to determine feasibility of this approach.

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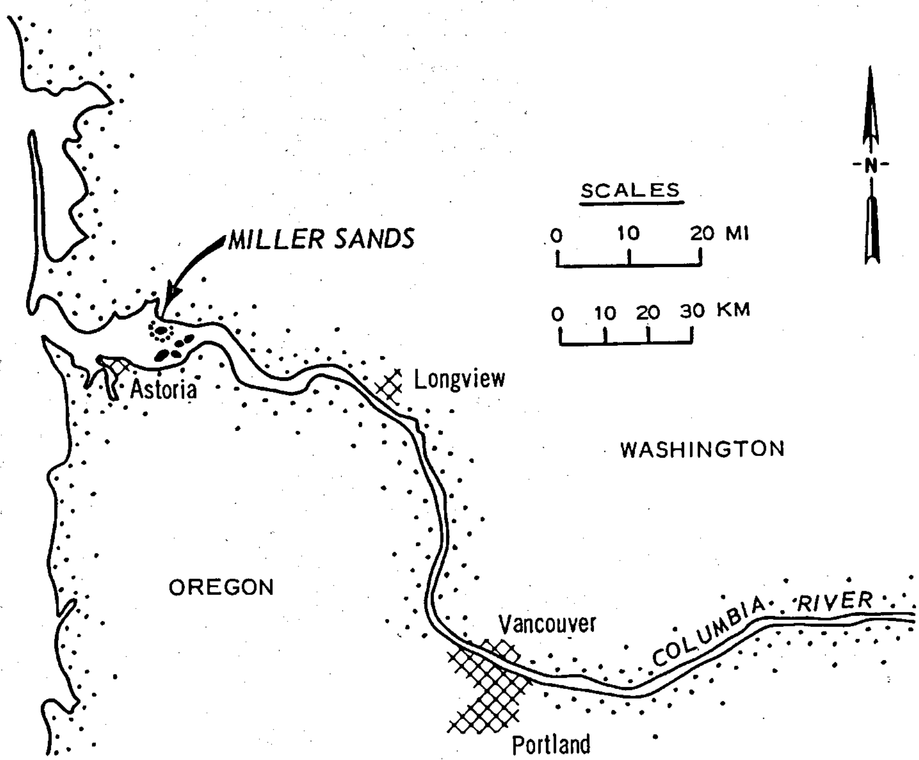


Figure 1. Lower Columbia River area showing location of Miller Sands

Figure 2. Aerial photograph of Miller Sands looking southwest with downstream being to the right. The marsh study plots are on the gray area just to the left of center in the foreground. Newly placed sand on the spit is clearly seen as the white areas. The lagoon and the older main island are also clearly evident

Figure 3. View of the spit looking west from the beachgrass area. Note the cutting due to wave and current actions

Figure 4. Sedge peat exposed at low tide. The material is from an old marsh now covered by dredged material placed on the spit. The picture is taken from the outside of the spit looking west near the European beachgrass area

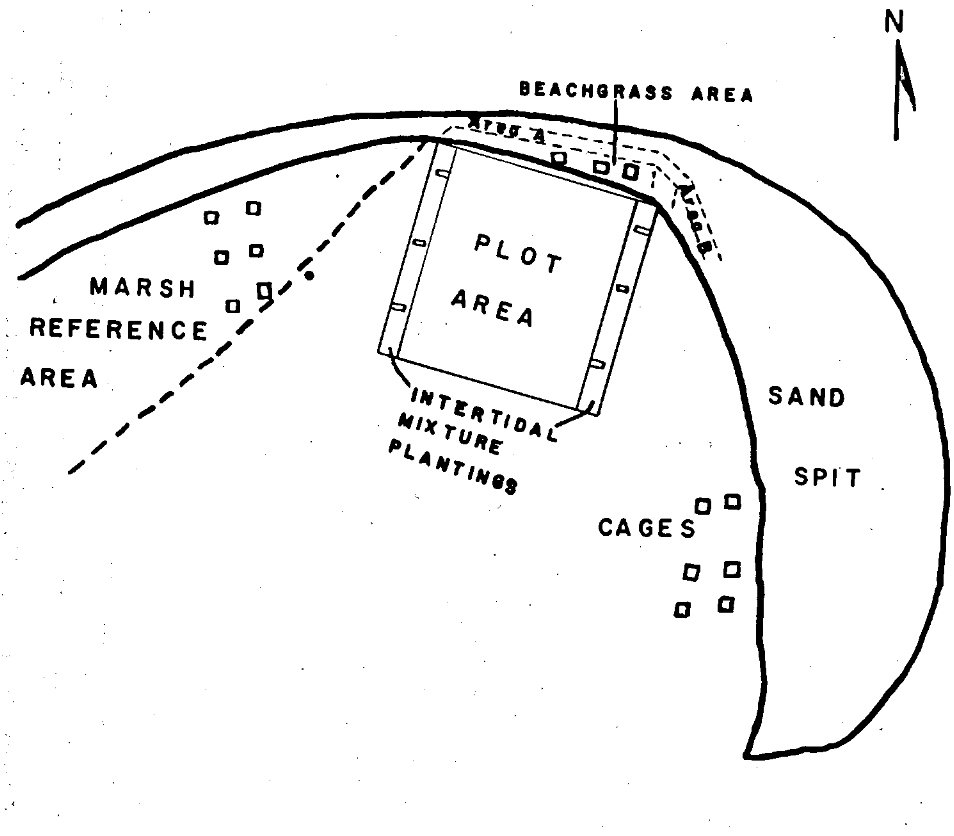


Figure 5. Map of the marsh study area showing the locations of the various experiments and cages

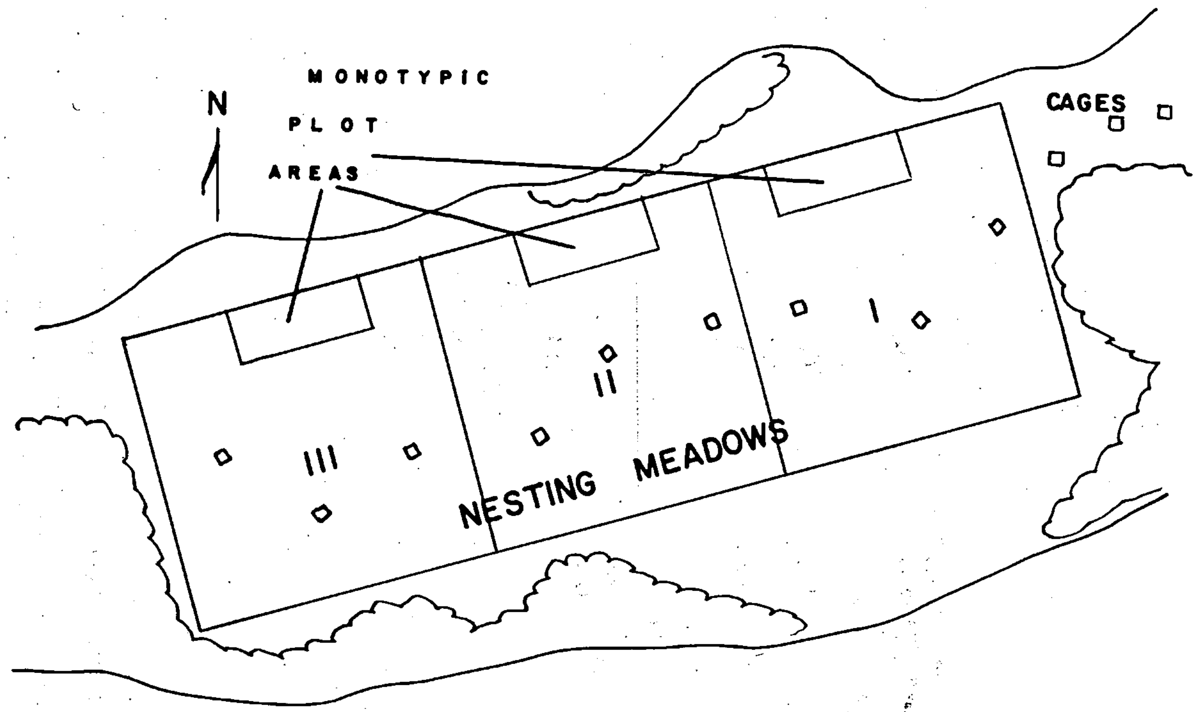


Figure 6. Map of the upland study area showing the three nesting meadows and the three corresponding monotypic plot experiments. Location of cages are also indicated with the reference meadow area to the upper right

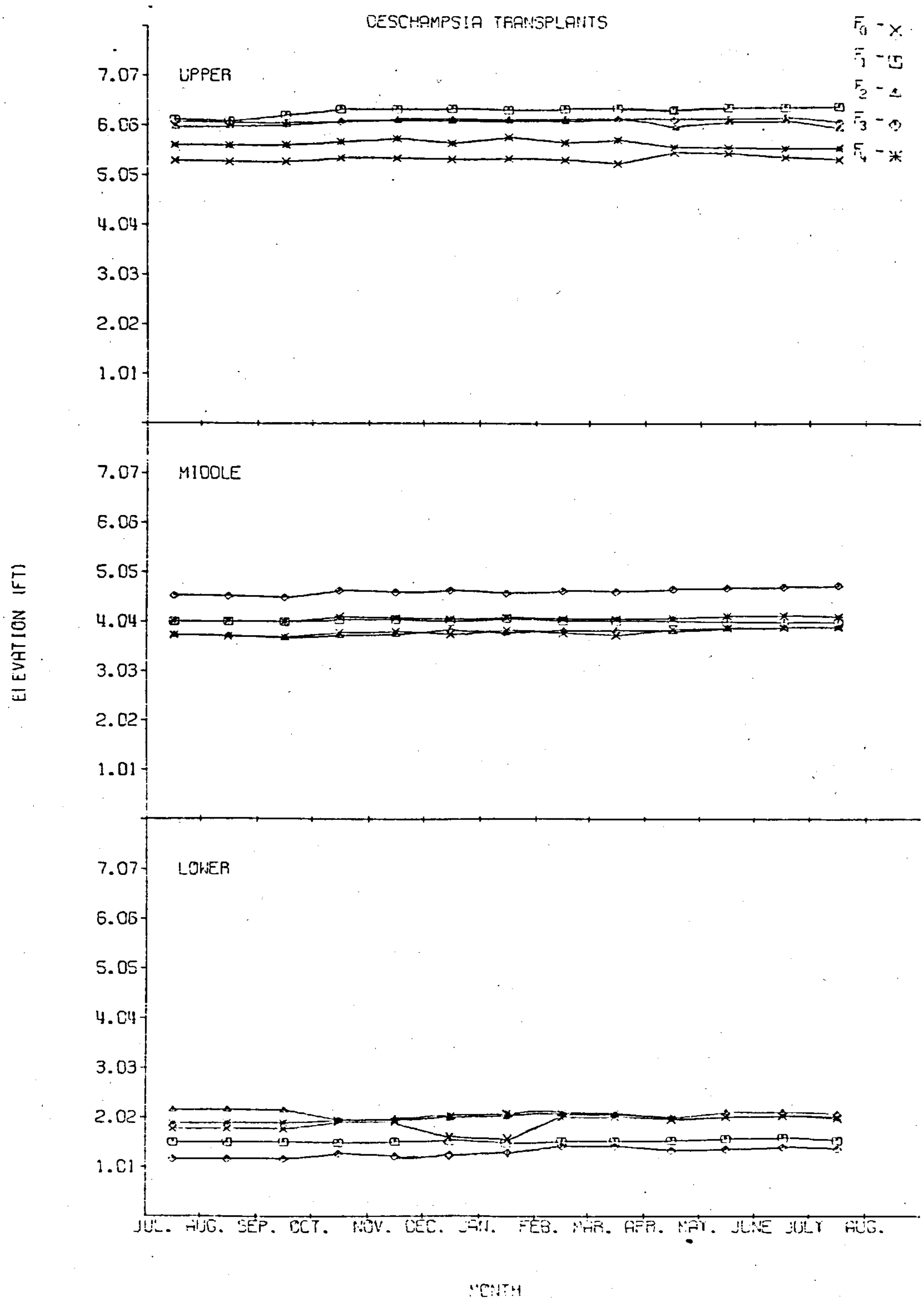


Figure 7. Average elevations of marsh plots above MLLW by treatment between July 1976 and August 1977 (Sheet 1 of 5)

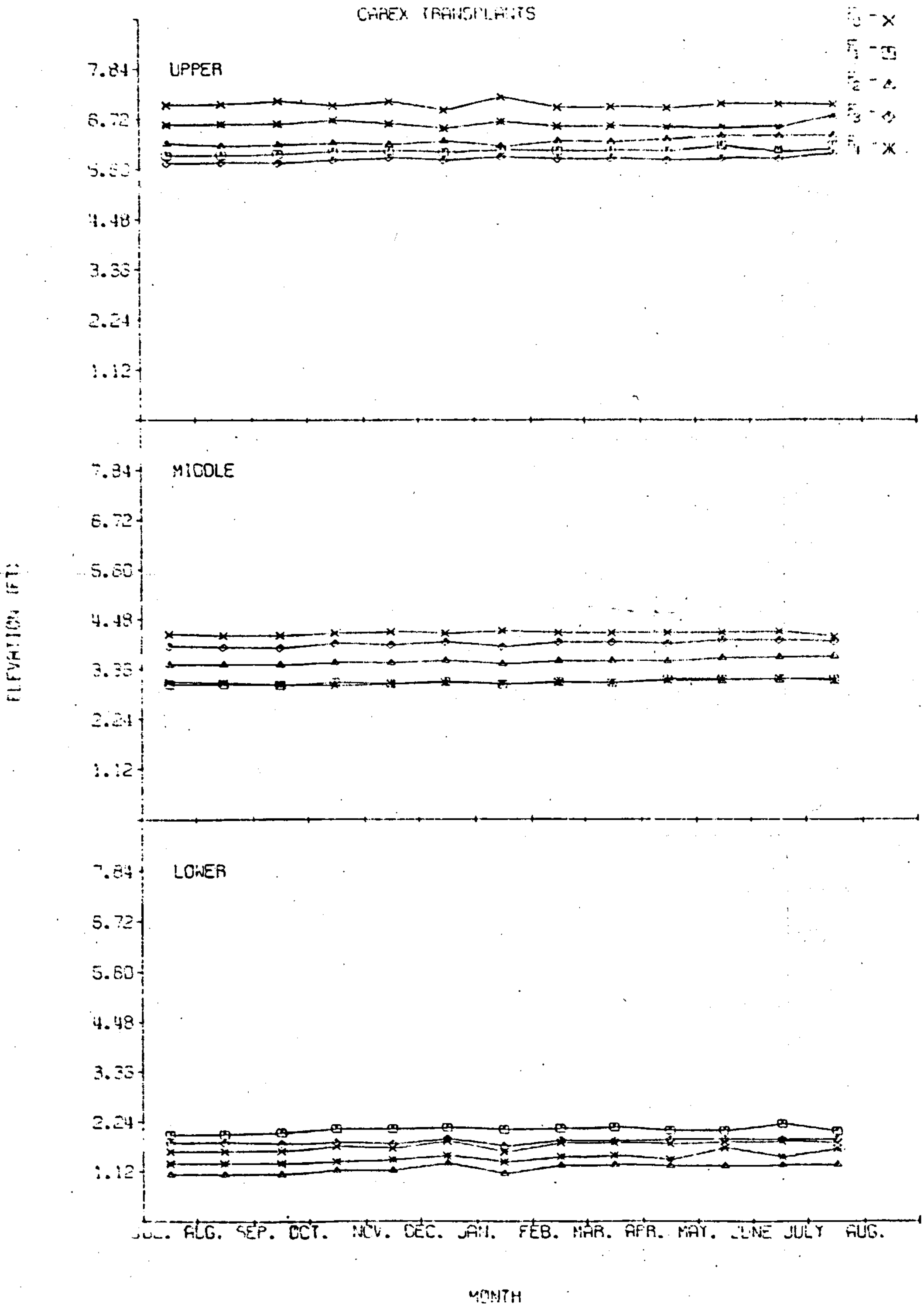
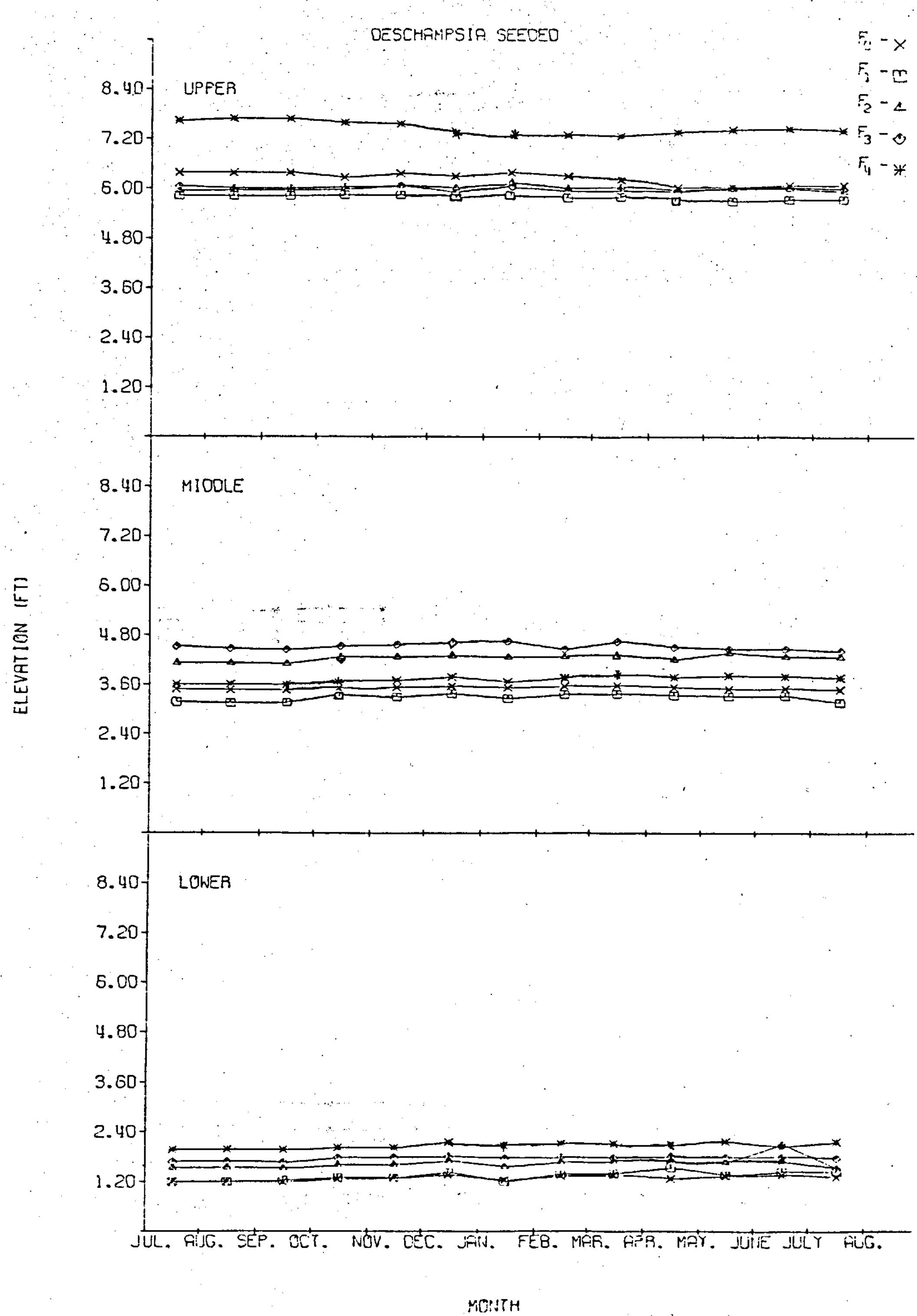


Figure 7. (Sheet 2 of 5)



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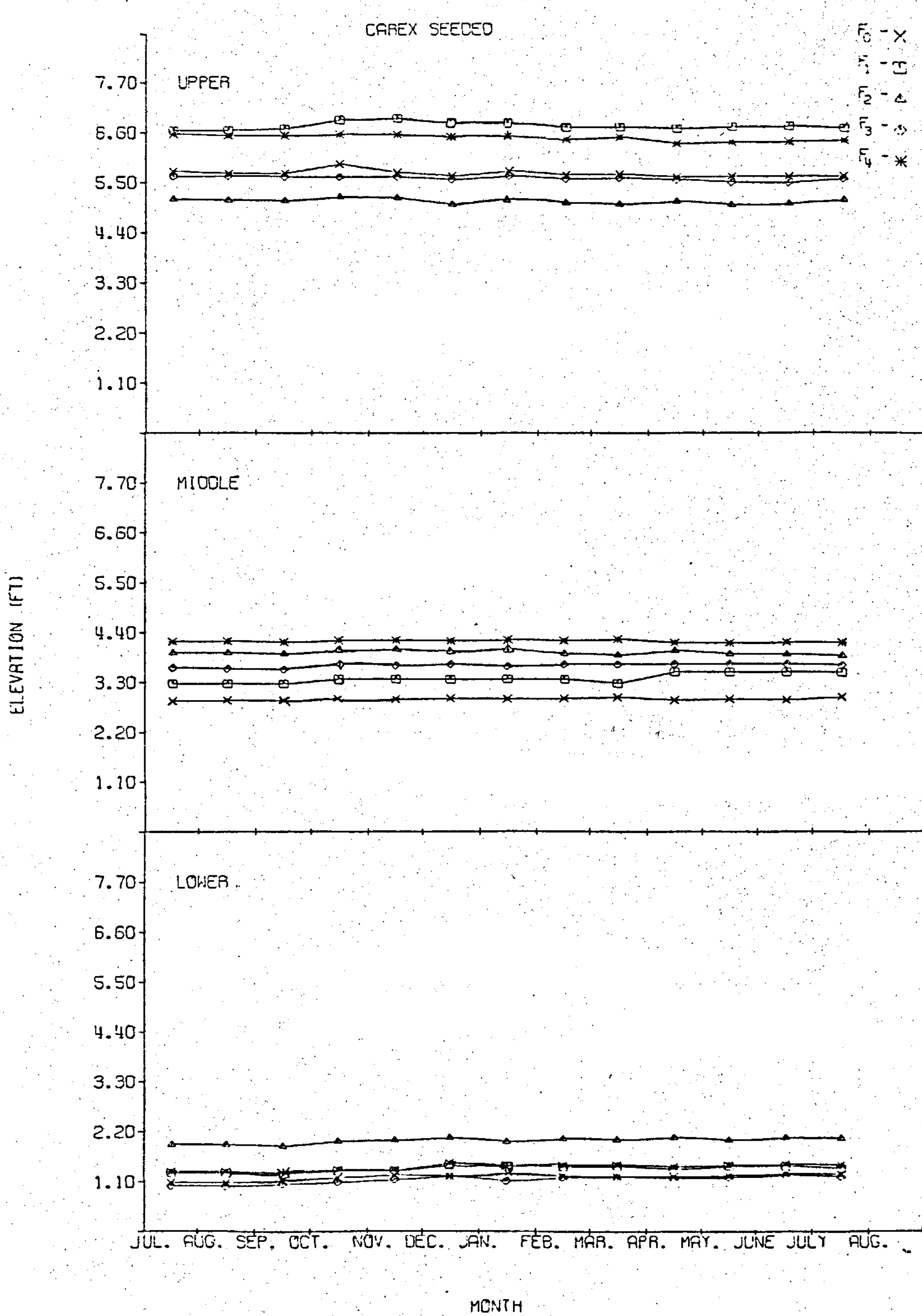

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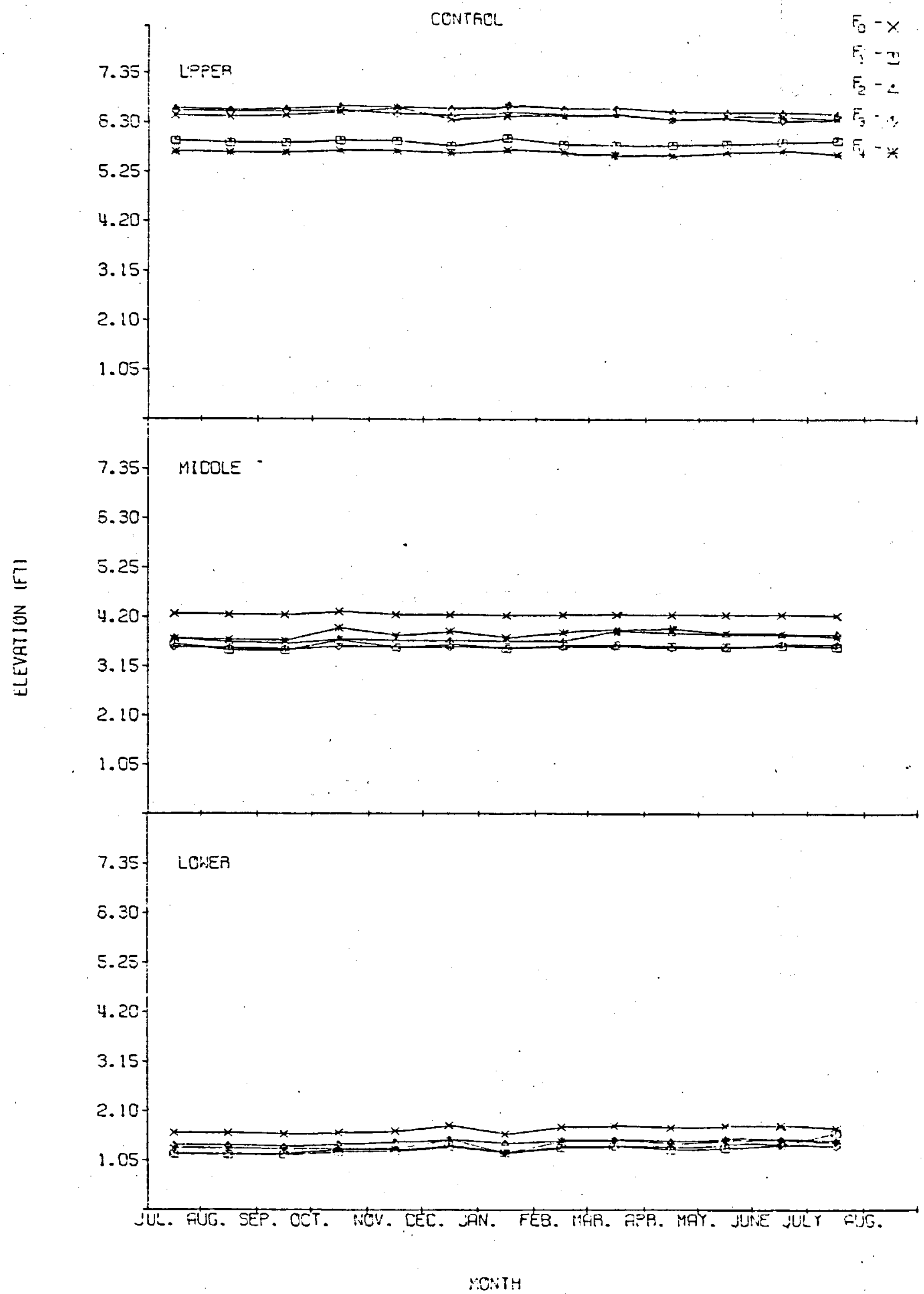


Figure 7. (Sheet 5 of 5)

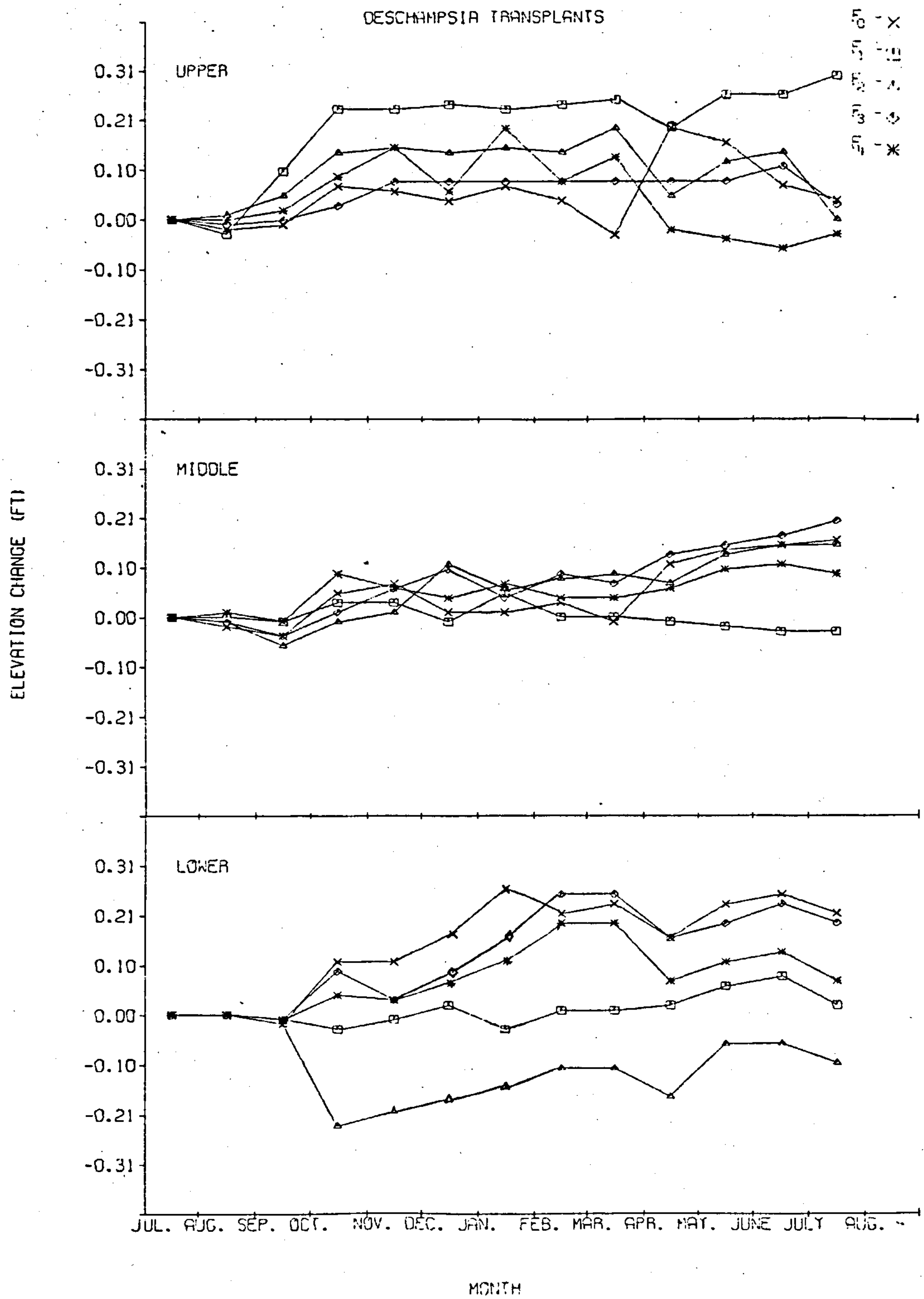
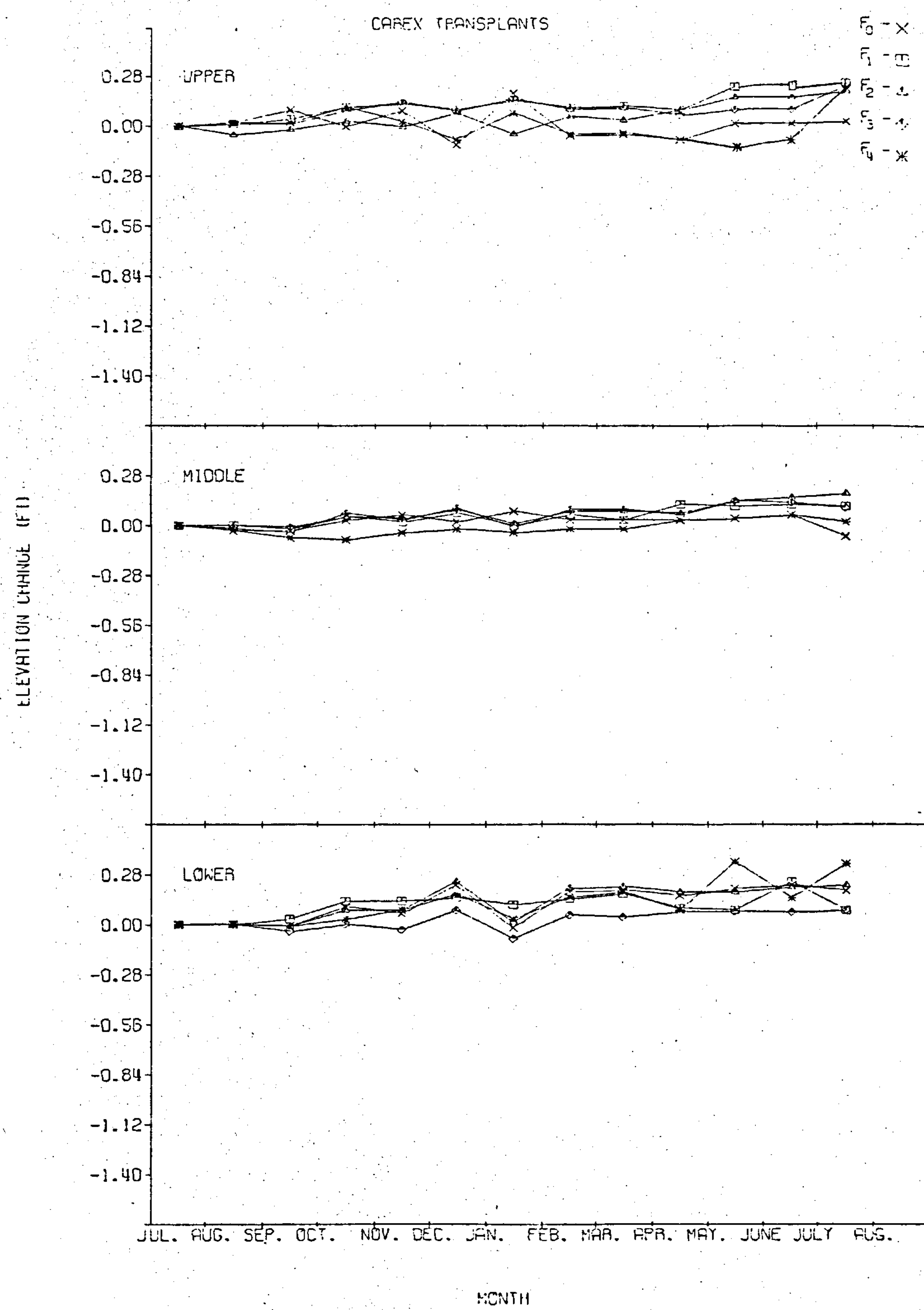


Figure 8. Changes in elevation on marsh plots between July 1976 and August 1977 (Sheet 1 of 5)



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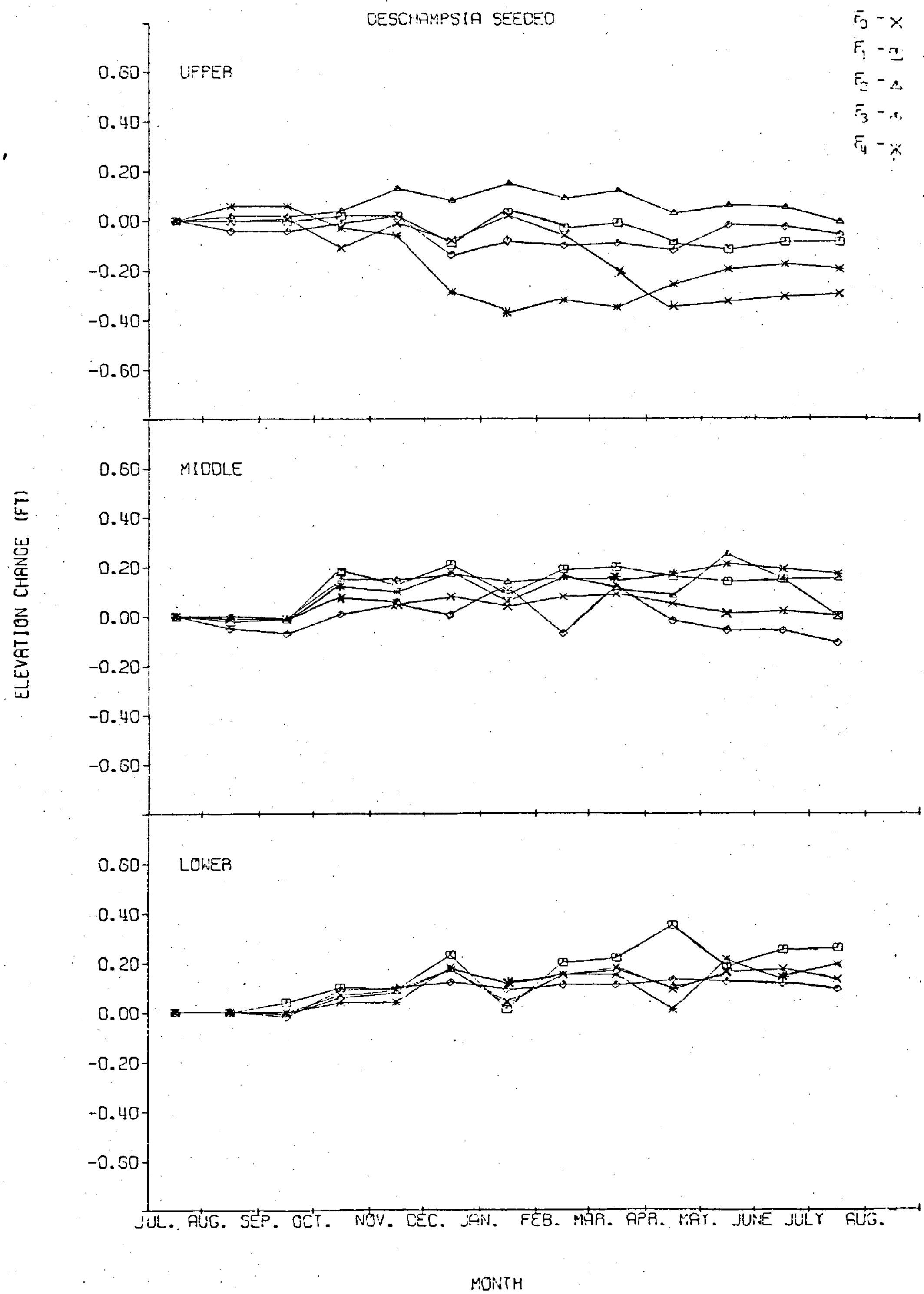

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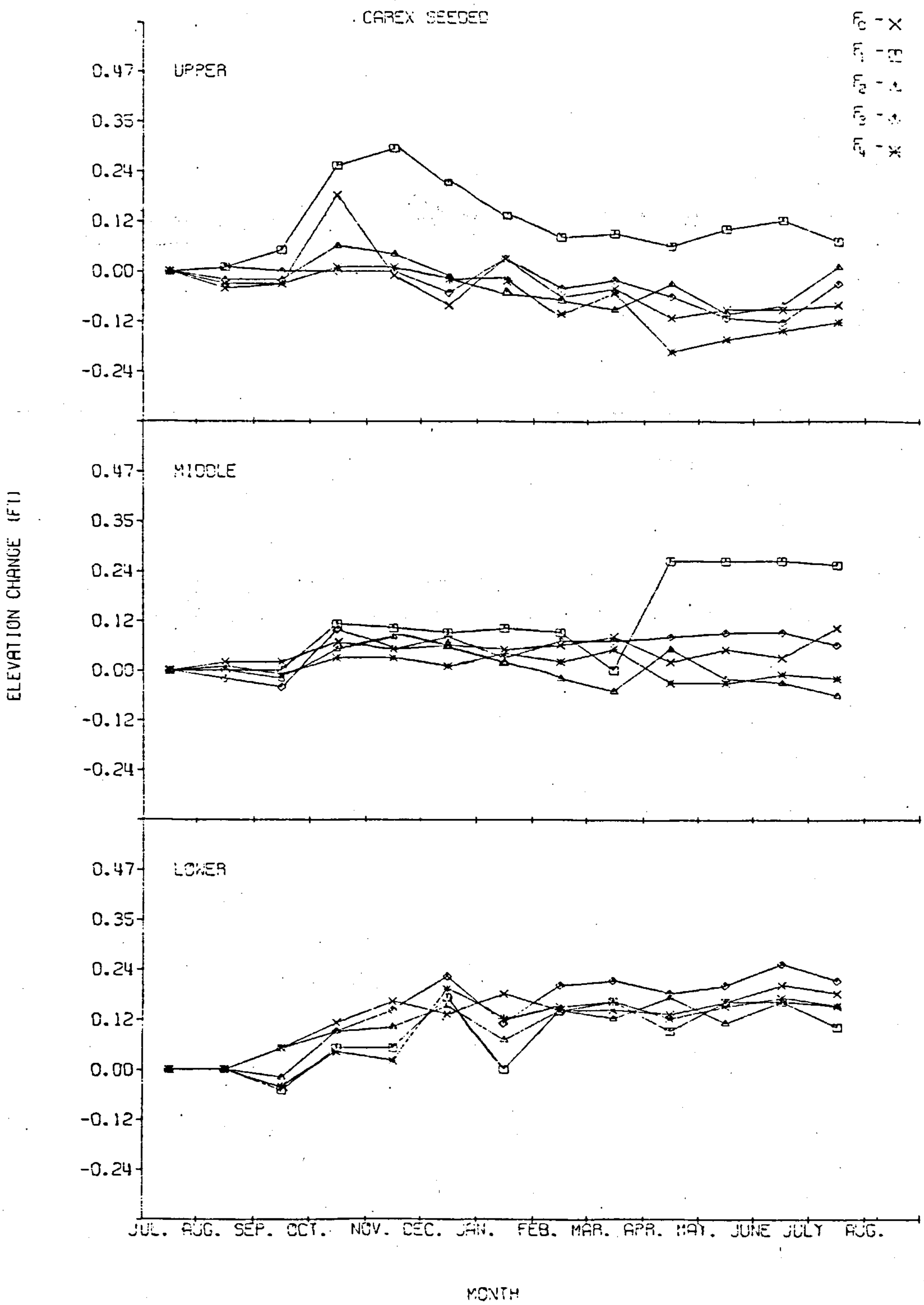

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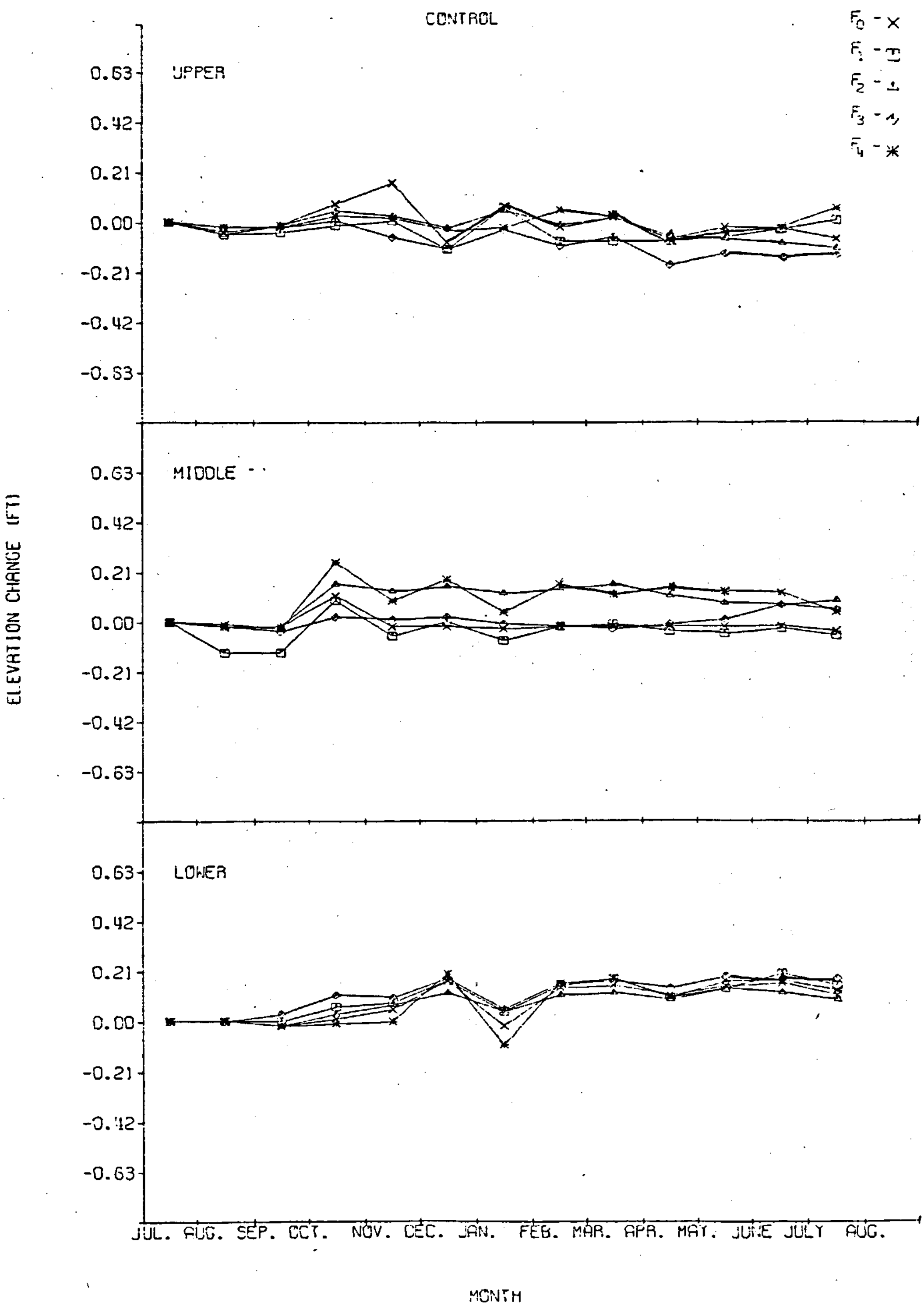

Figure 8. (Sheet 5 of 5)

Figure 9. Sand accumulation on a D. cespitosa transplant plot in the background compared with unplanted plots in the foreground, October 1977. The unvegetated sandspit area is in the background. Plants in the foreground are mainly D. cespitosa invaders

Figure 10. Ponding and the beginning of channeling in middle elevation plots, October 1977

Figure 11. Bulldozer tracks made during construction of the marsh area in 1975 still evident at low elevation in October 1977

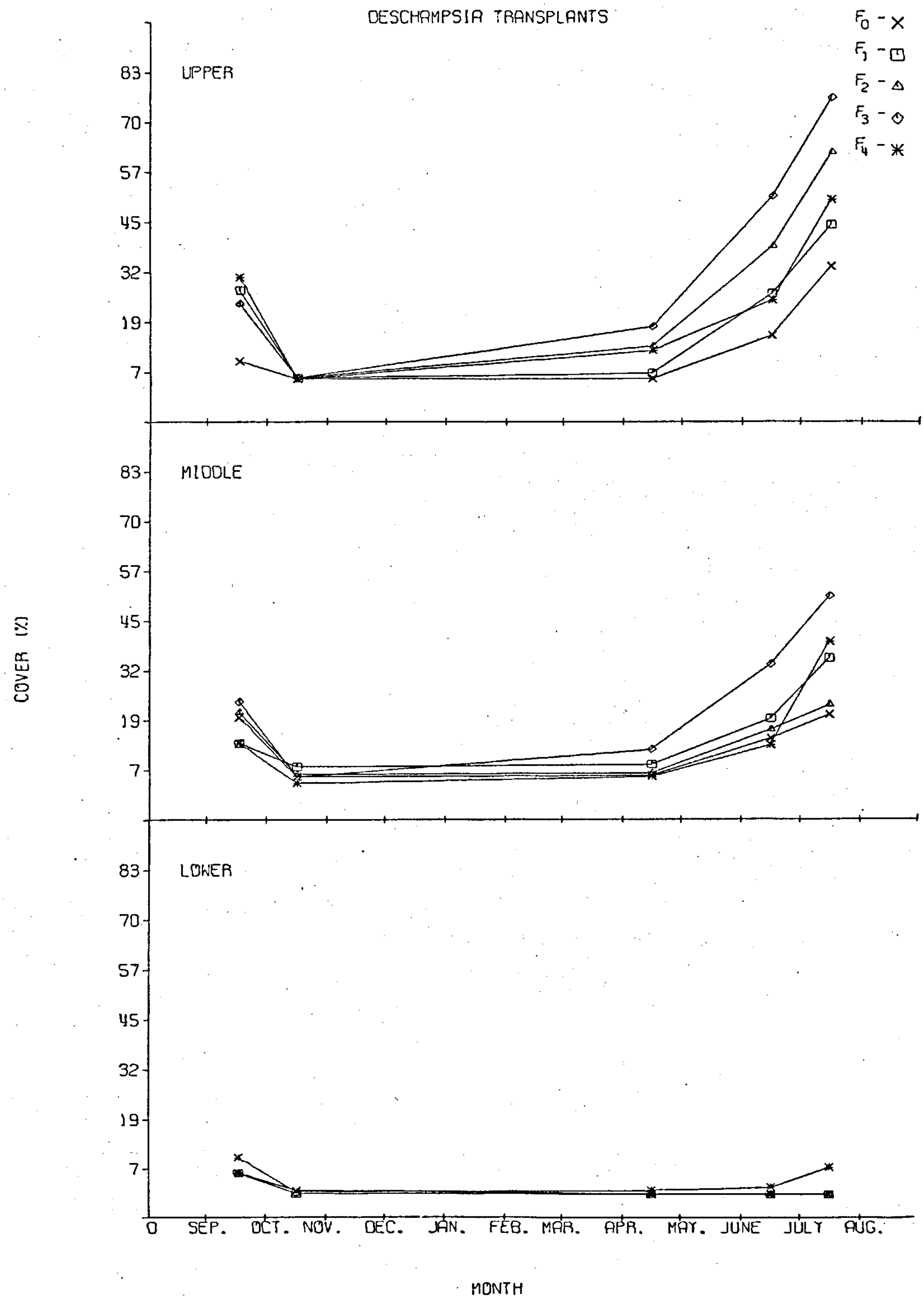

Figure 12. Percent cover of Deschampsia plants on transplant plots between September 1976 and August 1977.

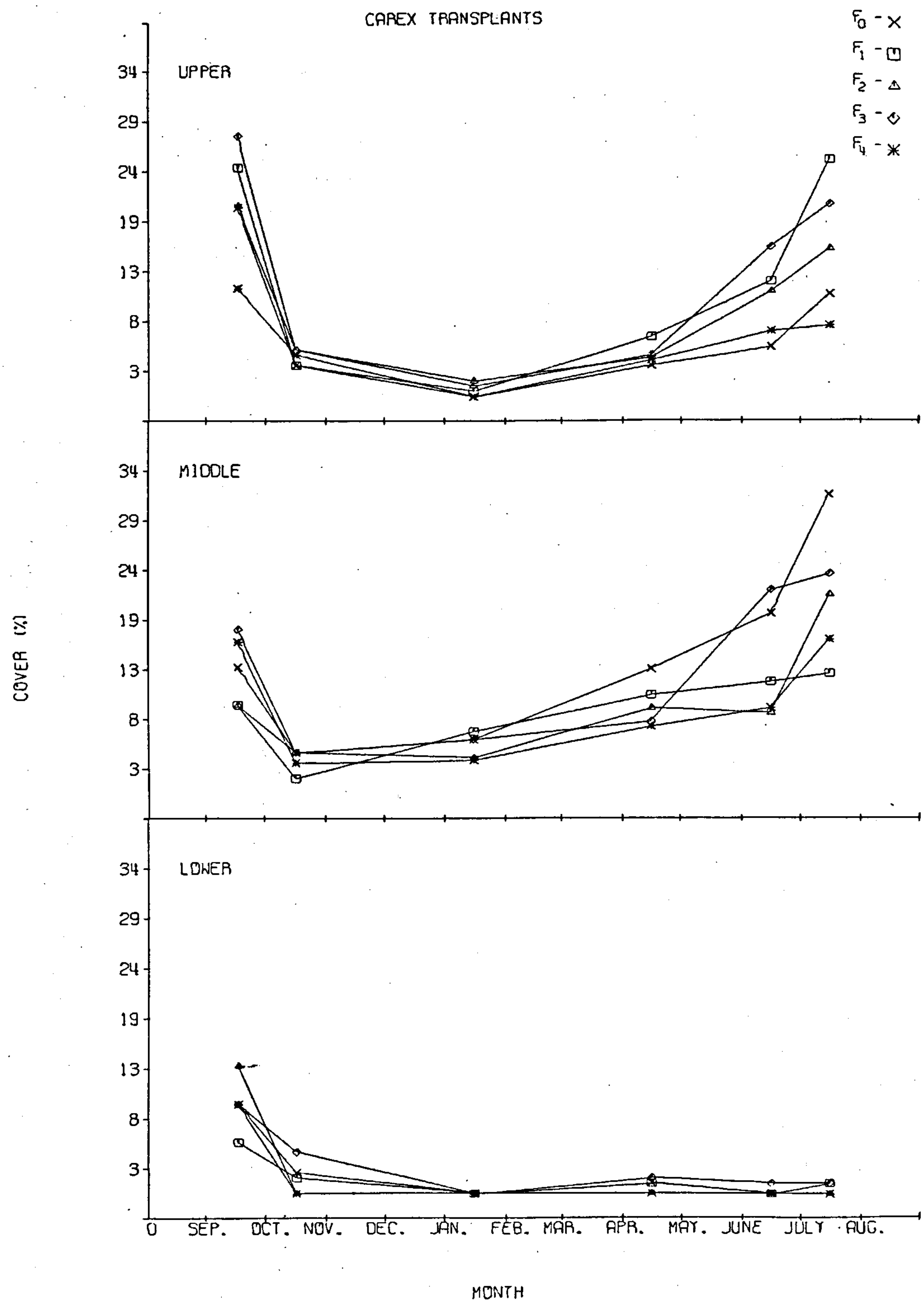

Figure 13. Percent cover of Carex obnupta plants on transplant plots between September 1976 and August 1977

Figure 14. A D. cespitosa transplant plot from the upper tier. Photo taken in October 1977 showing the sandspit in the background

Figure 15. A C. obnupta transplant plot from the upper tier. Photo taken in October 1977 showing the sandspit in the background

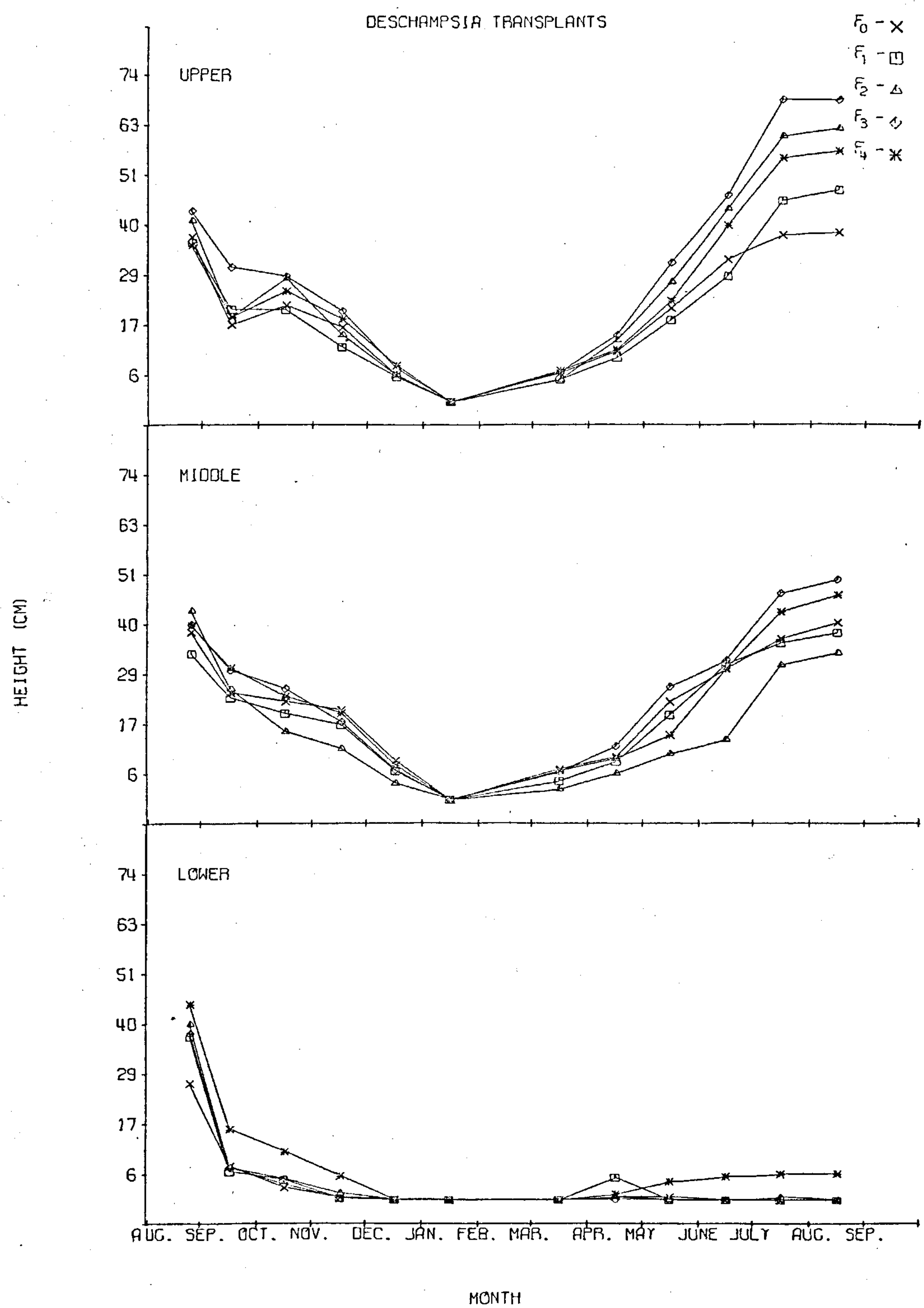

Figure 16. Average heights of Deschampsia plants in transplant plots between August 1976 and September 1977

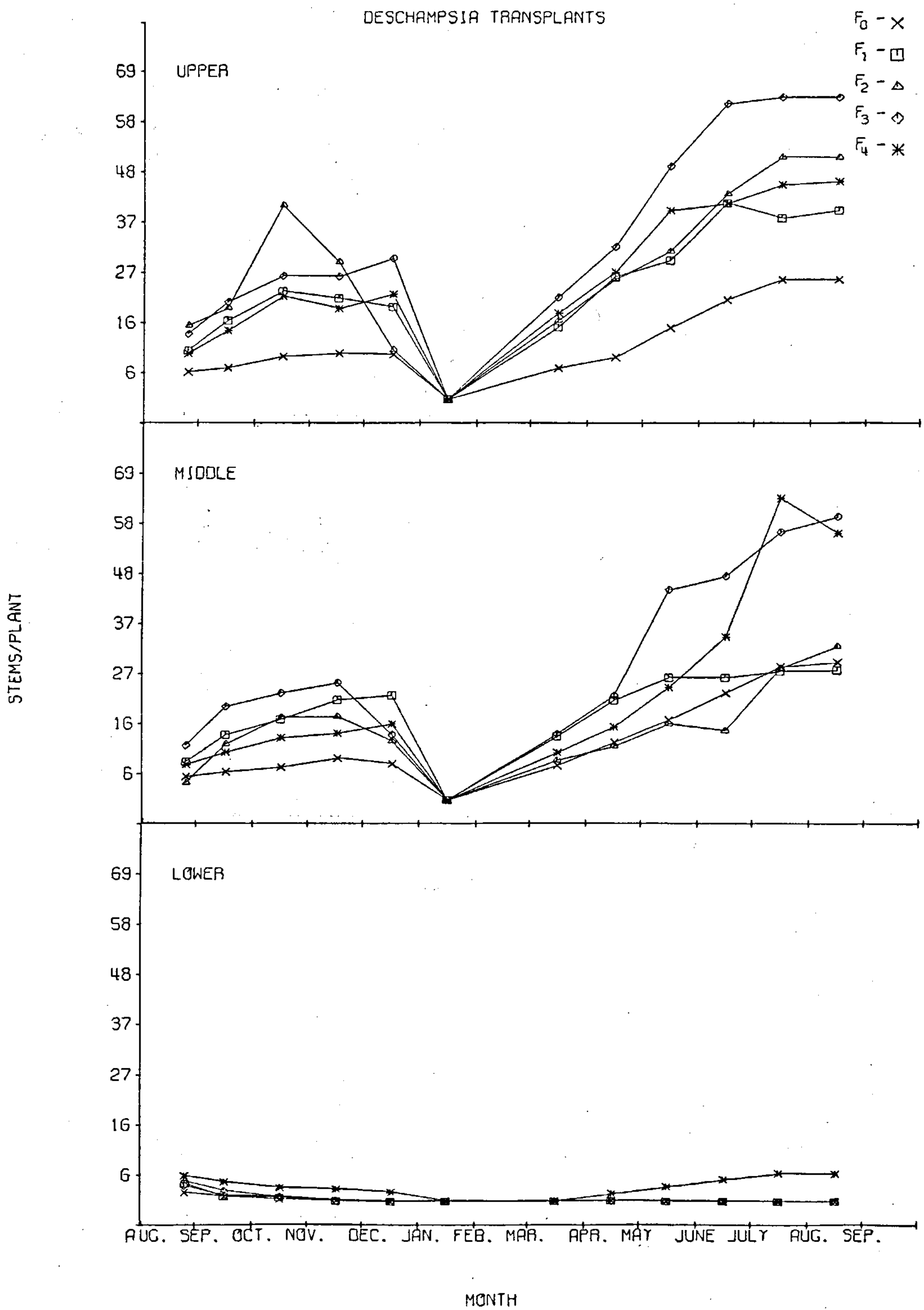

Figure 17. Average number of stems per plant of <u>Deschampsia</u> plants in transplant plots between August 1976 and September 1977

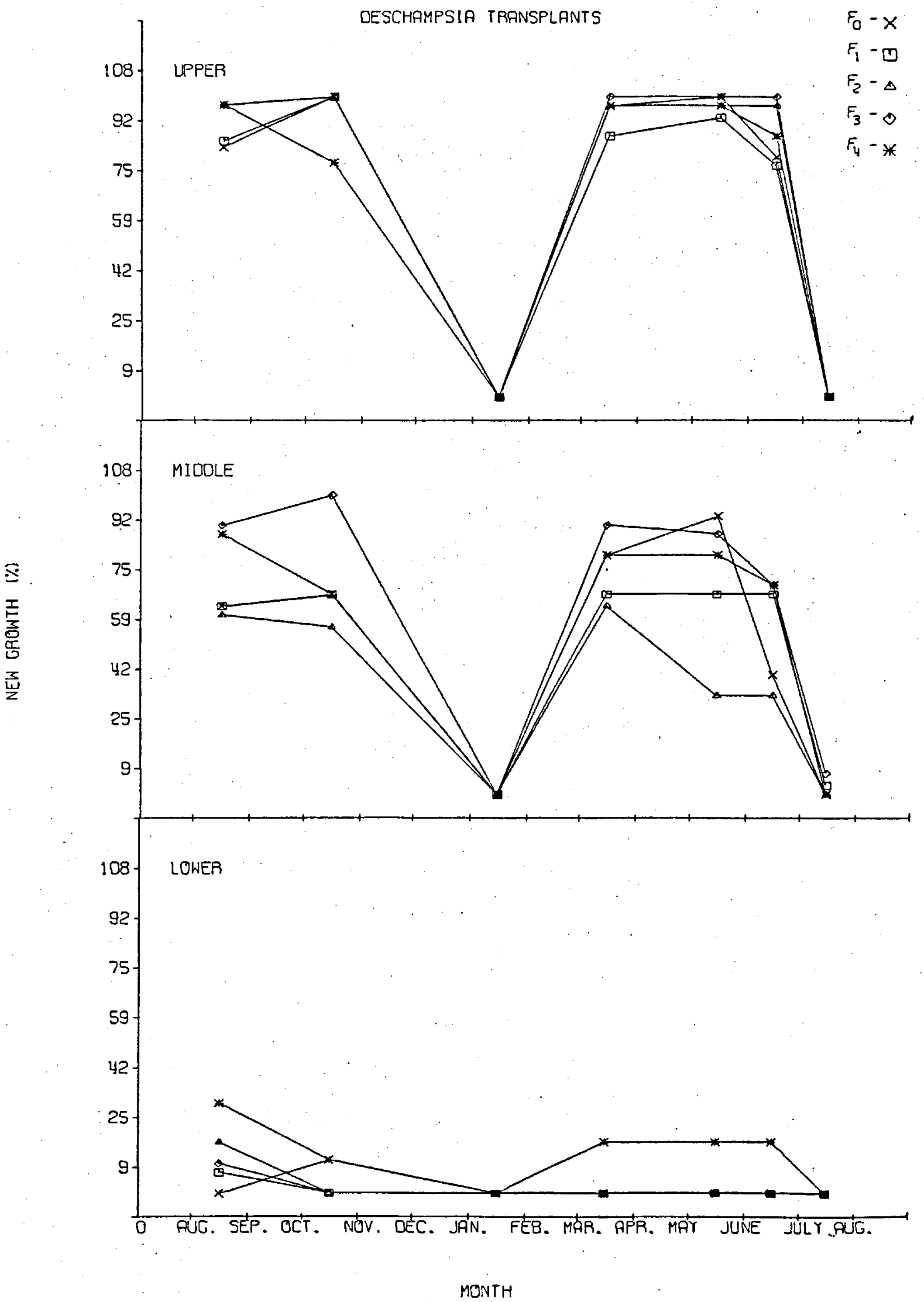

Figure 18. Percent of Deschampsia plants on transplant plots with new growth between August 1976 and August 1977

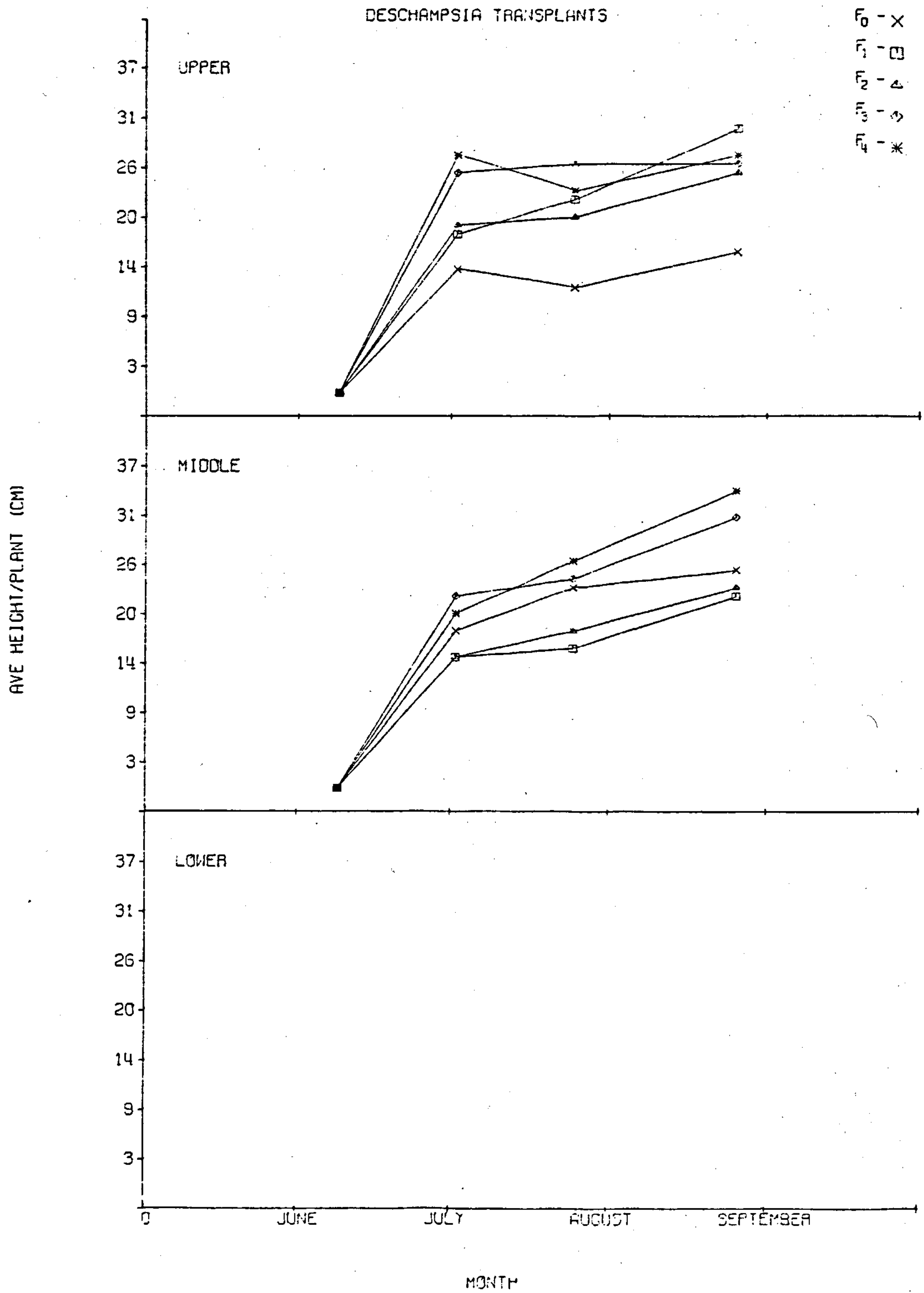

Figure 19. Growth of <u>Deschampsia</u> plants in monotypic plots following clipping in June 1977

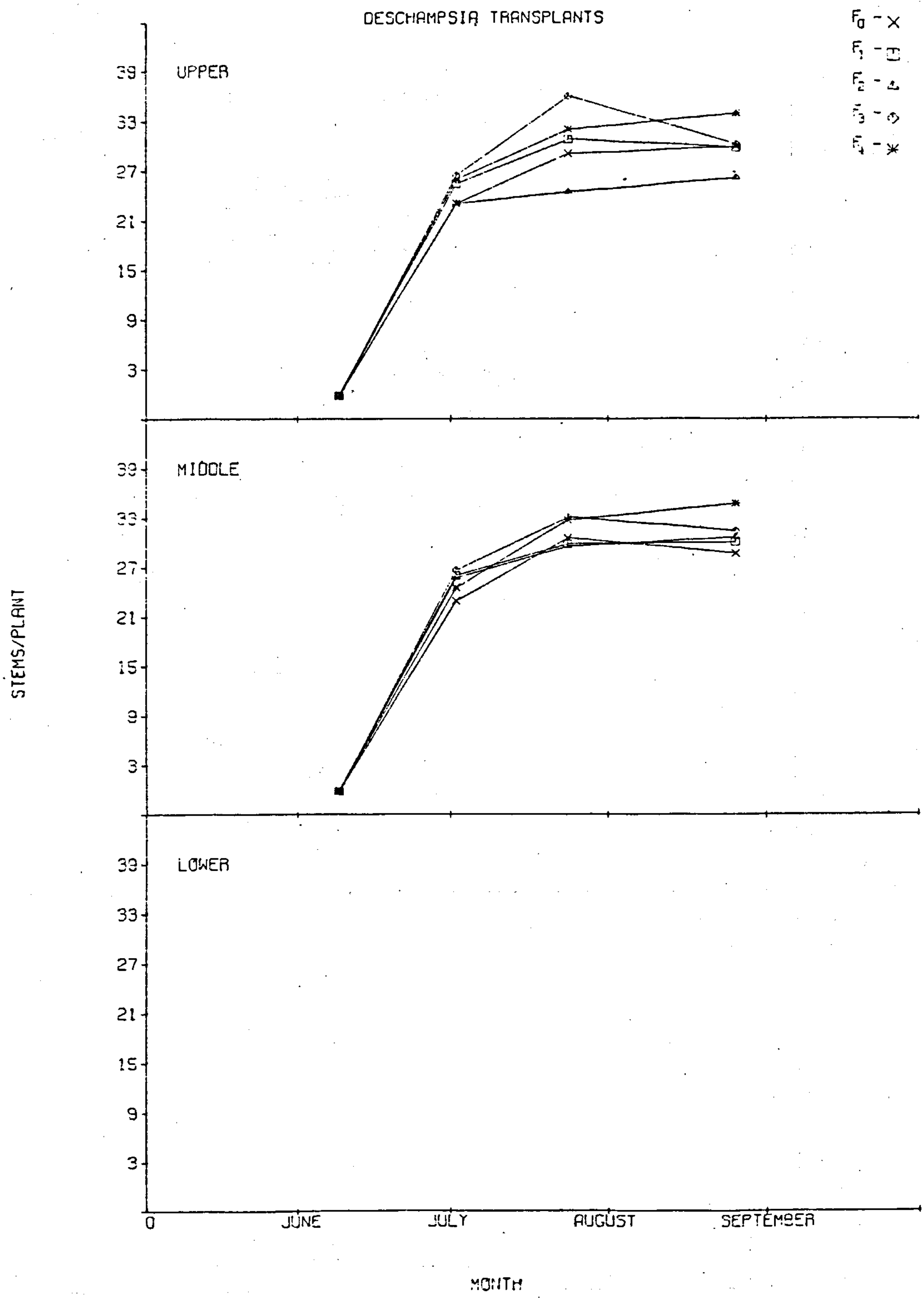

Figure 20. Stem production of Deschampsia plants in monotypic plots following clipping in June 1977

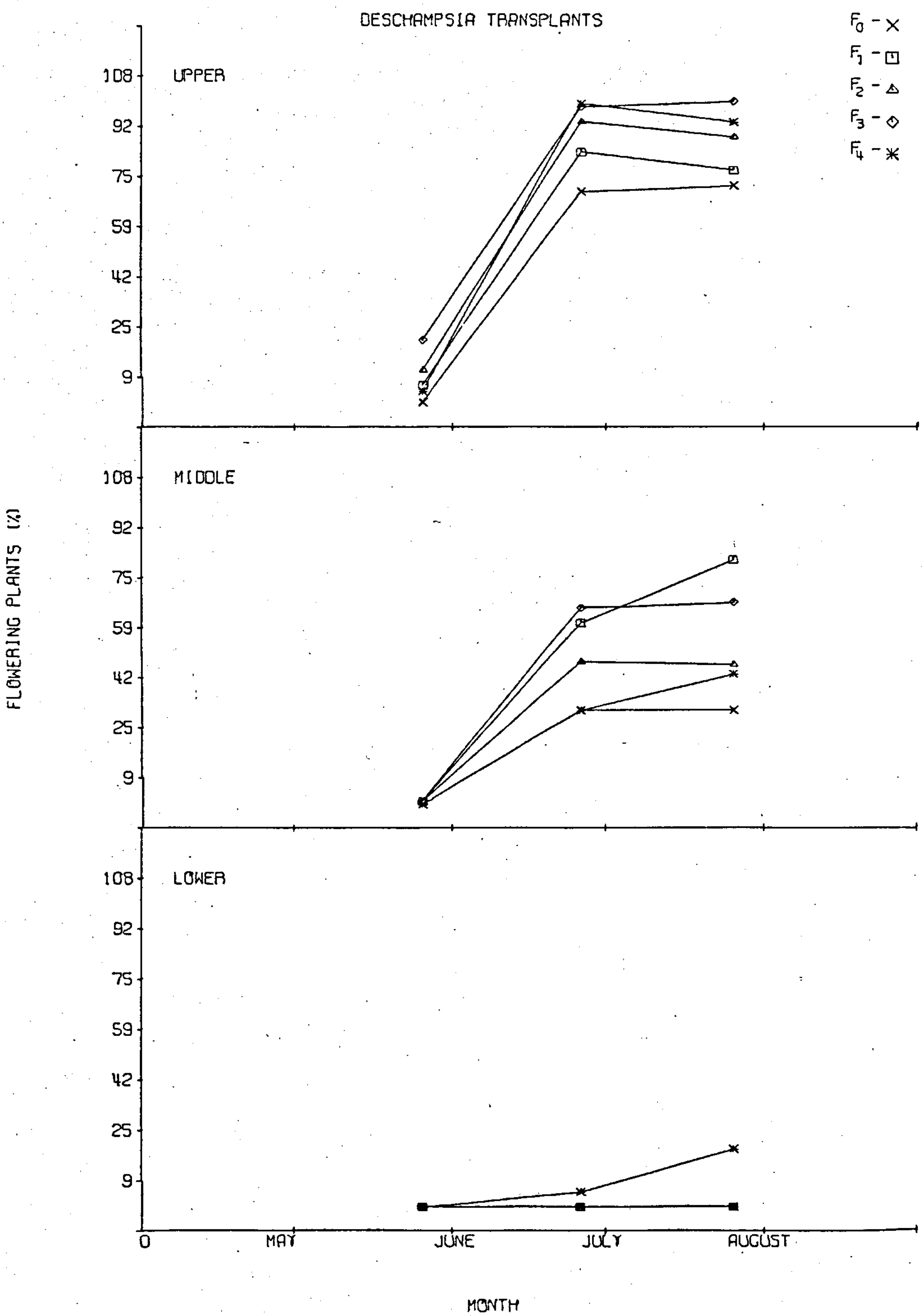

Figure 21. Percent of Deschampsia plants on transplant plots with flowering heads during the summer of 1977

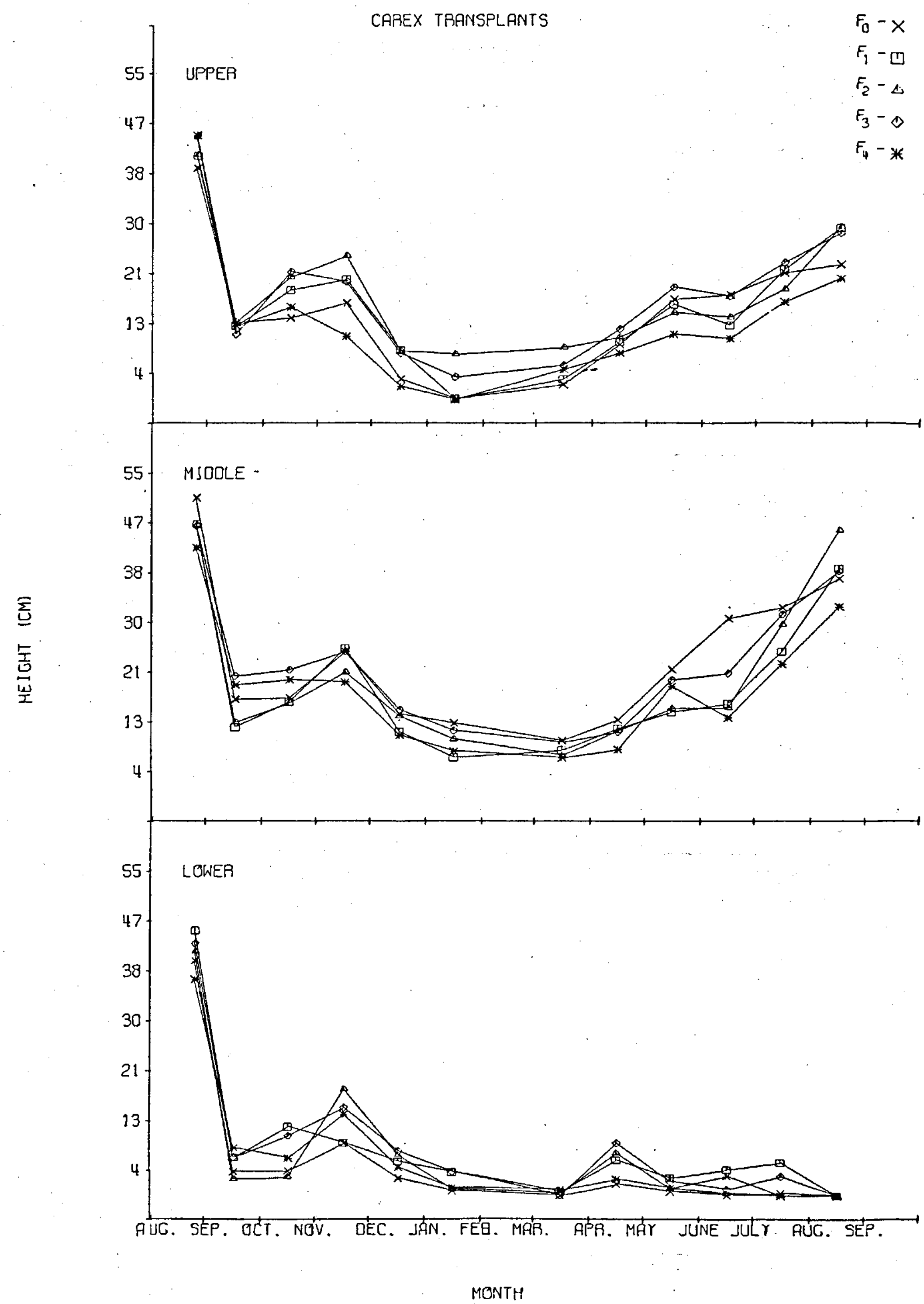

Figure 22. Average heights of Carex obnupta plants in transplant plots between August 1976 and September 1977

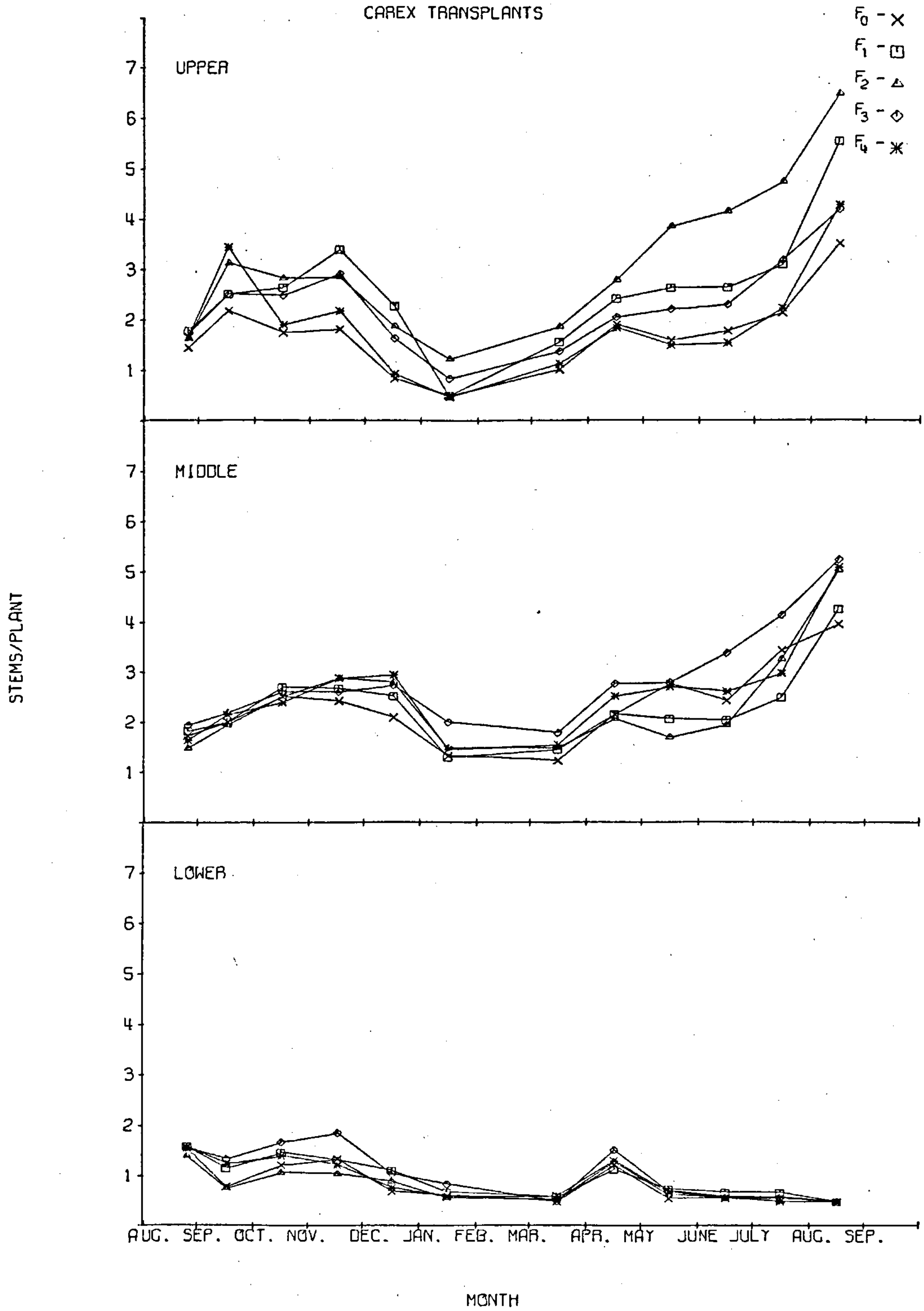

Figure 23. Average number of stems per plant of Carex obnupta plants in the transplant plots between August 1976 and September 1977

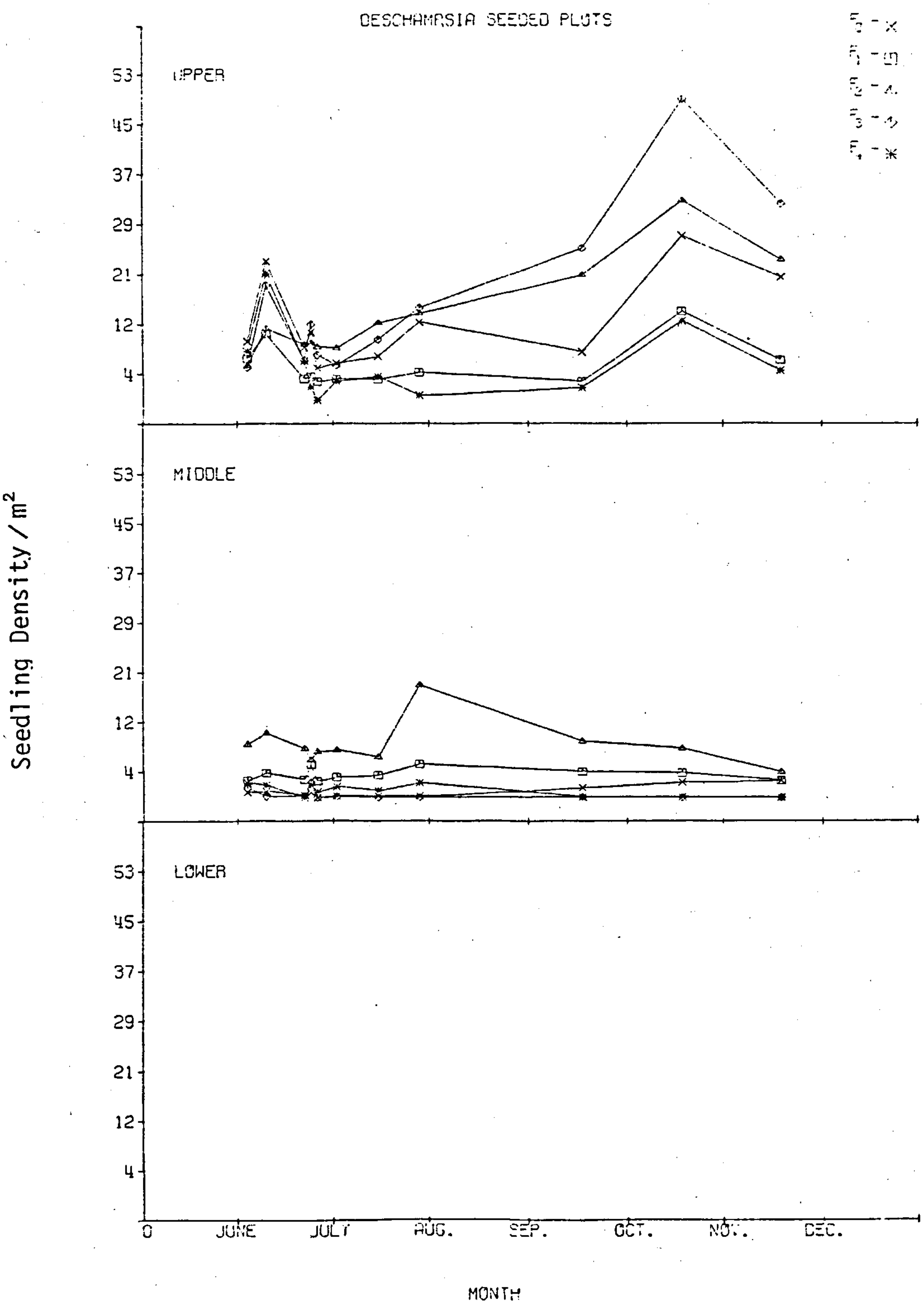

Figure 24. Density of Deschampsia seedlings in monotypic plots following seeding in 1977

Figure 25. Occurrence of Deschampsia seedlings in areas of algae concentration, October 1977

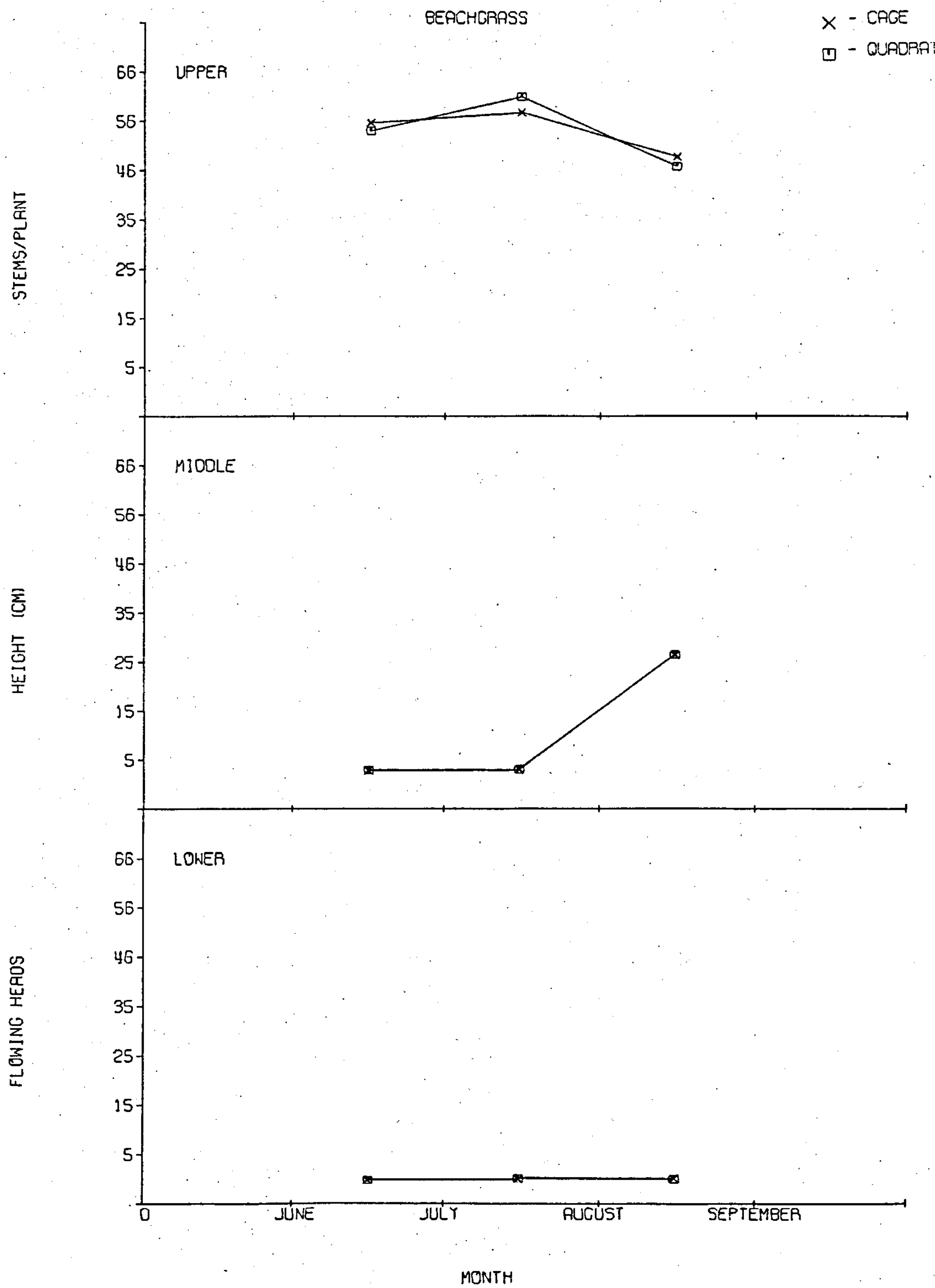

Figure 26. Growth measurements of European beachgrass in caged and uncaged (quadrat) samples in Area A during the summer of 1977

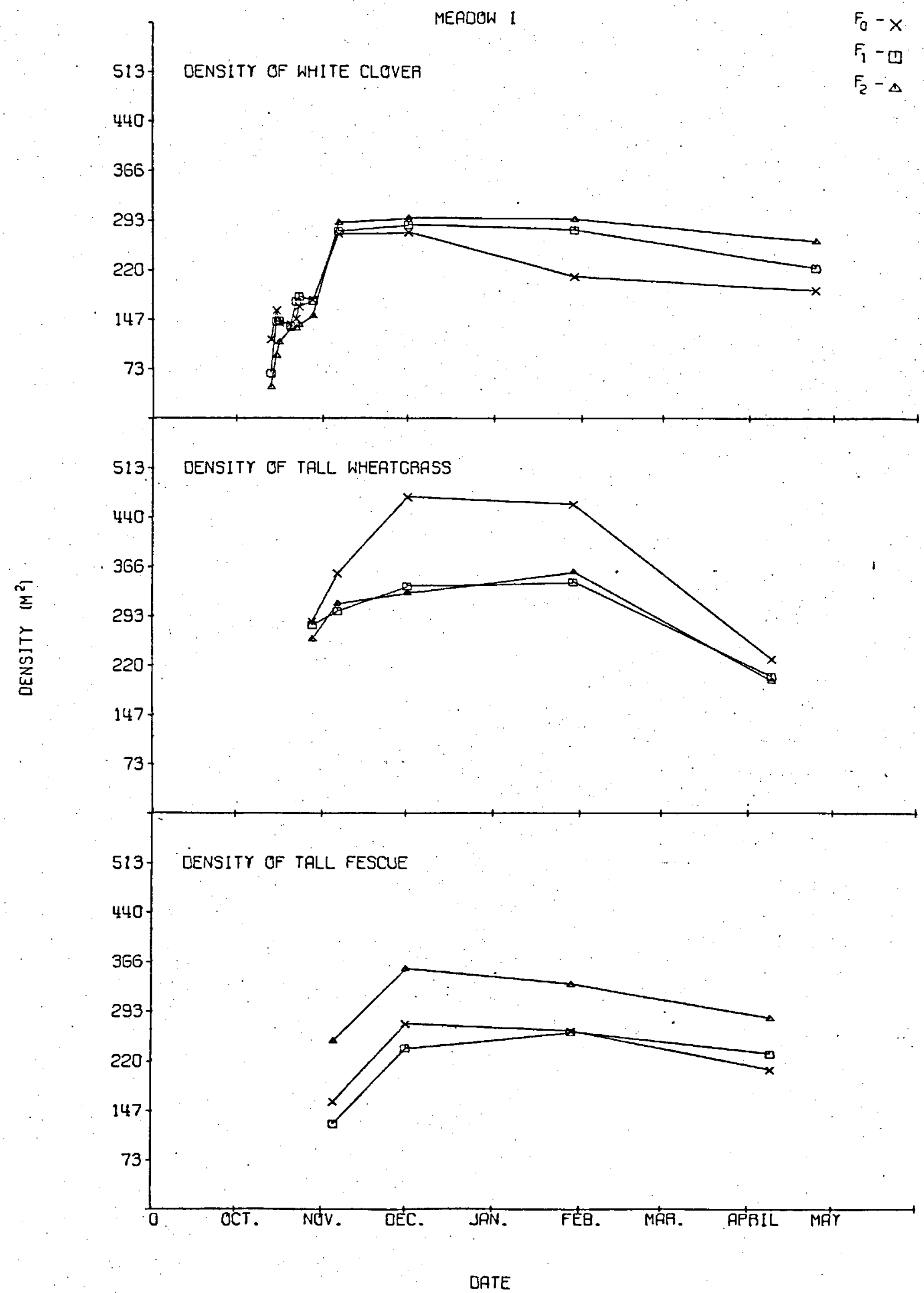

Figure 27. Plant density of white clover, tall wheatgrass, and tall fescue in monotypic plots between November 1976 and May 1977

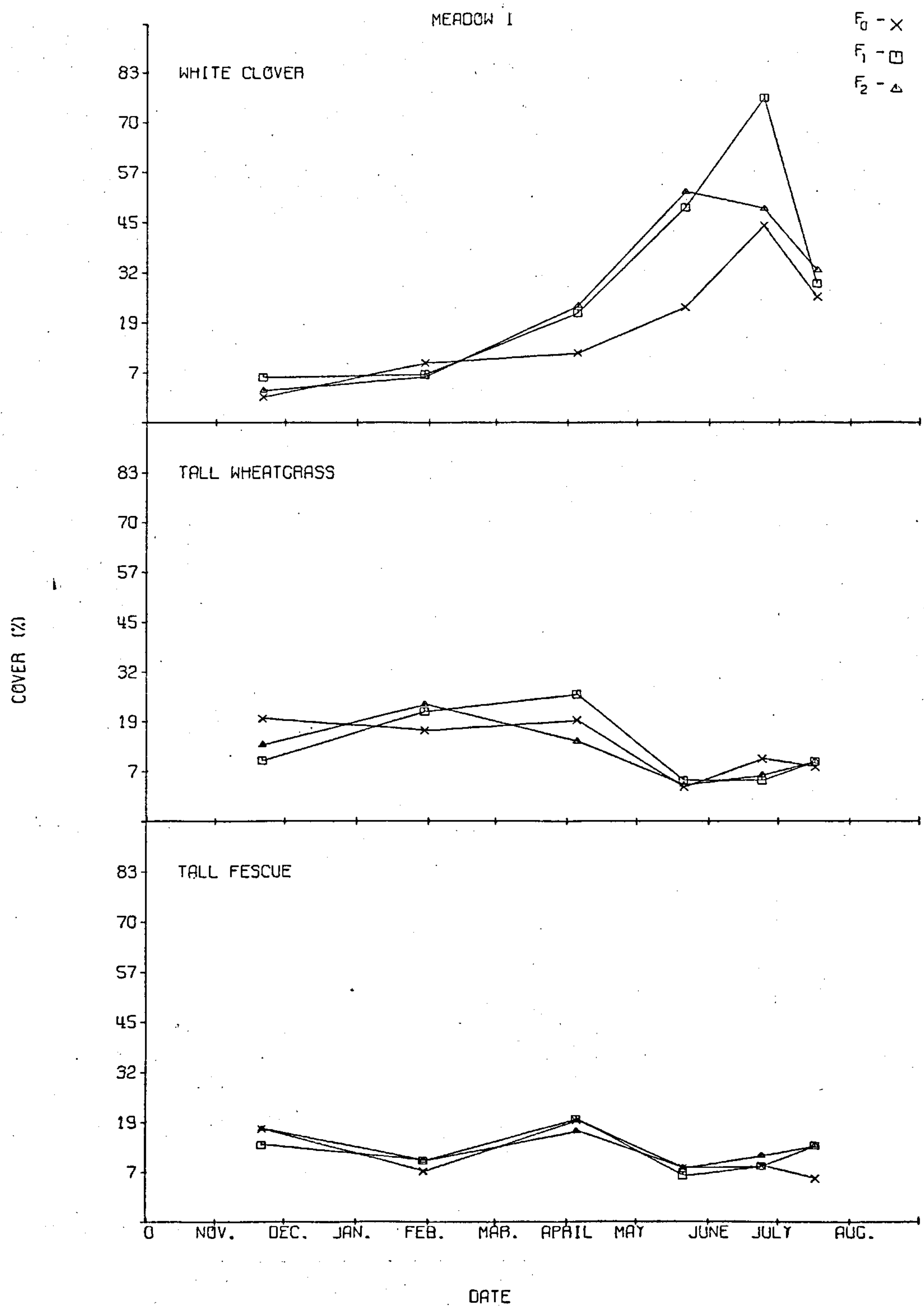

Figure 28. Percent of ground covered by white clover, tall wheatgrass, and tall fescue in monotypic plots between November 1976 and August 1977

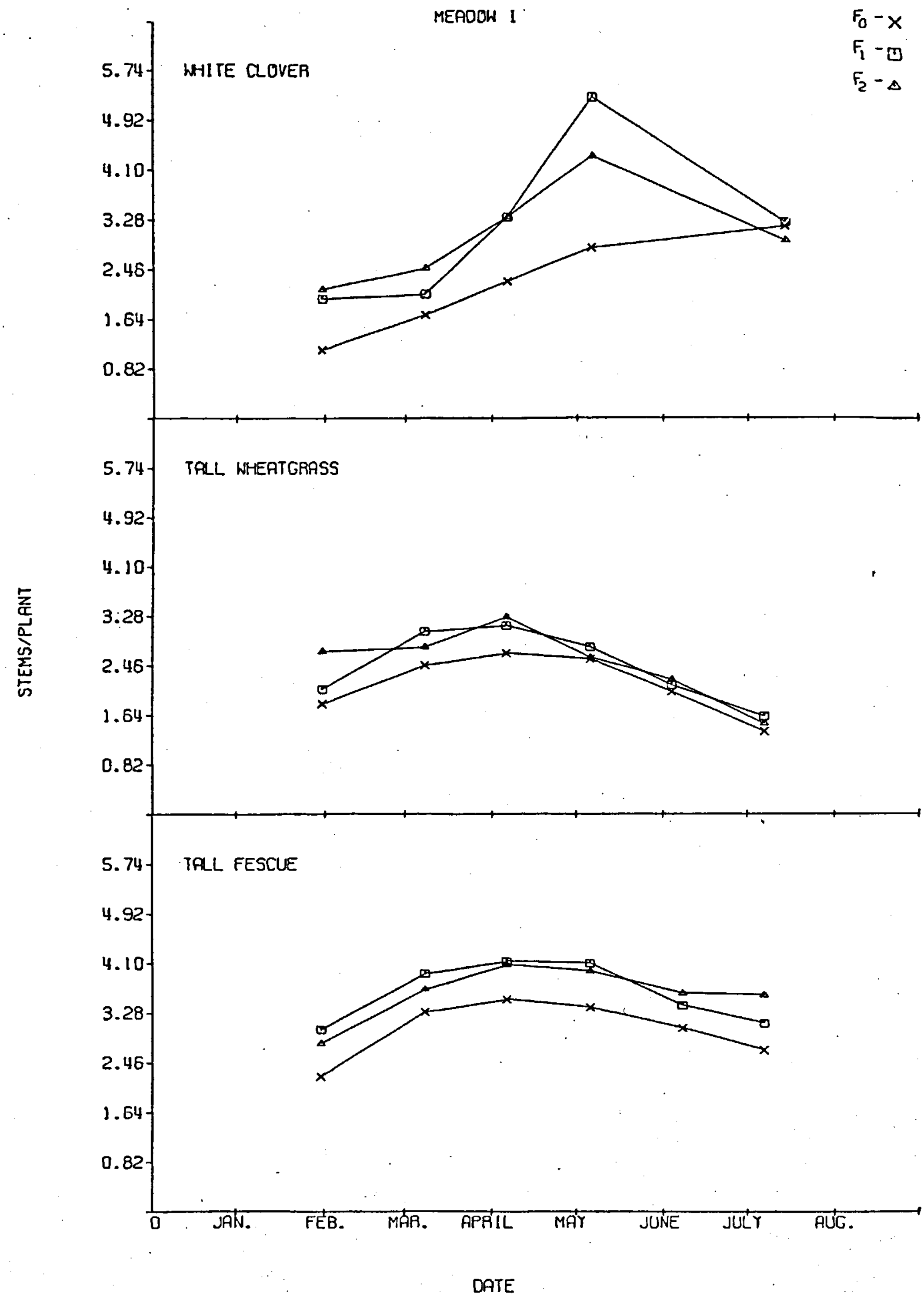

Figure 29. Number of primary stolons per plant of white clover and number of tillers per plant of tall wheatgrass and tall fescue during 1977

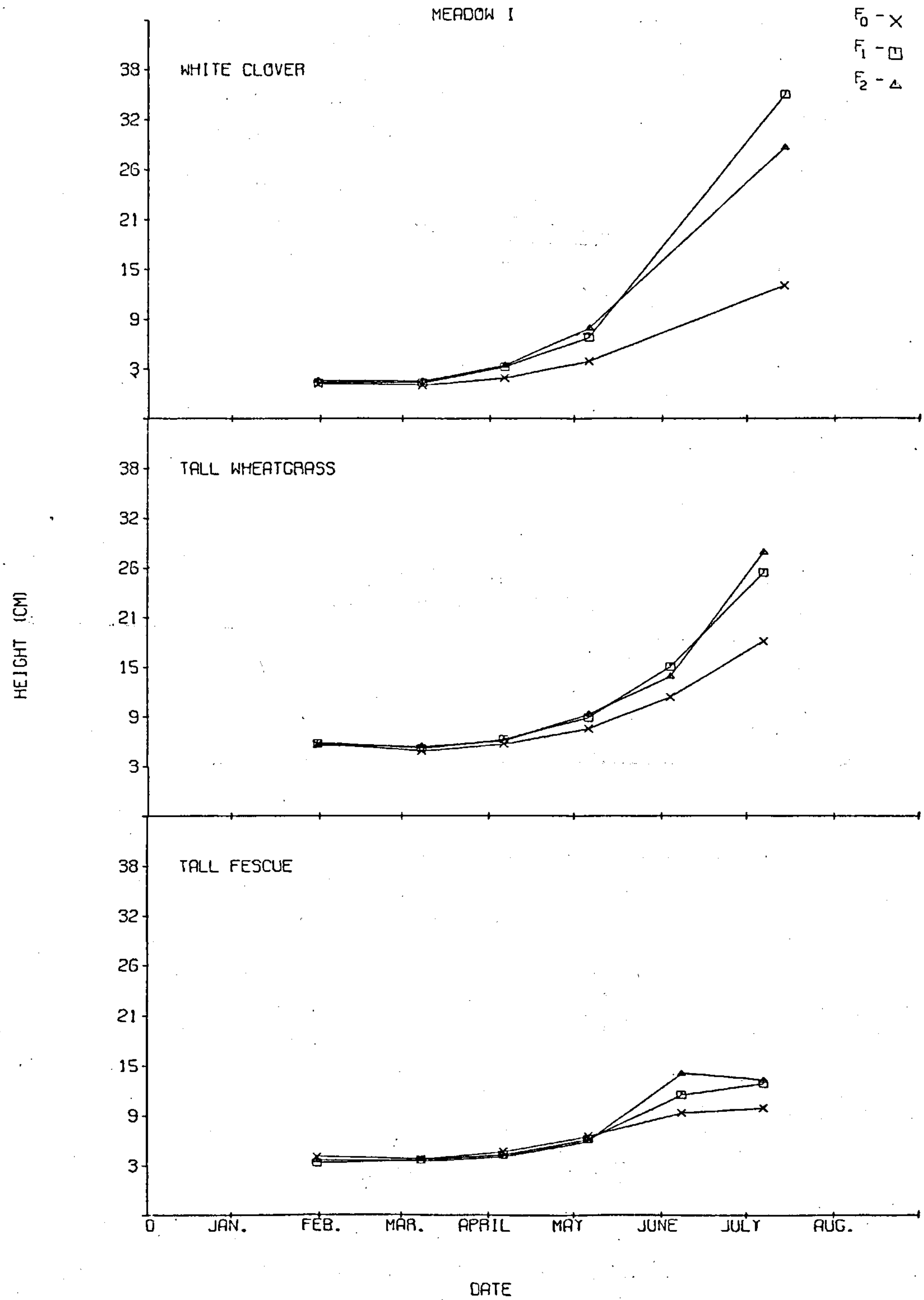

Figure 30. Plant height of white clover, tall wheatgrass, and tall fescue in monotypic plots during 1977

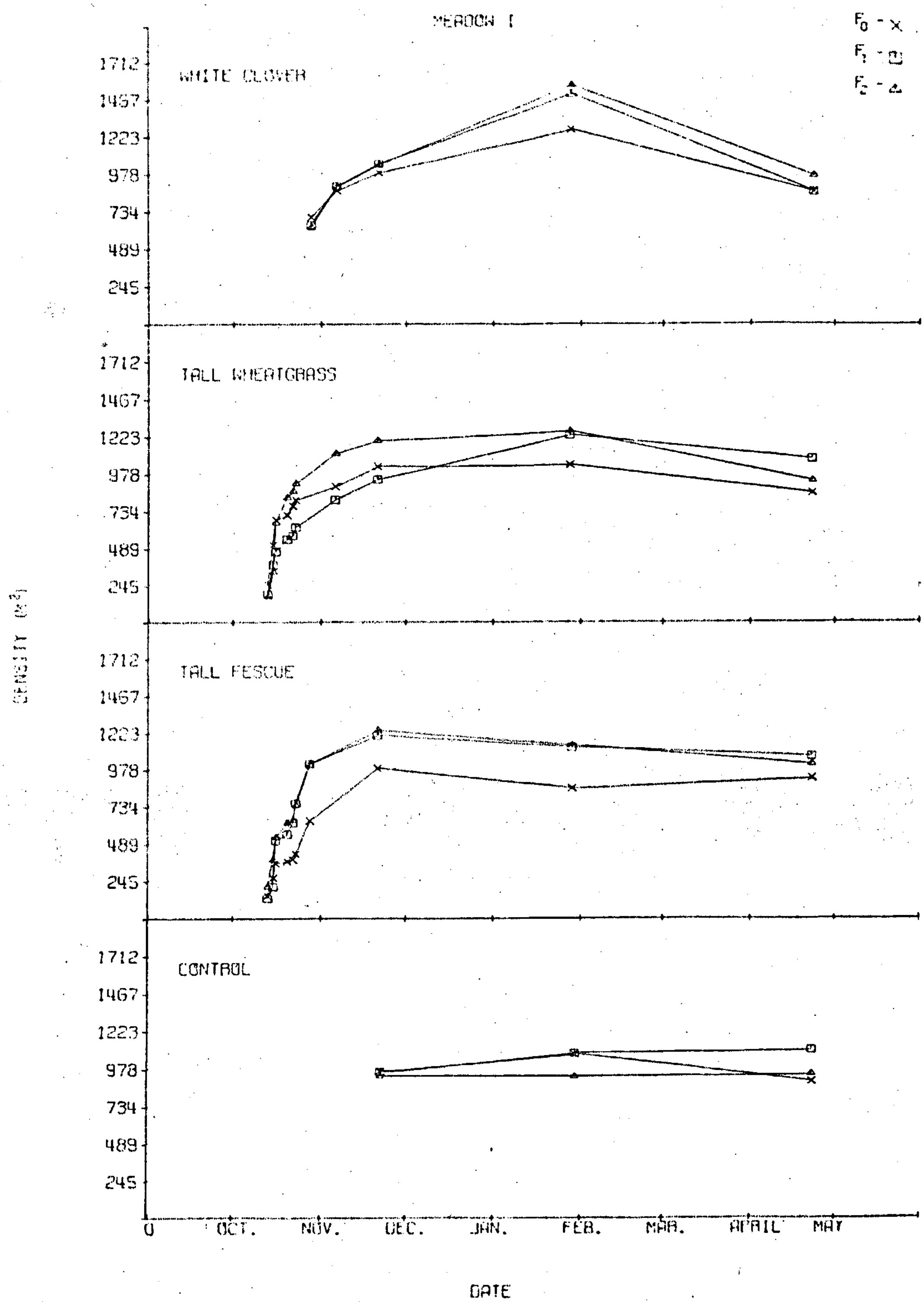

Figure 31. Total plant density of all invading and seeded species in white clover, tall wheatgrass, tall fescue, and control plots between November 1976 and May 1977

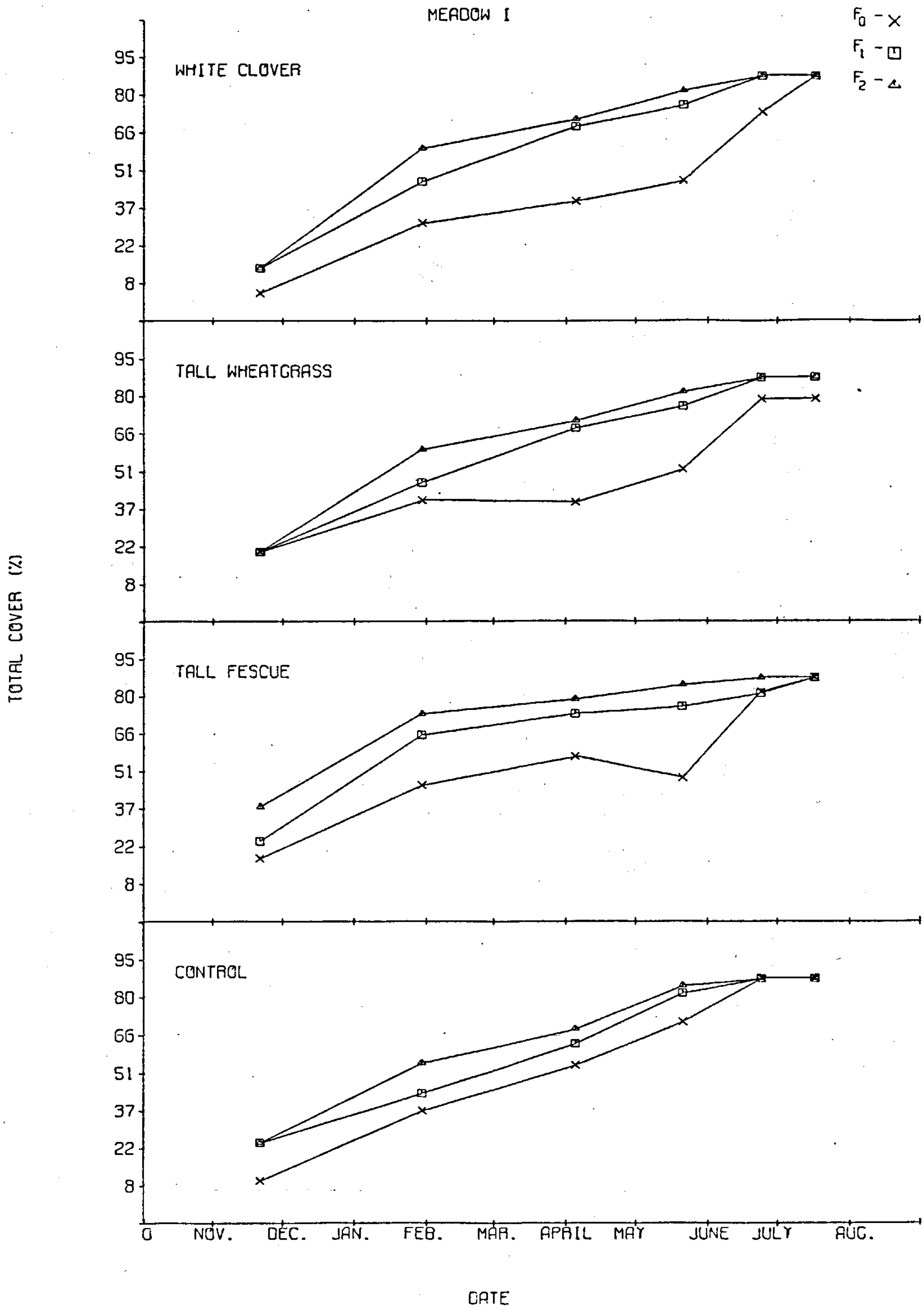

Figure 32. Percent total cover of all invading and seeded species in white clover, tall wheatgrass, tall fescue, and control plots between November 1976 and August 1977

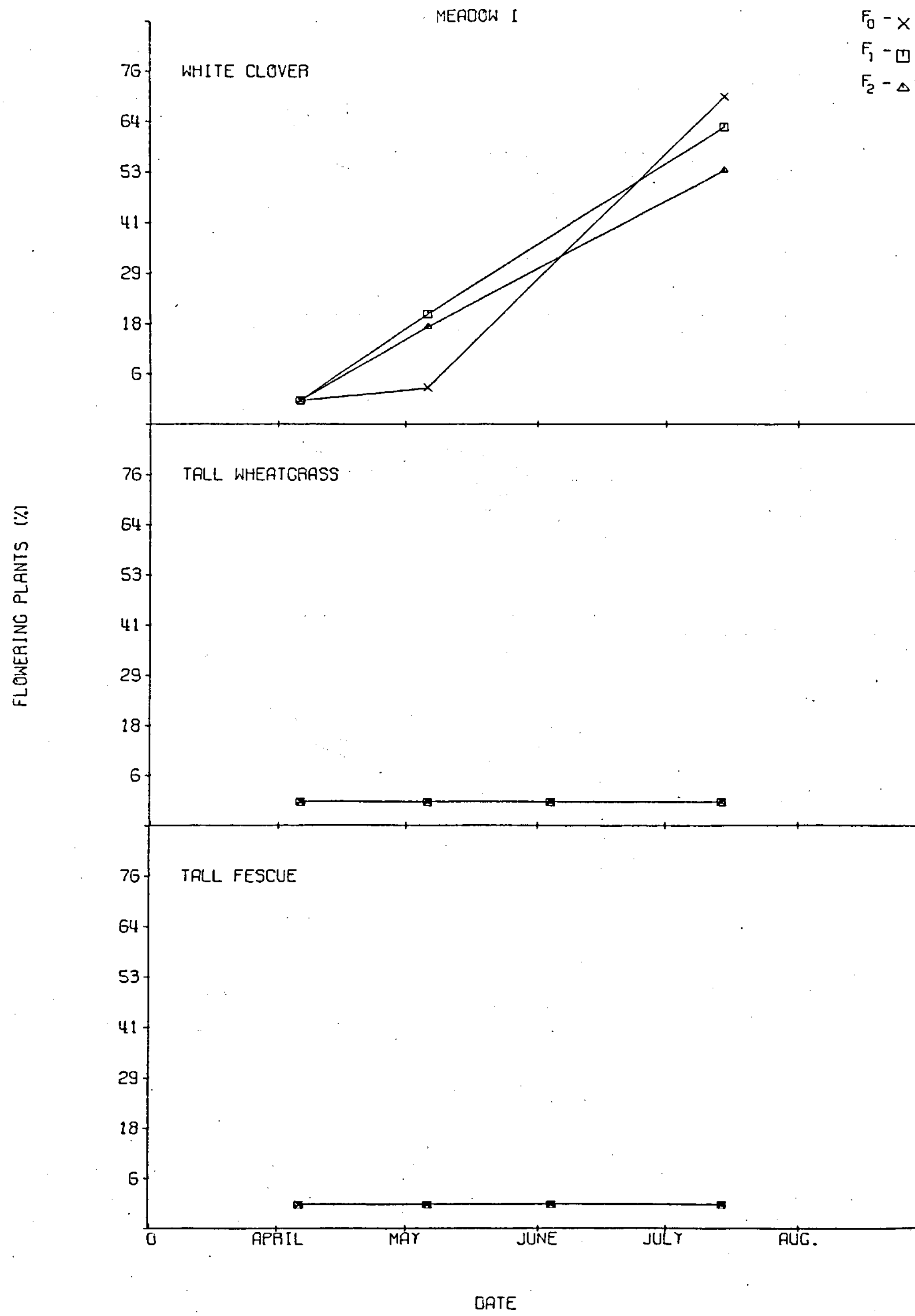

Figure 33. Percent flowering plants of white clover, tall wheatgrass, and tall fescue in monotypic plots during the summer months of 1977

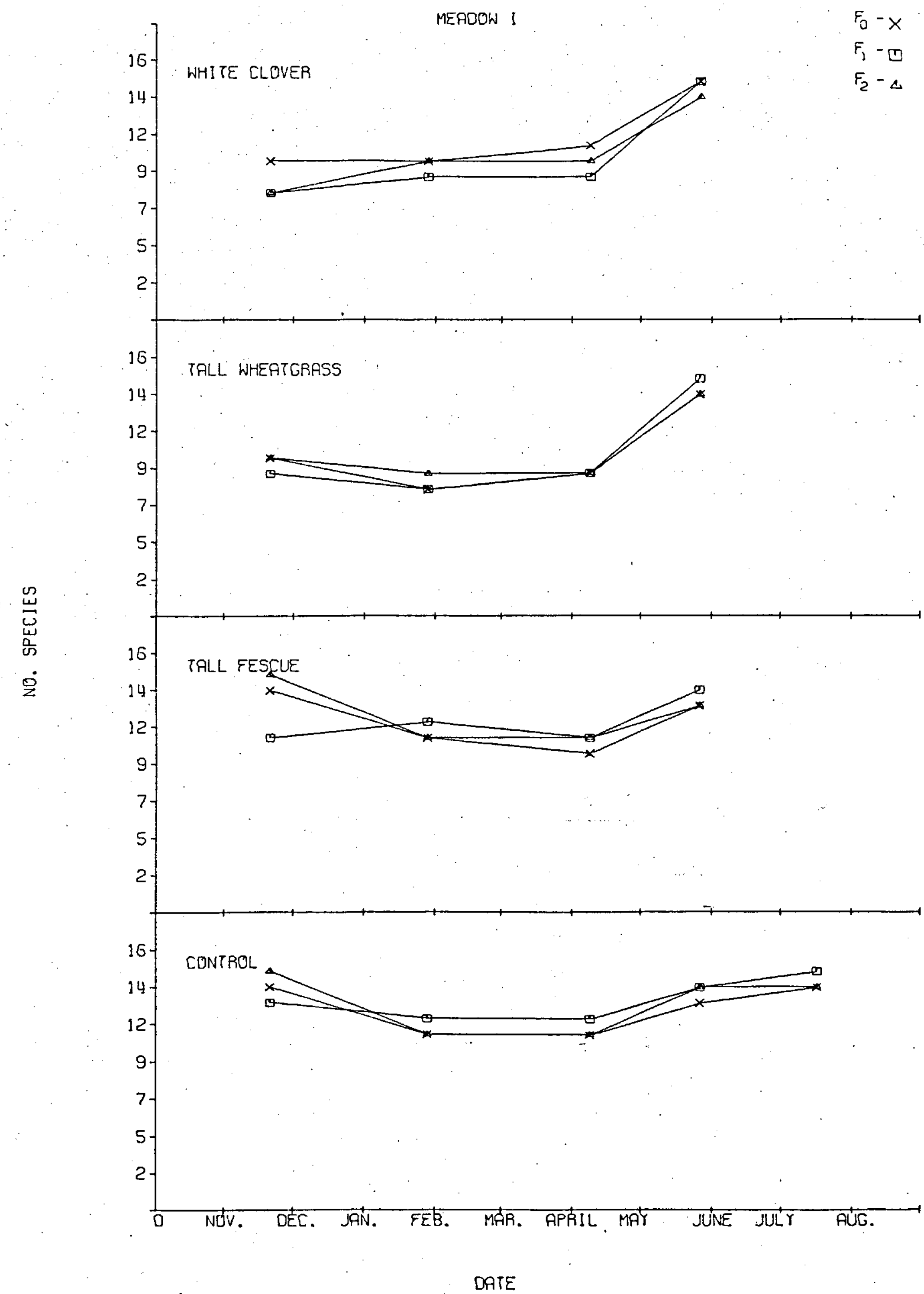

Figure 34. Number of different invading species in white clover, tall wheatgrass, tall fescue, and control plots between November 1976 and August 1977

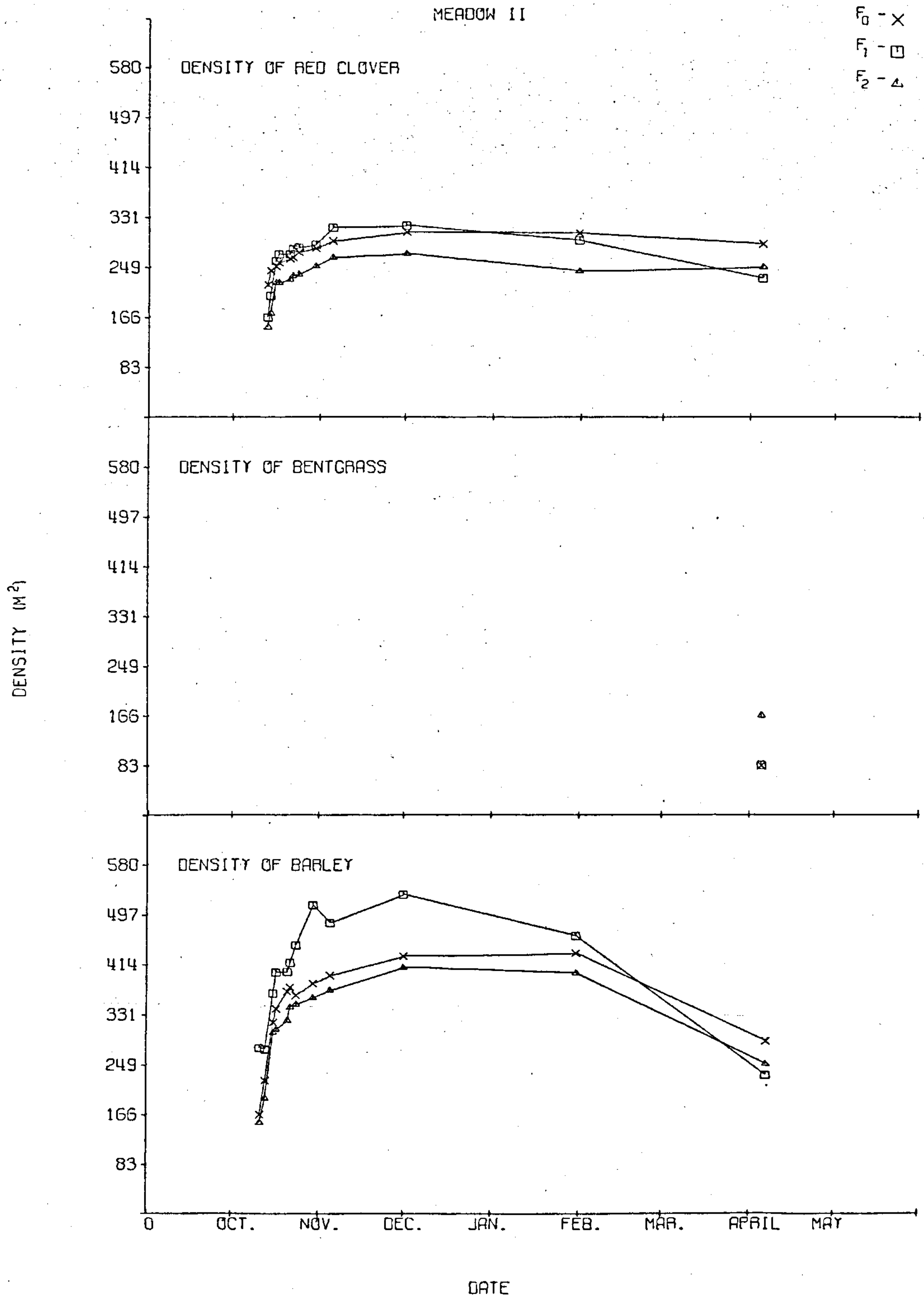

Figure 35. Plant density of red clover, Oregon bentgrass, and barley in monotypic plots of Meadow II

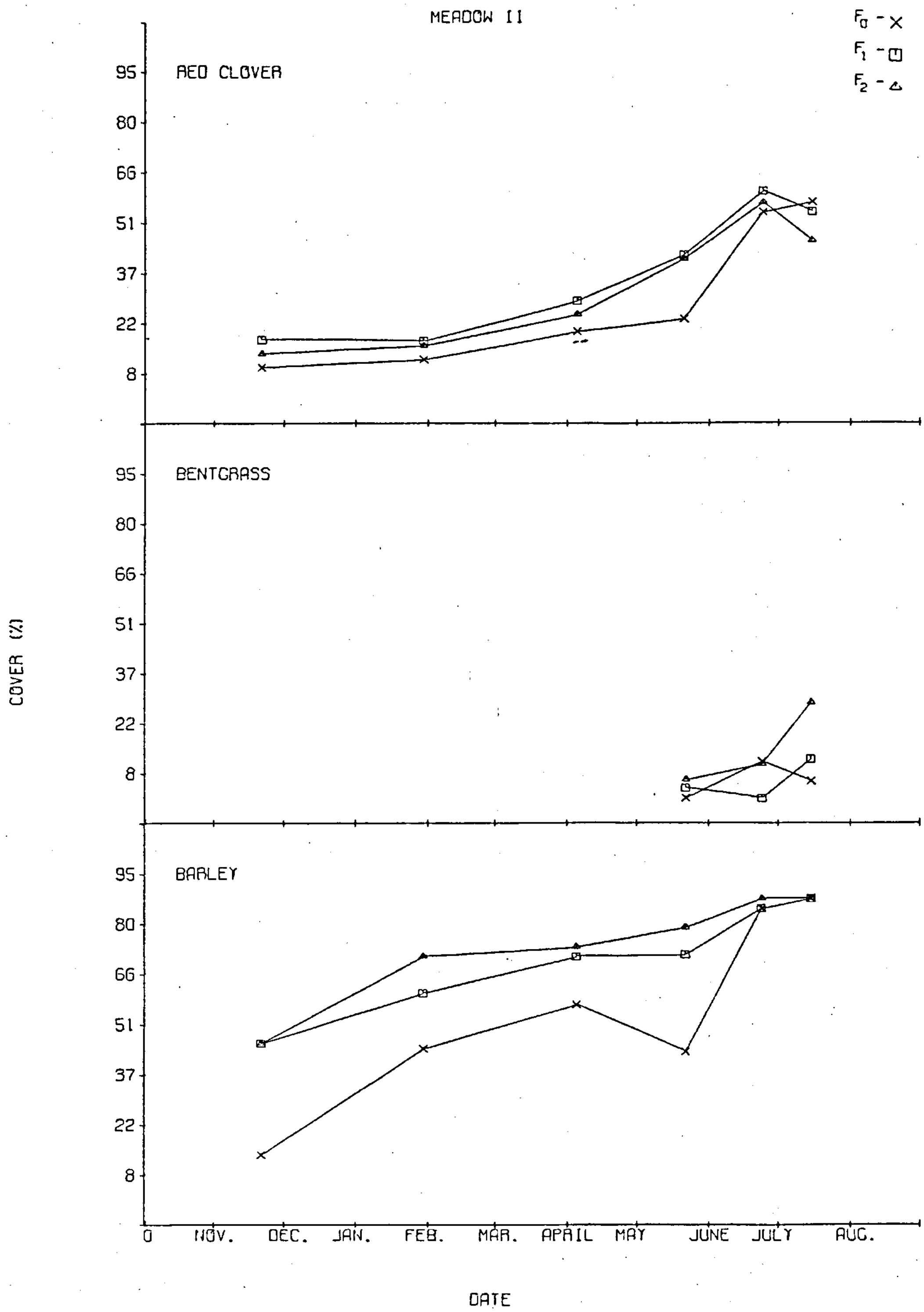

Figure 36. Percent of ground covered by red clover, Oregon bentgrass, and barley in monotypic plots between November 1976 and August 1977

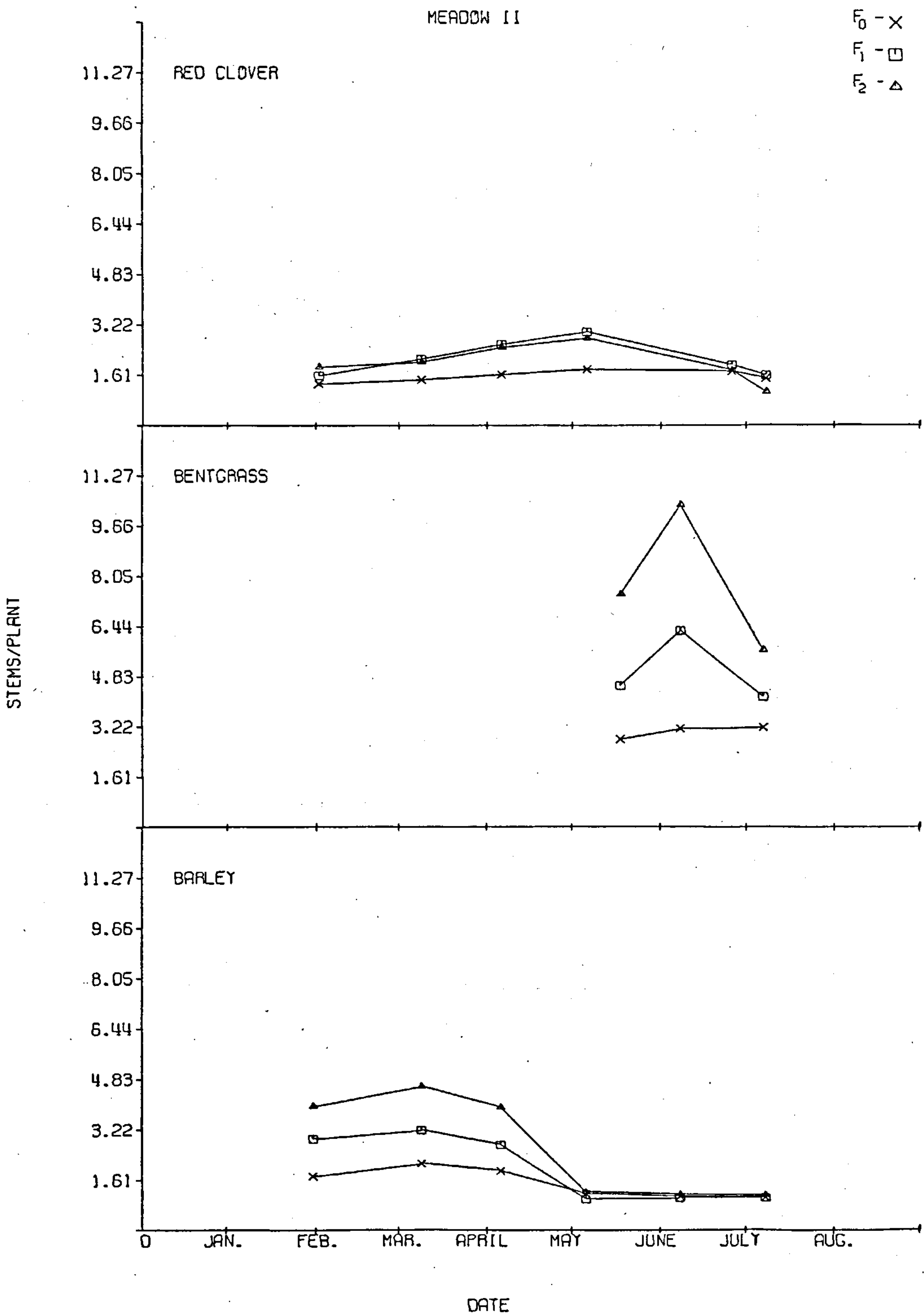

Figure 37. Number of stems per plant of red clover, Oregon bentgrass, and barley in monotypic plots during 1977

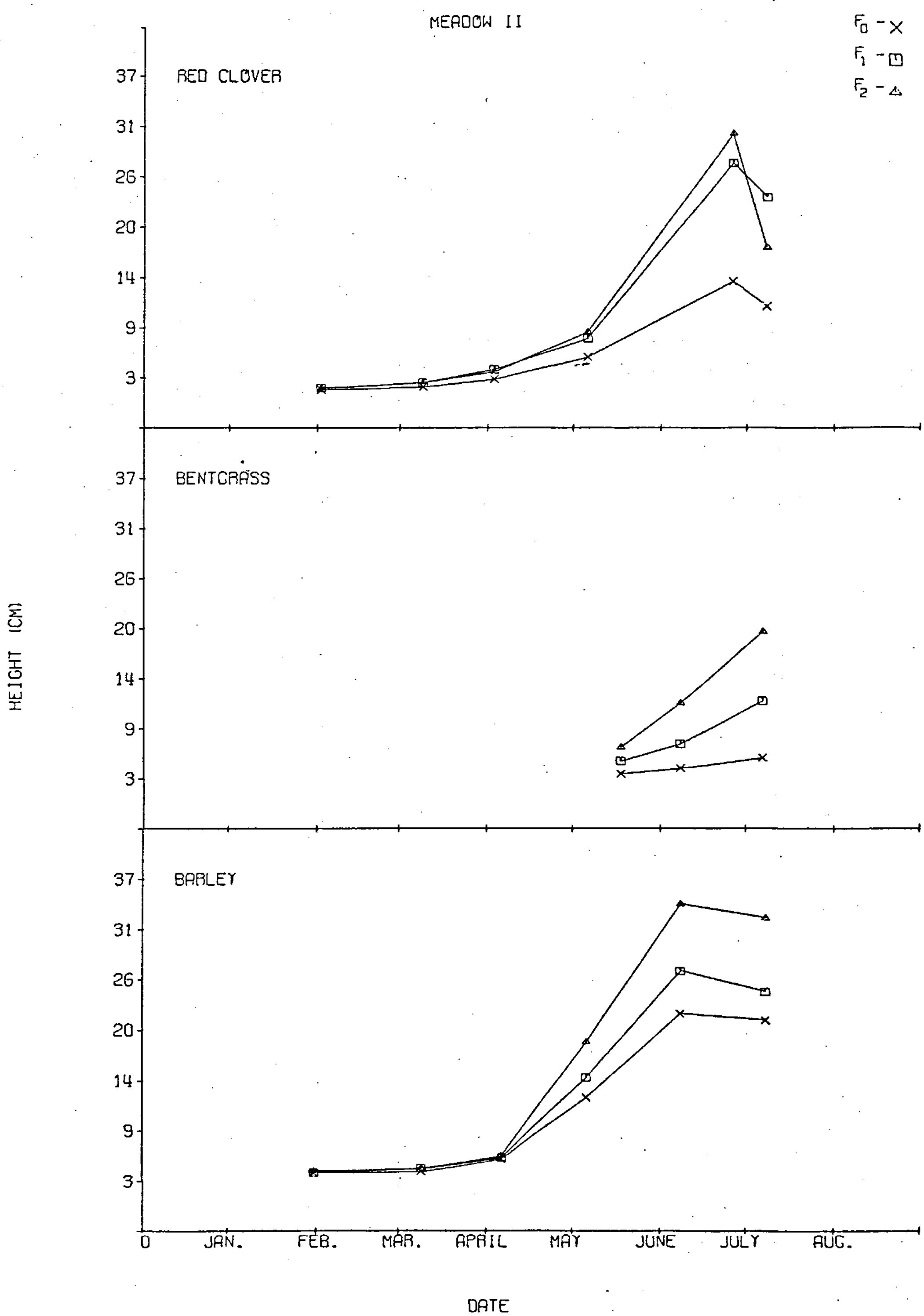

Figure 38. Plant height of red clover, Oregon bentgrass, and barley in monotypic plots in 1977

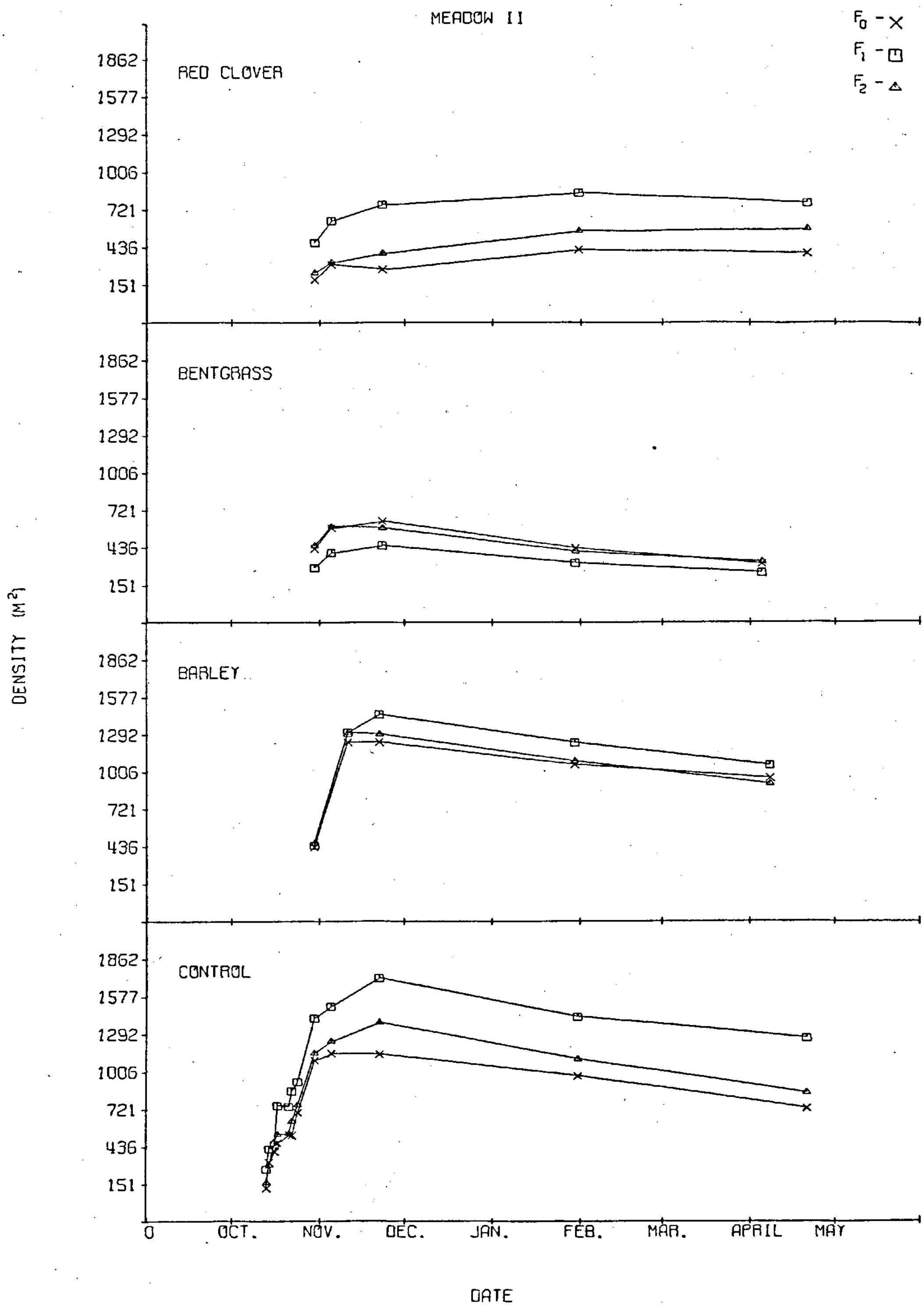

Figure 39. Total plant density of all invading and seeded species in red clover, Oregon bentgrass, barley, and control monotypic plots between October 1976 and May 1977

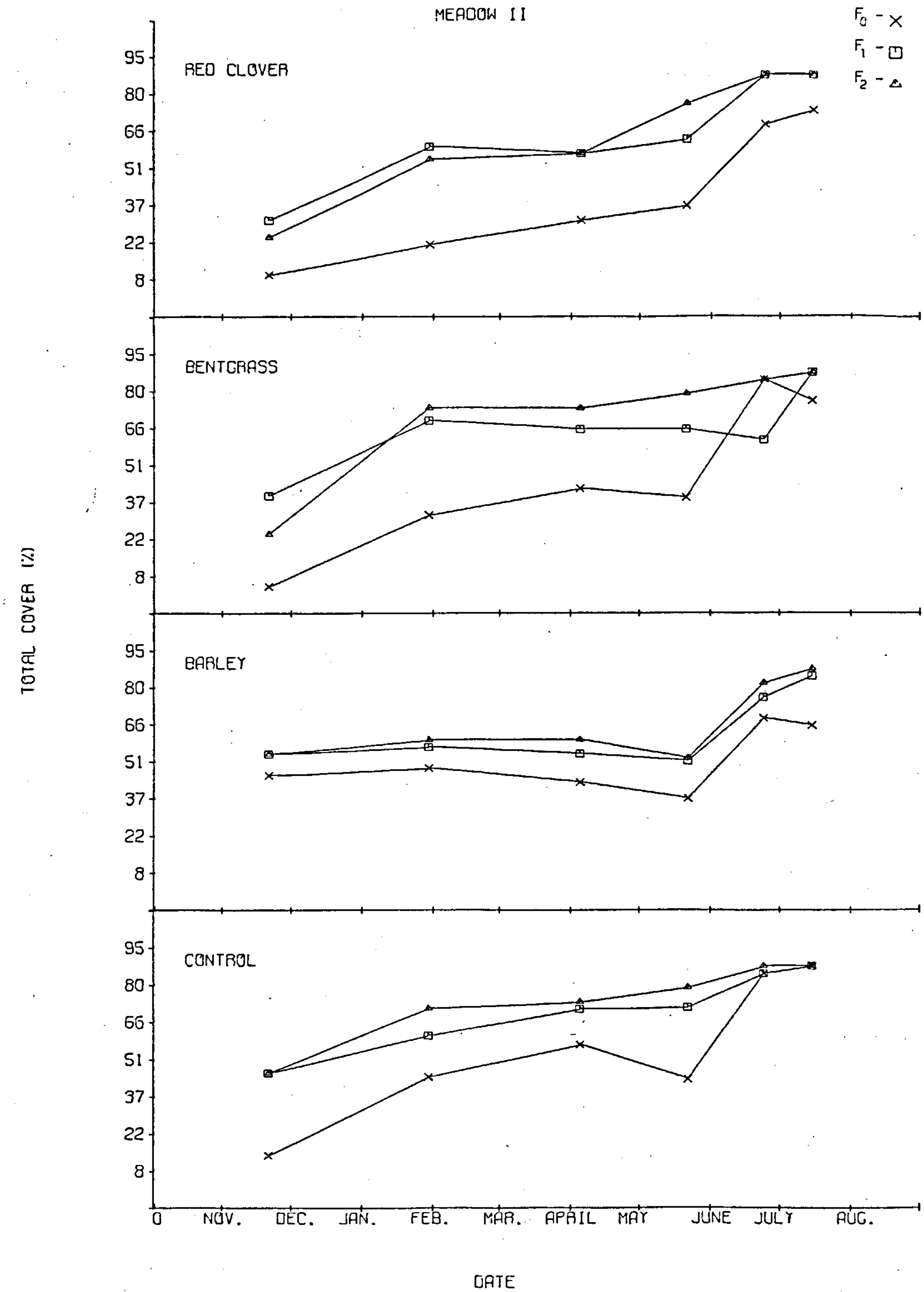

Figure 40. Percent total cover of all invading and seeded species in red clover, Oregon bentgrass, barley, and control plots between November 1976 and August 1977

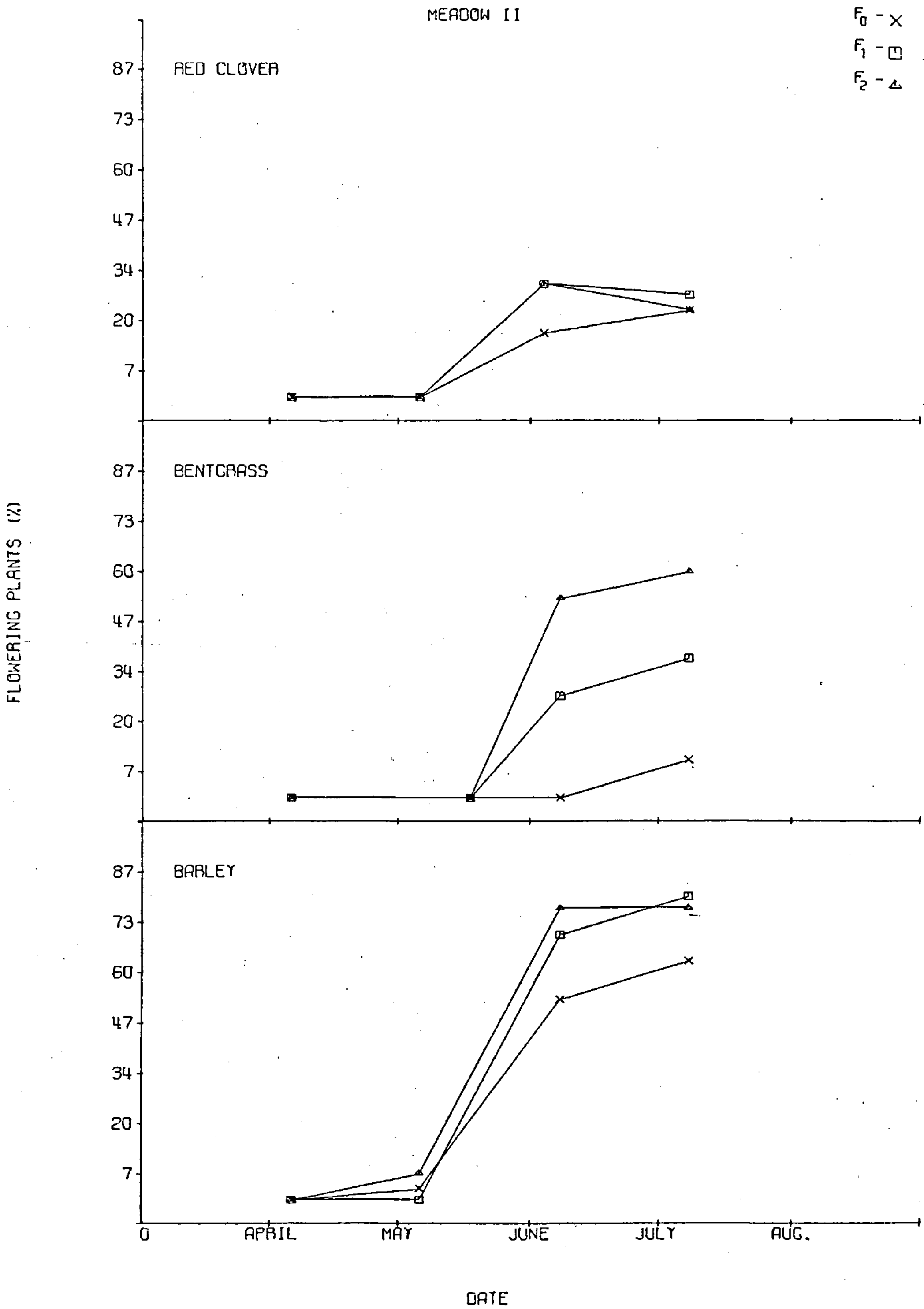

Figure 41. Percent flowering plants of red clover, Oregon bentgrass, and barley in monotypic plots during the summer months of 1977

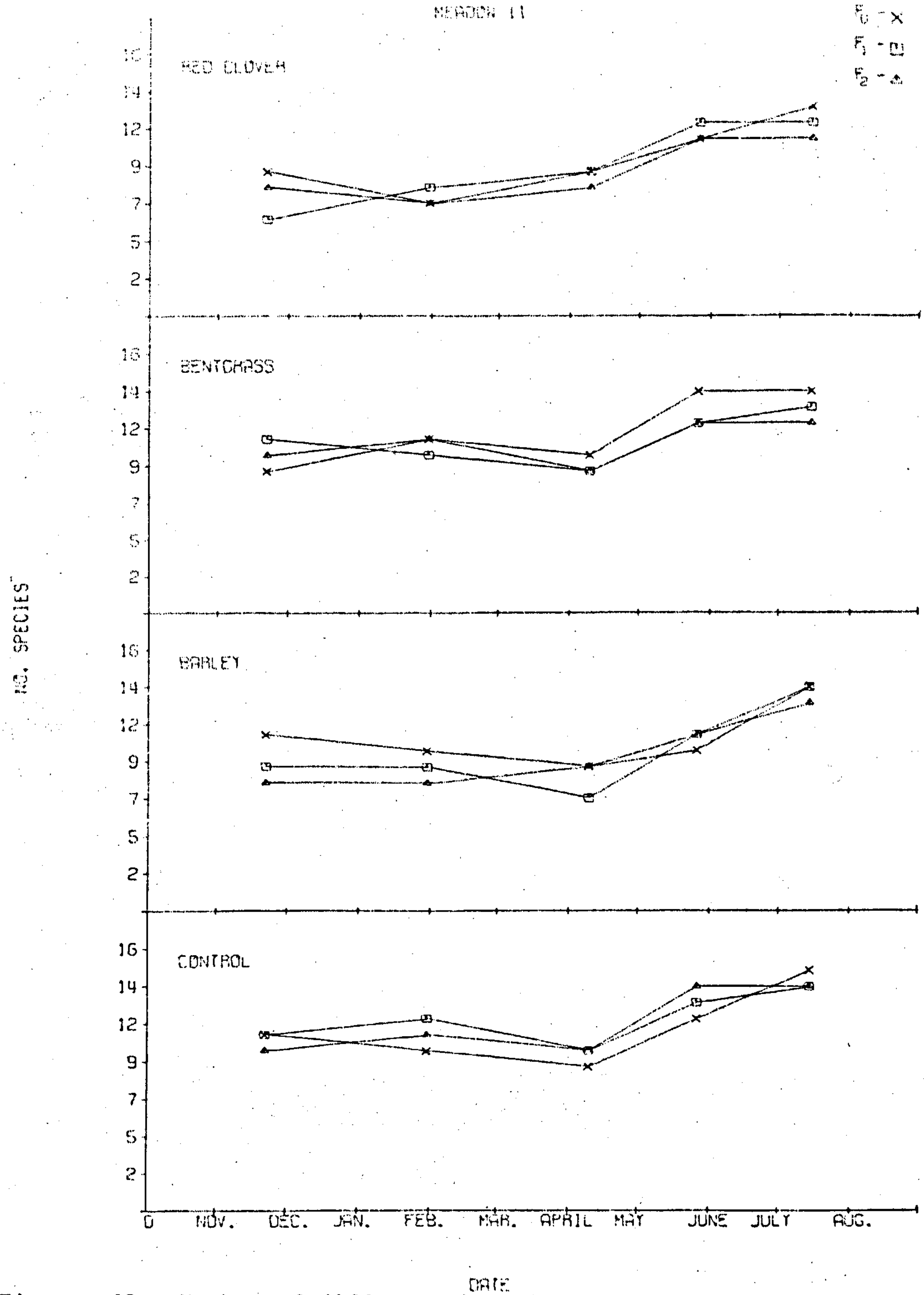

Figure 42. Number of different invading species in red clover, Oregon bentgrass, barley, and control plots between November 1976 and August 1977

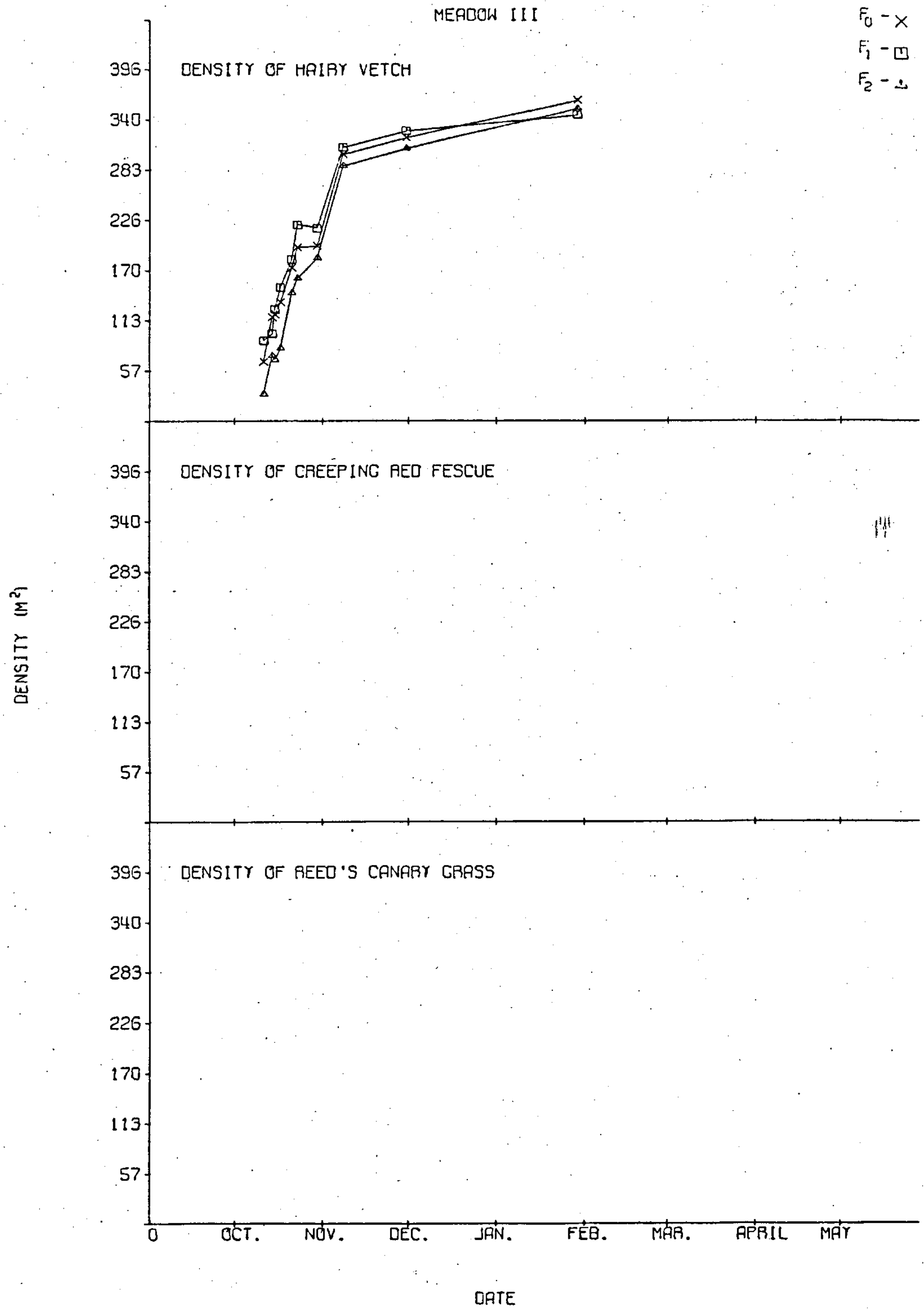

Figure 43. Plant density of hairy vetch in monotypic plots during 1976 and 1977

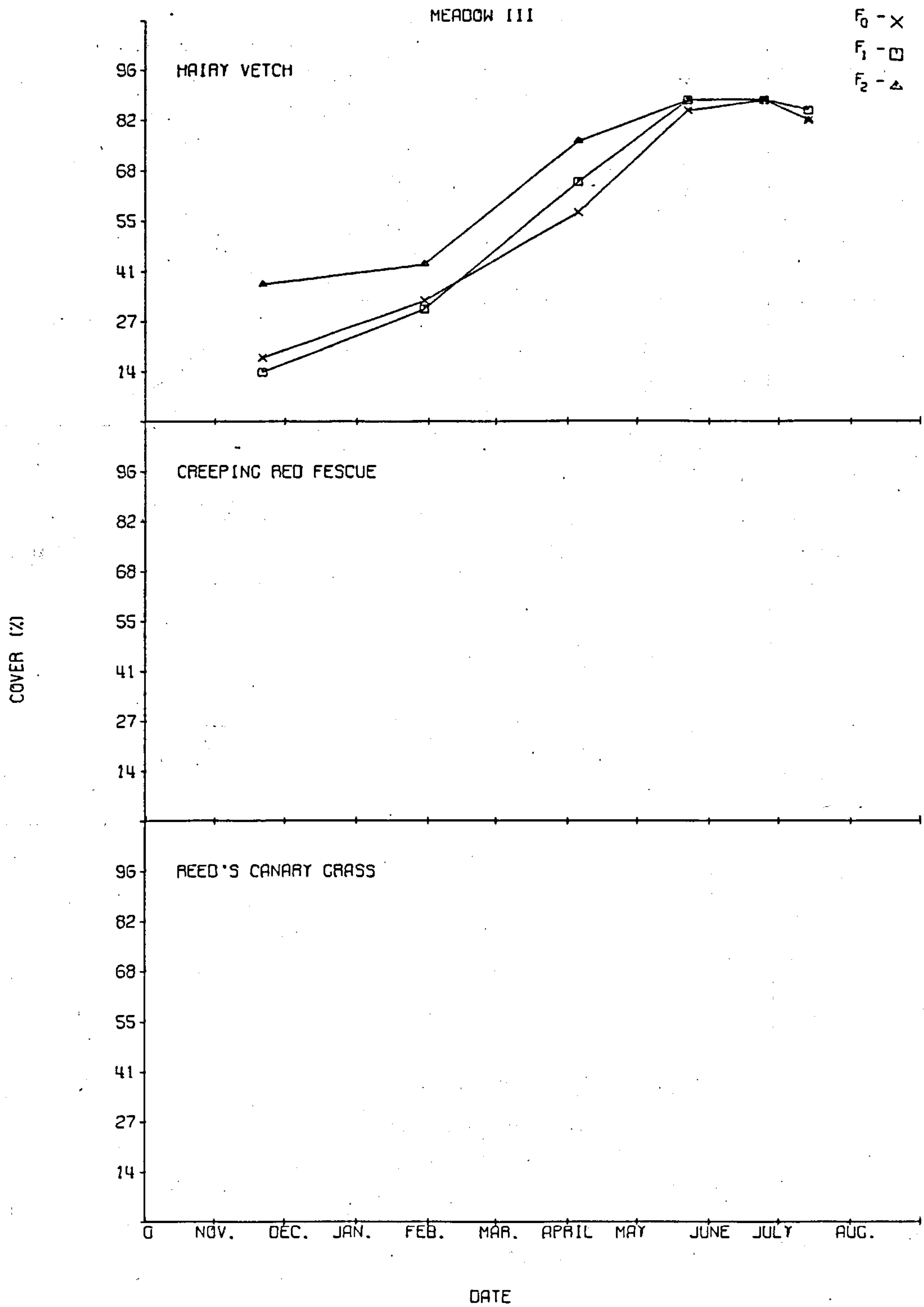

Figure 44. Percent of ground covered by hairy vetch in monotypic plot between November 1976 and August 1977

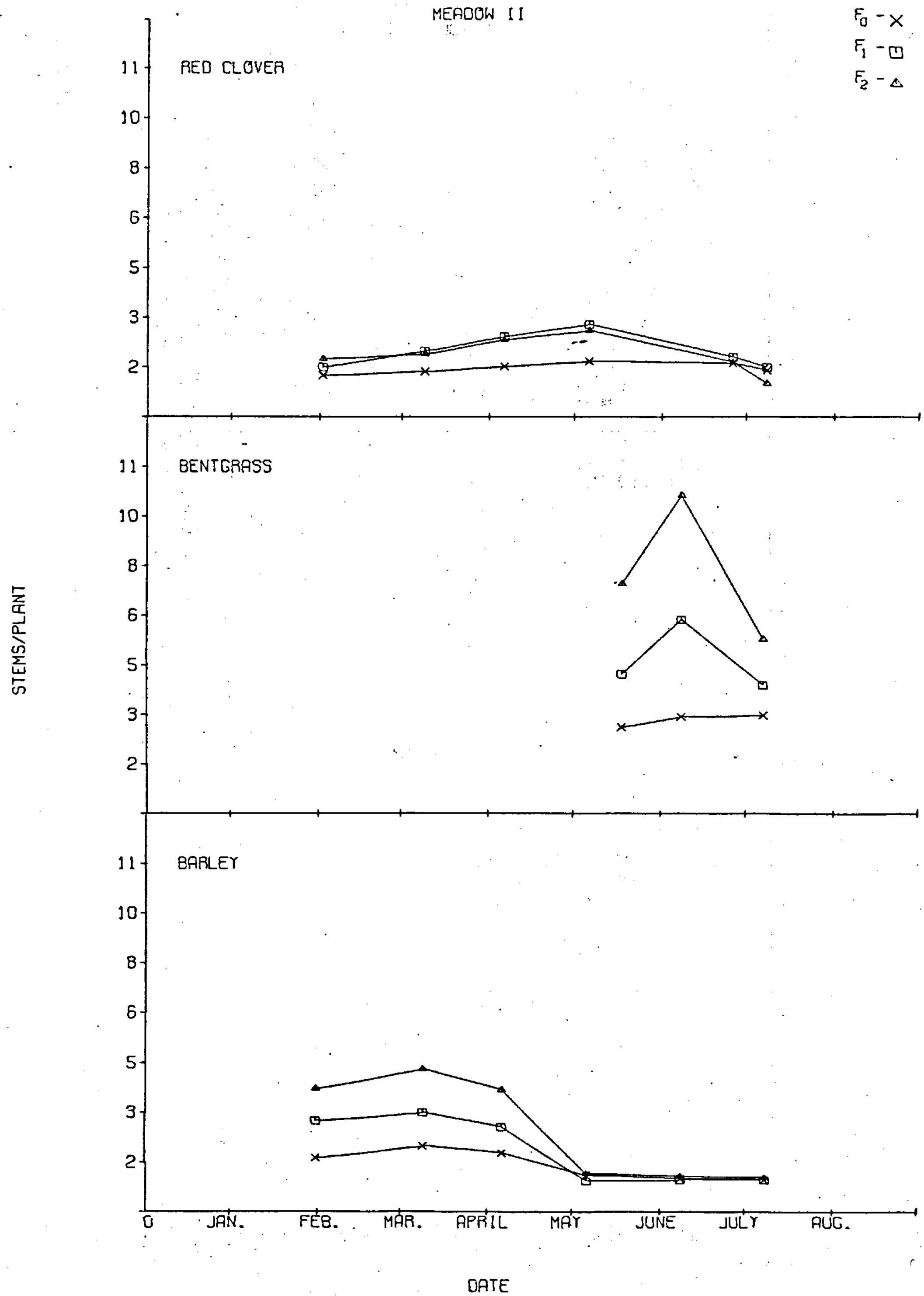

Figure 45. Average number of stems per plant of hairy vetch in the monotypic plot during 1977

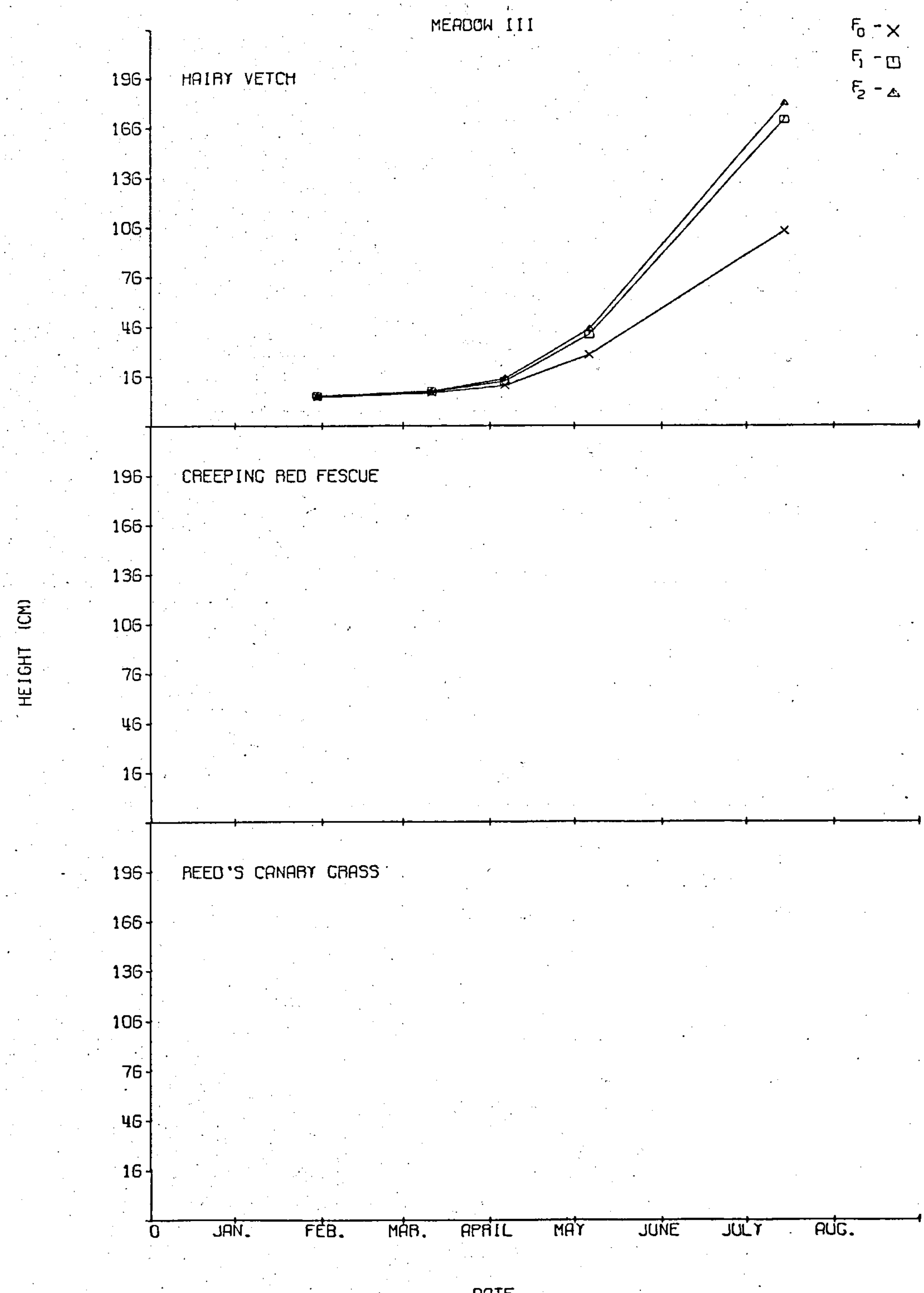

Figure 46. Plant height of hairy vetch in the monotypic plot during January 1977

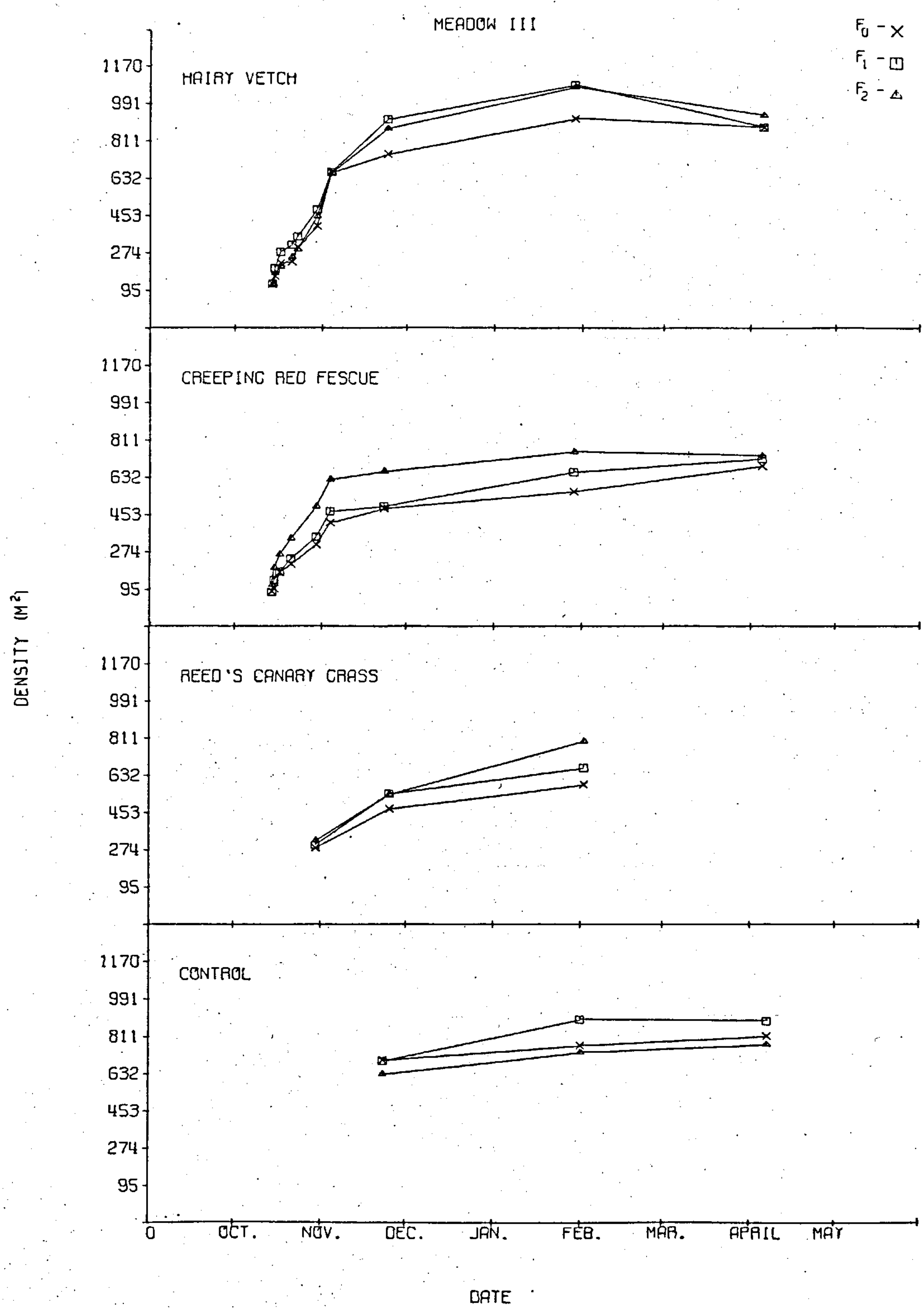

Figure 47. Total plant density of all invading and seeded species in monotypic plots of Meadow III between October 1976 and May 1977

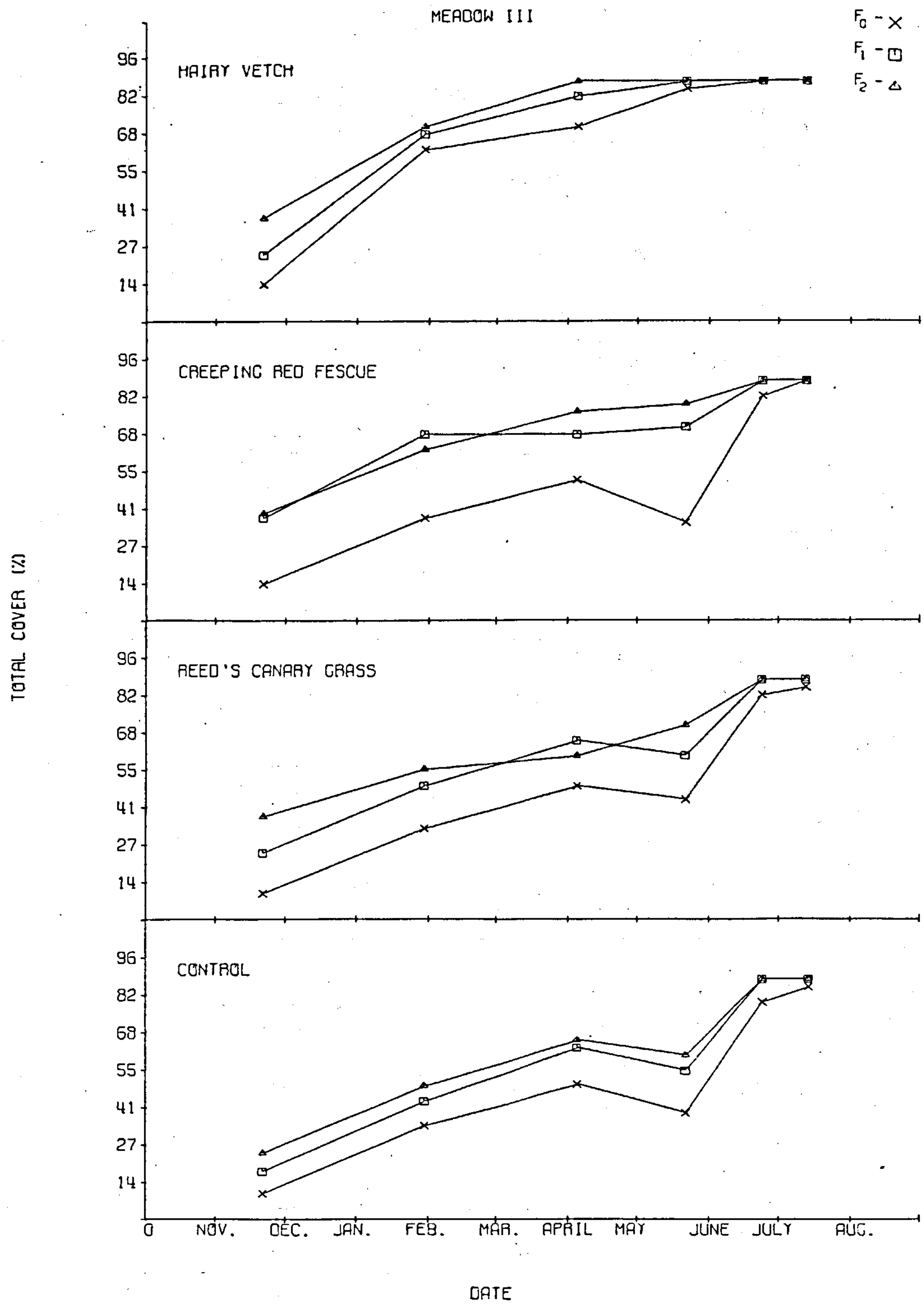

Figure 48. Percent total cover of all invading and seeded species in monotypic plots of Meadow III between November 1976 and August 1977

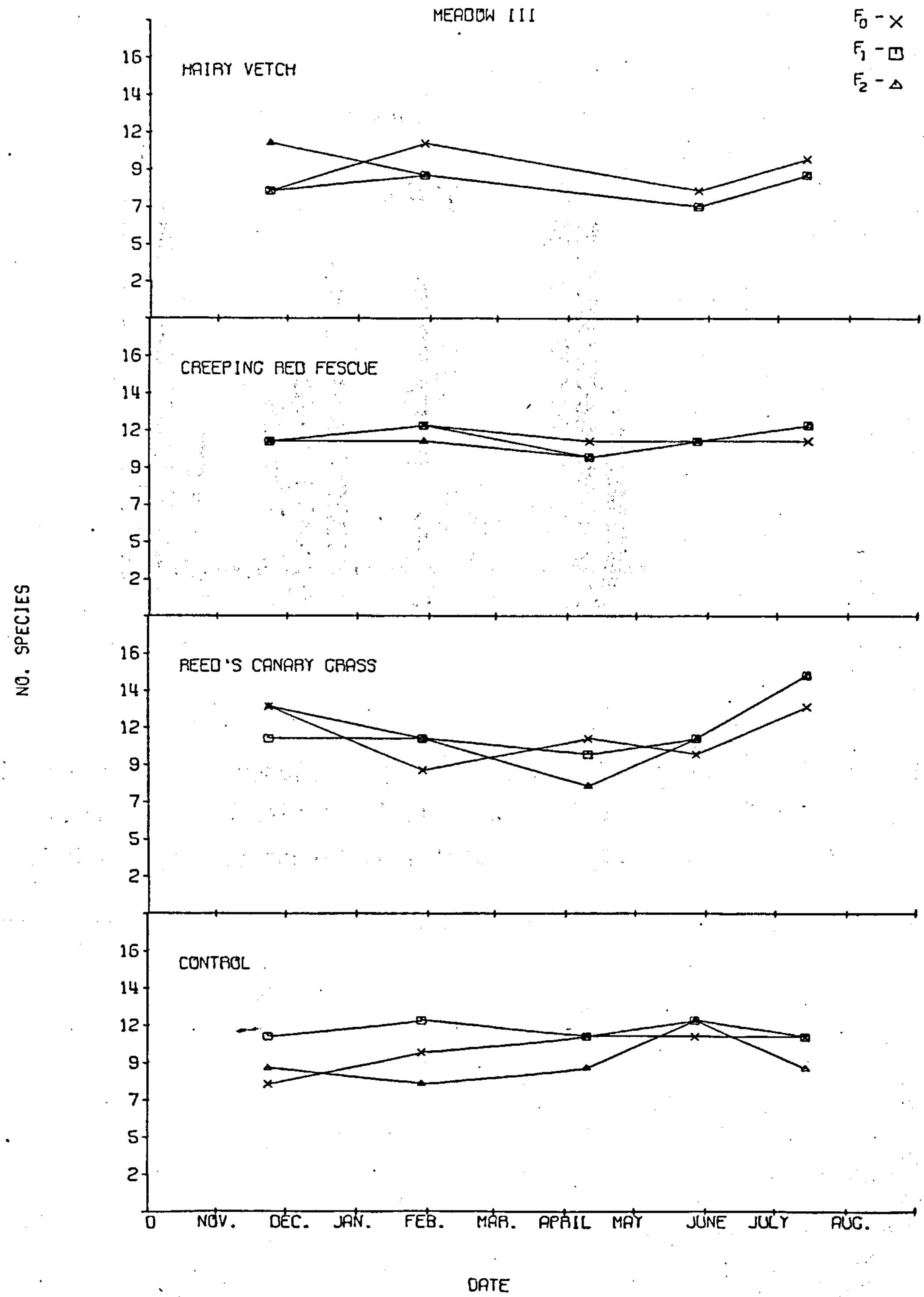

Figure 49. Number of different invading species in monotypic plots of Meadow III between November 1976 and August 1977

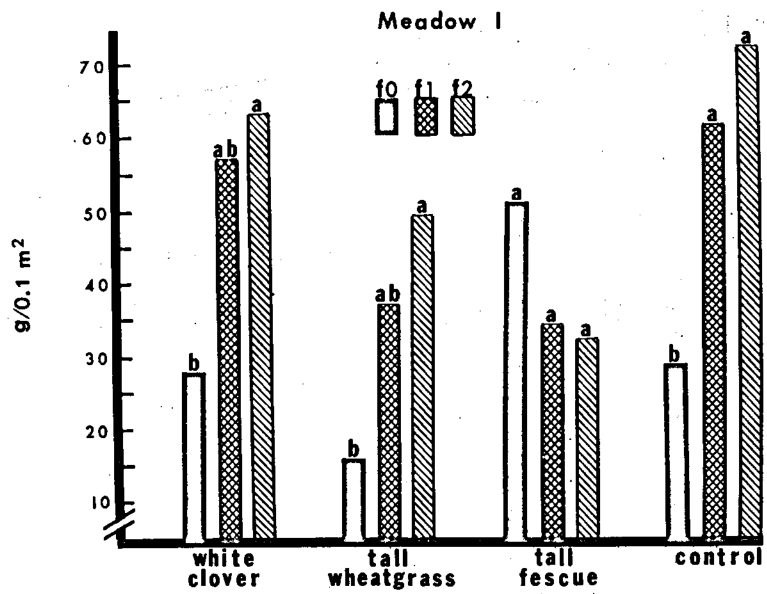

Figure 50. Biomass of plants (including invaders) in monotypic plots of Meadow I in July 1977. Means within species not accompanied by the same letter are significantly different (p=0.05) by DMRT

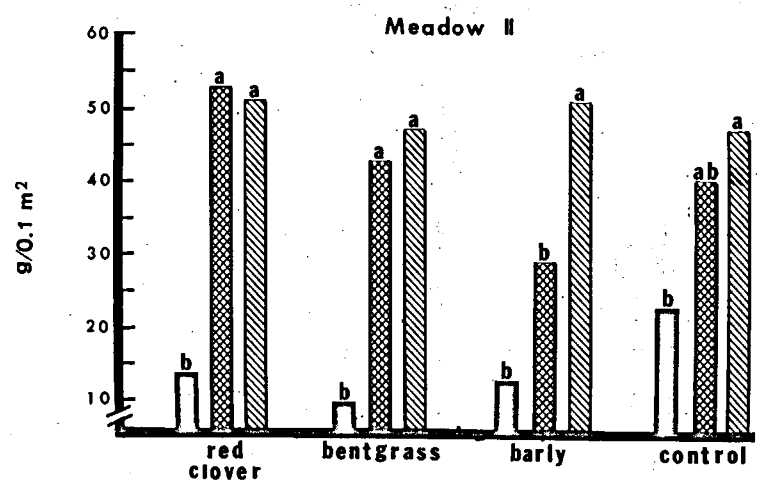

Figure 51. Biomass of plants (including invaders) in monotypic plots of Meadow II in July 1977. Means within species not accompanied by the same letter are significantly different (p=0.05) by DMRT.

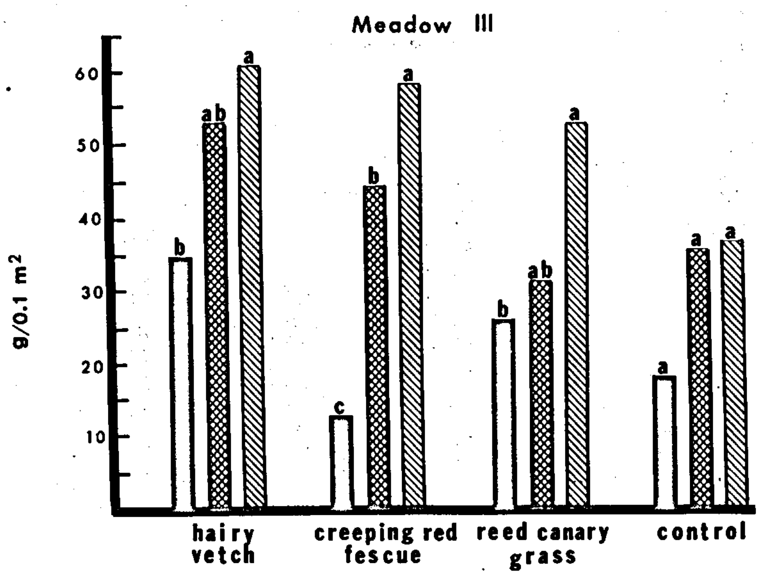

Figure 52. Biomass of plants (including invaders) in monotypic plots of Meadow III in July 1977. Means within species not accompanied by the same letter are significantly different (p=0.05) by DMRT

Table 1

Monotypic Plot Study Variables

Variable	Description
Plant species	S_1 *D. cespitosa*
	S_2 *C. obnupta*
	S_3 None
Propagation method	Transplant
	Seed
Fertilizer*	F_0 None
	F_1 Fall 1220 kg/ha
	F_2 Fall 2440 kg/ha
	F_3 Fall 610 kg/ha, Spring 610 kg/ha
	F_4 Fall 1220 kg/ha, Spring 1220 kg/ha
Elevation (tier)	Upper
	Middle
	Lower

* Fertilizer applied at 10-10-10 kg/ha (the equivalent was applied as 11.7-11.7-11.7)

Table 2

Size and Biomass of Transplants (Based on Random Samples of 20 Plants)

Description	D. cespitosa		C. obnupta		C. lyngbyei*		J. effusus*	
	x̄	SE	x̄	SE	x̄	SE	x̄	SE
Marsh Monotypic Plots								
Root length (cm)	10.7	±0.05	10.6	±0.6				
Shoot length (cm)	42.3	±1.2	54.5	±1.9				
No. tillers	6.0	±0.4	2.0	±0.3				
Total fresh wt. (gm)	14.0	±1.0	11.9	±1.1				
Total dry wt. (gm)	1.70	±0.15	4.20	±0.35				
Root dry wt. (gm)	0.29	±0.04	0.77	±0.03				
Shoot dry wt. (gm)	1.40	±0.01	3.43	±0.31				
Root:Shoot ratio	0.24	±0.03	0.25	±0.04				
Intertidal Mixture Planting								
Root length (cm)	11.1	±0.05	6.8	±0.03	7.5	±0.4	17.2	±0.8
Shoot length (cm)	30.1	±1.4	48.2	±2.1	43.7	±1.1	54.7	±2.3
No. tillers	5.0	±0.3	2.0	±0.1	3.0	±0.2	3.0	±0.3
Total fresh wt. (gm)	7.5	±0.5	13.3	±1.1	18.3	±1.5	12.4	±1.2
Total dry wt. (gm)	1.83	±0.52	3.55	±0.33	4.55	±0.39	1.75	±0.19
Root dry wt. (gm)	0.52	±0.05	0.53	±0.07	2.58	±0.34	0.24	±0.08
Shoot dry wt. (gm)	0.81	±0.07	3.02	±0.29	2.02	±0.16	1.33	±0.13
Root:Shoot ratio	0.70	±0.08	0.20	±0.02	1.40	±0.21	0.30	±0.04

* These two species were not planted in the marsh monotypic plots.

Table 3

Treatments on Upland Monotypic Plots

Meadow	Variable	Description
I	Plant species*	S_0 None
		S_{1-3} Listed in Table 4
II	Plant species*	S_0 None
		S_{1-3} Listed in Table 4
III	Plant species*	S_0 None
		S_{1-3} Listed in Table 4
I, II, and III	Fertilizers	F_0 None
		F_1 Fall 224 kg**, Spring 224 kg**
		F_2 Fall 448 kg**, Spring 448 kg**

* See Table 4.
** kg 10-10-10/ha (The equivalent was applied as 11.7-11.7-11.7).

Table 4

Plants and Seeding Rates Used in the Upland Nesting Meadows and the Upland Monotypic Plots

Meadow No.	Species No.	Species	Seeding Rate (kg/ha)	Seed/g	No. Seed/ m^2*	Germination %
I	1	Alta fescue (*Festuca elatior*, var. *arundinacea*)	6.3	480	302	95
	2	Tall wheatgrass (*Agropyron elongatum*)	19.2	156	299	90
	3	White clover (*Trifolium repens*), var. New Zealand	1.8	1,640	295	95
II	1	Barley (*Hordeum vulgare*), var. Scotia	106.0	28	297	95
	2	Oregon bentgrass (*Agrostis oregonensis*)	0.24	11,400	274	90
	3	Red clover (*Trifolium pratense*)	5.3	570	302	92
III	1	Reed canarygrass (*Phalaris arundinacea*)	0.30	1,000	30**	90
	2	Red fescue (*Festuca rubra*)	0.26	1,100	29**	95
	3	Hairy vetch (*Vicia villosa*)	71.0	43	305	90

* On upland monotypic plots. Approximately the same seeding rates were used on the nesting meadows except for hairy vetch, which was seeded at 150 seed/m^2.

** Contractor error - Low seed rate applied.

Table 5

Mean Annual Meterological Data by Month for Astoria Airport, 1941-1976*

	Mean Temperature								
	Daily Maximum		Mean Daily		Monthly Precipitation		Relative Humidity (16:00 hr)	Wind	
Month	°F	°C	°F	°C	in.	cm	%	Average Speed kph	Prevailing Direction
Jan	46.5	8.1	40.6	4.8	9.73	24.7	79	15.1	E
Feb	50.6	10.3	43.6	6.4	7.82	19.9	74	14.3	ESE
Mar	52.1	11.2	44.4	6.9	6.62	16.8	71	14.3	SE
Apr	55.6	13.1	47.8	8.8	4.61	11.7	69	13.8	WNW
May	60.3	15.7	52.3	11.3	2.72	6.9	70	13.5	NW
June	63.8	17.7	56.5	13.6	2.45	6.2	72	13.4	NW
July	67.7	19.8	60.0	15.6	0.96	2.4	69	13.5	NW
Aug	68.3	20.2	60.3	15.7	1.46	3.7	70	12.6	NW
Sept	67.6	19.8	58.4	14.7	2.83	7.2	69	11.9	SE
Oct	61.0	16.1	52.8	11.6	6.80	17.3	74	12.1	SE
Nov	53.4	11.9	46.5	8.1	9.78	24.8	78	13.5	SE
Dec	48.6	9.2	42.8	6.0	10.57	26.8	81	14.6	ESE
Year	58.0	14.4	50.5	10.3	66.34	168.5	73	13.5	SE

* National Oceanic and Atmospheric Administration (1976 and 1977).

Table 6

Meterological Data for Astoria Airport for June 1976 to July 1977*

		Mean Temperature								Wind	
		Daily Maximum		Mean Daily		Monthly Precipitation		Relative Humidity (16:00 hr)		Average Speed	Resultant Direction**
Year	Month	°F	°C	°F	°C	in.	cm	%	kph	
1976	June	63.2	17.3	55.9	13.3	1.27	3.2	70	14.8	27
	July	69.0	20.6	61.1	16.2	2.46	6.2	65	14.2	27
	Aug	68.0	20.0	61.7	16.5	2.55	6.5	66	12.6	26
	Sept	69.1	20.6	60.8	16.0	1.58	4.0	65	12.7	27
	Oct	61.8	16.6	53.2	11.8	2.96	7.5	72	12.1	13
	Nov	56.3	13.5	48.0	8.9	1.45	3.7	70	11.9	08
	Dec	49.9	9.9	43.5	6.4	4.20	10.7	83	12.1	12
1977	Jan	46.7	8.2	39.9	4.4	3.20	8.1	-	12.7	08
	Feb	53.3	11.8	46.8	8.2	5.22	13.2	-	14.6	14
	Mar	50.8	10.4	44.6	7.0	9.74	24.7	-	17.5	23
	Apr	56.9	13.8	48.9	9.2	1.65	4.2	-	12.2	24
	May	58.1	14.5	50.2	10.1	6.00	15.2	-	13.5	22
	June	64.5	18.1	56.8	13.4	1.36	3.5	-	13.7	28
	July	67.1	19.5	58.7	14.8	0.44	1.1	-	12.4	27

* National Oceanic and Atmospheric Administration (1976 and 1977).

** Indicated in tens of degrees from true north: i.e., 09 for east, 18 for south, 27 for west.

Table 7

Constituents in Filtered Rainwater at Long Beach, Washington, 1962 and 1963 (after Ellsworth and Moodie 1964)

Year	Constituents in Filtered Rainwater (lb/acre)								
	Na	K	Ca	Mg	NH_4-N	NO_3-N	SO_4-S	Cl	P
1962	59.0	4.3	5.5	4.6	0.5	0.1	16.4	96.1	0.08
1963	39.4	2.2	2.6	6.3	1.0	0.2	6.7	72.2	0.04

Table 8

Relationship of Elevation in the Marsh to Tier and Replication - July 1976

Tier	Elevation (ft) MLLW			
	Rep 1	Rep 2	Rep 3	Mean
Low	1.3	1.4	1.5	1.4
Middle	4.2	3.8	3.1	3.7
High	6.2	6.1	5.9	6.1
Mean	3.9	3.7	3.5	3.7

Table 9

Depth of Sand Accumulation in Upper Tier Transplant Plots - December 1976

Fertilizer Treatment	Depth (cm)							
	Deschampsia				Carex			
	Rep 1	Rep 2	Rep 3	$\bar{x}$	Rep 1	Rep 2	Rep 3	$\bar{x}$
F_0	10	9	3	7	15	15	7	12
F_1	13	22	0	12	20	9	9	13
F_2	9	26	8	14	19	17	0	12
F_3	3	14	18	12	10	13	2	8
F_4	8	7	3	6	12	15	12	13
Mean	9	16	6	10	15	14	6	12

Table 10

Particle-Size Distribution at the Beginning of the Marsh Experiment - June 1976*

Elevation and Particle Size**	Soil Depth 0 - 15 cm Rep 1	Rep 2	Rep 3	Mean	Soil Depth 15 - 30 cm Rep 1	Rep 2	Rep 3	Mean
Low								
Gravel	0.28	0.18	0.09	0.18	0.15	0.13	0.03	0.10
Very coarse sand	1.10	1.08	0.26	0.81	1.58	0.49	0.39	0.82
Coarse sand	7.94	3.91	1.51	4.45	11.74	4.27	3.17	6.39
Medium sand	20.40	11.70	7.52	13.20	26.09	15.37	9.57	17.01
Fine sand	57.82	62.78	66.46	62.35	54.34	62.61	74.62	63.86
Very fine sand	6.17	12.44	15.02	11.21	2.39	10.69	8.33	7.14
Silt	4.92	4.78	6.68	5.46	2.13	4.58	1.99	2.90
Clay	1.64	3.33	2.55	2.50	1.71	2.00	1.92	1.88
Middle								
Gravel	0.12	0.48	0.65	0.42	0.17	0.68	0.84	0.56
Very coarse sand	2.71	2.92	6.26	3.97	1.75	3.54	5.83	3.70
Coarse sand	26.63	23.35	28.14	26.04	20.80	27.02	26.14	24.65
Medium sand	47.66	40.32	34.12	40.71	43.40	43.91	32.73	40.02
Fine sand	21.30	30.89	23.71	25.30	32.42	23.92	28.29	28.22
Very fine sand	0.31	0.75	2.97	1.35	0.30	0.15	3.09	1.18
Silt	0.39	1.33	3.59	1.77	0.30	1.09	2.18	1.19
Clay	1.00	0.43	1.20	0.87	1.03	0.35	1.74	1.05

(Continued)

Table 10 (Concluded)

Elevation and Particle Size*	Soil Depth							
	0 - 15 cm				15 - 30 cm			
	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean
Upper								
Gravel	0.15	0.30	0.77	0.41	0.15	0.81	0.84	0.60
Very coarse sand	1.54	2.92	4.00	2.82	1.86	2.48	4.19	2.84
Coarse sand	18.54	24.98	28.98	24.17	19.25	25.62	32.10	25.63
Medium sand	43.27	49.17	41.88	44.80	39.32	47.05	43.44	42.93
Fine sand	34.62	21.52	22.91	26.37	35.50	23.90	19.41	26.30
Very fine sand	0.36	0.26	0.32	0.31	2.46	0.18	0.33	1.00
Silt	1.16	0.44	0.98	0.86	1.05	0.17	0.61	0.61
Clay	0.50	0.55	0.93	0.66	0.55	0.58	0.96	0.69

* Particle size distribution, except gravel, in percent of fine soil (less than 2 mm).

** Gravel - <2 mm, very coarse sand - 2.00-1.00 mm, coarse sand - 1.00-0.50 mm, medium sand - 0.50-0.25 mm, fine sand - 0.25-0.10 mm, very fine sand - 0.10-0.05 mm, silt - 0.05-0.002 mm, clay - below 0.002 mm.

Table 11

Parameters in Marsh Soils at the Beginning of the Experiment - June 1976

Parameter and Elevation	Soil Depth									
	0 - 15 cm					15 - 30 cm				
	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD
Temperature (°C)										
Low	13.6	13.6	13.6	13.6	0	13.7	13.6	13.6	13.6	0.05
Middle	12.8	13.1	13.1	13.0	0.14	13.4	13.4	13.7	13.5	0.14
Upper	13.6	13.5	13.9	13.7	0.17	13.7	13.7	13.5	13.6	0.09
Organic Carbon (%)										
Low	0.197	0.275	0.310	0.260	0.047	0.127	0.218	0.160	0.168	0.037
Middle	0.053	0.061	0.157	0.089	0.047	0.055	0.045	0.132	0.077	0.038
Upper	0.043	0.046	0.048	0.046	0.002	0.036	0.034	0.044	0.038	0.004
pH (Soil)										
Low	6.90	6.45	6.63	6.66	0.18	6.84	6.55	6.37	6.58	0.19
Middle	7.08	7.00	6.75	6.94	0.14	7.15	7.09	6.55	6.93	0.27
Upper	7.35	7.25	7.30	7.30	0.04	7.20	7.15	7.27	7.20	1.05
Eh										
Low	317	181	143	213	75	195	157	77	143	49
Middle	215	413	545	391	136	131	311	371	271	102
Upper	647	545	539	577	50	533	533	545	537	6
Conductivity (μmhos/cm)										
Low	0.35	0.44	0.73	0.51	0.20	0.28	0.48	0.41	0.39	0.10
Middle	0.25	0.25	0.45	0.32	0.10	0.20	0.17	0.29	0.22	0.06
Upper	0.22	0.20	0.25	0.22	0.03	0.17	0.15	0.11	0.14	0.03
Cation Exchange Capacity (meq/100 g)										
Low	5.00	6.86	6.86	6.24	0.88	3.91	6.22	5.90	5.34	1.02
Middle	3.72	3.32	4.34	3.79	0.42	3.62	3.82	4.51	3.98	0.38
Upper	2.96	2.93	3.15	3.01	0.10	2.96	2.91	3.26	3.04	0.15

(Continued)

Table 11 (Continued)

Parameter and Elevation	Soil Depth									
	0 - 15 cm					15 - 30 cm				
	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD
Exchangeable K (meq/100 g)										
Low	0.14	0.17	0.15	0.15	0.01	0.13	0.15	0.12	0.13	0.01
Middle	0.11	0.12	0.15	0.13	0.02	0.12	0.11	0.13	0.12	0.01
Upper	0.11	0.11	0.13	0.12	0.01	0.10	0.11	0.12	0.11	0.01
Exchangeable Ca (meq/100 g)										
Low	4.00	4.81	4.81	4.54	0.38	3.08	4.37	3.78	3.74	0.53
Middle	2.60	3.05	3.35	3.00	0.31	2.70	2.45	2.80	2.65	0.15
Upper	2.63	2.45	3.08	2.72	0.26	2.63	2.26	2.90	2.59	0.26
Exchangeable Mg (meq/100 g)										
Low	1.14	1.48	1.46	1.36	0.15	0.95	1.35	1.21	1.17	0.16
Middle	0.76	0.78	1.08	0.87	0.15	0.81	0.76	0.84	0.80	0.03
Upper	0.78	0.74	0.84	0.79	0.04	0.78	0.69	0.84	0.77	0.06
Exchangeable Na (meq/100 g)										
Low	0.038	0.041	0.037	0.039	0.002	0.042	0.042	0.034	0.039	0.003
Middle	0.043	0.037	0.042	0.040	0.002	0.037	0.050	0.038	0.041	0.006
Upper	0.033	0.034	0.038	0.035	0.002	0.034	0.036	0.039	0.036	0.002
Kjeldahl N (ppm)										
Low	0.013	0.019	0.013	0.015	0.003	0.020	0.015	0.010	0.012	0.002
Middle	0.002	0.004	0.012	0.006	0.004	0.003	0.002	0.009	0.004	0.003
Upper	0.004	0.002	0.003	0.003	0.001	0.003	0.003	0.001	0.002	0.001
NH_4-N (ppm)										
Low	3.13	7.99	8.10	6.41	2.84	3.43	6.93	7.02	5.79	2.05
Middle	0	0.57	6.48	2.24	3.70	0.63	2.39	5.43	2.82	2.43
Upper	0	0	0	0	0	0	0	0	0	0

(Continued)

Table 11 (Concluded)

Parameter and Elevation	Soil Depth 0 - 15 cm					15 - 30 cm				
	R1	R2	R3	Mean	SD	R1	R2	R3	Mean	SD
NO_3-N (ppm)										
Low	0	0	0	0	0	0.15	0	0	0.05	0.07
Middle	0.14	0.09	0	0.08	0.06	0	0	0.28	0.09	0.13
Upper	0.39	0	1.10	0.49	0.45	1.85	0	0	1.46	1.21
P (ppm)										
Low	151	316	379	282	96	258	282	293	278	15
Middle	173	173	248	198	35	178	169	230	192	27
Upper	166	159	172	165	5	169	146	150	155	10

Table 12

Relationship of pH in the Marsh to Replications and Treatments

a. Replication Effect

Replication No.	pH September 1976	pH June 1977	pH August 1977
I	7.03 a*	7.06 a*	7.14 a*
II	6.97 a	7.03 a	7.11 a
III	6.75 b	7.02 a	7.06 a
Mean	6.92	7.03	7.11

b. Tier Effect

Elevation	September 1976	June 1977	August 1977
Low	6.67 c	6.91 b	6.99 b
Middle	6.90 b	7.06 ab	6.99 b
Upper	7.19 a	7.12 a	7.34 a

c. Fertilizer Effect

Fertilizer Treatment	September 1976	June 1977	August 1977
F0	7.01 a	7.10 a	7.22 a
F1	6.86 b	6.99 b	7.09 ab
F2	6.88 b	7.01 ab	7.12 ab
F3	6.89 b	7.05 ab	7.10 ab
F4	6.95 ab	7.02 ab	7.00 b

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Tukey's Multiple Range Test for the September 1976 data and Duncan's Multiple Range Test for the 1977 data.

Table 13

Relationship of Exchangeable K in the Marsh to Replications and Treatments

a. Replication and Tier Effect

Elevation	Exchangeable K (meq/100 g) Rep I	Rep II	Rep III	Mean
	September 1976 Sampling			
Low	0.134	0.155	0.174	0.154 a*
Middle	0.129	0.118	0.135	0.128 b
Upper	0.108	0.132	0.133	0.124 b
Mean	0.124 b	0.135 ab	0.147 a	0.135
	June 1977 Sampling			
Low	0.154 b	0.169 b	0.192 a	0.171 a
Middle	0.140 a	0.141 a	0.161 a	0.148 b
Upper	0.132 a	0.137 a	0.141 a	0.137 b
Mean	0.142 a	0.150 a	0.163 a	0.151
	August 1977 Sampling			
Low	0.140 c	0.155 b	0.174 a	0.156 a
Middle	0.124 ab	0.113 b	0.133 a	0.123 b
Upper	0.101 a	0.103 a	0.112 a	0.105 b
Mean	0.122 a	0.124 a	0.139 a	0.128

b. Fertilizer Effect

Fertilizer Treatment	Mean Exchangeable K (meq/100 g) September 1976	June 1977	August 1977
F0	0.113 c	0.132 b	0.119 b
F1	0.137 b	0.152 ab	0.128 ab
F2	0.160 a	0.164 a	0.131 ab
F3	0.132 b	0.152 ab	0.126 ab
F4	0.134 b	0.157 a	0.134 a

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 14

Relationship of Available P in the Marsh Experiment to Replication and Treatments

a. Replication and Tier Effect

Elevation	Available P (ppm) Rep I	Rep II	Rep III	Mean
	September 1976 Sampling			
Low	240	167	221	209 a*
Middle	191	199	229	206 a
Upper	83	166	164	138 b
Mean	171 c	177 a	204 a	184
	June 1977 Sampling			
Low	138 b	153 ab	168 a	152 a
Middle	96 b	100 b	127 a	107 b
Upper	67 ab	64 b	78 a	70 c
Mean	100 b	105 ab	123 a	109
	August 1977 Sampling			
Low	164 c	183 b	202 a	182 a
Middle	104 b	107 b	142 a	118 b
Upper	109 a	105 a	108 a	108 b
Mean	126 a	132 a	149 a	135

b. Fertilizer Effect

Fertilizer Treatment	Mean Available P (ppm) September 1976	June 1977	August 1977
F0	187 a	107 ab	103 b
F1	184 a	118 a	103 b
F2	182 a	104 ab	109 ab
F3	181 a	103 b	112 a
F4	188 a	114 ab	111 a

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 15

Relationship of Ammonium N in the Substrate in the Marsh Experiment to Replication and Treatments

a. Replication and Tier Effects

Elevation	NH_4-N (ppm) Rep I	Rep II	Rep III	Mean
	September 1976 Sampling			
Low	10.11	11.25	13.17	11.51 a*
Middle	11.05	9.47	12.80	11.11 a
High	4.69	10.52	8.48	7.90 a
Mean	8.62 a	10.41 a	11.48 a	10.17
	June 1977 Sampling			
Low	10.35 b	10.89 b	13.68 a	11.57 a
Middle	6.03 a	7.96 a	11.48 a	8.49 b
Upper	4.40 a	3.90 a	5.83 a	4.71 c
Mean	6.93 b	7.58 ab	10.21 a	8.22
	August 1977 Sampling			
Low	10.57 b	10.90 b	14.01 a	11.76 a
Middle	4.68 b	7.76 b	14.55 a	9.00 a
Upper	2.24 a	2.38 a	4.11 a	2.91 b
Mean	5.83 a	7.02 a	10.78 a	7.84

b. Fertilizer Effect

Fertilizer Treatment	Mean NH_4-N (ppm) September 1976	June 1977	August 1977
F0	5.67 c	5.55 b	6.47 a
F1	10.99 b	8.52 ab	7.95 a
F2	17.82 a	12.27 a	7.98 a
F3	6.20 c	7.18 b	7.04 a
F4	10.18 b	7.48 b	9.72 a

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 16

Relationship of Kjeldahl N in Substrate in the Marsh Experiment to Replication and Treatments

a. Replication and Tier Effect

Elevation	Kjeldahl N (Percent) Rep I	Rep II	Rep III	Mean
	September 1976 Sampling			
Low	0.0163	0.0201	0.0248	0.0204 a*
Middle	0.0048	0.0057	0.0149	0.0085 b
Upper	0.0034	0.0039	0.0044	0.0039 c
Mean	0.0082 b	0.0099 b	0.0147 a	0.0109
	June 1977 Sampling			
Low	0.0164 b	0.0191 b	0.0234 a	0.0195 a
Middle	0.0043 b	0.0060 b	0.0132 a	0.0079 b
Upper	0.0038 a	0.0033 b	0.0039 a	0.0037 b
Mean	0.0082 a	0.0095 a	0.0132 a	0.0102
	August 1977 Sampling			
Low	0.0182 b	0.0212 b	0.0248 a	0.0213 a
Middle	0.0058 b	0.0063 b	0.0131 a	0.0084 b
Upper	0.0036 a	0.0038 a	0.0046 a	0.0040 b
Mean	0.0092 a	0.0105 a	0.0138 a	0.0111

b. Fertilizer Effect

Fertilizer Treatment	Mean Kjeldahl N (Percent) September 1976	June 1977	August 1977
F0	0.0098 b	0.0099 a	0.0108 a
F1	0.0124 a	0.0114 a	0.0128 a
F2	0.0114 ab	0.0097 a	0.0106 a
F3	0.0107 ab	0.0095 a	0.0103 a
F4	0.0104 b	0.0106 a	0.0111 a

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 17

Relationship of Nitrate N in the Substrate in the Marsh Experiment to Replication and Treatments

a. Replication and Tier Effects

Elevation	NO_3-N (ppm) Rep I	Rep II	Rep III	Mean
	September 1976 Sampling			
Low	0.368	0.142	0.306	0.272 a*
Middle	0.572	0.166	0.252	0.330 a
Upper	0.447	0.689	0.468	0.535 a
Mean	0.462 a	0.332 a	0.342 a	0.379
	June 1977 Sampling			
Low	0.896 a	0.386 b	0.623 b	0.636 a
Middle	1.097 a	0.497 b	0.334 b	0.643 a
Upper	0.867 a	0.571 a	0.802 a	0.747 a
Mean	0.953 a	0.485 b	0.585 ab	0.675
	August 1977 Sampling			
Low	0.503 a	0.541 a	0.610 a	0.549 b
Middle	0.976 a	0.811 a	0.737 a	0.841 a
Upper	1.190 a	0.984 a	0.965 a	1.046 a
Mean	0.890 a	0.808 a	0.747 a	0.815

b. Fertilizer Effect

Treatment	Mean NO_3-N (ppm) September 1976	June 1977	August 1977
F0	0.253 a	0.509 a	0.718 bc
F1	0.416 a	0.672 a	0.609 c
F2	0.463 a	0.756 a	0.670 bc
F3	0.300 a	0.718 a	0.973 ab
F4	0.462 a	0.720 a	1.110 a

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 18

Relationship of Carbon in Substrate in the Marsh Experiment to Replication and Treatments

a. Replication and Tier Effects - August 1977

Elevation	Carbon Percent Rep I	Rep II	Rep III	Mean
Low	0.240 c	0.328 b	0.400 b	0.320 a*
Middle	0.058 b	0.059 b	0.150 a	0.089 b
Upper	0.044 a	0.041 a	0.048 a	0.044 b
Mean	0.114 a	0.143 a	0.192 a	0.149

b. Fertilizer Effect - August 1977

Fertilizer Treatment	Mean Carbon Percent
F0	0.173 a
F1	0.159 ab
F2	0.144 ab
F3	0.125 b
F4	0.143 ab

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 19

Relationship of CEC in the Marsh Experiment to Replication and Treatments

a. Replication and Tier Effect - August 1977

	CEC (meq/100 g)			
Elevation	Rep I	Rep II	Rep III	Mean
Low	5.09 c	5.85 b	6.76 a	5.87 a*
Middle	3.35 b	3.35 b	4.42 a	3.71 b
Upper	3.48 a	3.26 b	3.39 ab	3.38 b
Mean	3.97 a	4.16 a	4.79 a	4.30

b. Fertilizer Effect - August 1977

Fertilizer Treatment	Mean CEC (meq/100 g)
F0	4.30 a
F1	4.56 a
F2	4.21 a
F3	4.20 a
F4	4.23 a

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 20

Relationship of Substrate Moisture in the Marsh Experiment to Tier and Replication

Elevation	Moisture Content (Percent) Rep I	Rep II	Rep III	Mean
	September 1976 Sampling			
Low	25.48	27.18	30.29	27.65
Middle	22.68	23.33	25.29	23.77 ab
Upper	18.12	17.99	20.05	18.72 b
Mean	22.09 b	22.83 b	25.21 a	23.38
	June 1977 Sampling			
Low	21.81 b	27.66 b	30.47 a	28.24 a
Middle	25.15 a	24.82 a	25.84 a	25.27 b
Upper	24.53 a	23.60 a	23.53 a	23.89 b
Mean	25.50 a	25.36 a	26.48 a	25.77
	August 1977 Sampling			
Low	29.99 b	30.87 b	34.48 a	31.68 a
Middle	24.98 b	25.52 b	27.37 a	25.96 b
Upper	14.20 a	14.79 a	16.61 a	15.20 c
Mean	23.06 b	23.73 ab	25.86 a	24.20

* Means and values in lines not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 21

Effect of Plants on Ammonium Levels in the Marsh Substrate

Elevation	Ammonium N Levels (ppm) Transplant Plots	No Plant Plots	Significance of Difference
	September 1976		
Low	11.2	11.6	N.S.
Middle	9.3	12.0	N.S.
Upper	5.0	9.3	*
Mean	8.5	11.0	*
	June 1977		
Low	11.8	11.4	N.S.
Middle	6.3	9.6	N.S.
Upper	1.4	6.3	**
Mean	6.5	9.1	*
	August 1977		
Low	12.6	11.3	N.S.
Middle	6.0	10.5	**
Upper	1.6	3.6	*
Mean	6.7	8.4	*

* Means are significantly different at p=0.05.
** Means are significantly different at p=0.01.
N.S. Not significant.

Table 22

Effect of Plants on Nitrate Levels in Marsh Monotypic Plots

Elevation	Nitrate-N Levels (ppm) Transplant Plots	No Plant Plots	Significance of Difference
	September 1976		
Low	0.208	0.304	N.S.
Middle	0.286	0.351	N.S.
Upper	0.420	0.592	N.S.
Mean	0.305	0.416	N.S.
	June 1977		
Low	0.684	0.611	N.S.
Middle	0.394	0.767	*
Upper	0.340	0.940	**
Mean	0.477	0.775	**
	August 1977		
Low	0.471	0.588	N.S.
Middle	0.645	0.939	N.S.
Upper	0.688	1.226	*
Mean	0.603	0.921	**

* Means are significantly different at p=0.05.
** Means are significantly different at p=0.01.
N.S. Not significant.

Table 23

Effect of Plots on K Levels in the Marsh Substrate

Elevation	Exchangeable K (meq/100 g) Transplant Plots	No Plant Plots	Significance of Difference
	September 1976		
Low	0.160	0.151	N.S.
Middle	0.121	0.131	N.S.
Upper	0.122	0.126	N.S.
Mean	0.134	0.136	N.S.
	June 1977		
Low	0.172	0.171	N.S.
Middle	0.135	0.154	*
Upper	0.118	0.146	*
Mean	0.141	0.157	**
	August 1977		
Low	0.157	0.156	N.S.
Middle	0.114	0.128	*
Upper	0.091	0.112	***
Mean	0.120	0.132	**

* Means are significantly different at p=0.05.
** Means are significantly different at p=0.01.
*** Means are significantly different at $p \leq 0.001$.
N.S. Not significant.

Table 24

Changes in Fertility Levels in the Marsh Substrate

Sampling Date	Low	Middle	Upper	Mean
	Elevation			
		NH_4-N (ppm)		
August 1976	11.5 a*	11.1 a	7.9 a	10.2 a
June 1977	11.6 a	8.5 a	4.7 ab	8.2 b
August 1977	11.8 a	9.0 a	2.9 b	7.8 b
		NO_3-N (ppm)		
August 1976	0.27 b	0.33 b	0.54 a	0.38 b
June 1977	0.64 a	0.64 ab	0.75 ab	0.68 a
August 1977	0.55 ab	0.84 a	1.05 a	0.82 a
		Oxalate Available P (ppm)		
August 1976	209 a	207 a	138 a	184 a
June 1977	182 a	107 c	70 b	109 c
August 1977	152 a	118 b	108 ab	135 b
		Exchangeable K (meq/100 g)		
August 1976	0.154 b	0.128 b	0.124 a	0.135 b
June 1977	0.171 a	0.148 a	0.137 a	0.151 a
August 1977	0.156 b	0.123 b	0.105 b	0.128 c

* Means in vertical sequence not followed by the same letter are significantly different according to DMRT.

Table 25

Measurements of Soil Parameters in Cage-Quadrat Locations in the Intertidal Area at the End of the 1977 Growing Season

Parameter and Elevation	Cage (Inside)	Quadrat (Outside)	Mean
Kjeldahl N (%)			
Lower*	0.006 a ††	0.017 a	0.011 a
Middle**	0.005 a	0.006 a	0.005 a
Upper†	0.004 a	0.004 a	0.004 a
Mean	0.005 a	0.009 a	0.007
NH_4-N (ppm)			
Lower	13.15 a	14.50 a	13.83 a
Middle	1.83 a	1.74 a	1.78 a
Upper	1.71 a	1.26 a	1.48 a
Mean	5.56 a	5.83 a	5.70
NO_3-N (ppm)			
Lower	1.10 a	1.31 a	1.21 a
Middle	0.97 a	1.08 a	1.02 a
Upper	1.23 a	0.95 a	1.09 a
Mean	1.10 a	1.11 a	1.11
P (ppm)			
Lower	193 a	173 a	183 a
Middle	92 a	98 a	95 b
Upper	88 a	99 a	93 b
Mean	124 a	123 a	124
Exchangeable K (ppm)			
Lower	0.18 a	0.16 a	0.17 a
Middle	0.10 a	0.09 a	0.09 a
Upper	0.10 a	0.11 a	0.10 a
Mean	0.12 a	0.12 a	0.12

(Continued)

Table 25 (Concluded)

Parameter and Elevation	Cage (Inside)	Quadrat (Outside)	Mean
pH			
Lower	6.95 a	7.27 a	7.11 a
Middle	7.15 a	7.17 a	7.16 a
Upper	7.46 a	7.42 a	7.44 a
Mean	7.19 a	7.23 a	7.24
Moisture (%)			
Lower	35.05 a	35.15 a	36.10 a
Middle	25.82 a	26.43 a	26.12 b
Upper	25.62 a	23.51 a	24.57 b
Mean	29.50 a	28.36 a	28.93
Organic C (%)			
Lower	0.31 a	0.21 a	0.26 a
Middle	0.04 a	0.03 a	0.04 b
Upper	0.03 a	0.03 a	0.03 b
Mean	0.13 a	0.09 a	0.11
CEC (meq/100 g)			
Lower	5.98 a	5.15 a	5.57 a
Middle	2.98 a	2.98 a	2.98 a
Upper	3.30 a	3.21 a	3.26 a
Mean	4.09 a	3.78 a	3.93

* Lower elevation measureu 71.3 cm above mllw.
** Middle elevation measured 135.6 cm above mllw.
† Upper elevation measured 186.2 cm above mllw.
†† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 26

Measurements of Soil Parameters at Three Elevation Levels in the Marsh Reference Area at the End of the 1977 Growing Season

Parameter	Elevation and Soil Measurements			
	Lower*	Middle**	Upper†	Mean
Kjeldahl N (%)	0.025 a††	0.016 a	0.028 a	0.023
NH_4-N (ppm)	5.67 a	2.71 b	2.21 b	3.53
NO_3-N (ppm)	1.01 ab	0.75 b	1.21 a	0.99
P (ppm)	243 a	166 c	201 b	203
K (meq/100 g)	0.14 a	0.09 a	0.08 a	0.10
pH	6.53 a	6.74 a	6.28 a	6.51
Moisture (%)	34.54 ab	30.94 b	38.70 a	34.72
Organic C (%)	0.36 a	0.18 b	0.32 ab	0.29
CEC (meq/100 g)	6.94 a	4.95 b	6.42 ab	6.10

* Mean elevation - 80.5 cm above mllw.
** Mean elevation - 140.5 cm above mllw.
† Mean elevation - 160.6 cm above mllw.
†† Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 27

Measurements of Soil Parameters at Three Elevation Levels in the Unvegetated Reference Area at the End of the 1977 Growing Season

Parameter	Elevation and Soil Measurements			
	Lower*	Middle**	Upper†	Mean
Kjeldahl N	0.021 a††	0.007 b	0.005 b	0.011
NH_4-N (ppm)	15.16 a	2.62 b	0.50 b	6.09
NO_3-N (ppm)	1.15 a	0.98 a	1.80 a	1.31
P (ppm)	184 a	93 b	88 b	122
K (meq/100 g)	0.11 a	0.11 a	0.11 a	0.11
pH	6.87 c	7.07 b	7.42 a	7.12
Moisture (%)	31.12 a	27.09 b	30.07 a	29.43
Organic C (%)	0.18 a	0.05 b	0.04 b	0.09
CEC (meq/100 g)	4.88 a	3.91 a	3.74 a	4.17

* Mean elevation - 52.1 cm above mllw.
** Mean elevation - 132 cm above mllw.
† Mean elevation - 158.2 cm above mllw.
†† Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 28

Measurements of Soil Parameters in Two Areas of European Beachgrass at the End of the 1977 Growing Season

Parameter	Location and Soil Measurements Area A*	Area B**
Kjeldahl N (%)	0.004 a†	0.005 a
NH_4-N (ppm)	12.39 a	15.71 a
NO_3-N (ppm)	1.18 a	0.80 a
P (ppm)	87 a	90 a
K (meq/100 g)	0.08 a	0.07 a
pH	6.76 a	6.80 a
Moisture (%)	7.49 a	7.86 a
Organic C (%)	0.30 a	0.35 a
CEC (meq/100 g)	3.04 a	2.82 a

* European beachgrass in this area was planted January 1977 and fertilized with ammonium sulfate in January and April at the rate of 224 kg/ha.

** European beachgrass in this area was planted May 1977 and fertilized with ammonium sulfate in May at the rate of 448 kg/ha.

† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 29

Effect of Treatment and Tier on Cover of Marsh Plots - September 1976

Species and Plot	Elevation	Fertilizer Treatment and Percent Cover F0	F1	F2	F3	F4	Mean
D. cespitosa							
Transplant	Low	5.50	5.50	5.50	5.50	9.50	6.30
	Middle	20.17	13.50	14.33	24.17	13.50	17.13
	Upper	9.50	18.33	24.17	24.17	30.83	21.40
D. cespitosa							
Seeded	Low	0.00	0.00	0.00	0.00	0.00	0.00
	Middle	0.17	0.17	0.17	3.83	0.33	0.93
	Upper	0.33	1.83	0.50	0.50	0.33	0.70
C. obnupta							
Transplant	Low	9.50	5.50	13.50	9.50	9.50	9.50
	Middle	13.50	9.50	9.50	17.50	16.17	13.23
	Upper	20.17	24.17	20.17	24.17	13.50	20.43
C. obnupta							
Seeded	Low	0.00	0.00	0.00	0.00	0.00	0.00
	Middle	0.12	0.17	0.00	0.17	0.33	0.16
	Upper	0.33	0.33	0.00	2.17	2.17	1.00
Unplanted	Low	0.00	0.00	0.00	0.00	0.17	0.03
	Middle	0.25	1.17	0.25	0.17	1.00	0.57
	Upper	0.33	0.08	3.17	0.33	0.25	0.83

Table 30

Effect of Treatments on Total Plant Cover

a. Effect of Propagation Method and Tier

Elevation	Cover, percent			
	No Plant	Seed	Transplant	Mean
Low	0.03	0.00	7.90	2.64 a
Middle	0.57	0.55	15.18	5.43 ab
Upper	0.83	0.85	20.92	7.53 b
Mean	0.48 a	0.47 a	14.67 b*	5.21

b. Effect of Replications

Replication	Cover, percent
1	4.81 a
2	3.47 a
3	7.33 a

* Means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 31

Percent Survival of Deschampsia cespitosa Plants One Year Following Transplanting

Fertilizer Application	Elevation														
	Upper					Middle					Lower				
	R_1	R_2	R_3	$\bar{x}$	SD	R_1	R_2	R_3	$\bar{x}$	SD	R_1	R_2	R_3	$\bar{x}$	SD
F0	92	98	95	95	3	95	94	78	89	9	0	0	0	0	0
F1	96	92	97	95	2	98	97	16	70	47	0	0	0	0	0
F2	98	95	98	97	2	98	19	84	67	42	9	0	0	3	5
F3	99	98	97	98	1	98	97	84	93	8	0	0	0	0	0
F4	87	97	97	94	6	97	92	57	82	22	57	0	0	19	33
Mean	-	-	-	96		-	-	-	80		-	-	-	4	

Table 32

Effect of Treatment and Tier on Cover of Marsh Transplant Plots - August 1977

Species and Tier	Treatment and Percent Cover					
	F0	F2	F2	F3	F4	Mean
D. cespitosa						
Lower	0.00 a*	0.00 a	0.01 a	0.00 a	6.94 a	1.39 b
Middle	17.06 b	35.28 ab	23.33 ab	51.11 a	39.44 ab	32.56 a
Upper	33.61 b	44.17 b	62.50 ab	76.39 a	50.56 ab	53.44 a
Mean	16.90 c	26.48 bc	28.62 bc	42.50 a	32.32 ab	29.18
C. obnupta						
Lower	0.01 a	1.12 a	0.00 a	1.12 a	0.02 a	0.46 a
Middle	29.46 a	12.82 a	21.12 a	23.34 a	16.40 a	20.63 a
Upper	10.28 a	25.00 a	15.58 a	20.84 a	7.52 a	15.84 a
Mean	13.25 a	12.98 a	12.23 a	15.10 a	7.98 a	12.31

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 33

Effect of Treatment and Tier on Cover of Marsh Seeded Plots - August 1977

Species and Tier	Treatment and Percent Cover					
	F0	F1	F2	F3	F4	Mean
D. cespitosa						
Lower	0.00 a*	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
Middle	0.56 a	5.83 a	5.56 a	1.11 a	4.20 a	3.45 a
Upper	1.73 a	6.72 a	1.18 a	1.19 a	0.59 a	2.28 a
Mean	0.76 a	4.19 a	2.24 a	0.77 a	1.60 a	1.91
C. obnupta						
Lower	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
Middle	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
Upper	0.00 b	0.01 ab	0.01 ab	0.01 ab	0.04 a	0.01 a
Mean	0.00 a	0.00 a	0.00 a	0.00 a	0.01 a	0.00

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 34

Percent Survival of Carex obnupta Plants One Year Following Transplanting

Fertilizer Application	Elevation														
	Upper					Middle					Lower				
	R_1	R_2	R_3	$\bar{x}$	SD	R_1	R_2	R_3	$\bar{x}$	SD	R_1	R_2	R_3	$\bar{x}$	SD
F0	92	87	74	84	9	87	91	89	89	2	7	7	0	5	4
F1	86	87	91	88	3	90	66	46	67	22	69	0	0	23	40
F2	45	68	89	67	22	70	79	60	70	10	0	0	0	0	0
F3	86	72	89	82	9	93	32	84	70	33	14	15	0	10	8
F4	86	73	79	79	7	94	25	22	47	41	0	0	0	0	0
Mean	-	-	-	80		-	-	-	69		-	-	-	7	

Table 35

Effect of Fertilizer and Tier on Average Heights of D. cespitosa Transplants - September 1976

Tier	Fertilizer Treatment and Plant Height (cm)					
	F0	F1	F2	F3	F4	Mean
Lower	14 c*	16 bc	15 bc	18 ab	21 a	17 a
Middle	25 a	33 a	30 a	31 a	29 a	30 a
Upper	18 b	22 b	20 b	30 a	20 b	22 a
Mean	20 b	25 ab	23 b	29 a	23 b	24

Table 36

Effect of Fertilizer and Tier on Average Number of Leaves per Plant of D. cespitosa - September 1976

Tier	Fertilizer Treatment and Number of Leaves per Plant					
	F0	F1	F2	F3	F4	Mean
Lower	3 a*	2 a	5 a	3 a	5 a	4 a
Middle	6 a	20 a	14 a	20 a	10 a	14 a
Upper	7 b	17 ab	20 a	20 a	15 ab	16 a
Mean	6 c	15 ab	15 ab	17 a	11 bc	13

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 37

Effect of Fertilizer and Tier on Biomass Characteristics of Deschampsia cespitosa Transplants at the End of the 1976 Growing Season

Parameter and Tier	Fertilizer Treatments					
	F0	F1	F2	F3	F4	Mean
Shoot Weight (g)						
Lower	1.03 a*	1.56 a	1.33 a	1.17 a	1.58 a	1.32 b
Middle	2.38 a	3.51 a	2.76 a	3.44 a	2.10 a	2.84 ab
Upper	2.58 b	3.48 ab	4.09 ab	5.45 a	3.97 ab	3.91 a
Mean	2.00 c	2.85 ab	2.73 ab	3.35 a	2.55 bc	2.69
Root Weight (g)						
Lower	0.43 a	0.35 a	0.42 a	0.48 a	0.35 a	0.41 b
Middle	0.51 c	0.78 a	0.72 ab	0.94 a	0.42 c	0.68 ab
Upper	0.67 b	1.01 ab	0.91 ab	1.27 a	0.83 b	0.94 a
Mean	0.54 b	0.71 b	0.68 b	0.90 a	0.54 b	0.67
Total Weight (g)						
Lower	1.46 a	1.99 a	1.75 a	1.64 a	1.93 a	1.74 b
Middle	2.89 ab	4.30 a	3.48 ab	4.38 a	2.52 b	3.51 ab
Upper	3.25 b	4.49 ab	5.01 ab	6.72 a	4.80 ab	4.93 a
Mean	2.53 c	3.59 ab	3.41 ab	4.25 a	3.08 bc	3.37
Root/Shoot Ratio						
Lower	0.43 a	0.23 b	0.32 ab	0.41 a	0.24 b	0.32 a
Middle	0.21 a	0.23 a	0.27 a	0.27 a	0.21 a	0.24 a
Upper	0.28 ab	0.30 ab	0.23 ab	0.23 ab	0.21 b	0.25 a
Mean	0.31 a	0.25 ab	0.28 a	0.30 a	0.22 b	0.27

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 38

Effect of Fertilizer and Tier on Average Number of Stems Per Plant of D. cespitosa Transplants - June 1977

Tier*	Fertilizer Treatment and No. Stems Per Plant					
	F0	F1	F2	F3	F4	Mean
Middle	21.50 a**	43.75 a	41.75 a	34.33 a	30.00 a	33.00 a
Upper	18.00 b	35.00 ab	46.00 a	51.00 a	58.00 a	42.00 a
Mean	20.00 b	39.00 a	44.00 a	43.00 a	44.00 a	38.00

Table 39

Effect of Fertilizer and Tier on Average Number of Flowering Heads Per Plant of D. cespitosa Transplants - June 1977

Tier*	Fertilizer Treatment and No. Flowering Heads Per Plant					
	F0	F1	F2	F3	F4	Mean
Middle	0.00 a	0.25 a	5.13 a	0.67 a	0.00 a	0.98 a
Upper	0.50 b	2.50 ab	9.17 a	8.17 a	3.33 ab	4.73 a
Mean	0.25 c	1.60 bc	7.55 a	4.42 ab	1.67 bc	2.99

Table 40

Effect of Fertilizer and Tier on Average Shoot Weight Per Plant of D. cespitosa Transplants - June 1977

Tier*	Fertilizer Treatment and Ave. Shoot Wt. (g) Per Plant					
	F0	F1	F2	F3	F4	Mean
Middle	3.63 a	12.88 a	14.00 a	8.38 a	5.25 a	8.12 a
Upper	4.79 a	9.38 a	22.96 a	23.25 a	22.46 a	16.57 a
Mean	4.21 b	10.78 ab	19.38 a	15.81 a	13.85 a	12.64

* No plants survived in the lower tier.

** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 41

Effect of Fertilizer and Tier on Biomass Characteristics of Surviving D. cespitosa Transplants at the End of the 1977 Growing Season

Parameter and Tier*	F0	F1	F2	F3	F4	Mean
Shoot Weight (g)**						
Middle	14.79 a†	33.94 a	25.17 a	42.07 a	33.25 a	29.87 a
Upper	12.08 b	29.42 b	50.94 ab	83.21 a	47.55 ab	44.64 a
Mean	13.44 c	31.38 bc	39.75 b	62.64 a	40.40 b	37.62
Seed Weight (g)						
Middle	0.09 a	1.18 a	0.84 a	1.14 a	0.29 a	0.68 a
Upper	0.38 b	1.26 b	3.21 ab	5.56 a	2.61 ab	2.60 a
Mean	0.23 c	1.22 bc	2.19 ab	3.35 a	1.45 bc	1.69
Root Weight (g)						
Middle	2.93 b	8.84 ab	7.46 ab	10.20 a	6.45 ab	7.08 a
Upper	1.97 a	11.57 a	9.66 a	13.53 a	11.52 a	9.65 a
Mean	2.45 a	10.38 a	8.71 a	11.86 a	8.99 a	8.43
Total Weight (g)						
Middle	17.72 a	42.78 a	32.63 a	52.27 a	39.70 a	36.95 a
Upper	14.06 b	40.98 b	60.60 ab	96.74 a	59.08 ab	54.30 a
Mean	15.89 c	41.76 bc	48.46 ab	74.50 a	49.39 ab	46.04
Root/Shoot Ratio						
Middle	0.25 a	0.26 a	0.35 a	0.27 a	0.24 a	0.27 a
Upper	0.18 a	0.29 a	0.24 a	0.19 a	0.23 a	0.23 a
Mean	0.21 a	0.27 a	0.29 a	0.23 a	0.23 a	0.25

* No plants survived in the lower tier.
** Shoot weight values include weight of seeds.
† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 42

Effect of Fertilizer and Tier on Growth Characteristics of Surviving D. cespitosa Transplants at the End of the 1977 Growing Season

Parameter	Tier*	F0	F1	F2	F3	F4	Mean
Shoot Length (cm)	Middle	40 a**	51 a	44 a	50 a	47 a	46 a
	Upper	38 b	48 ab	62 a	68 a	57 ab	55 a
	Mean	39 c	49 b	54 ab	59 a	52 ab	51
No. Stems	Middle	29 b	36 ab	42 ab	60 a	56 ab	45 a
	Upper	25 b	40 ab	51 ab	64 a	46 ab	45 a
	Mean	27 c	38 bc	47 ab	62 a	51 ab	45
No. Seedheads	Middle	1 a	8 a	10 a	8 a	21 a	10 a
	Upper	3 a	11 a	18 a	19 a	14 a	13 a
	Mean	2 a	10 a	14 a	14 a	18 a	11
Root Length (cm)	Middle	11 a	12 a	10 a	13 a	11 a	11 a
	Upper	12 a	17 a	14 a	15 a	14 a	14 a
	Mean	11 a	15 a	13 a	14 a	12 a	13

* No plants survived in the lower tier.

** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 43

Effect of Fertilizer and Tier on Average Heights of C. obnupta Transplants - September 1976

Tier	Fertilizer Treatment and Plant Height (cm)					
	F0	F1	F2	F3	F4	Mean
Lower	14 a*	14 a	13 ab	10 b	16 a	13 b
Middle	20 ab	16 ab	15 b	24 ab	26 a	20 a
Upper	16 a	17 a	15 a	13 a	16 a	15 b
Mean	17 ab	16 ab	15 b	16 b	20 a	17

Table 44

Effect of Fertilizer and Tier on Average Number of Stems per Plant of C. obnupta Transplants - September 1976

Tier	Fertilizer Treatments and Number of Stems per Plant					
	F0	F1	F2	F3	F4	Mean
Lower	1.1 a*	1.6 a	1.3 a	1.4 a	1.7 a	1.4 b
Middle	2.0 a	2.2 a	1.9 a	2.2 a	2.5 a	2.1 b
Upper	2.2 a	3.0 a	3.4 a	2.6 a	4.1 a	3.0 a
Mean	2.0 b	2.4 ab	2.5 ab	2.1 ab	2.7 a	2.3

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 45

Effect of Fertilizer and Tier on Biomass Characteristics of Carex obnupta Transplants at the End of the 1976 Growing Season

Parameter and Tier	Fertilizer Treatments					
	F0	F1	F2	F3	F4	Mean
Shoot Weight (g)						
Lower	3.73 a*	2.86 a	3.76 a	2.81 a	3.49 a	3.33 a
Middle	4.76 a	3.56 a	5.04 a	5.03 a	3.24 a	4.33 a
Upper	4.25 ab	4.19 b	3.95 b	5.34 a	3.26 b	4.22 a
Mean	4.25 a	3.54 a	4.25 a	4.39 a	3.33 a	3.96
Root Weight (g)						
Lower	0.72 a	0.54 a	0.67 a	0.64 a	0.68 a	0.65 b
Middle	1.27 a	0.63 b	0.69 b	0.76 b	0.70 b	0.81 ab
Upper	0.86 ab	1.08 ab	1.01 ab	1.27 a	0.64 b	0.98 a
Mean	0.95 a	0.75 ab	0.79 ab	0.89 ab	0.68 b	0.81
Total Weight (g)						
Lower	4.45 a	3.39 a	4.43 a	3.45 a	4.17 a	3.98 a
Middle	6.03 a	4.19 a	5.73 a	5.79 a	3.94 a	5.14 a
Upper	5.11 bc	5.27 b	4.97 bc	6.71 a	3.90 c	5.19 a
Mean	5.20 a	4.29 a	5.04 a	5.32 a	4.00 a	4.77
Root/Shoot Ratio						
Lower	0.20 a	0.20 a	0.17 a	0.22 a	0.20 a	0.20 a
Middle	0.27 a	0.18 b	0.16 b	0.17 b	0.21 ab	0.20 a
Upper	0.21 a	0.28 a	0.26 a	0.23 a	0.20 a	0.24 a
Mean	0.23 a	0.22 a	0.20 a	0.21 a	0.20 a	0.21

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 46

Effect of Fertilizer and Tier on Growth Characteristics of Surviving C. obnupta Transplants at the End of the 1977 Growing Season

Parameter	Tier*	Fertilizer Treatments					
		F0	F1	F2	F3	F4	Mean
Shoot Length (cm)	Middle	37 a**	39 a	46 a	39 a	34 a	39 a
	Upper	27 a	30 a	29 a	30 a	23 a	28 a
	Mean	33 a	35 a	38 a	35 a	29 a	34
No. Stems/Plant	Middle	4 a	4 a	5 a	5 a	5 a	5 a
	Upper	4 a	6 a	7 a	4 a	5 a	5 a
	Mean	4 a	5 a	6 a	5 a	5 a	5
Root Length (cm)	Middle	23 a	15 ab	19 ab	18 ab	10 b	17 a
	Upper	16 a	22 a	24 a	21 a	18 a	20 a
	Mean	20 a	19 a	22 a	20 a	14 a	19

* No plants survived in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 47

Effect of Fertilizer and Tier on Biomass Characteristics of Surviving C. obnupta Transplants at the End of the 1977 Growing Season

Parameter and Tier *	Fertilizer Treatments					
	F0	F1	F2	F3	F4	Mean
Shoot Weight (g)**						
Middle	8.42 a††	8.19 a	11.66 a	12.11 a	11.67 a	10.42 a
Upper	3.94 a	7.51 a	15.81 a	9.39 a	3.37 a	8.23 a
Mean	6.39 a	7.85 a	13.73 a	10.85 a	7.67 a	9.36
Root Weight (g)†						
Middle	2.93 a	1.24 a	4.90 a	3.24 a	4.47 a	3.36 a
Upper	2.97 a	3.83 a	5.87 a	3.90 a	3.64 a	4.04 a
Mean	2.95 a	2.54 a	5.39 a	3.57 a	4.06 a	3.70
Total Weight (g)†						
Middle	15.85 a	7.68 a	17.75 a	11.94 a	24.25 a	14.49 a
Upper	8.58 a	10.34 a	19.35 a	13.85 a	7.15 a	11.85 a
Mean	12.22 a	9.01 a	18.55 a	12.89 a	15.70 a	13.67
Root/Shoot Ratio						
Middle	0.23 a	0.20 a	1.85 a	0.29 a	0.15 a	0.54 b
Upper	0.96 ab	0.99 ab	0.59 b	0.56 a	1.37 a	0.89 a
Mean	0.59 a	0.59 a	1.22 a	0.43 a	0.76 a	0.72

* No plants survived in the lower tier.
** Values based on 30 plants per treatment.
† Values based on three plants per treatment.
†† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 48

Effect of Treatment and Tier on Nitrogen Content in Shoot Material of Deschampsia cespitosa

Tier*	Fertilizer Treatment and Shoot Nitrogen Content					
	F0	F1	F2	F3	F4	Mean
September 1976						
			Percent N			
Low	1.50 a**	1.39 a	1.53 a	1.50 a	1.45 a	1.47 a
Middle	0.85 d	1.91 a	1.92 a	1.16 c	1.47 b	1.46 a
Upper	0.73 b	1.22 ab	1.41 a	1.16 ab	1.42 a	1.19 a
Mean	1.03 c	1.51 a	1.62 a	1.27 b	1.45 ab	1.37
			mg N/Plant			
Low	16 b	21 ab	20 ab	18 ab	23 a	20 a
Middle	20 c	66 a	53 ab	39 bc	31 c	42 a
Upper	19 b	44 ab	64 a	63 a	60 a	50 a
Mean	18 b	44 a	46 a	40 a	38 a	37
June 1977						
			Percent N			
Middle	1.77 ab	1.45 b	1.89 a	1.70 ab	2.06 a	1.77 a
Upper	1.39 a	1.26 a	1.18 a	1.42 a	1.39 a	1.33 a
Mean	1.58 ab	1.35 b	1.53 ab	1.56 ab	1.73 a	1.55
			mg N/Plant			
Middle	61 a	172 a	88 a	206 a	139 a	134 a
Upper	43 a	94 a	236 a	366 a	422 a	252 a
Mean	52 a	125 a	237 a	286 a	281 a	197
August 1977						
			Percent N			
Middle	0.87 a	1.19 a	0.82 a	0.72 a	0.91 a	0.90 a
Upper	0.76 a	0.70 ab	0.60 ab	0.55 b	0.54 b	0.63 a
Mean	0.82 a	0.95 a	0.71 a	0.63 a	0.73 a	0.77
			mg N/Plant			
Middle	121 a	176 a	141 a	263 a	295 a	199 a
Upper	92 b	190 b	302 ab	451 a	265 ab	260 a
Mean	106 d	183 cd	222 bc	357 a	280 ab	230

* No plants survived past the 1976 growing season in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 49

Effect of Treatment and Tier on Phosphorus Content in Shoot Material of Deschampsia cespitosa

Tier*	Fertilizer Treatment and Shoot Phosphorus Content					
	F0	F1	F2	F3	F4	Mean
September 1976						
			Percent P			
Low	0.26 ab**	0.28 a	0.23 ab	0.28 a	0.20 b	0.25 a
Middle	0.14 a	0.23 a	0.24 a	0.17 a	0.18 a	0.19 b
Upper	0.11 a	0.13 a	0.16 a	0.15 a	0.12 a	0.14 c
Mean	0.17 a	0.21 a	0.21 a	0.20 a	0.17 a	0.19
			mg P/Plant			
Low	3 a	4 a	3 a	3 a	3 a	3 a
Middle	3 b	8 a	6 ab	6 ab	4 b	5 a
Upper	3 b	5 ab	7 a	8 a	5 ab	6 a
Mean	3 b	6 a	6 a	6 a	4 b	5
June 1977						
			Percent P			
Middle	0.23 a	0.21 a	0.30 a	0.19 a	0.24 a	0.24 a
Upper	0.14 a	0.15 a	0.16 a	0.20 a	0.19 a	0.17 a
Mean	0.19 a	0.18 a	0.23 a	0.20 a	0.21 a	0.20
			mg P/Plant			
Middle	8 a	25 a	13 a	25 a	16 a	17 a
Upper	4 a	11 a	43 a	53 a	62 a	35 a
Mean	6 a	16 a	31 a	39 a	39 a	26
August 1977						
			Percent P			
Middle	0.10 b	0.20 a	0.13 b	0.09 b	0.11 b	0.12 a
Upper	0.09 a	0.09 a	0.08 a	0.08 a	0.07 a	0.08 a
Mean	0.09 b	0.14 a	0.10 ab	0.08 b	0.09 b	0.10
			mg P/Plant			
Middle	14 a	38 a	20 a	36 a	30 a	28 a
Upper	10 b	23 b	42 ab	64 a	37 ab	35 a
Mean	12 c	31 b	31 b	50 a	33 b	31

* No plants survived past the 1976 growing season in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 50

Effect of Treatment and Tier on Potassium Content in Shoot Material of Deschampsia cespitosa

Tier*	Fertilizer Treatment and Shoot Potassium Content					
	F0	F1	F2	F3	F4	Mean
September 1976						
			Percent K			
Low	1.13 a	1.11 a	1.18 a	1.14 a	1.20 a	1.15 a
Middle	0.99 c	1.54 a	1.38 ab	1.18 bc	1.20 bc	1.27 a
Upper	0.86 b	1.13 ab	1.42 a	1.55 a	1.41 a	1.27 a
Mean	0.99 b	1.26 a	1.33 a	1.29 a	1.27 a	1.23
			mg K/Plant			
Low	12 c	17 ab	16 abc	13 bc	19 a	15 a
Middle	23 b	56 a	39 ab	41 ab	25 b	37 a
Upper	23 c	40 bc	61 ab	85 a	55 b	53 a
Mean	19 c	38 ab	38 ab	46 a	33 b	35
June 1977						
			Percent K			
Middle	1.73 a	1.60 a	1.45 a	1.49 a	1.44 a	1.54 a
Upper	1.42 a	1.02 b	1.37 ab	1.52 a	1.38 ab	1.34 a
Mean	1.58 a	1.31 c	1.41 bc	1.50 ab	1.41 bc	1.44
			mg K/Plant			
Middle	58 a	224 a	87 a	179 a	103 a	126 a
Upper	40 a	80 a	407 a	407 a	414 a	270 a
Mean	49 a	138 a	279 a	293 a	258 a	203
August 1977						
			Percent K			
Middle	0.76 a	0.84 a	0.70 a	0.63 a	0.61 a	0.71 a
Upper	0.67 a	0.72 a	0.64 a	0.69 a	0.55 a	0.65 a
Mean	0.71 a	0.78 a	0.69 a	0.65 a	0.58 a	0.68
			mg K/Plant			
Middle	113 a	171 a	110 a	248 a	191 a	167 a
Upper	84 b	198 b	327 ab	573 a	251 b	287 a
Mean	99 c	185 bc	219 b	411 a	221 b	227

* No plants survived past the 1976 growing season in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 51

Effect of Treatment and Tier on Nitrogen Content in Shoot Material of *Carex obnupta*

Tier*	F0	F1	F2	F3	F4	Mean
	Fertilizer Treatment and Shoot Nitrogen Content					
September 1976						
			Percent N			
Low	0.89 a**	1.06 a	0.90 a	0.83 a	0.93 a	0.92 a
Middle	0.67 b	0.92 ab	1.14 a	0.85 ab	0.99 a	0.92 a
Upper	0.68 a	0.86 a	1.00 a	0.77 a	0.81 a	0.83 a
Mean	0.75 b	0.95 ab	1.01 a	0.82 ab	0.91 ab	0.89
			mg N/Plant			
Low	34 a	28 a	33 a	23 a	32 a	30 a
Middle	31 a	33 a	54 a	43 a	32 a	39 a
Upper	29 bc	36 ab	40 ab	42 a	25 c	35 a
Mean	31 b	32 ab	42 a	36 ab	30 b	34
August 1977						
			Percent N			
Middle	1.34 a	1.54 a	1.60 a	1.63 a	2.04 a	1.62 a
Upper	1.62 a	1.43 a	1.42 a	1.64 a	1.57 a	1.54 a
Mean	1.48 a	1.48 a	1.51 a	1.63 a	1.79 a	1.58
			mg N/Plant			
Middle	110 a	114 a	175 a	178 a	195 a	154 a
Upper	65 a	92 a	209 a	138 a	53 a	111 a
Mean	88 a	103 a	192 a	158 a	124 a	133

* No plants survived past the 1976 growing season in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 52

Effect of Treatment and Tier on Phosphorus Content in Shoot Material of *Carex obnupta*

Tier*	Fertilizer Treatment and Shoot Nitrogen Content					
	F0	F1	F2	F3	F4	Mean
September 1976						
			Percent P			
Low	0.10 a**	0.16 a	0.11 a	0.10 a	0.10 a	0.11 a
Middle	0.08 b	0.13 ab	0.16 a	0.10 ab	0.12 ab	0.12 a
Upper	0.07 b	0.08 ab	0.11 a	0.07 ab	0.06 b	0.08 b
Mean	0.08 b	0.12 a	0.13 a	0.09 ab	0.09 ab	0.10
			mg P/Plant			
Low	4 a	4 a	4 a	3 a	3 a	4 b
Middle	4 b	5 ab	7 a	5 ab	4 b	5 a
Upper	3 ab	3 ab	4 a	4 a	2 b	3 b
Mean	4 b	4 ab	5 a	4 ab	3 b	4
August 1977						
			Percent P			
Middle	0.20 a	0.21 a	0.26 a	0.25 a	0.26 a	0.24 a
Upper	0.20 a	0.21 a	0.20 a	0.24 a	0.22 a	0.21 a
Mean	0.20 a	0.21 a	0.23 a	0.24 a	0.24 a	0.22
			mg P Plant			
Middle	16 a	17 a	28 a	28 a	25 a	23 a
Upper	8 a	14 a	32 a	20 a	8 a	16 a
Mean	12 a	16 a	30 a	24 a	16 a	20

* No plants survived past the 1976 growing season in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 53

Effect of Treatment and Tier on Potassium Content in Shoot Material of *Carex obnupta*

Tier*	Fertilizer Treatment and Shoot Potassium Content					
	F0	F1	F2	F3	F4	Mean
September 1976						
			Percent K			
Low	0.61 a**	0.69 a	0.60 a	0.55 a	0.61 a	0.61 a
Middle	0.63 a	0.63 a	0.93 a	0.66 a	0.65 a	0.70 a
Upper	0.52 ab	0.69 a	0.74 a	0.38 b	0.51 ab	0.57 a
Mean	0.59 a	0.67 a	0.76 a	0.53 a	0.59 a	0.63
			mg K/Plant			
Low	23 a	17 a	21 a	15 a	21 a	20 a
Middle	31 ab	22 b	40 a	33 ab	20 b	29 a
Upper	22 a	30 a	29 a	22 a	16 a	24 a
Mean	25 ab	23 ab	30 a	23 ab	19 b	24
August 1977						
			Percent K			
Middle	1.69 a	1.09 a	1.17 a	1.15 a	1.22 a	1.26 a
Upper	1.32 a	1.38 a	1.16 a	1.42 a	1.26 a	1.31 a
Mean	1.51 a	1.23 a	1.17 a	1.28 a	1.24 a	1.29
			mg K/Plant			
Middle	134 a	86 a	143 a	135 a	135 a	127 a
Upper	54 a	94 a	156 a	45 a	44 a	92 a
Mean	94 a	90 a	149 a	125 a	90 a	110

* No plants survived past the 1976 growing season in the lower tier.
** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 54

Effect of Treatment and Tier on the Number of Deschampsia Seedlings Established in the Deschampsia Seeded Plots - October 1977 Sampling Period

Tier	Fertilizer Treatment and No. Seedlings per m^2					
	F0	F1	F2	F3	F4	Mean
Lower	0.00 a*	0.00 a	0.00 a	0.00 a	0.00 a	0.00 b
Middle	2.56 ab	4.04 ab	8.04 a	0.00 b	0.11 b	2.95 b
Upper	26.74 a	14.44 a	32.52 a	49.00 a	12.89 a	27.12 a
Mean	9.77 a	6.16 a	13.52 a	16.33 a	4.33 a	10.02

Table 55

Effect of Treatment and Tier on the Average Heights of Deschampsia Seedlings Established in the Deschampsia Seeded Plots - October 1977 Sampling Period

Tier	Fertilizer Treatment and Average Height (cm)					
	F0	F1	F2	F3	F4	Mean
Lower	0.00 a*	0.00 a	0.00 a	0.00 a	0.00 a	0.00 b
Middle	1.44 a	3.67 a	5.22 a	0.00 a	0.89 a	2.24 ab
Upper	3.22 a	3.56 a	5.67 a	5.11 a	3.22 a	5.16 a
Mean	1.56 a	2.41 a	3.63 a	1.70 a	1.37 a	2.13

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 56

Performance of Intertidal Species during August 1977 Sampling Period

Species and Location*	No. Planted C**	No. Planted Q†	Shoots: Survival % C	Survival % Q	Stems/Plant C	Stems/Plant Q	Seed Heads/Plant C	Seed Heads/Plant Q	Height (cm) C	Height (cm) Q	Dry Wt (g) C	Dry Wt (g) Q	Roots: Length (cm) C	Length (cm) Q	Dry Wt. (g) C	Dry Wt. (g) Q	Rhizomes: No./Plant C	No./Plant Q	Length (cm) C	Length (cm) Q	Root/Shoot Ratio C	Root/Shoot Ratio Q	Total (g) C	Total (g) Q
Juncus effusus																								
Upper 1	12	12	75	17	8	4	2.0	0.5	36	37	1.3	0.5	15	7	0.7	0.7	0.3	0.0	0.8	0.0	0.6	5.0	2.00	1.15
Upper 2	6	6	50	33	26	2	3.0	2.0	27	20	8.5	0.6	17	7	3.8	0.1	0.0	0.0	0.0	0.0	0.5	0.3	12.20	0.70
Middle 1	6	6	50	33	2	3	4.0	0.0	22	26	2.0	0.6	17	15	0.7	0.3	0.0	0.0	0.0	0.0	0.6	0.5	2.74	0.89
Middle 2	12	12	67	33	57	39	24.0	1.0	54	45	40.5	16.1	20	13	18.9	2.5	0.3	0.3	8.4	6.3	0.4	0.1	59.33	18.62
Lower 1	3	3	100	67	8	9	3.0	4.0	30	32	1.0	1.9	8	14	0.2	0.4	0.0	0.0	0.0	0.0	0.3	0.3	1.18	2.30
Lower 2	6	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				30	20††	12††	7.0	1.6	34	32	10.7	4.0	16	11	4.8	0.8	0.1	0.1	1.8	1.3	0.5	1.2	15.49	4.73
Alisma plantago-aquatica																								
Upper 1	3	3	100	0	1	0	1.3	0.0	30	0	2.2	0.0	10	0	.6	0.0	0.0	0.0	0.0	0.0	0.4	0.0	2.80	0.00
Iris pseudocorus																								
Upper 1	3	3	100	0	7	0	0.0	0.0	23	0	1.9	0.0	15	0	1.8	0.0	1.3	0.0	4.0	0.0	2.0	0.0	3.62	0.00
Carex lyngbyei																								
Upper 1	6	6	50	67	3	3	0.0	0.0	51	47	6.0	7.5	27	29	3.1	8.9	4.0	5.3	20.3	26.0	0.8	1.1	9.03	16.39
Upper 2	3	3	100	100	3	5	0.0	0.0	22	24	1.9	2.9	13	22	2.2	3.0	0.3	2.3	5.7	19.7	0.8	1.2	4.14	5.36
Middle 1	6	6	67	67	4	10	0.0	0.0	39	50	6.1	16.9	22	27	4.7	12.5	5.3	9.3	18.5	36.0	0.8	0.8	10.75	29.35
Middle 2	6	6	17	0	5	0	0.0	0.0	61	0	6.0	0.0	22	0	5.6	0.0	4.0	0.0	30.0	0.0	0.9	0.0	11.59	0.00
Lower 1	6	6	83	67	4	5	0.0	0.0	31	33	4.3	4.0	14	12	1.2	1.1	0.2	0.0	1.2	0.0	0.3	0.3	5.46	5.12
Lower 2	6	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
					4	5	0.0	0.0	41	31	4.9	37.6	19	18	3.4	5.2	2.8	3.4	15.1	18.7	0.7	0.7	8.20	11.34
Carex obnupta																								
Upper 2	6	6	67	67	6	9	0.0	0.0	42	42	11.7	17.0	24	36	4.4	6.8	2.0	3.3	5.0	16.0	0.4	0.4	16.13	23.73
Middle 1	6	6	67	67	10	4	0.0	0.0	35	25	13.8	2.7	33	15	8.1	1.6	5.3	1.8	15.0	28.5	0.6	0.9	21.88	4.37
Lower 2	6	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
												9.9	29	26	6.3	4.2	3.7	2.5	10.0	22.3	0.5	0.7	19.01	14.05
Deschampsia cespitosa																								
Upper 2	6	6	100	100	152	136	4.0	0.2	53	46	58.3	48.7	21	18	14.2	30.1	0.0	0.0	0.0	0.0	0.3	0.6	72.51	78.72
Lower 1	5	5	83	83	137	131	0.0	1.8	70	68	60.4	50.1	15	13	7.7	5.0	0.0	0.0	0.0	0.0	0.1	0.1	68.10	55.12
Lower 2	6	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				61	145	134	2.0	1.0	62	57	59.4	49.4	18	15	11.0	17.6	0.0	0.0	0.0	0.0	0.2	0.4	70.30	66.92
Scirpus validus																								
Lower 1	6	6	33	50	2	3	0.0	0.7	73	89	0.3	2.4	5	6	0.4	1.5	1.0	0.3	0.3	1.3	1.2	0.4	0.72	3.97

* Upper 1 (184.7 cm above mllw); Upper 2 (187.5 cm above mllw); Middle 1 (140.2 cm above mllw); Middle 2 (131 cm above mllw); Lower 1 (96.3 cm above mllw); Lower 2 (46.1 cm above mllw).
** Caged plants - plants located in caged areas.
† Quadrat plants - plants located in uncaged areas.
†† Cage-Quadrats with zero survival were not included in determination of means.

Table 57

Effect of Elevation on Nutrient Concentration in Shoot Parts of Intertidal Plants - August 1977 Harvest

Species and Elevation	Nutrient Concentration (%)		
	N	P	K
Alisma plantago-aquatica			
Lower*	-	-	-
Middle**	-	-	-
Upper†	1.45	0.28	2.26
Mean	1.45	0.28	2.26
Carex lyngbyei			
Lower	1.90 a††	0.29 a	1.69 ab
Middle	1.60 a	0.15 b	2.32 a
Upper	1.12 b	0.07 c	1.34 b
Mean	1.45	0.14	1.74
Carex obnupta			
Lower	-	-	-
Middle	1.57 a	0.22 a	1.55 a
Upper	1.39 a	0.18 a	1.47 a
Mean	1.51	0.21	1.52
Deschampsia cespitosa			
Lower	1.42 a	0.24 a	1.75 a
Middle	-	-	-
Upper	1.54 a	0.16 a	1.04 a
Mean	1.48	0.20	1.40

(Continued)

Table 57 (Concluded)

Species and Elevation	Nutrient Concentration (%) N	P	K
Iris pseudocorus			
Lower	-	-	-
Middle	-	-	-
Upper	1.86	0.22	2.07
Mean	1.86	0.22	2.07
Juncus effusus			
Lower	2.29 a	0.34 a	3.55 a
Middle	1.67 a	0.23 a	2.20 b
Upper	1.81 a	0.22 a	1.80 b
Mean	1.85	0.25	2.31
Scirpus validus			
Lower	2.08	0.32	4.12
Middle	-	-	-
Upper	-	-	-
Mean	2.08	0.32	4.12

* Lower elevation measured 71.3 cm above mllw.
** Middle elevation measured 135.6 cm above mllw.
† Upper elevation measured 186.2 cm above mllw.
†† Values in vertical sequence not followed by the same letter are significantly different (p=0.05) by DMRT.

Table 58

Effect of Fertilizer and Tier on Biomass on an Area Basis of D. cespitosa Transplants in the Upper and Middle Tiers at the End of the 1977 Growing Season

Plant Part and Tier*	Fertilizer Treatment and Biomass (kg/ha)					
	F0	F1	F2	F3	F4	Mean
Stems						
Middle	532	964	685	1582	1104	973 a
Upper	464	1130	1997	3295	1807	1739 a
Mean	498 b**	1047 ab	1341 ab	2439 a	1456 ab	1356
Roots						
Middle	106	251	203	384	214	232 a
Upper	76	444	379	536	438	375 a
Mean	91 a	348 a	291 a	460 a	326 a	303
Total						
Middle	638	1215	888	1965	1318	1205 a
Upper	540	1574	2376	3831	2245	2113 a
Mean	589 b	1394 ab	1632 ab	2898 a	1782 ab	1659

* No plants survived in the lower tier.

** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 59

Effect of Fertilizer and Tier on Biomass on an Area Basis of C. obnupta Transplants in the Upper and Middle Tiers - August 1977

Plant Part and Tier*	Fertilizer Treatment and Biomass (kg/ha)					
	F0	F1	F2	F3	F4	Mean
Stems**						
Middle	303	223	331	344	224	285 a
Upper	134	267	430	312	108	250 a
Mean	219 a†	245 a	381 a	328 a	166 a	268
Roots†						
Middle	106	34	139	92	86	91 a
Upper	101	136	160	130	117	129 a
Mean	104 a	85 a	150 a	111 a	102 a	110
Total						
Middle	571	209	504	339	466	418 a
Upper	292	368	526	460	229	375 a
Mean	431 a	289 a	515 a	399 a	347 a	397

* No plants survived in the lower tier.
** Values based on 30 plants per treatment.
† Values based on 3 plants per treatment.
†† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 60

Effect of Elevation on Above-Ground Biomass Values of Plants Clipped from Cage-Quadrat Pairs Located in Marsh Reference Area - 1976 Harvest

		Biomass (kg/ha)					
		Cage (Inside)		Quadrat (Outside)			
Species	Elevation	Mean	SE	Mean	SE	Mean	SE
D. cespitosa	Low	-		-		-	
	Middle	2826 ±	652	3654 ±	288	3240 ±	385
	Upper	936 ±	269	2166 ±	1026	1551 ±	573
C. lyngbyei	Low	72 ±	43	89 ±	36	81 ±	28
	Middle	32 ±	16	56 ±	14	44 ±	11
	Upper	4274 ±	197	2976 ±	834	3625 ±	486
Total All Species	Low	116 ±	31	221 ±	50	168 ±	36
	Middle	3069 ±	350	4087 ±	364	3578 ±	310
	Upper	5244 ±	266	5230 ±	297	5237 ±	199

Table 61

Effect of Elevation on Above-Ground Biomass Values of Plants Clipped from Cage-Quadrat Pairs Located in Marsh Reference Area - 1977 Harvest

Elevation	Biomass (kg/ha) Cage (Inside)	Quadrat (Outside)	Mean
Lower*	914 a††	1324 a	1119 b
Middle**	4970 a	6487 a	5729 a
Upper†	7507 a	5664 a	6585 a
Mean	4524 a	5305 a	4914

* Mean elevation 79.9 cm above mllw.
** Mean elevation 140.5 cm above mllw.
† Mean elevation 160.6 cm above mllw.
†† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 62

Above Ground Biomass of Plants Clipped from Cage-Quadrat Pairs Located in Marsh Reference Area - 1977 Harvest

Species	Tier	Biomass (g/0.5 m²)* Cage (Inside)	Quadrat (Outside)	Mean
Deschampsia cespitosa	Lower**	0.07 a ++	0.00 a	0.03 b
	Middle†	111.06 a	191.47 a	151.26 a
	Upper††	8.51 a	54.61 a	31.56 b
	Mean	39.88 a	82.03 a	74.28
Carex lyngbyei	Lower	14.22 a	20.20 a	17.21 b
	Middle	0.00 a	61.55 a	30.78 b
	Upper	249.76 a	165.01 a	207.39 a
	Mean	87.99 a	82.25 a	85.12
Alopecurus geniculatus	Lower	0.00 a	0.00 a	0.00 b
	Middle	51.92 a	21.75 a	36.83 a
	Upper	0.52 a	0.03 a	0.27 b
	Mean	17.48 a	7.26 a	12.39
Lilaeopsis occidentalis	Lower	0.07 a	0.02 a	0.04 a
	Middle	0.03 a	0.07 a	0.05 a
	Upper	0.00	0.00	0.00 a
	Mean	0.03 a	0.03 a	0.03
Polygonum punctatum	Lower	0.00 a	0.10 a	0.05 a
	Middle	3.94 a	3.35 a	3.65 a
	Upper	10.85 a	9.37 a	10.11 a
	Mean	4.93 a	4.28 a	4.60
Eleocharis palustris	Lower	13.77 a	41.19 a	27.48 a
	Middle	0.00	0.00	0.00 b
	Upper	0.00	0.00	0.00 b
	Mean	4.59 b	13.73 a	9.16

(Continued)

Table 62 (Continued)

Species	Tier	Biomass ($g/0.5\ m^2$)* Cage (Inside)	Quadrat (Outside)	Mean
Juncus tenuis	Lower	5.40 a	4.68 a	5.04 a
	Middle	3.73 a	5.07 a	4.40 a
	Upper	0.00	0.00	0.00 a
	Mean	3.04 a	3.25 a	5.65
Mimulus guttatus	Lower	0.00 a	0.00 a	0.00 b
	Middle	8.02 a	5.33 a	6.67 a
	Upper	2.39 a	1.89 a	1.09 b
	Mean	3.47 a	3.13 a	3.30
Bidens cernua	Lower	0.00	0.00	0.00 a
	Middle	0.34 a	0.00 a	0.17 a
	Upper	7.11 a	1.71 a	4.41 a
	Mean	2.48 a	0.57 a	1.53
Erigeron philadelphicus	Lower	0.00 a	0.00 a	0.00 b
	Middle	50.47 a	18.81 a	34.64 a
	Upper	11.03 a	5.63 a	8.33 b
	Mean	20.50 a	8.15 b	15.09
Daucus carota	Lower	0.00	0.00	0.00 b
	Middle	0.00	0.00	0.00 b
	Upper	40.88 a	11.07 a	25.78 a
	Mean	13.50 a	3.69 a	8.59
Juncus balticus	Lower	0.00	0.00	0.00 a
	Middle	0.70 a	0.61 a	0.65 a
	Upper	0.00	0.00	0.00 a
	Mean	0.23 a	0.20 a	0.22

(Continued)

Table 62 (Concluded)

Species	Tier	Biomass (g/0.5 m²)* Cage (Inside)	Quadrat (Outside)	Mean
Polygonum hydropiper	Lower	0.00 a	0.15 a	0.07 a
	Middle	0.45 a	0.00 a	0.23 a
	Upper	0.30 a	0.07 a	0.19 a
	Mean	0.25 a	0.07 a	0.16
Rorippa nasturtium-aquaticum	Lower	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00 a
	Upper	0.01 a	0.01 a	0.01 a
	Mean	0.00 a	0.00 a	0.00
Dead material	Lower	12.12 a	19.97 a	20.55 ab
	Middle	17.86 a	16.35 a	17.10 b
	Upper	35.94 a	32.67 a	34.30 a
	Mean	24.97 a	23.00 a	23.98
Limosella aquatica	Lower	0.03 a	0.00 a	0.01 a
	Middle	0.00	0.00	0.00 a
	Upper	0.00	0.00	0.00 a
	Mean	0.01 a	0.00 a	0.01
Epilobium watsonii	Lower	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00 a
	Upper	8.47 a	1.10 a	4.79 a
	Mean	2.82 a	0.37 a	1.60
Callitriche verna	Lower	0.00	tr+	tr+
	Middle	0.00	0.00	0.00
	Upper	0.00	0.00	0.00
	Mean	0.00 a	0.00 a	0.00

* Multiply by 20 to get kg/ha.
** Mean elevation is 79.9 cm above mllw.
† Mean elevation is 140.5 cm above mllw.
†† Mean elevation is 160.6 cm above mllw.
+ tr - trace values; less than 0.01 g
++ Values in horizontal sequence and means not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 63

Effect of Elevation on Above-Ground Biomass Values of Plants Clipped from Cage-Quadrat Pairs Located in Unvegetated Intertidal Area - August 1977 Harvest

	Biomass (kg/ha)		
Elevation	Cage (Inside)	Quadrat (Outside)	Mean
Lower*	22 a††	0 a	11 b
Middle**	44 a	0 a	22 b
Upper†	374 a	1097 a	735 a
Mean	146 a	366 a	256

* Mean elevation is 52.1 cm above mllw.
** Mean elevation is 132 cm above mllw.
† Mean elevation is 158.2 cm above mllw.
†† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 64

Above-Ground Biomass of Plants Clipped from Cage-Quadrat Pairs Located in Unvegetated Intertidal Area - August 1977 Harvest

Species	Tier	Biomass (g/0.5 m²)* Cage (Inside)	Quadrat (Outside)	Mean
Deschampsia cespitosa	Lower**	0.00 a+	0.00 a	0.00 a
	Middle†	0.03 a	0.00 a	0.02 a
	Upper††	10.80 a	22.12 a	16.46 a
	Mean	3.61 a	7.37 a	5.46
Polygonum punctatum	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.00 a	0.00 a	0.00 a
	Upper	7.88 a	16.86 a	12.37 a
	Mean	2.63 a	5.62 a	4.12
Elodea nuttalli	Lower	1.10 a	0.00 a	0.55 a
	Middle	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	0.00 a	0.00 a
	Mean	0.37 a	0.00 a	0.19
Trifolium repens	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	0.36 a	0.18 a
	Mean	0.00 a	0.12 a	0.06
Ammophilia arenaria	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	2.02 a	1.00 a
	Mean	0.00 a	0.67 a	0.34
Phalaris arundinacea	Lower	0.00 a	0.00 a	0.00 a
	Middle	1.23 a	0.00 a	0.62 a
	Upper	0.00 a	0.00 a	0.00 a
	Mean	0.41 a	0.00 a	0.21

(Continued)

Table 64 (Concluded)

Species	Tier	Biomass (g/0.5 m^2)* Cage (Inside)	Quadrat (Outside)	Mean
Eleocharis palustris	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.72 a	0.00 a	0.36 a
	Upper	0.00 a	0.00 a	0.00 a
	Mean	0.24 a	0.00 a	0.12
Lilaeopsis occidentalis	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.08 a	0.00 a	0.04 a
	Upper	0.00 a	0.00 a	0.00 a
	Mean	0.03 a	0.00 a	0.01
Alopecurus geniculatus	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	0.05 a	0.03 a
	Mean	0.00 a	0.02 a	0.01
Dead Material	Lower	0.00 a	0.00 a	0.00 a
	Middle	0.13 a	0.00 a	0.00 a
	Upper	0.00 a	13.45 a	6.73 a
	Mean	0.04 a	4.48 a	2.24

* Multiply by 20 to get kg/ha.
** Mean elevation is 52.1 cm above mllw.
† Mean elevation is 132 cm above mllw.
†† Mean elevation is 158.2 cm above mllw.
\+ Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table 65

Importance Values of Plants Located in Five Transect Areas in the Marsh Reference Area

Species	Transect No.* and Importance Values				
	Transect I	Transect II	Transect III	Transect IV	Transect V
Carex lyngbyei	50.49	30.46	36.27	40.78	48.80
Deschampsia cespitosa	39.27	47.12	55.06	37.16	37.28
Polygonum punctatum	23.13	26.53	24.21	22.75	14.85
Erigeron philadelphus	24.78	26.53	22.88	18.69	8.80
Alopecurus geniculatus	18.99	15.57	9.77	4.06	8.10
Juncus tenuis	11.13	9.20	14.79	13.98	4.38
Mimulus guttatus	16.51	18.04	16.84	19.85	6.08
Lilaeopsis occidentalis	8.25	18.98	3.72	15.46	23.70
Gratiola neglecta	3.72	0.00	0.00	0.00	7.43
Bidens cernua	3.72	0.00	10.43	9.93	0.00
Rumex occidentalis	0.00	4.10	0.00	0.00	3.72
Eleocharis palustris	0.00	3.46	0.00	8.12	24.37
Daucus carota	0.00	0.00	6.05	0.00	0.00
Alisma plantago-aquatica	0.00	0.00	0.00	3.35	0.00
Rorippa nasturtium-aquaticum	0.00	0.00	0.00	0.00	4.38
Callitriche verna	0.00	0.00	0.00	0.00	4.38

(Continued)

Table 65 (Concluded)

Species	Transect No.* and Importance Values				
	Transect I	Transect II	Transect III	Transect IV	Transect V
Juncus effusus	0.00	0.00	0.00	5.87	0.00
Limosella aquatica	0.00	0.00	0.00	0.00	3.72

* Transects were evenly spaced between the Upper (Transect I) and Lower (Transect V) boundaries of the plant zone.

Table 66

Aboveground Biomass Values of Plants Clipped from Random Plots Located in Five Transect Areas in the Marsh Reference Area - August 1977 Harvest

Species	Transect No.* and Biomass (g/0.5 m²)**					
	I	II	III	IV	V	Mean
Deschampsia cespitosa	114.29 a†	133.05 a	205.84 a	154.76 a	76.89 a	136.97
Carex lyngbyei	153.82 a	194.82 a	93.45 a	87.10 a	172.46 a	140.33
Daucus carota	0.00 a	8.01 a	6.85 a	0.00 a	0.00 a	2.97
Mimulus guttatus	6.42 a	2.55 a	12.17 a	2.04 a	8.60 a	6.38
Polygonum punctatum	14.03 a	2.22 b	1.97 b	2.36 b	8.70 ab	5.85
Polygonum hydropiper	0.00 a	0.00 a	0.00 a	0.06 a	0.00 a	0.01
Erigeron philadelphus	1.95 b	19.06 ab	40.33 a	13.59 ab	0.00 b	14.99
Juncus tenuis	0.09 a	14.72 a	0.00 a	13.39 a	2.34 a	6.11
Alopecurus geniculatus	0.05 a	0.15 a	11.53 a	5.25 a	3.49 a	4.09
Eleocharis palustris	0.00 a	0.40 a	1.55 a	0.15 a	3.55 a	1.13
Rumex occidentalis	0.00 a	1.18 a	0.00 a	0.00 a	0.00 a	0.24
Bidens cernua	0.00 a	1.15 a	0.00 a	0.00 a	0.00 a	0.23
Alisma plantago-aquatica	0.00 a	0.00 a	0.00 a	0.00 a	0.40 a	0.08
Rorippa nasturtium-aquaticum	0.00 a	0.06 a	1.04 a	0.00 a	0.00 a	0.22
Juncus balticus	0.00 a	0.00 a	0.00 a	0.20 a	0.00 a	0.04
Lilaeopsis occidentalis	0.12 ab	0.00 b	0.21 a	0.00 b	0.00 b	0.07

(Continued)

Table 66 (Concluded)

Species	Transect No.* and Biomass (g/0.5 m²)**					
	I	II	III	IV	V	Mean
Dead material	11.58 b	19.07 ab	30.59 a	7.80 ab	23.40 b	18.49
Total	302.35 a	396.42 a	405.63 a	286.68 a	299.83 a	338.18

* Transects were evenly spaced between the upper (Transect I) and Lower (Transect V) boundaries of the plant zone.

** Multiply by 20 to get kg/ha.

† Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 67

Importance Values of Plants Located in Four Transect Areas in the Unvegetated Intertidal Area

Species	Transect No.* and Importance Values			
	Transect I	Transect II	Transect III	Transect IV
Algae	101.55	71.84	90.23	114.29
Deschampsia cespitosa	31.41	27.51	0.00	85.71
Eleocharis palustris	12.10	12.40	17.65	0.00
Mimulus guttatus	7.22	3.04	0.00	0.00
Phalaris arundinacea	15.91	3.76	9.87	0.00
Callitriche verna	10.60	12.18	21.54	0.00
Lilaeopsis occidentalis	5.30	3.04	5.98	0.00
Polygonum punctatum	5.30	12.27	0.00	0.00
Limosella aquatica	5.30	19.80	35.27	0.00
Polygonum hydropiper	5.30	6.81	0.00	0.00
Juncus tenuis	0.00	14.23	7.78	0.00
Juncus effusus	0.00	7.52	0.00	0.00
Carex lyngbyei	0.00	5.59	0.00	0.00
Alisma plantago-aquatica	0.00	0.00	7.78	0.00
Gratiola neglecta	0.00	0.00	3.89	0.00

* Transects were evenly spaced between the Upper (Transect I) and Lower (Transect IV) boundaries of the plant zone.

Table 68

Aboveground Biomass Values of Plants Clipped from Random Plots Located in Four Transect Areas in the Unvegetated Intertidal Area - August 1977 Harvest

Species	Transect No.* and Biomass ($g/0.5\ m^2$)**				
	I	II	III	IV	Mean
Deschampsia cespitosa	19.81 a††	14.53 a	16.17 a	0.00 a	12.63
Carex lyngbyei	4.31 a	0.29 a	0.15 a	0.00 a	1.19
Iris pseudocorus	1.92 a	0.35 a	0.12 a	0.00 a	0.60
Mimulus guttatus	3.52 a	0.00 a	0.00 a	0.00 a	0.88
Polygonum punctatum	11.15 a	12.07 a	4.23 a	0.00 a	6.86
Phalaris arundinacea	0.04 a	0.03 a	0.00 a	0.00 a	0.02
Alisma plantago-aquatica	0.00 a	0.02 a	0.24 a	0.00 a	0.07
Juncus tenuis	0.00 a	0.47 a	0.97 a	0.00 a	0.36
Eleocharis palustris	0.00 a	3.97 a	1.74 a	0.00 a	1.43
Lilaeopsis occidentalis	0.00 a	0.31 a	tr†	0.00 a	0.08
Juncus effusus	0.00 a	0.02 a	1.04 a	0.00 a	0.26
Erigeron philadelphus	0.00 a	0.00 a	4.55 a	0.00 a	1.14
Callitriche verna	0.00 a	0.00 a	0.26 a	0.00 a	0.07
Polygonum hydropiper	0.00 a	1.25 a	0.05 a	0.00 a	0.33
Limosella aquatica	0.00 a	0.44 a	1.49 a	0.00 a	0.48
Alopecurus geniculatus	0.00 a	0.08 a	0.00 a	0.00 a	0.02
Dead material	1.11 a	1.04 a	0.70 a	0.00 a	0.72
Total	41.85 a	34.87 a	31.71 a	0.00 b	27.11

* Transects were evenly spaced between the upper (Transect I) and Lower (Transect IV) boundaries of the plant zone.
** Multiply by 20 to get kg/ha.
† Trace (i.e., less than 0.01 g)
†† Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 69

Measurements of European Beachgrass Performance in Cage-Quadrat Comparisons during August 1977 Sampling Period

Location and Parameter	Cage (Inside) Mean ± SE	Quadrat (Outside) Mean ± SE
Area A*		
No. stems	27.88 ± 1.64	26.85 ± 1.86
Height (cm)	50.91 ± 1.18	46.31 ± 1.09
No. seedheads	0.52 ± 0.08	0.35 ± 0.08
Shoot weight (g)	10.74 ± 0.81	9.91 ± 0.82
Underground shoot weight (g)	-	9.25 ± 0.78
Total shoot weight (g)	-	22.64 ± 2.03
Seedhead weight (g)	0.70 ± 0.65	0.96 ± 0.14
Seed weight (g)	0.12 ± 0.03	0.18 ± 0.05
Root length (cm)	-	23.61 ± 0.97
Root weight (g)	-	1.42 ± 0.20
Total weight (g)	-	24.06 ± 2.14
Root/Shoot ratio	-	0.07 ± 0.01
Area B**		
No. stems	-	6.30 ± 1.48
Height (cm)	-	66.05 ± 4.73
No. seedheads	-	0.00 ± 0.00
Total shoot weight (g)	-	18.65 ± 2.43
Seedhead weight (g)	-	0.00 ± 0.00
Root length (cm)	-	35.80 ± 3.58
Root weight (g)	-	2.27 ± 0.49
Total weight (g)	-	20.92 ± 2.70
Root/Shoot ratio	-	0.13 ± 0.02

* Beachgrass in this area was planted January 1977.

** Beachgrass in this area was planted May 1977.

Table 70

Nutrient Concentration in Shoot Material of European Beachgrass - August 1977 Harvest

Nutrient	Location and Nutrient Concentration		
	Area A* N=12	Area B** N=2	Mean
		Percent	
N	0.73 b†	1.11 a	0.92
P	0.04 b	0.09 a	0.07
K	0.81 a	1.01 a	0.91

* European beachgrass in this area was planted January 1977.

** European beachgrass in this area was planted May 1977.

† Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 71

Particle-Size Distribution at the Beginning of the Upland Experiment - June 1976*

Elevation and Particle Size**	0 - 15 cm Rep 1	0 - 15 cm Rep 2	0 - 15 cm Rep 3	0 - 15 cm Mean	15 - 30 cm Rep 1	15 - 30 cm Rep 2	15 - 30 cm Rep 3	15 - 30 cm Mean
Meadow I								
Gravel	0.22	0.73	0.75	0.57	0.16	0.18	0.44	0.26
Very coarse sand	3.71	4.76	5.26	4.58	4.59	5.36	5.12	5.02
Coarse sand	49.31	34.14	34.53	39.34	31.17	27.56	37.24	31.99
Medium sand	16.39	28.74	33.18	26.07	33.07	33.18	35.45	33.88
Fine sand	28.53	30.23	24.65	27.81	29.25	31.60	20.53	27.13
Very fine sand	0.40	0.57	0.75	0.57	0.64	0.63	0.33	0.53
Silt	0.27	0.43	0.71	0.47	0.29	0.38	0.61	0.43
Clay	1.39	1.13	0.98	1.17	1.04	1.29	0.71	1.01
Meadow II								
Gravel	0.36	0.38	0.20	0.31	0.07	0.27	0.27	0.20
Very coarse sand	8.93	4.88	4.12	5.98	3.17	2.69	7.26	4.37
Coarse sand	37.13	37.97	34.53	36.54	22.99	19.81	31.97	24.92
Medium sand	31.57	31.62	33.90	32.36	40.06	40.75	36.80	39.20
Fine sand	20.27	23.46	25.17	22.97	31.46	34.82	21.92	29.40
Very fine sand	0.35	0.45	0.46	0.42	0.57	0.43	0.53	0.51
Silt	0.42	0.21	0.15	0.26	0.60	0.48	0.50	0.53
Clay	1.32	1.41	1.67	1.46	1.16	1.02	1.02	1.07

(Continued)

Table 71 (Concluded)

Elevation and Particle size	Soil Depth							
	0 - 15 cm				15 - 30 cm			
	Rep 1	Rep 2	Rep 3	Mean	Rep 1	Rep 2	Rep 3	Mean
Meadow III								
Gravel	0.07	0.07	0.11	0.08	0.24	0.24	0.14	0.21
Very coarse sand	1.23	2.49	2.18	1.97	3.18	1.59	3.14	2.64
Coarse sand	28.30	29.56	21.51	26.46	27.11	16.39	24.73	22.75
Medium sand	34.44	36.70	35.66	35.60	35.73	32.62	30.50	32.95
Fine sand	33.70	28.17	38.10	33.33	31.58	46.06	38.56	38.73
Very fine sand	0.56	0.99	0.91	0.82	0.85	1.72	1.28	1.28
Silt	0.11	0.67	0.48	0.42	0.46	0.63	0.48	0.52
Clay	1.64	1.42	1.16	1.41	1.10	0.98	1.29	1.12

* Particle size distribution, except gravel, in percent of fine soil (less than 2 mm).

** Gravel - <2 mm, very coarse sand - 2.00-1.00 mm, coarse sand - 1.00-0.50 mm, medium sand - 0.50-0.25 mm, fine sand - 0.25-0.10 mm, very fine sand - 0.10-0.05 mm, silt - 0.05-0.002 mm, clay - below 0.002 mm.

Table 72

Chemical Parameters in Upland Soils at the Beginning of the Experiment

Parameter and Meadow Number	Soil Depth 0 - 15 cm R1	R2	R3	Mean	SD	Soil Depth 15 - 30 cm R1	R2	R3	Mean	SD
Moisture (%)										
I	6.36	7.43	7.29	7.02	0.474	6.92	7.77	6.74	7.14	0.449
II	5.01	6.61	5.60	5.74	0.660	7.51	7.37	6.84	7.24	0.288
III	5.93	7.47	7.38	6.92	0.705	7.23	7.13	7.86	7.40	0.323
Organic C (%)										
I	0.377	0.226	0.354	0.319	0.064	0.104	0.139	0.127	0.122	0.015
II	0.168	0.186	0.191	0.180	0.010	0.081	0.098	0.093	0.087	0.007
III	0.423	0.441	0.377	0.412	0.027	0.156	0.151	0.127	0.145	0.012
pH										
I	6.10	6.07	6.01	6.06	0.037	6.25	6.23	6.21	6.23	0.016
II	6.17	6.07	6.13	6.12	0.041	6.35	6.20	6.27	6.27	0.061
III	6.10	6.07	6.25	6.14	0.078	6.21	6.10	6.07	6.12	0.060
Conductivity (μmhos/cm)										
I	0.44	0.38	0.42	0.41	0.024	0.20	0.21	0.18	0.19	0.012
II	0.32	0.27	0.30	0.29	0.020	0.19	0.22	0.20	0.20	0.012
III	0.34	0.34	0.37	0.35	0.014	0.25	0.21	0.29	0.25	0.032
Cation Exchange Capacity (meq/100 g)										
I	3.91	3.62	3.81	3.78	0.120	3.77	3.35	2.92	3.34	0.347
II	3.52	3.59	4.19	3.76	0.300	3.14	3.16	3.52	3.27	0.174
III	4.21	4.50	4.14	4.28	0.155	3.99	3.52	3.92	3.81	0.206
Exchangeable K (meq/100 g)										
I	0.20	0.16	0.18	0.180	0.016	0.16	0.15	0.14	0.15	0.007
II	0.15	0.14	0.19	0.160	0.021	0.11	0.12	0.11	0.11	0.003
III	0.20	0.20	0.23	0.210	0.014	0.18	0.18	0.15	0.17	0.014

(Continued)

Table 72 (Concluded)

Parameter and Meadow Number	Soil Depth 0 - 15 cm R1	R2	R3	Mean	SD	Soil Depth 15 - 30 cm R1	R2	R3	Mean	SD
Exchangeable Ca (meq/100 g)										
I	2.60	2.30	2.26	2.38	0.151	2.26	2.30	2.30	2.28	0.019
II	2.15	2.15	2.45	2.25	0.141	2.65	2.53	2.60	2.59	0.049
III	2.56	3.05	2.65	2.75	0.213	2.40	2.40	2.45	2.41	0.024
Exchangeable Mg (meq/100 g)										
I	1.08	0.92	0.94	0.980	0.071	0.85	0.78	0.68	0.770	0.069
II	0.92	0.92	1.05	0.963	0.061	0.75	0.94	1.05	0.913	0.123
III	0.98	1.03	1.05	1.02	0.029	0.92	0.97	0.97	0.953	0.023
Exchangeable Na (meq/100 g)										
I	0.026	0.024	0.026	0.025	0.003	0.024	0.021	0.021	0.022	0.001
II	0.025	0.028	0.032	0.028	0.003	0.024	0.023	0.025	0.024	0.001
III	0.024	0.026	0.030	0.026	0.002	0.024	0.023	0.026	0.024	0.001
Kjeldahl N (ppm)										
I	0.024	0.014	0.024	0.019	0.004	0.007	0.007	0.009	0.008	0.001
II	0.010	0.009	0.010	0.009	0.000	0.003	0.005	0.004	0.004	0.001
III	0.024	0.025	0.02	0.023	0.002	0.009	0.009	0.007	0.007	0.002
NH_4-N (ppm)										
I	4.06	2.46	3.42	3.31	0.657	1.17	2.23	1.16	1.52	0.502
II	3.19	3.24	2.96	3.13	0.121	0.52	1.83	1.29	1.21	0.537
III	2.95	2.45	2.60	2.66	0.209	1.96	0.45	1.77	1.39	0.671
NO_3-N (ppm)										
I	1.11	1.68	0.86	1.21	0.343	0.06	0.00	0.19	0.083	0.079
II	1.34	0.71	0.90	0.983	0.263	0.92	0.00	0.13	0.35	0.406
III	0.77	1.29	0.71	0.923	0.260	0.26	0.77	0.65	0.56	0.217
Phosphorus (ppm)										
I	8.57	6.75	7.77	7.69	0.744	5.95	5.39	4.90	5.41	0.429
II	7.03	7.35	7.70	7.36	0.273	5.95	6.06	6.05	6.02	0.049
III	8.92	8.86	9.80	9.19	0.429	6.30	6.76	7.04	6.70	0.305

Table 73

Relationship of Soil pH in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil pH June 1977	Soil pH August 1977
I	5.85 a*	5.97 b*
II	5.82 a	6.18 a
III	5.89 a	5.86 c
Mean	5.85	6.00

b. Fertilizer Effect

Fertilizer Treatment No.	Soil pH June 1977	Soil pH August 1977
F0	5.89 a*	6.18 a*
F1	5.86 a	5.98 b
F2	5.82 a	5.84 c

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 74

Relationship of Soil Potassium in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

	Soil K (meq/100 g)	
Meadow No.	June 1977	August 1977
I	0.213 a*	0.188 a*
II	0.144 b	0.140 b
III	0.168 b	0.148 b
Mean	0.175	0.159

b. Fertilizer Effect

Fertilizer Treatment No.	June 1977	August 1977
F0	0.163 a*	0.150 a*
F1	0.174 ab	0.162 a
F2	0.188 b	0.163 a

* Values in columns not followed by the same letter are significantly different at $p=0.05$ according to Duncan's Multiple Range Test.

Table 75

Relationship of Soil Phosphorus in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil Phosphorus (ppm) June 1977	August 1977
I	6.89 a*	8.28 a*
II	6.15 a	7.20 b
III	6.82 a	7.32 b
Mean	6.62	7.60

b. Fertilizer Effect

Fertilizer Treatment No.	June 1977	August 1977
F0	5.73 b*	6.50 b*
F1	6.46 b	7.94 a
F2	7.67 a	8.35 a

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 76

Relationship of Soil Ammonium N in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil NH_4-N (ppm) June 1977	Soil NH_4-N (ppm) August 1977
I	0.795 b*	1.078 b*
II	0.577 b	1.541 ab
III	1.154 a	1.935 a
Mean	0.842	1.518

b. Fertilizer Effect

Fertilizer Treatment	June 1977	August 1977
F0	0.717 a*	1.175 b*
F1	0.896 a	1.751 a
F2	0.913 a	1.629 a

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 77

Relationship of Soil Kjeldahl N in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil Kjeldahl N (Percent) June 1977	August 1977
I	0.0189 a*	0.0178 a*
II	0.0096 b	0.0086 a
III	0.0178 a	0.0187 a
Mean	0.0154	0.0150

b. Fertilizer Effect

Fertilizer Treatment	June 1977	August 1977
F0	0.0141 b*	0.0133 b*
F1	0.0154 ab	0.0158 a
F2	0.0168 a	0.0159 a

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 78

Relationship of Nitrate N in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil NO_3-N (ppm) June 1977	Soil NO_3-N (ppm) August 1977
I	0.400 b*	0.424 b*
II	0.833 a	0.396 b
III	0.712 a	1.507 a
Mean	0.648	0.776

b. Fertilizer Effect

Fertilizer Treatment No.	June 1977	August 1977
F0	0.575 b*	0.718 a*
F1	0.713 a	0.784 a
F2	0.658 ab	0.826 a

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 79

Relationship of Soil Moisture Levels in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil Moisture (Percent) June 1977	Soil Moisture (Percent) August 1977
I	8.17 a*	16.59 b*
II	6.98 a	19.80 a
III	8.71 a	15.95 b
Mean	7.95	17.45

b. Fertilizer Effect

Fertilizer Treatment	June 1977	August 1977
F0	7.54 a*	18.99 a*
F1	7.35 a	17.04 ab
F2	8.97 a	16.31 b

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 80

Relationship of Soil Carbon in the Upland Experiment to Meadow and Fertilizer Treatments

a. Meadow Differences

Meadow No.	Soil Carbon (Percent) August 1977
I	0.290 a*
II	0.275 a
III	0.129 b
Mean	0.232

b. Fertilizer Effect

Fertilizer Treatment	
F0	0.200 b*
F1	0.252 a
F2	0.243 a

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 81

Relationship of Cation Exchange Capacity in the Upland Experiment to Meadows and Fertilizer Treatments

a. Meadow Differences

Meadow No.	CEC (meq/100 g) August 1977
I	4.27 a*
II	3.95 ab
III	3.64 b
Mean	3.95

b. Fertilizer Effect

Fertilizer Treatment	
F0	3.92 a*
F1	3.98 a
F2	3.97 a

* Values in columns not followed by the same letter are significantly different at p=0.05 according to Duncan's Multiple Range Test.

Table 82

Effect of Fertilizer on Characteristics of Meadow I Species

Fertilizer Treatment No.	Shoot Height (cm)	Root Length (cm)	No./Plant		Dry Weight (g)				Root/ Shoot Ratio
			Stems	Seed Heads	Shoot	Root	Seed	Total	
White Clover									
0	36.62 a*	14.18 a	2.97 a	1.33 a	0.38 b	0.12 b	0.00	0.50 b	0.37 a
1	18.62 b	12.92 a	3.27 a	1.57 a	1.26 a	0.16 ab	0.00	1.42 a	0.33 a
2	24.54 b	14.82 a	3.10 a	1.40 a	0.74 ab	0.17 a	0.00	0.91 ab	0.33 a
Tall Wheatgrass									
0	23.25 a	17.54 a	1.70 a	0.00	0.19 a	0.13 a	0.00	0.31 a	0.88 a
1	25.56 a	17.16 a	1.27 a	0.00	0.22 a	0.15 a	0.00	0.37 a	0.96 a
2	23.46 a	17.11 a	1.50 a	0.00	0.21 a	0.16 a	0.00	0.37 a	0.94 a
Tall Fescue									
0	13.55 a	12.96 a	3.10 a	0.00	0.12 a	0.11 a	0.00	0.23 a	0.95 a
1	12.85 a	12.84 a	3.23 a	0.00	0.16 a	0.17 a	0.00	0.33 a	1.46 a
2	11.12 a	13.57 a	3.03 a	0.00	0.06 a	0.04 a	0.00	0.10 a	0.90 a

* Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 83

Effect of Fertilizer on Characteristics of Meadow II Species

Fertilizer Treatment No.	Shoot Height (cm)	Root Length (cm)	No./Plant		Dry Weight (g)				Root/Shoot Ratio
			Stems	Seed Heads	Shoot	Root	Seed	Total	
Red Clover									
0	20.50 a*	20.91 a	1.57 a	0.20 a	0.48 a	0.36 a	0.00	0.84 a	0.98 a
1	25.02 a	20.14 a	1.77 a	0.53 a	0.79 a	0.34 a	0.00	1.13 a	0.53 a
2	23.73 a	21.66 a	1.77 a	0.40 a	0.71 a	0.42 a	0.00	1.13 a	0.73 a
European Bentgrass									
0	13.87 a	11.39 a	5.33 a	1.53 a	0.07 a	0.05 a	0.00	0.12 a	0.94 a
1	12.11 a	10.06 a	4.50 a	1.03 a	0.12 a	0.06 a	0.00	0.17 a	0.56 a
2	11.02 a	10.10 a	3.13 a	0.23 a	0.35 a	0.17 a	0.00	0.52 a	0.60 a
Barley									
0	24.09 a	11.62 a	1.07 a	0.77 a	0.32 a	0.08 a	0.09 a	0.40 a	0.41 a
1	31.82 a	12.36 a	1.03 a	0.80 a	0.38 a	0.12 a	0.05 a	0.50 a	0.51 a
2	24.45 a	12.81 a	1.07 a	0.63 a	0.51 a	0.15 a	0.14 a	0.67 a	0.31 a

* Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 84

Effect of Fertilizer on Characteristics of Meadow III Species

Fertilizer Treatment No.	Shoot Height (cm)	Root Length (cm)	No./Plant		Dry Weight (g)				Root/ Shoot Ratio
			Stems	Seed Heads	Shoot	Root	Seed	Total	
Hairy Vetch									
0	14.94 a*	15.70 a	1.47 a	0.00	1.09 a	0.22 a	0.00	1.30 a	0.28 a
1	14.19 a	17.63 a	1.27 a	0.00	2.35 a	0.25 a	0.00	2.60 a	0.12 a
2	14.92 a	16.83 a	1.37 a	0.00	2.44 a	0.41 a	0.00	2.85 a	0.20 a

* Values in vertical sequence not followed my the same letters are significantly different (p=0.05) by DMRT.

Table 85

Effect of Fertilizer on Biomass Values of Clipped Plants in Upland Monotypic Plots of Meadow I

Monotypic Plot and Species	Fertilizer Treatment and Biomass (g/0.1 m²)*		
	F0	F1	F2
White Clover			
Common Velvetgrass	4.95 a †	10.53 a	16.71 a
Rat-tail Fescue	4.65 b	18.65 a	19.01 a
Invaders**	16.33 a	20.38 a	22.55 a
White Clover	2.33 b	7.51 a	4.99 ab
Total	28.26 b	57.07 ab	63.25 a
Tall Wheatgrass			
Common Velvetgrass	2.51 c	8.40 b	14.13 a
Rat-tail Fescue	4.29 a	12.93 a	13.85 a
Invaders	8.46 a	12.26 a	15.79 a
Tall Wheatgrass	1.09 a	1.59 a	5.04 a
Total	16.34 b	37.18 ab	48.80 a
Tall Fescue			
Common Velvetgrass	19.21 a	6.65 a	9.62 a
Rat-tail Fescue	12.44 a	6.44 a	9.91 a
Invaders	17.59 ab	20.82 a	11.61 b
Tall Fescue	1.22 a	0.41 b	0.37 b
Total	50.46 a	34.31 a	31.51 a
Control			
Common Velvetgrass	4.39 b	8.81 b	33.94 a
Rat-tail Fescue	3.59 a	9.49 a	7.69 a
Invaders	21.13 a	42.87 a	30.09 a
Total	29.11 b	61.18 a	71.72 a

* Multiply by 100 to get kg/ha.

** Invaders refers to the additive weights of all other species of plants clipped in the plots and not listed in the table.

† Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 86

Effect of Fertilizer on Biomass Values of Clipped Plants in Upland Monotypic Plots of Meadow II

Monotypic Plot and Species	Fertilizer Treatment and Biomass (g/0.1 m²)*		
	F0	F1	F2
Red Clover			
Common Velvetgrass	3.27 a †	10.96 a	13.11 a
Rat-tail Fescue	3.61 b	15.20 a	20.61 a
Invaders**	2.76 b	9.80 a	7.23 ab
Red Clover	4.25 a	16.89 a	9.79 a
Total	13.88 b	52.85 a	50.74 a
Oregon Bentgrass			
Common Velvetgrass	0.52 a	8.13 a	6.19 a
Rat-tail Fescue	4.14 b	19.32 a	27.35 a
Invaders	4.77 a	14.68 a	8.51 a
Oregon Bentgrass	0.13 a	0.71 a	5.05 a
Total	9.56 b	42.84 a	47.09 a
Barley			
Common Velvetgrass	0.16 b	2.31 b	6.87 a
Rat-tail Fescue	1.43 b	10.26 a	10.73 a
Invaders	7.67 a	3.69 a	8.97 a
Barley	3.50 b	14.42 b	24.16 a
Total	12.77 b	28.68 b	50.74 a
Control			
Common Velvetgrass	2.78 b	5.98 b	10.89 a
Rat-tail Fescue	4.86 b	12.72 ab	21.26 a
Invaders	15.31 a	20.13 a	14.79 a
Total	22.95 b	38.83 ab	46.93 a

* Multiply by 100 to get kg/ha.

** Invaders refers to the additive weights of all other species of plants clipped in the plots and not listed in the table.

† Values in horizontal sequence not followed by the same letters are significantly different ($p=0.05$) by DMRT.

Table 87

Effect of Fertilizer on Biomass Values of Clipped Plants in Upland Monotypic Plots of Meadow III

Monotypic Plot and Species	Fertilizer Treatment and Biomass (g/0.1 m²)* F0	F1	F2
Hairy Vetch			
Common Velvetgrass	5.32 a +	6.31 a	11.42 a
Rat-tail Fescue	0.55 a	0.11 a	0.43 a
Invaders**	5.75 a	1.54 a	3.43 a
Hairy Vetch	23.11 b	44.95 a	45.99 a
Total	34.73 b	52.92 ab	61.26 a
Red Fescue†			
Common Velvetgrass	3.67 c	12.58 b	20.59 a
Rat-tail Fescue	3.66 b	15.86 a	14.03 ab
Invaders	6.11 b	15.27 ab	23.69 a
Total	13.43 c	43.71 b	58.31 a
Reed Canarygrass††			
Common Velvetgrass	8.65 b	14.57 b	26.79 a
Rat-tail Fescue	4.43 a	6.45 a	6.85 a
Invaders	12.54 a	9.83 a	14.53 a
Total	25.61 b	30.85 ab	48.17 a
Control			
Common Velvetgrass	6.86 a	14.48 a	19.87 a
Rat-tail Fescue	4.80 a	9.27 a	6.27 a
Invaders	6.23 a	10.82 a	9.65 a
Total	17.89 a	34.57 a	35.79 a

* Multiply by 100 to get kg/ha.

** Invaders refers to the additive weights of all other species of plants clipped in the plots and not listed in the table.

† No emergence of Creeping Red Fescue - see Table E4.

†† No emergence of Reed Canary Grass - see Table E4.

\+ Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 88

Percent Cover Values of Planted Species and Major Grass Invaders in Upland Monotypic Plots of Meadow I during July 1977 Sampling Period

Monotypic Plot and Species	Fertilizer Treatment and Percent Cover		
	F0	F1	F2
White Clover			
Common Velvetgrass	23.6 b *	54.7 ab	62.5 a
Rat-tail Fescue	35.8 b	76.4 a	73.6 a
White Clover	25.8 a	29.2 a	32.5 a
Tall Wheatgrass			
Common Velvetgrass	25.8 b	44.7 ab	70.8 a
Rat-tail Fescue	49.2 b	76.4 a	65.8 ab
Tall Wheatgrass	7.8 a	9.2 a	9.2 a
Tall Fescue			
Common Velvetgrass	43.1 b	56.9 ab	76.4 a
Rat-tail Fescue	51.9 a	50.8 a	62.5 a
Tall Wheatgrass	5.0 b	13.3 a	13.3 a
Control			
Common Velvetgrass	28.6 b	65.3 a	76.4 a
Rat-tail Fescue	33.3 a	43.3 a	47.5 a

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 89

Percent Cover Values of Planted Species and Major Grass Invaders in Upland Monotypic Plots of Meadow II during July 1977 Sampling Period

Monotypic Plot and Species	Fertilizer Treatment and Percent Cover		
	F0	F1	F2
Red Clover			
Common Velvetgrass	5.8 b *	46.4 a	70.8 a
Rat-tail Fescue	27.8 c	76.4 b	84.7 a
Red Clover	56.9 a	54.2 a	45.8 a
Oregon Bentgrass			
Common Velvetgrass	21.1 a	63.6 a	59.7 a
Rat-tail Fescue	55.3 b	84.7 a	87.5 a
Oregon Bentgrass	5.3 a	11.7 a	28.1 a
Barley			
Common Velvetgrass	4.2 a	11.7 a	21.7 a
Rat-tail Fescue	20.8 a	44.2 a	44.2 a
Barley	38.1 a	56.9 a	57.5 a
Control			
Common Velvetgrass	46.4 a	59.7 a	70.8 a
Rat-tail Fescue	63.1 a	79.2 a	87.5 a

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 90

Percent Cover Values of Planted Species and Major Grass Invaders in Upland Monotypic Plots of Meadow III during July 1977 Sampling Period

Monotypic Plot and Species	Fertilizer Treatment and Percent Cover		
	F0	F1	F2
Hairy Vetch			
Common Velvetgrass	34.2 a*	30.0 a	39.7 a
Rat-tail Fescue	1.7 a	0.6 a	0.6 a
Hairy Vetch	81.9 a	84.7 a	81.9 a
Creeping Red Fescue			
Common Velvetgrass	38.1 b	60.3 a	73.6 a
Rat-tail Fescue	57.5 a	68.6 a	56.7 a
Red Fescue	0.0	0.0	0.0
Reed Canarygrass			
Common Velvetgrass	43.6 b	59.7 b	76.9 a
Rat-tail Fescue	25.6 a	20.0 a	23.3 a
Reed Canarygrass	0.0	0.0	0.0
Control			
Common Velvetgrass	56.9 a	62.5 a	76.4 a
Rat-tail Fescue	46.1 a	43.3 a	47.5 a

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 91

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: White Clover

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	0.00	0.00	0.00
Festuca arundinacea	2.42	2.65	2.64	2.57
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	17.74	18.72	20.29	18.92
Aira praecox	0.00	11.82	10.16	7.33
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	32.54	39.25	37.82	36.54
Holcus lanatus	25.13	30.95	33.62	29.90
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	0.00	0.00	0.00	0.00
Trifolium repens	25.84	29.17	32.50	29.17
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	1.54	1.32	0.00	0.95
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	31.07	15.75	22.70	23.17
Medicago lupulina	1.21	0.00	0.00	0.40
Vicia sp.	4.76	1.32	2.96	3.01

(Continued)

Table 91 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	1.32	0.00	0.44
Cerastium vulgatum	19.09	20.95	17.45	19.16
Epilobium angustifolium	2.38	0.00	1.32	1.23
Hypochaeris radicata	3.96	9.59	8.42	7.32
Plantago lanceolata	0.00	0.00	0.00	0.00
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	5.18	7.68	4.49	5.78
Silene antirrhina	4.85	3.55	1.12	3.17
Teesdalia nudicaulus	2.42	0.00	3.35	1.92
Equisetum				
Equisetum hyemale	13.21	13.94	11.39	12.85

Table 92

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Tall Wheatgrass

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	13.51	11.99	13.85	13.12
Agrostis oregonensis	0.00	0.00	1.55	0.52
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	17.48	13.80	14.00	15.09
Aira praecox	2.16	0.97	0.00	1.04
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	33.90	36.42	40.48	36.93
Holcus lanatus	22.40	24.91	43.06	30.12
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	3.78	1.16	0.00	1.65
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	31.30	31.07	22.18	28.18
Medicago lupulina	18.48	16.93	8.36	14.59
Vicia sp.	0.00	2.83	1.27	1.37

(Continued)

Table 92 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	1.08	1.16	4.38	2.21
Cerastium vulgatum	19.99	18.55	10.75	16.43
Epilobium angustifolium	2.70	0.00	0.00	0.90
Hypochaeris radicata	10.13	10.27	10.30	10.23
Plantago lanceolata	0.00	0.00	0.00	0.00
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	2.43	10.47	9.31	7.40
Silene antirrhina	2.16	0.97	1.27	1.47
Teesdalia nudicaulus	3.78	4.26	2.82	3.62
Equisetum				
Equisetum hyemale	12.56	9.99	11.58	11.38

Table 93

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Tall Fescue

Species	Fertilizer Treatments F0	F1	F2	x̄
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.91	0.00	1.90	0.94
Festuca arundinacea	10.04	13.78	13.62	12.48
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	20.89	17.58	18.11	18.86
Aira praecox	4.97	2.03	4.21	3.74
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	27.51	26.95	32.53	29.00
Holcus lanatus	24.20	29.10	37.87	30.39
Poa sp.	0.00	1.01	2.10	1.04
Legumes				
Trifolium pratense	4.46	1.21	4.00	3.22
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	22.75	23.11	16.33	20.73
Medicago lupulina	17.79	18.33	14.40	16.84
Vicia sp.	7.23	16.96	6.25	10.15

(Continued)

Table 93 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.91	2.22	0.95	1.36
Cerastium vulgatum	26.47	16.80	14.48	19.25
Epilobium angustifolium	0.00	2.41	3.05	1.82
Hypochaeris radicata	5.38	4.63	4.42	4.81
Plantago lanceolata	1.83	1.01	0.95	1.26
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	9.43	8.25	10.74	9.47
Silene antirrhina	0.91	0.00	0.00	0.30
Teesdalia nudicaulus	2.94	3.42	5.16	3.84
Equisetum				
Equisetum hyemale	9.95	10.19	8.95	9.70

Table 94

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Control (Meadow I)

Species	Fertilizer Treatments FO	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	0.00	0.00	0.00
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	15.21	13.31	14.62	14.38
Aira praecox	7.63	8.13	8.06	7.94
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	20.70	22.06	23.44	22.07
Holcus lanatus	18.97	28.97	32.43	26.79
Poa sp.	1.15	4.20	0.00	1.78
Legumes				
Trifolium pratense	1.15	1.11	0.00	0.75
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	28.34	24.34	15.65	22.78
Medicago lupulina	23.86	15.35	18.59	19.27
Vicia sp.	18.52	21.56	22.31	20.80

(Continued)

Table 94 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	1.89	0.00	0.97	0.95
Cerastium vulgatum	17.96	16.99	17.13	17.36
Epilobium angustifolium	0.00	0.94	0.00	0.31
Hypochaeris radicata	10.30	10.11	7.83	9.41
Plantago lanceolata	0.00	9.52	4.03	4.52
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	11.05	13.60	14.62	13.09
Silene antirrhina	6.28	2.81	2.90	4.00
Teesdalia nudicaulus	4.70	6.25	5.67	5.54
Equisetum				
Equisetum hyemale	11.14	9.30	11.77	10.74

Table 95

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Red Clover

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	1.22	1.22	0.81
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	1.25	0.00	0.00	0.42
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	16.58	18.54	18.62	17.91
Aira praecox	10.47	11.31	12.83	11.54
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	37.11	46.25	46.29	43.22
Holcus lanatus	14.60	32.39	40.50	29.16
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	64.42	35.99	30.08	43.50
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	1.75	1.48	0.00	1.08
Lupinus rivularis	7.86	5.07	4.93	5.95
Medicago lupulina	0.00	0.00	0.00	0.00
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 95 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	0.00	0.00	0.00
Cerastium vulgatum	14.32	14.12	9.06	12.50
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	5.49	8.10	12.61	8.73
Plantago lanceolata	0.00	0.00	3.20	1.07
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	3.73	13.03	11.38	9.38
Silene antirrhina	11.20	3.93	3.90	6.34
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	11.20	8.57	7.34	9.04

Table 96

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Oregon Bentgrass

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	12.14	14.01	23.97	16.71
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	3.28	1.24	0.00	1.51
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	14.80	13.30	14.53	14.21
Aira praecox	4.26	8.81	8.35	7.14
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	44.19	44.77	52.79	47.25
Holcus lanatus	22.29	35.88	39.32	32.50
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	12.25	8.18	0.00	6.81
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	30.11	24.77	13.11	22.66
Medicago lupulina	5.31	5.26	1.42	4.00
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 96 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	3.20	0.00	0.00	1.07
Cerastium vulgatum	12.23	11.68	9.14	11.02
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	10.08	11.71	8.92	10.24
Plantago lanceolata	0.00	0.00	0.00	0.00
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	8.52	10.97	12.70	10.73
Silene antirrhina	4.89	3.04	2.31	3.41
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	11.63	8.02	10.66	10.10

Table 97

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Barley

Species	Fertilizer Treatments			
	F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	4.16	1.13	0.00	1.76
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	46.63	42.01	46.28	44.97
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	14.01	12.91	14.74	13.89
Aira praecox	2.43	7.69	10.48	6.87
Avena fatua	0.00	4.52	2.72	2.41
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	30.45	34.85	38.01	34.44
Holcus lanatus	13.59	15.53	22.87	17.33
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	4.16	0.00	0.00	1.39
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	39.96	31.71	14.02	28.56
Medicago lupulina	7.61	6.56	1.52	5.23
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 97 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	0.00	0.00	0.00
Cerastium vulgatum	8.83	4.30	11.49	8.21
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	8.92	12.26	8.45	9.88
Plantago lanceolata	0.00	0.00	0.00	0.00
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	4.16	12.26	11.17	9.20
Silene antirrhina	6.59	9.74	8.45	8.26
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	8.51	4.52	9.80	7.61

Table 98

Importance Values of Plants Located in Upland Monotypic Plots During July 1977 Sampling Period: Control (Meadow II)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.87	6.85	3.33	3.68
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	0.00	0.00	1.23	0.41
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	12.25	12.25	12.92	12.47
Aira praecox	10.43	8.79	10.57	9.93
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	35.79	42.24	40.33	39.45
Holcus lanatus	29.34	33.53	34.43	32.43
Poa sp.	5.71	5.39	6.23	5.78
Legumes				
Trifolium pratense	1.11	0.00	0.00	0.37
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	0.00	0.00	0.00	0.00
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	2.81	0.00	0.00	0.94
Lupinus rivularis	36.87	35.89	31.88	34.88
Medicago lupulina	9.52	9.17	12.70	10.46
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 98 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	0.00	0.00	0.00
Cerastium vulgatum	9.86	6.93	6.23	7.67
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	11.71	11.63	10.89	11.41
Plantago lanceolata	1.98	1.46	2.28	1.91
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	9.13	6.93	10.01	8.69
Silene antirrhina	9.16	4.96	5.61	6.58
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	13.44	14.00	11.36	12.93

Table 99

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Hairy Vetch

Species	Fertilizer Treatments			
	F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	2.17	0.00	0.72
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	14.43	11.54	10.08	12.02
Aira praecox	11.83	5.29	5.80	7.64
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	12.53	12.76	10.08	11.79
Holcus lanatus	34.67	38.67	48.20	40.51
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	0.00	0.00	0.00	0.00
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	65.17	80.41	81.04	75.54
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	0.00	0.00	0.00	0.00
Medicago lupulina	1.78	0.00	0.00	0.59
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 99 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	0.00	0.00	0.00
Cerastium vulgatum	16.21	18.87	10.08	15.05
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	4.31	0.00	0.00	1.44
Plantago lanceolata	0.00	0.00	0.00	0.00
Raphanus sativus	1.44	1.76	4.71	2.64
Rumex acetosella	20.86	11.41	10.51	14.26
Silene antirrhina	0.00	0.00	0.00	0.00
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	16.78	17.11	19.50	17.80

Table 100

Importance Values of Plants Located in Upland Monotypic Plots during July 1977 Sampling Period: Red Fescue

Species	Fertilizer Treatments			
	F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	0.00	3.31	1.10
Festuca arundinacea	0.00	0.00	0.00	0.00
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	29.24	18.71	23.13	23.69
Aira praecox	12.02	9.98	10.11	10.70
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	0.00	0.00	0.00
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	34.95	41.46	32.22	36.21
Holcus lanatus	26.63	37.79	38.90	34.44
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	0.00	0.00	0.00	0.00
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	1.39	1.49	2.64	1.84
Lathyrus japonicus	0.00	0.00	0.00	0.00
Lathyrus sphaericus	0.00	5.53	0.00	1.84
Lupinus rivularis	16.49	16.70	19.64	17.61
Medicago lupulina	19.26	15.91	18.54	17.90
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 100 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	0.00	0.00	0.00
Cerastium vulgatum	25.32	14.16	15.04	18.17
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	12.48	9.26	10.11	10.62
Plantago lanceolata	0.00	0.00	0.00	0.00
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	13.67	18.71	16.90	16.43
Silene antirrhina	0.00	0.00	0.00	0.00
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	8.55	10.28	9.47	9.43

Table 101

Importance Values of Plants Located in Upland Monotypic Plots During July 1977 Sampling Period: Reed Canarygrass

Species	Fertilizer Treatments F0	F1	F2	x̄
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	0.00	0.00	0.00
Festuca arundinacea	12.94	12.80	11.17	12.30
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	2.29	0.76
Aira caryophyllea	28.25	30.12	26.96	28.44
Aira praecox	16.63	18.53	15.65	16.94
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	1.46	1.38	1.14	1.33
Bromus stellarium	0.00	0.00	0.00	0.00
Festuca myuros	26.76	19.60	22.66	23.01
Holcus lanatus	38.76	38.65	51.23	42.88
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	0.00	0.00	0.00	0.00
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	2.91	4.13	1.14	2.73
Lathyrus japonicus	2.38	2.76	0.00	1.71
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	9.71	16.48	8.84	11.68
Medicago lupulina	17.76	18.17	15.65	17.19
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 101 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	0.00	0.00	0.00	0.00
Cerastium vulgatum	10.56	11.17	11.95	11.23
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	7.48	4.99	5.44	5.97
Plantago lanceolata	6.56	2.49	5.44	4.83
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	10.56	12.35	10.81	11.24
Silene antirrhina	0.00	0.00	2.86	0.95
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	7.29	6.37	6.85	6.84

Table 102

Importance Values of Plants Located in Upland Monotypic Plots During July 1977 Sampling Period: Control (Meadow III)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Grasses				
Agropyron elongatum	0.00	0.00	0.00	0.00
Agrostis oregonensis	0.00	0.00	0.00	0.00
Festuca arundinacea	2.58	5.96	11.00	6.51
Hordeum vulgare	0.00	0.00	0.00	0.00
Phalaris arundinacea	0.00	0.00	0.00	0.00
Aira caryophyllea	25.71	27.26	36.11	29.69
Aira praecox	13.74	14.08	18.40	15.41
Avena fatua	0.00	0.00	0.00	0.00
Bromus rigidus	0.00	8.14	0.00	2.71
Bromus stellarium	4.39	0.00	1.63	2.01
Festuca myuros	34.63	32.02	33.52	33.39
Holcus lanatus	43.55	38.00	46.31	42.62
Poa sp.	0.00	0.00	0.00	0.00
Legumes				
Trifolium pratense	0.00	0.00	0.00	0.00
Trifolium repens	0.00	0.00	0.00	0.00
Vicia villosa	1.43	0.00	0.00	0.48
Lathyrus japonicus	0.00	3.66	0.00	1.22
Lathyrus sphaericus	0.00	0.00	0.00	0.00
Lupinus rivularis	18.36	14.37	0.00	10.91
Medicago lupulina	1.43	1.62	1.63	1.56
Vicia sp.	0.00	0.00	0.00	0.00

(Continued)

Table 102 (Concluded)

Species	Fertilizer Treatments F0	F1	F2	$\bar{x}$
Broadleaves				
Anaphalis margaritacea	4.89	0.00	0.00	1.63
Cerastium vulgatum	10.42	9.21	10.80	10.14
Epilobium angustifolium	0.00	0.00	0.00	0.00
Hypochaeris radicata	4.01	2.98	1.39	2.79
Plantago lanceolata	0.00	8.41	6.97	5.13
Raphanus sativus	0.00	0.00	0.00	0.00
Rumex acetosella	16.10	16.79	17.79	16.89
Silene antirrhina	0.00	0.00	0.00	0.00
Teesdalia nudicaulus	0.00	0.00	0.00	0.00
Equisetum				
Equisetum hyemale	18.75	17.49	14.44	16.89

Table 103

Frequency and Dominance Values of Plant Species Present in Meadow Reference Area During July 1977 Sampling Period

Species	Frequency	Relative Frequency	Relative Dominance	Importance Value
Lupinus rivularis	0.80	12.8	29.47	42.27
Moss	0.55	8.8	23.49	32.29
Equisetum hyemale	1.00	16.0	15.10	31.10
Holcus lanatus	0.70	11.2	13.94	25.14
Hypochaeris radicata	1.00	16.0	9.41	25.41
Cerastium vulgatum	0.25	4.0	2.41	6.41
Anaphalis margaritacea	0.20	3.2	1.75	4.95
Agrostis alba	0.30	4.8	1.61	6.41
Aira praecox	0.20	3.2	0.81	4.01
Aira caryophyllea	0.45	7.2	0.60	7.80
Trifolium pratense	0.05	0.8	0.51	1.31
Rumex acetosella	0.10	1.6	0.29	1.89
Festuca myuros	0.25	4.0	0.16	4.16
Poa reflexa	0.20	3.2	0.15	3.35
Deschampsia cespitosa	0.05	0.8	0.15	0.95
Hieracium albiflorum	0.05	0.8	0.15	0.95
Plantago lanceolata	0.05	0.8	0.00	0.80
Epilobeum luteum	0.05	0.8	0.00	0.80

Table 104

Frequency and Dominance Values of Plant Species Present in Meadow I During July 1977 Sampling Period

Species	Frequency	Relative Frequency	Relative Dominance	Importance Value
Holcus lanatus	1.00	9.43	25.45	34.89
Festuca myuros	1.00	0.43	20.36	29.80
Lupinus rivularis	1.00	9.43	18.27	27.71
Aira caryophyllea	1.00	9.43	11.64	21.07
Medicago lupulina	0.60	5.66	7.82	13.48
Aira praecox	0.80	7.55	5.00	12.55
Trifolium repens	0.85	8.02	3.41	11.43
Cerastium vulgatum	0.45	4.25	2.45	6.70
Equisetum hyemale	0.95	8.96	2.05	11.01
Agropyron elongatum	0.85	8.02	1.10	9.12
Festuca elatior	0.50	4.72	0.78	5.50
Hypochaeris radicata	0.75	7.08	0.65	7.72
Rumex acetosella	0.45	4.25	0.64	4.88
Agrostis alba	0.15	1.42	0.09	1.51
Epilobium luteum	0.05	0.47	0.09	0.56
Teesdalia nudicaulis	0.05	0.47	0.09	0.56
Plantago lanceolata	0.10	0.94	0.00	0.95

Table 105

Frequency and Dominance Values of Plant Species Present in Meadow II During July 1977 Sampling Period

Species	Frequency	Relative Frequency	Relative Dominance	Importance Value
Festuca myuros	1.00	10.26	25.61	35.86
Holcus lanatus	1.00	10.26	16.55	26.81
Lupinus rivularis	1.00	10.26	15.08	25.34
Hordeum vulgare	1.00	10.26	13.79	24.05
Trifolium pratense	1.00	10.26	9.84	20.09
Aira caryophyllea	1.00	10.26	9.80	20.05
Medicago lupulina	0.50	5.13	3.77	8.90
Aira praecox	0.75	7.69	1.76	9.45
Agrostis oregonensis	0.65	6.67	1.16	7.83
Equisetum hyemale	0.45	4.62	0.97	5.59
Hypochaeris radicata	0.40	4.10	0.56	4.66
Rumex acetosella	0.35	3.59	0.46	4.05
Cerastium vulgatum	0.10	1.03	0.18	1.21
Agropyron elongatum	0.20	2.05	0.10	2.15
Poa reflexa	0.10	1.03	0.09	1.12
Lathyrus japonicus	0.05	0.51	0.09	0.60
Daucus carota	0.05	0.51	0.09	0.60
Bromus sp.	0.05	0.51	0.09	0.60
Avena fatua	0.10	1.03	0.00	1.03

Table 106

Frequency and Dominance Values of Plant Species Present in Meadow III During July 1977 Sampling Period

Speceis	Frequency	Relative Frequency	Relative Dominance	Importance Value
Vicia villosa	1.00	16.26	50.11	66.37
Holcus lanatus	1.00	16.26	26.41	42.67
Festuca myuros	1.00	16.26	15.33	31.60
Anaphalis margaritacea	0.15	2.44	2.61	5.04
Equisetum hyemale	0.90	14.63	1.77	16.40
Aira caryophyllea	0.80	13.01	1.30	14.31
Lupinus rivularis	0.10	1.63	0.87	2.49
Rumex acetosella	0.25	4.07	0.77	4.84
Hypochaeris radicata	0.30	4.88	0.40	5.28
Aira praecox	0.40	6.50	0.22	6.72
Epilobium angustifolium	0.05	0.81	0.19	1.01
Poa compressa	0.10	1.63	0.01	1.63
Cerastium vulgatum	0.05	0.81	0.00	0.82
Phalaris arundinacea	0.05	0.81	0.00	0.82

Table 107

Aboveground Biomass of Cage and Quadrat Pairs in the Upland Reference Meadow - 1976 Harvest

Species	Cage Quadrat No.	Biomass (kg/ha) Cage (Inside) Mean ± SE	Quadrat (Outside) Mean ± SE	Mean ± SE
Common Scouring Rush	Pair 1	-	-	305 ± 58
	Pair 2	-	-	1000 ± 91
	Pair 3	-	-	440 ± 85
	Mean	538 ± 120	627 ± 100	582 ± 96
Common Velvetgrass	Pair 1	-	-	637 ± 74
	Pair 2	-	-	21 ± 21
	Pair 3	-	-	0
	Mean	269 ± 157	170 ± 108	220 ± 92
Grass Species (except Common Velvetgrass)	Pair 1	-	-	0
	Pair 2	-	-	70 ± 25
	Pair 3	-	-	18 ± 8
	Mean	19 ± 7	40 ± 25	29 ± 12
Stream Lupine	Pair 1	-	-	176 ± 93
	Pair 2	-	-	185 ± 48
	Pair 3	-	-	415 ± 72
	Mean	148 ± 55	368 ± 59	258 ± 51
Broadleaf Species (except Stream Lupine)	Pair 1	-	-	119 ± 67
	Pair 2	-	-	41 ± 13
	Pair 3	-	-	36 ± 5
	Mean	51 ± 8	79 ± 48	65 ± 24
Total all species	Pair 1	-	-	1163 ± 81
	Pair 2	-	-	1320 ± 140
	Pair 3	-	-	908 ± 130
	Mean	1025 ± 111	1235 ± 109	1130 ± 81

Table 108

Aboveground Biomass of Cage and Quadrat Pairs in Upland Reference Area - 1977 Harvest

Species	Cage Quadrat No.	Biomass ($g/0.1\ m^2$)* Cage (Inside)	Quadrat (Outside)	Mean
Common Velvetgrass	Pair 1	1.27 **	2.45	1.86 b
	Pair 2	1.75	0.01	0.87 b
	Pair 3	11.76	9.02	10.39 a
	Mean	4.93 a	3.83 a	4.38
Rat-tail fescue	Pair 1	0.00	0.24	0.12 b
	Pair 2	0.33	0.36	0.35 a
	Pair 3	0.04	0.00	0.02 b
	Mean	0.12 a	0.20 a	0.16
Invaders†	Pair 1	31.53	37.28	34.41 a
	Pair 2	40.35	30.06	35.20 a
	Pair 3	24.52	52.13	38.33 a
	Mean	32.13 a	39.82 a	35.98
Total	Pair 1	32.81	39.97	36.39 a
	Pair 2	42.43	30.43	36.43 a
	Pair 3	36.32	61.15	48.73 a
	Mean	37.18 a	43.85 a	40.52

* Multiply by 100 to get kg/ha.

** Means not followed by the same letters are significantly different (p=0.05) by DMRT.

† Invaders include combined weights of all other plants not listed in table.

Table 109

Aboveground Biomass of Plants Randomly Harvested in Upland Meadow Areas - 1977 Harvest

Species	Biomass kg/ha			
	Meadow I	Meadow II	Meadow III	Control
Holcus lanatus	2540 a*	791 b	646 b	1083 b
Festuca myuros	851 b	1930 a	320 bc	0 c
Invaders**	1476 a	2191 a	248 b	2232 a
Agropyron elongatum	71 a	0 a	88 a	0 a
Festuca elatior	19 a	0 a	0 a	0 a
Trifolium repens	109 a	0 a	0 a	0 a
Agrostis oregonensis	0 a	4 a	0 a	0 a
Hordeum vulgare	0 b	1000 a	0 b	0 b
Trifolium pratense	0 b	247 a	0 b	0 b
Vicia villosa	0 b	0 b	3434 a	0 b
Total	5066 ab	6163 a	4736 ab	3315 b

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

** Invaders represent combined weights of all other plant species not listed in table.

Table 110

Aboveground Biomass of Cage and Quadrat Pairs in Upland Meadow I - 1977 Harvest

Species	Cage Quadrat No.	Biomass ($g/0.1\ m^2$)* Cage (Inside)	Quadrat (Outside)	Mean
Common Velvetgrass	Pair 1	0.00 **	0.68	0.34 b
	Pair 2	8.67	7.78	8.22 a
	Pair 3	7.60	9.46	8.53 a
	Mean	5.42 a	5.97 a	5.70
Rat-tail Fescue	Pair 1	16.70	17.58	17.14 b
	Pair 2	34.40	14.95	24.68 a
	Pair 3	22.92	19.11	21.01 ab
	Mean	24.67 a	17.22 b	20.94
Invaders	Pair 1	5.70	2.17	3.94 b
	Pair 2	19.55	6.80	13.17 a
	Pair 3	13.32	11.79	12.56 a
	Mean	12.86 a	6.29 b	9.89
Tall Fescue	Pair 1	2.38	0.94	1.66 a
	Pair 2	0.38	0.64	0.51 a
	Pair 3	0.08	0.81	0.44 a
	Mean	0.94 a	0.80 a	0.87
Tall Wheatgrass	Pair 1	0.96	0.84	0.90 a
	Pair 2	0.12	1.46	0.79 a
	Pair 3	0.43	0.37	0.40 a
	Mean	0.50 a	0.89 a	0.70
White Clover	Pair 1	0.18	0.14	0.16 b
	Pair 2	0.01	0.66	0.33 b
	Pair 3	1.11	7.50	4.30 a
	Mean	0.43 b	2.76 a	1.60

(Continued)

Table 110 (Concluded)

Species	Cage Quadrat No.	Biomass (g/0.1 m²)* Cage (Inside)	Quadrat (Outside)	Mean
Total	Pair 1	25.91	22.36	24.13 b
	Pair 2	63.12	32.29	47.71 a
	Pair 3	45.44	49.04	47.24 a
	Mean	44.83 a	34.56 b	39.69

* Multiply by 100 to get kg/ha.

** Means not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 111

Aboveground Biomass of Cage and Quadrat Pairs in Upland Meadow II - 1977 Harvest

Species	Cage Quadrat No.	Biomass (g/0.1 m²)*		
		Cage (Inside)	Quadrat (Outside)	Mean
Common Velvetgrass	Pair 1	5.46 **	2.54	4.00 a
	Pair 2	5.58	2.98	4.28 a
	Pair 3	2.22	0.65	1.43 a
	Mean	4.42 a	2.06 a	3.24
Rat-tail Fescue	Pair 1	16.34	22.97	19.65 a
	Pair 2	24.29	24.70	24.49 a
	Pair 3	4.48	3.68	4.08 b
	Mean	15.03 a	17.12 a	16.07
Invaders	Pair 1	11.32	9.27	10.29 b
	Pair 2	8.44	19.54	13.99 b
	Pair 3	24.83	24.43	24.63 a
	Mean	14.86 a	17.75 a	16.30
Barley	Pair 1	11.78	17.38	14.58 a
	Pair 2	6.98	9.34	8.16 a
	Pair 3	14.18	5.93	10.05 a
	Mean	10.98 a	10.88 a	10.93
Oregon Bentgrass	Pair 1	0.00	0.21	0.11 a
	Pair 2	0.00	0.00	0.00 a
	Pair 3	0.25	0.45	0.35 a
	Mean	0.08 a	0.22 a	0.15
Red Clover	Pair 1	2.64	0.41	1.52 a
	Pair 2	5.78	2.33	4.06 a
	Pair 3	0.55	3.05	1.80 a
	Mean	2.99 a	1.93 a	2.46

(Continued)

Table 111 (Concluded)

Species	Cage Quadrat No.	Biomass (g/0.1 m^2)* Cage (Inside)	Quadrat (Outside)	Mean
Total	Pair 1	47.53	52.77	50.15 ab
	Pair 2	51.07	58.90	54.98 a
	Pair 3	46.49	38.13	42.33 b
	Mean	48.36 a	49.95 a	49.16

* Multiply by 100 to get kg/ha.
** Means not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 112

Aboveground Biomass of Cage and Quadrat Pairs in Upland Meadow III - 1977 Harvest

Species**	Cage Quadrat No.	Biomass (g/0.1 m²)* Cage (Inside)	Quadrat (Outside)	Mean
Common Velvetgrass	Pair 1	0.35 †	0.23	0.29 b
	Pair 2	0.00	0.10	0.05 b
	Pair 3	6.35	3.25	4.80 a
	Mean	2.23 a	1.19 a	1.71
Rat-tail Fescue	Pair 1	1.00	0.53	0.76 a
	Pair 2	0.08	0.13	0.10 b
	Pair 3	0.00	0.00	0.00 b
	Mean	0.36 a	0.22 a	0.29
Invaders	Pair 1	11.67	9.15	10.41 a
	Pair 2	6.63	5.38	6.00 a
	Pair 3	10.63	6.90	8.76 a
	Mean	9.64 a	7.14 a	8.39
Hairy Vetch	Pair 1	17.20	25.73	21.46 a
	Pair 2	21.98	28.93	25.45 a
	Pair 3	24.93	29.65	27.29 a
	Mean	21.37 a	28.10 a	24.73
Total	Pair 1	30.22	35.63	32.92 a
	Pair 2	28.68	34.53	31.60 a
	Pair 3	41.90	39.80	40.85 a
	Mean	33.60 a	36.65 a	35.12

* Multiply by 100 to get kg/ha.

** Planted species reed canarygrass and creeping red fescue failed to emerge.

† Means not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 113

Effect of Treatment on Nutrient Concentration in Shoot Material of Monotypic Species of Meadow I - July 1977 Harvest

Species and Fertilizer Treatment	Shoot Nutrient Concentration (%) N	P	K
White Clover			
F0	1.99 a*	0.12 a	1.35 a
F1	2.23 a	0.21 a	1.81 a
F2	2.10 a	0.11 a	1.46 a
Mean	2.11	0.15	1.54
Tall Wheatgrass			
F0	0.56 a	0.11 a	0.75 a
F1	0.56 a	0.09 a	0.87 a
F2	0.54 a	0.14 a	0.86 a
Mean	0.55	0.11	0.83
Tall Fescue			
F0	0.98 a	0.10 a	1.13 a
F1	1.19 a	0.15 a	1.39 a
F2	0.85 a	0.12 a	1.44 a
Mean	1.01	0.12	1.32

* Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 114

Effect of Treatment on Nutrient Concentration in Shoot Material of Monotypic Species of Meadow II - July 1977 Harvest

Species and Fertilizer Treatment	Shoot Nutrient Concentration (%)		
	N	P	K
Red Clover			
F0	1.62 a*	0.13 a	0.87 a
F1	1.35 a	0.14 a	1.08 a
F2	1.73 a	0.15 a	0.96 a
Mean	1.56	0.14	0.98
Oregon Bentgrass			
F0	0.51 a	0.15 a	0.60 a
F1	0.51 a	0.11 a	0.47 a
F2	0.54 a	0.11 a	0.54 a
Mean	0.52	0.12	0.54
Barley			
F0	0.35 a	0.08 a	0.52 ab
F1	0.34 a	0.07 a	0.43 b
F2	0.34 a	0.06 a	0.58 a
Mean	0.34	0.07	0.51

* Values in vertical sequence not followed by the same letters are significantly different ($p=0.05$) by DMRT.

Table 115

Effect of Treatment on Nutrient Concentration in Shoot Material of Monotypic Species of Meadow III - July 1977 Harvest

Species* and Fertilizer Treatment	Shoot Nutrient Concentration (%)		
	N	P	K
Hairy Vetch			
F0	1.63 a**	0.10 a	1.04 a
F1	1.51 a	0.08 a	0.96 a
F2	1.64 a	0.12 a	1.06 a
Mean	1.59	0.10	1.02

* No data available on Creeping Red Fescue and Reed Canarygrass. Refer to Table E4.

** Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 116

Effect of Treatment on Nutrient Uptake in Shoot Material of Monotypic Species of Meadow I - July 1977 Harvest

Species and Fertilizer Treatment	Shoot Nutrient Uptake (mg/Plant)		
	N	P	K
White Clover			
F0	7.5 b*	0.4 b	5.0 b
F1	28.1 a	2.6 a	23.4 a
F2	15.6 ab	0.8 b	10.6 ab
Mean	17.1	1.3	13.0
Tall Wheatgrass			
F0	1.0 b	0.2 a	1.4 a
F1	1.2 a	0.2 a	1.9 a
F2	1.1 ab	0.3 a	1.7 a
Mean	1.1	0.2	1.7
Tall Fescue			
F0	0.7 a	0.1 a	1.0 a
F1	1.2 a	0.2 a	2.1 a
F2	0.5 a	0.1 a	0.9 a
Mean	0.8	0.1	1.3

* Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 117

Effect of Treatment on Nutrient Uptake in Shoot Material of Monotypic Species of Meadow II - July 1977 Harvest

Species and Fertilizer Treatment	Shoot Nutrient Uptake (mg/Plant) N	P	K
Red Clover			
F0	7.1 a*	0.5 a	3.8 a
F1	10.2 a	1.1 a	8.9 a
F2	12.7 a	1.2 a	7.0 a
Mean	10.4	1.0	6.9
Oregon Bentgrass			
F0	0.4 b	0.1 a	0.4 a
F1	0.5 b	0.1 a	0.5 a
F2	1.6 a	0.4 a	1.6 a
Mean	0.9	0.2	0.9
Barley			
F0	1.1 a	0.2 a	1.8 a
F1	1.3 a	0.3 a	1.7 a
F2	1.7 a	0.3 a	3.0 a
Mean	1.4	0.3	2.2

* Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table 118

Effect of Treatment on Nutrient Uptake in Shoot Material of Monotypic Species of Meadow III - July 1977 Harvest

Species* and Fertilizer Treatment	Shoot Nutrient Uptake (mg/Plant)		
	N	P	K
Hairy Vetch			
F0	17.4 b**	1.1 b	11.2 b
F1	34.9 ab	1.6 b	21.0 ab
F2	40.0 a	2.8 a	25.7 a
Mean	30.8	1.3	19.3

* No data was collected on creeping red fescue and reed canarygrass. Refer to Table 4.

** Values in vertical sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

APPENDIX A': DATA SUPPLEMENT

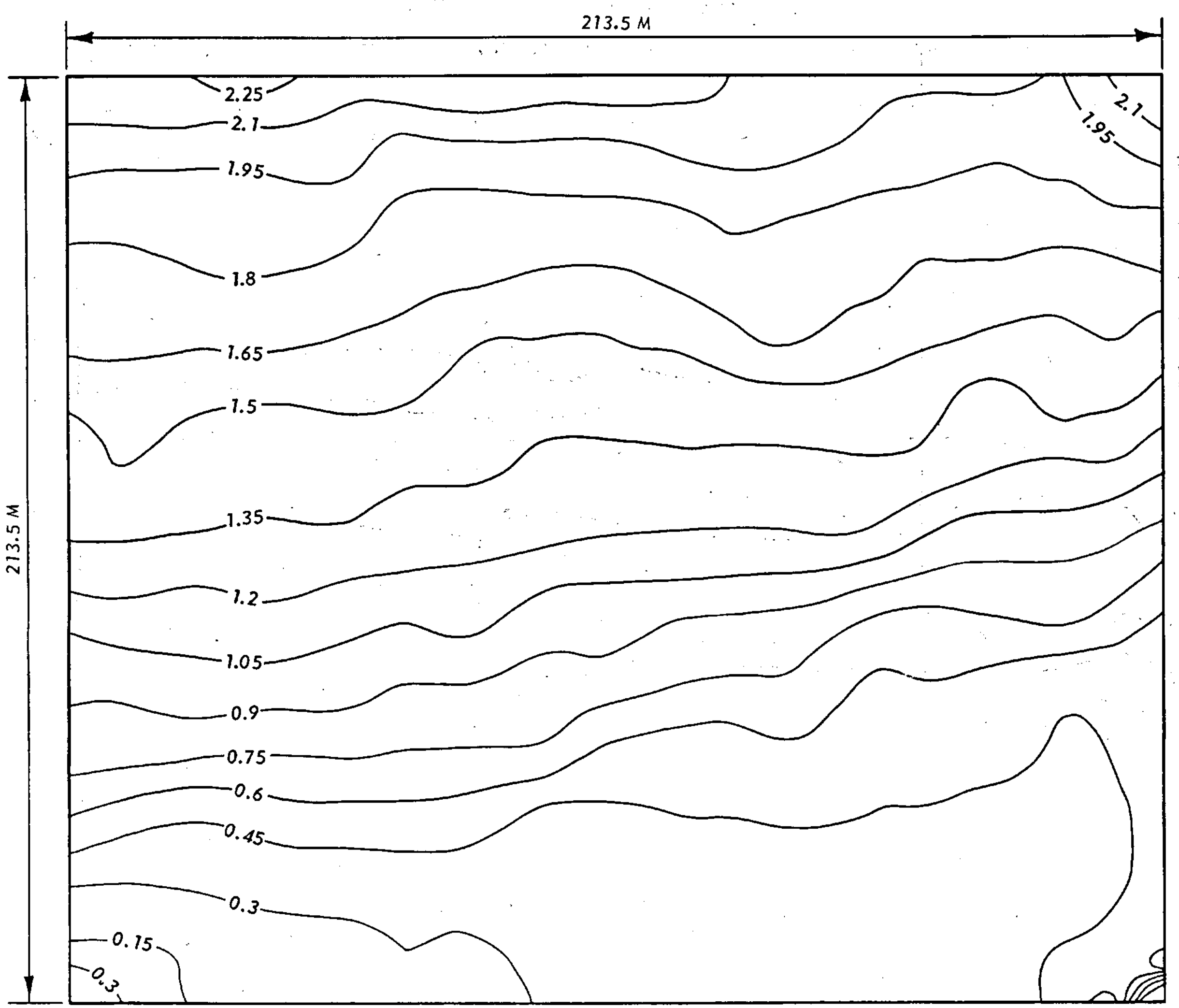

Figure A1. Contour map depicting elevations above MLLW in marsh monotypic plots during July 1976

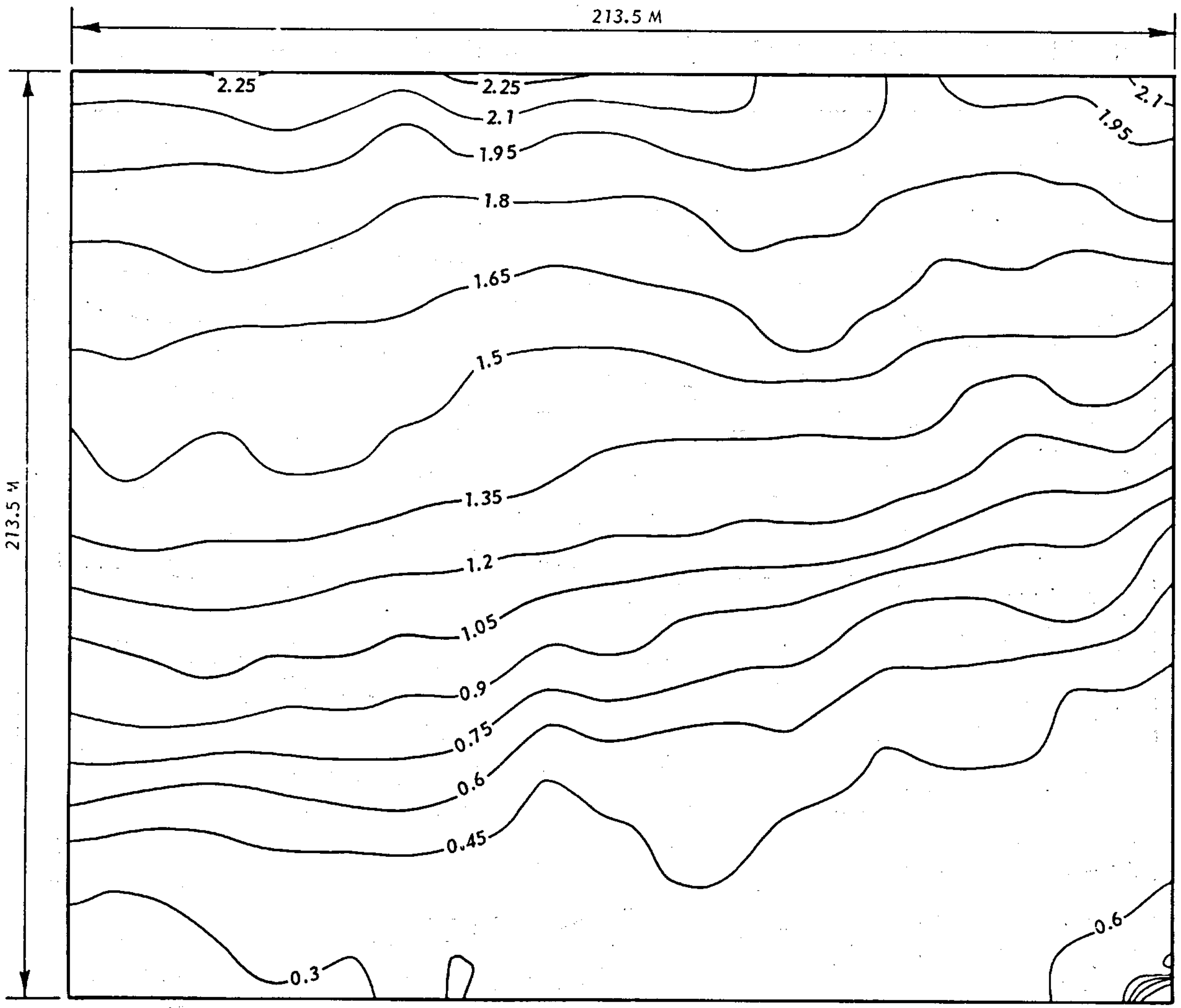

Figure A2. Contour map depicting elevations above MLLW in marsh monotypic plots during July 1976

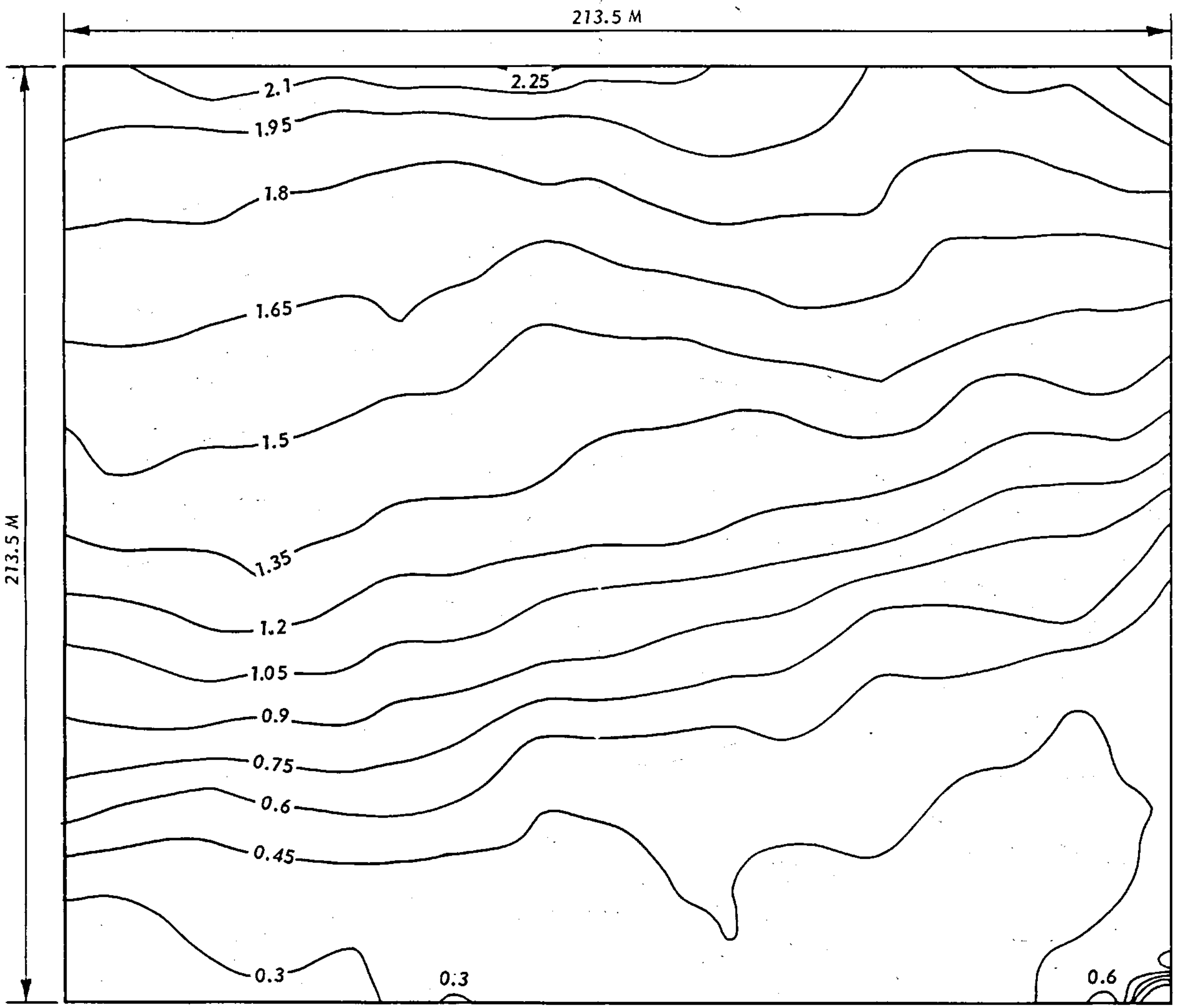

Figure A3. Contour map depicting elevations above MLLW of marsh monotypic plots during April 1977

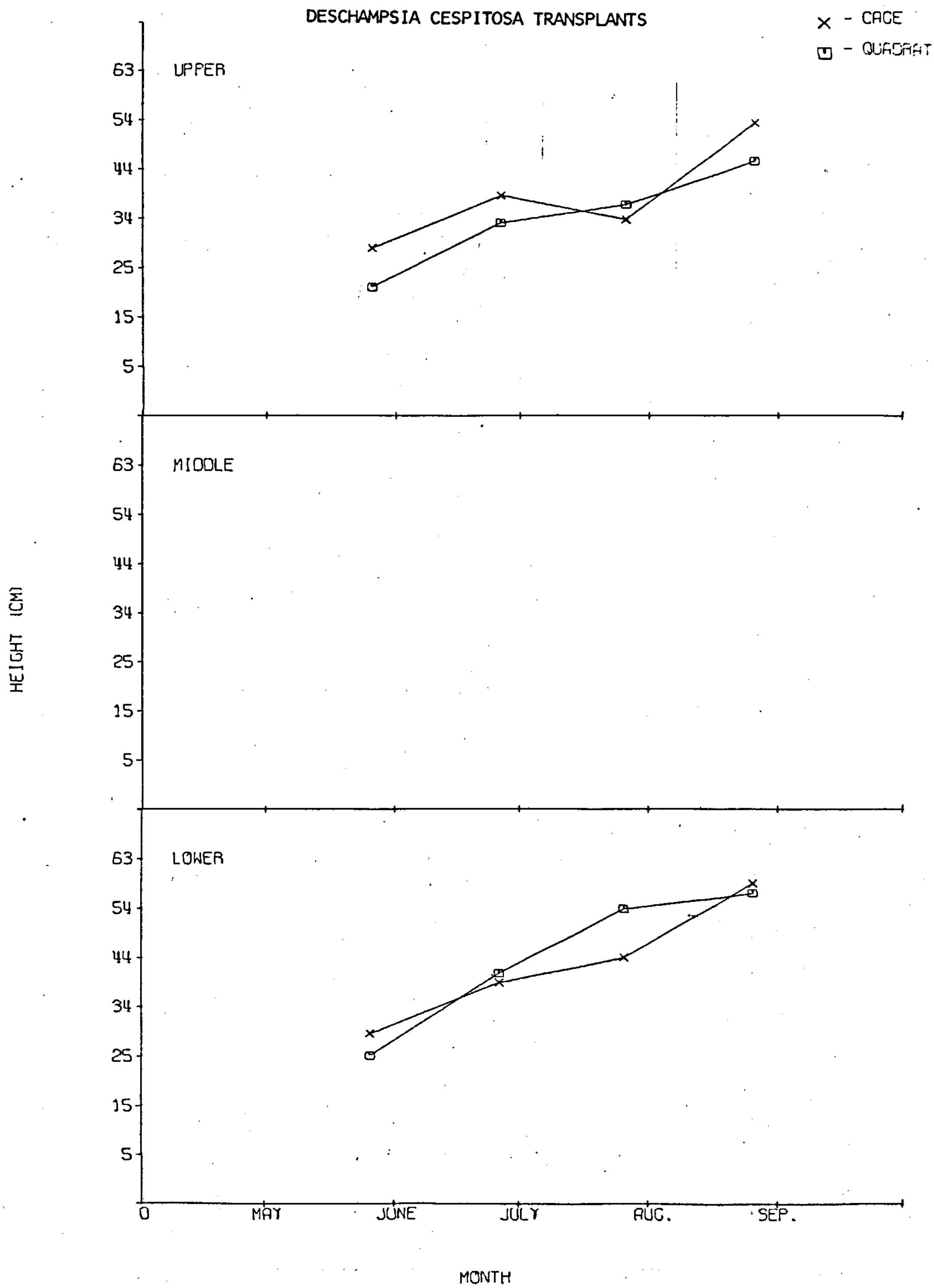

Figure A4. Average heights of plants in caged and uncaged (quadrat) areas at three elevation levels in the intertidal mixture plantings - Summer 1977 (Sheet 1 of 5).

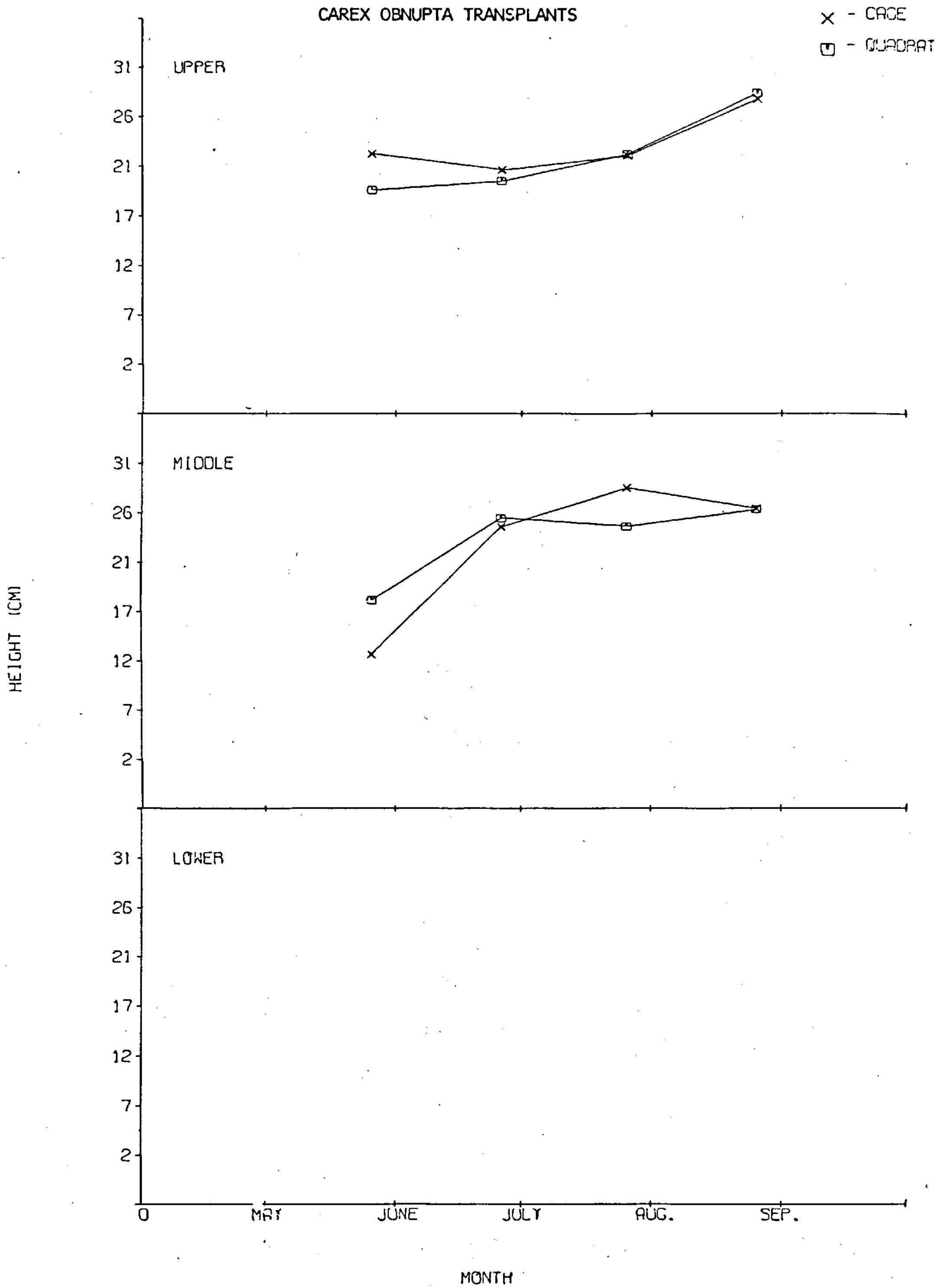

Figure A4. (Sheet 2 of 5).

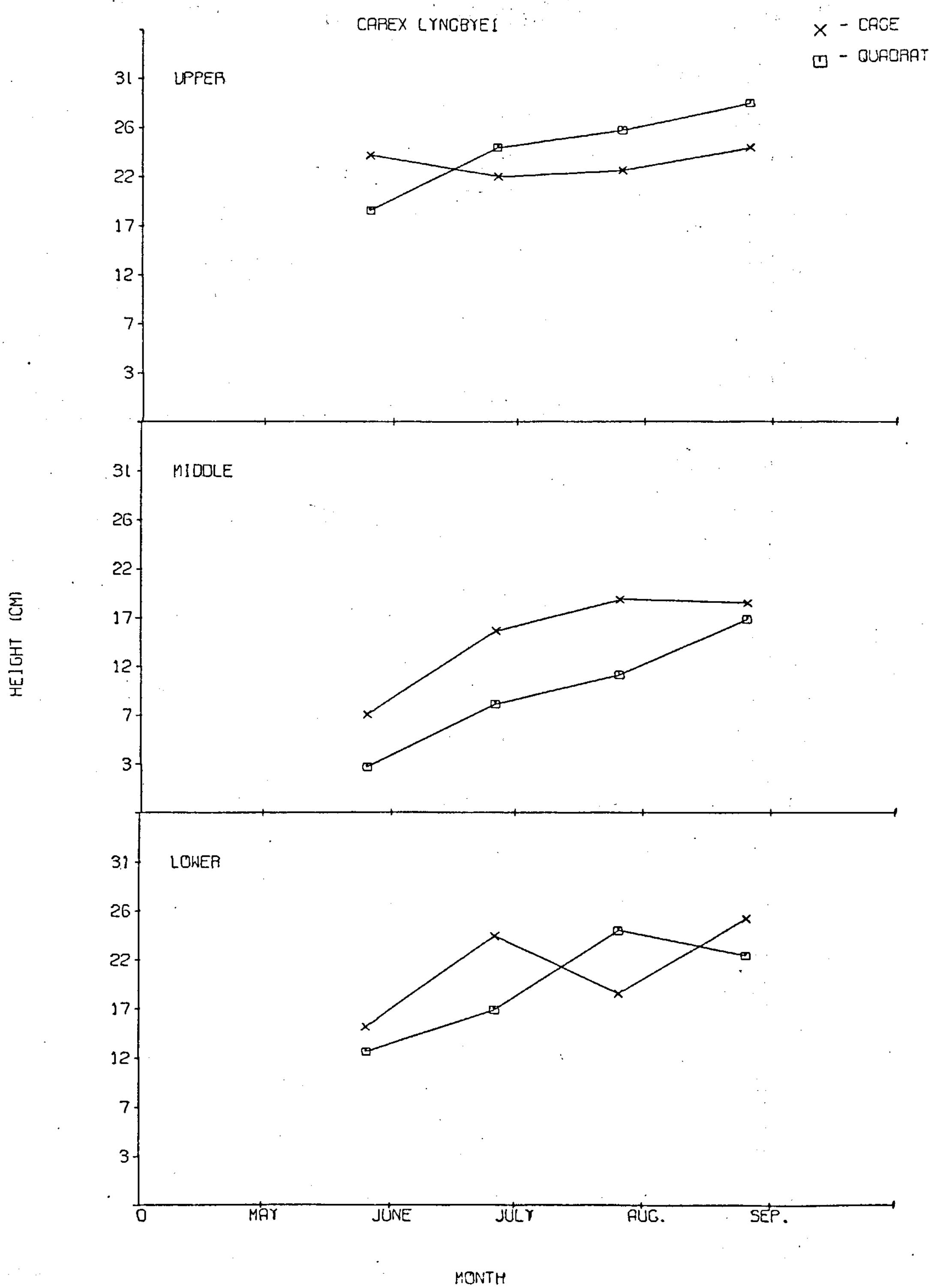

Figure A4. (Sheet 3 of 5).

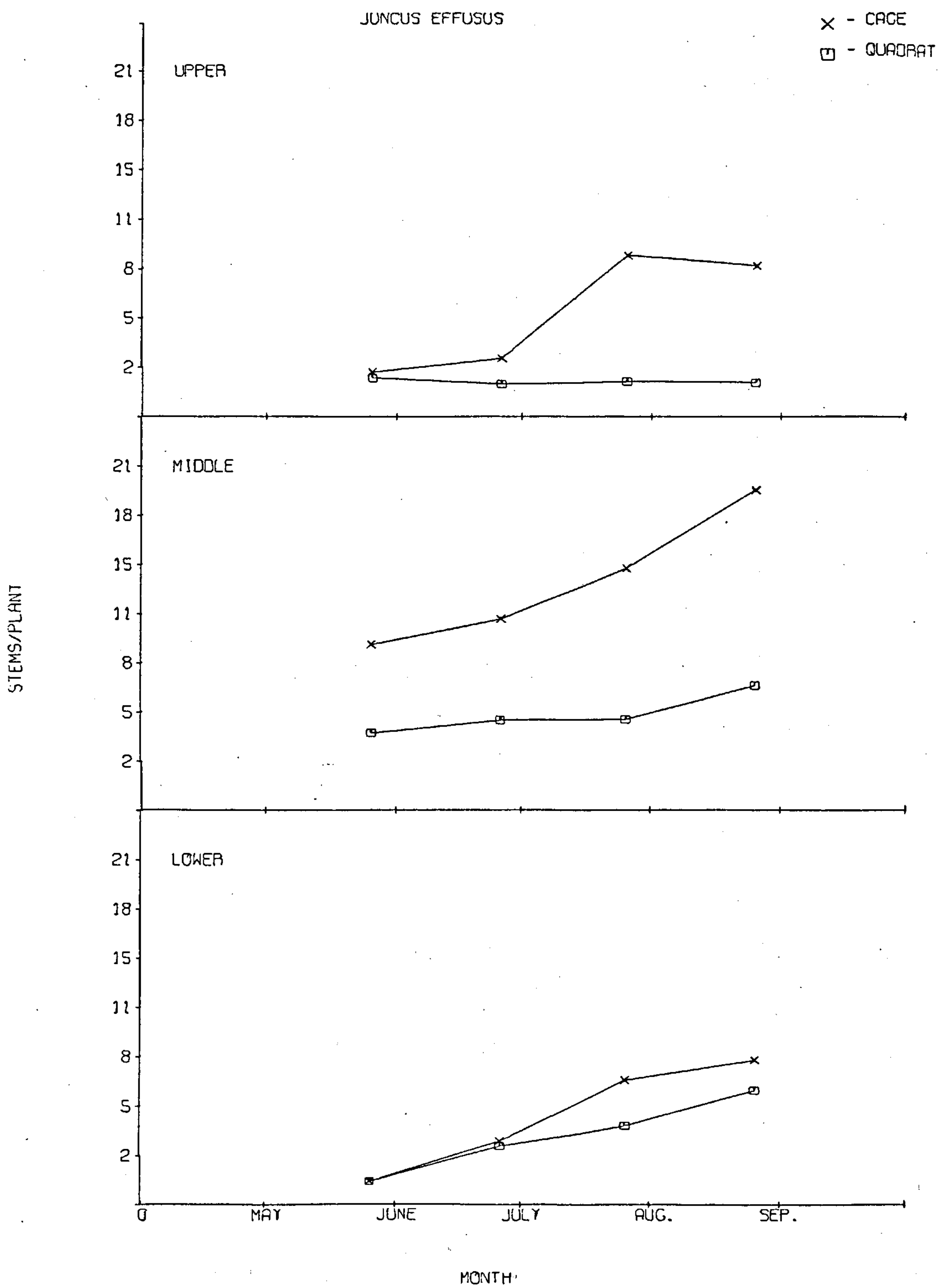

Figure A4. (Sheet 4 of 5).

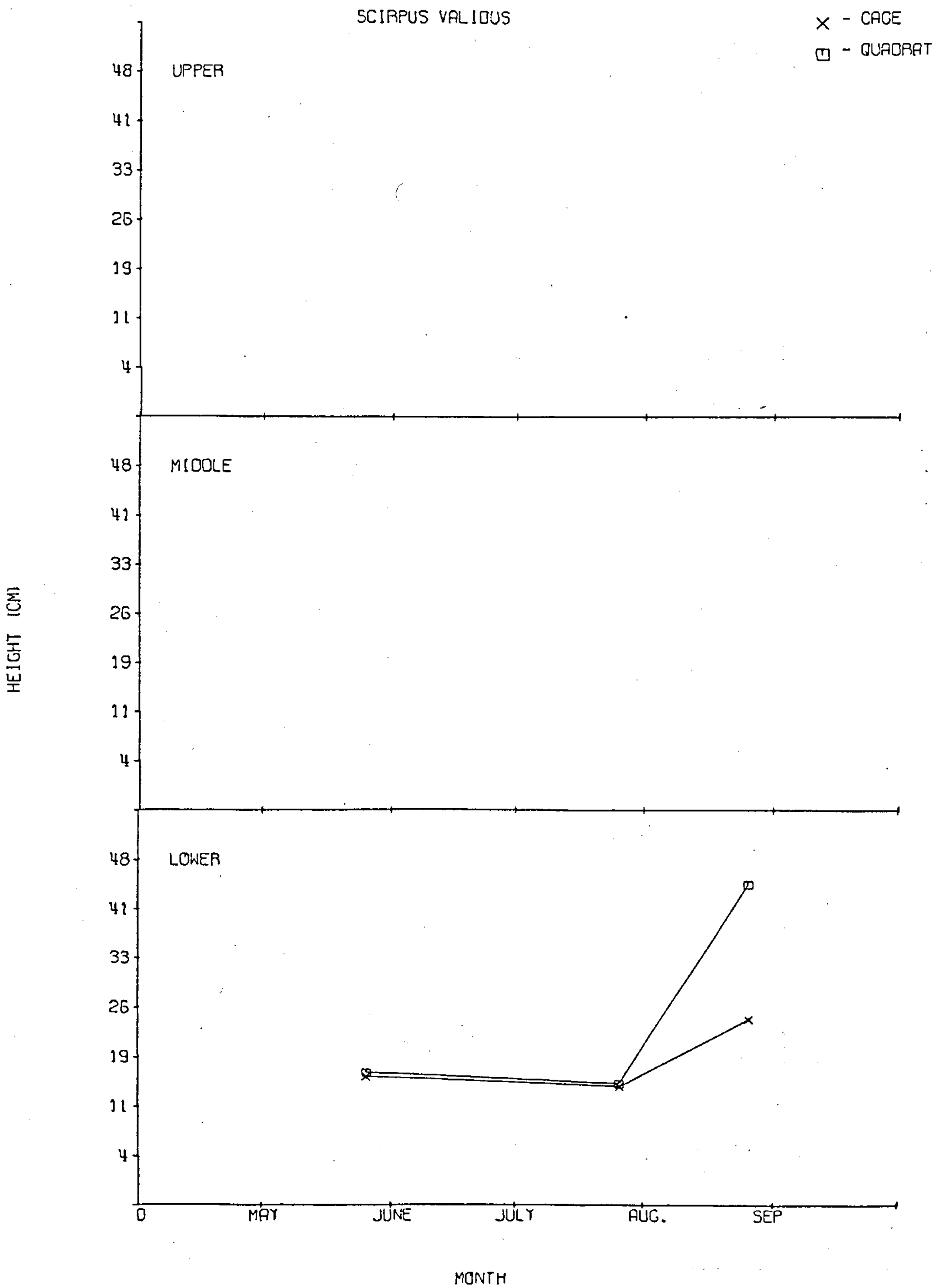

Figure A4. (Sheet 5 of 5).

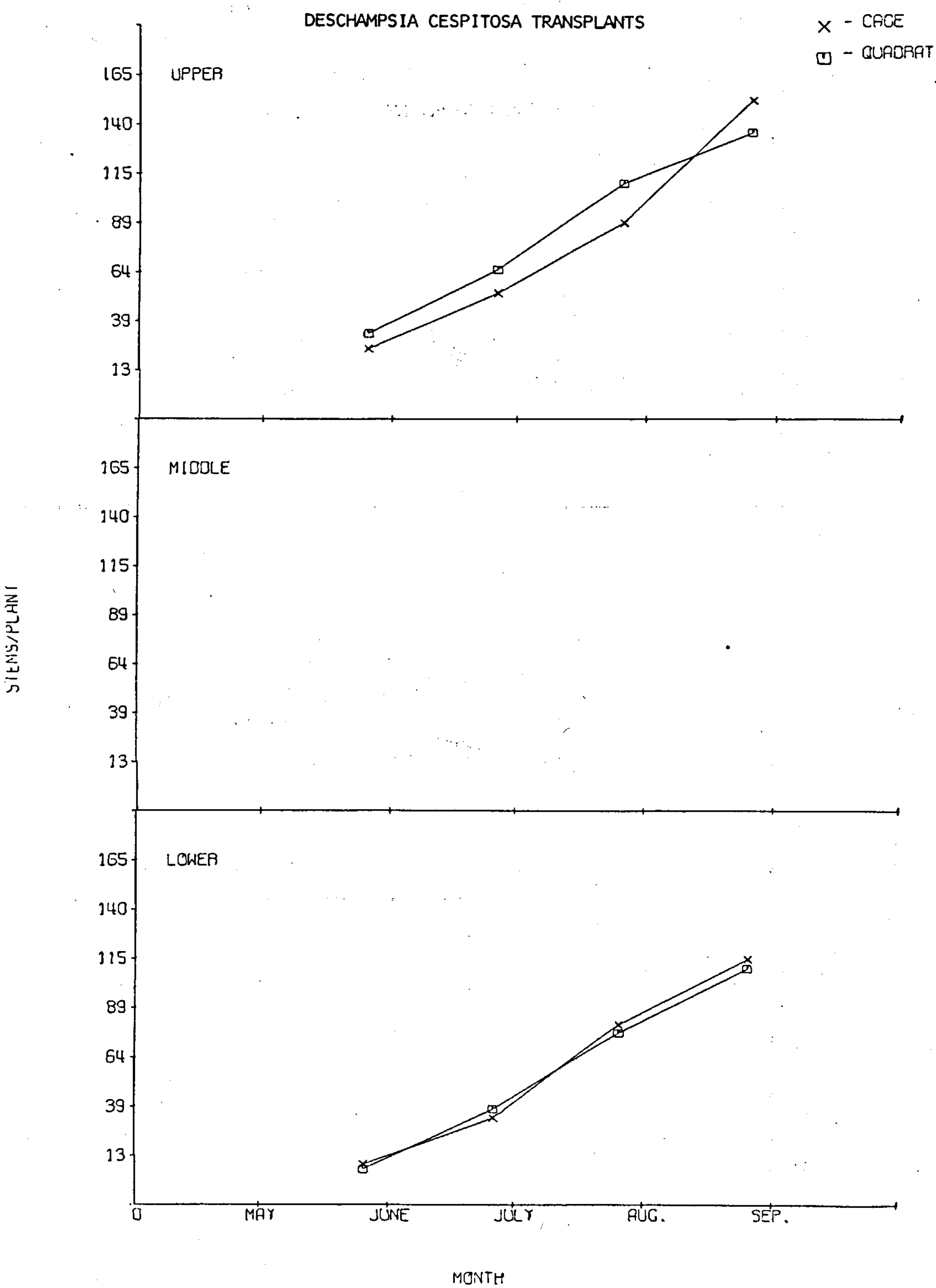

Figure A5. Average number of stems per plant in caged and uncaged (quadrat) areas at three elevation levels in the intertidal mixture plantings - Summer 1977 (Sheet 1 of 5).

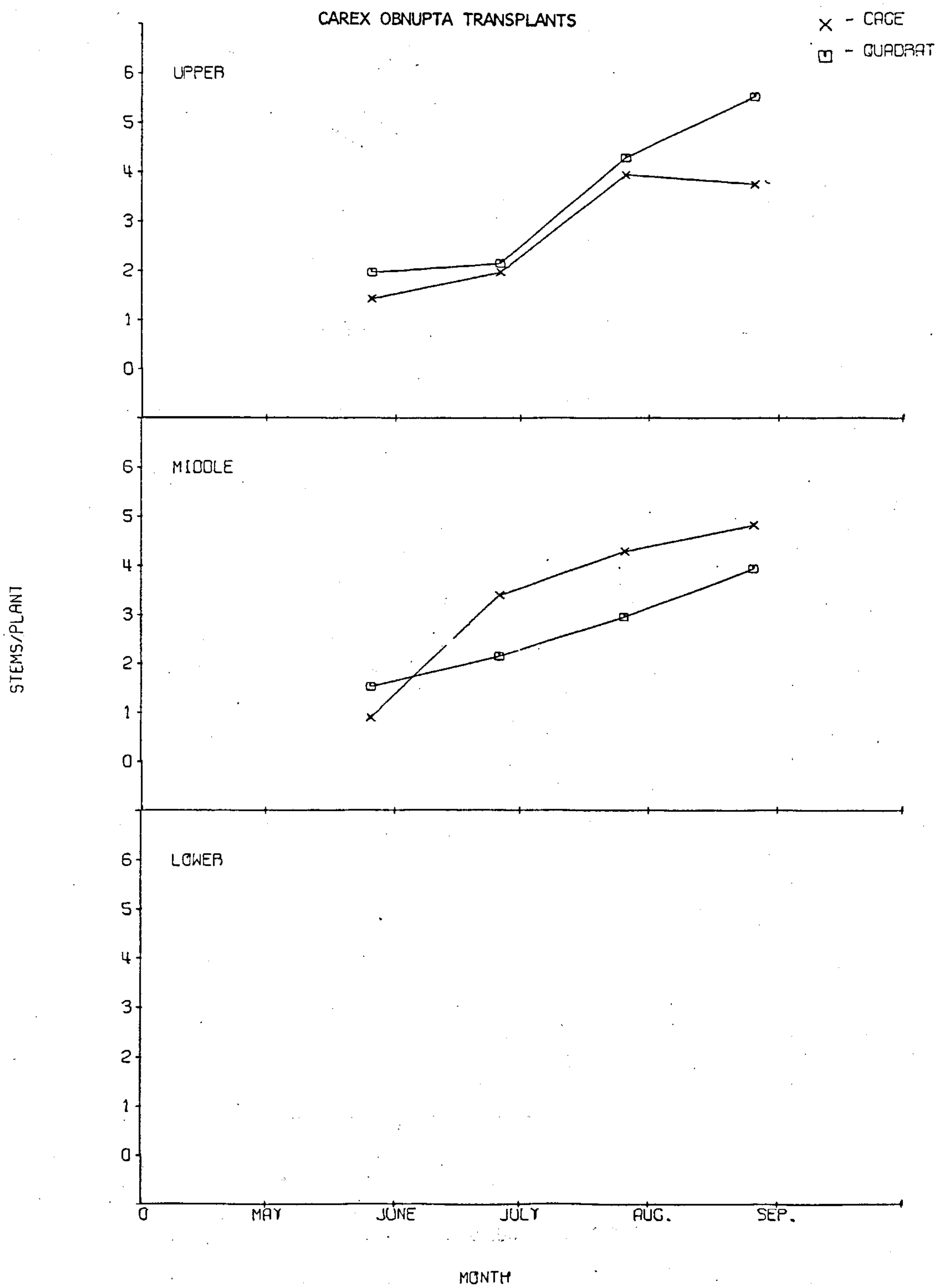

Figure A5. (Sheet 2 of 5).

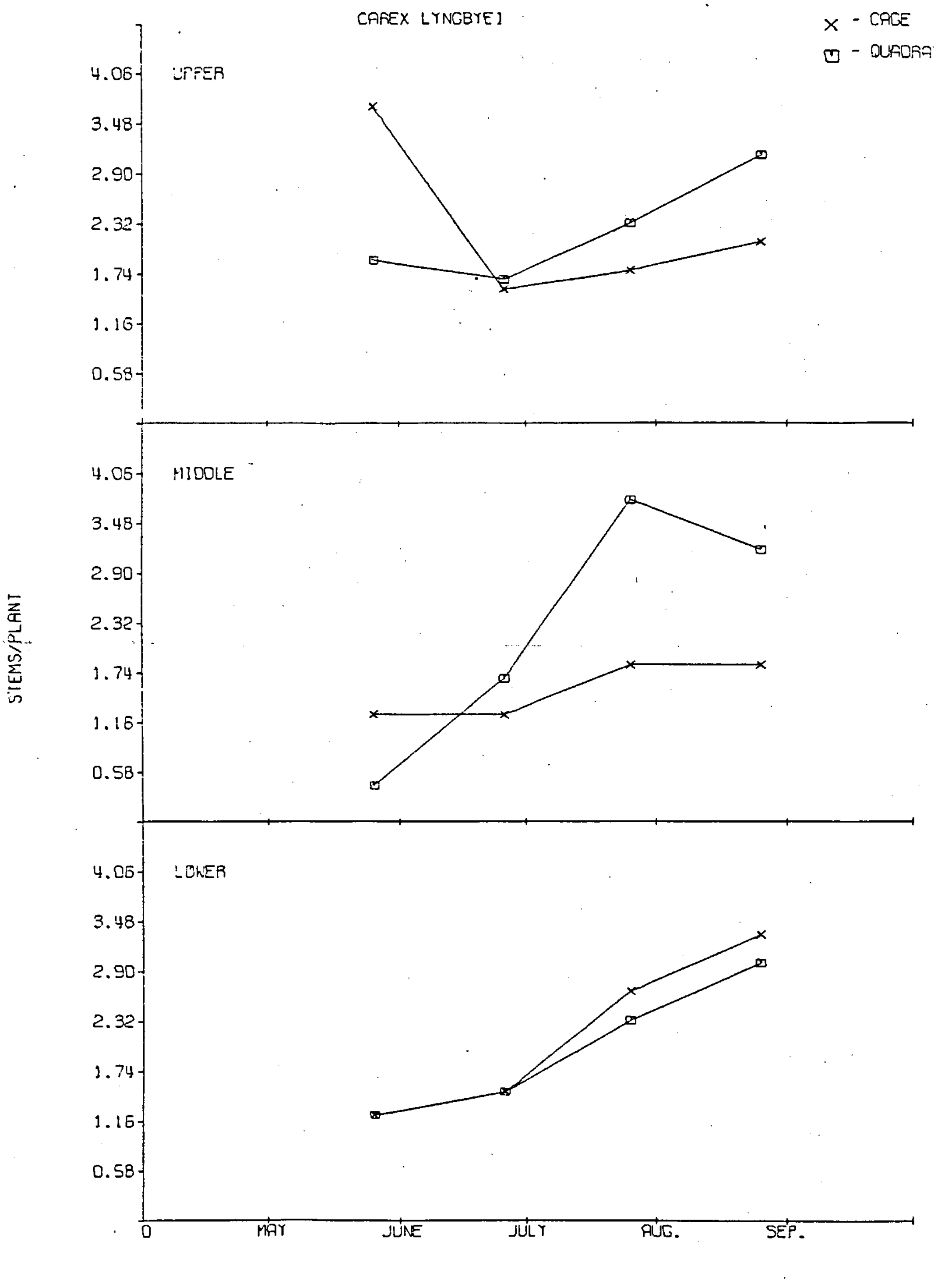

Figure A5. (Sheet 3 of 5).

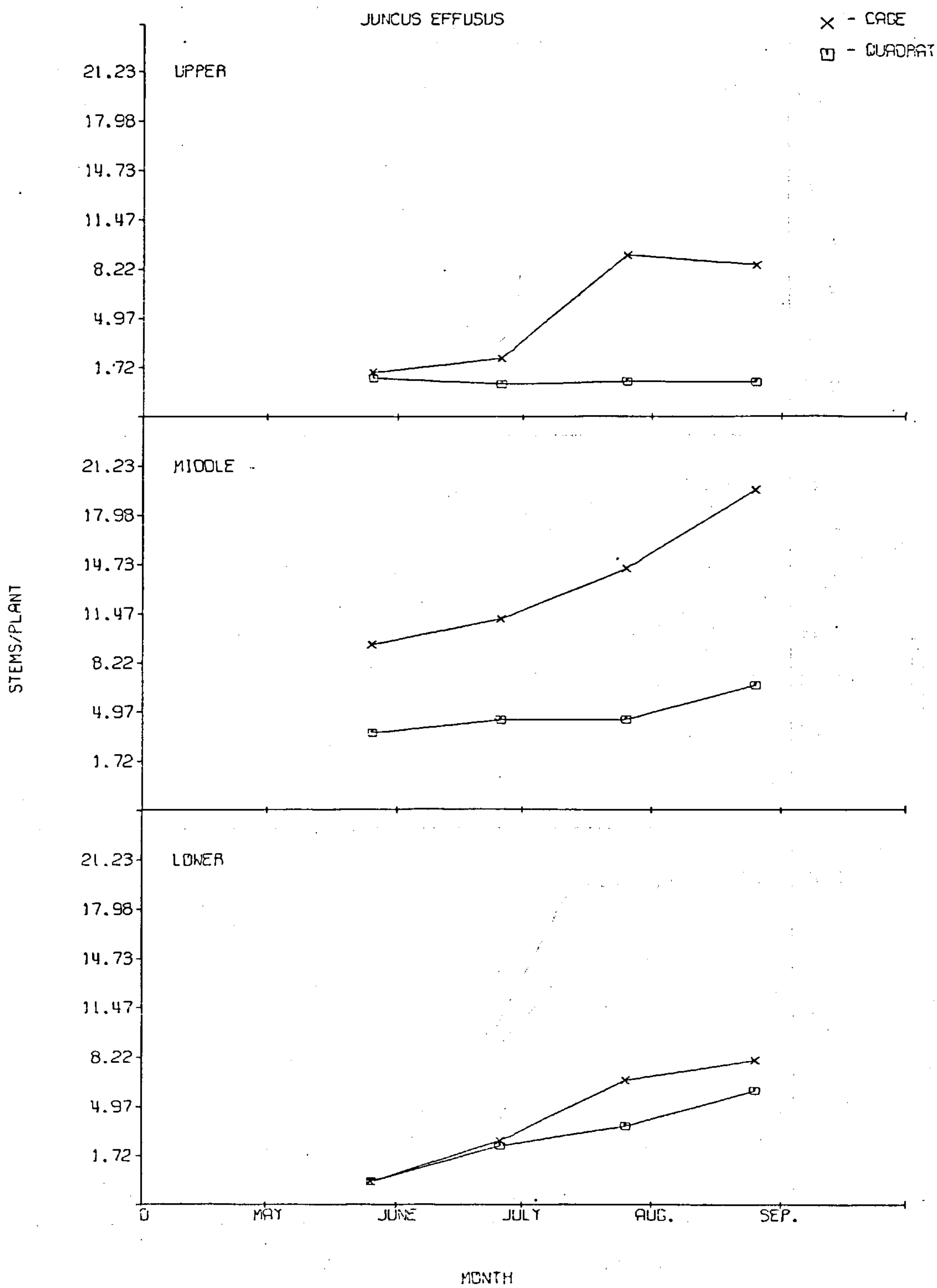

Figure A5. (Sheet 4 of 5).

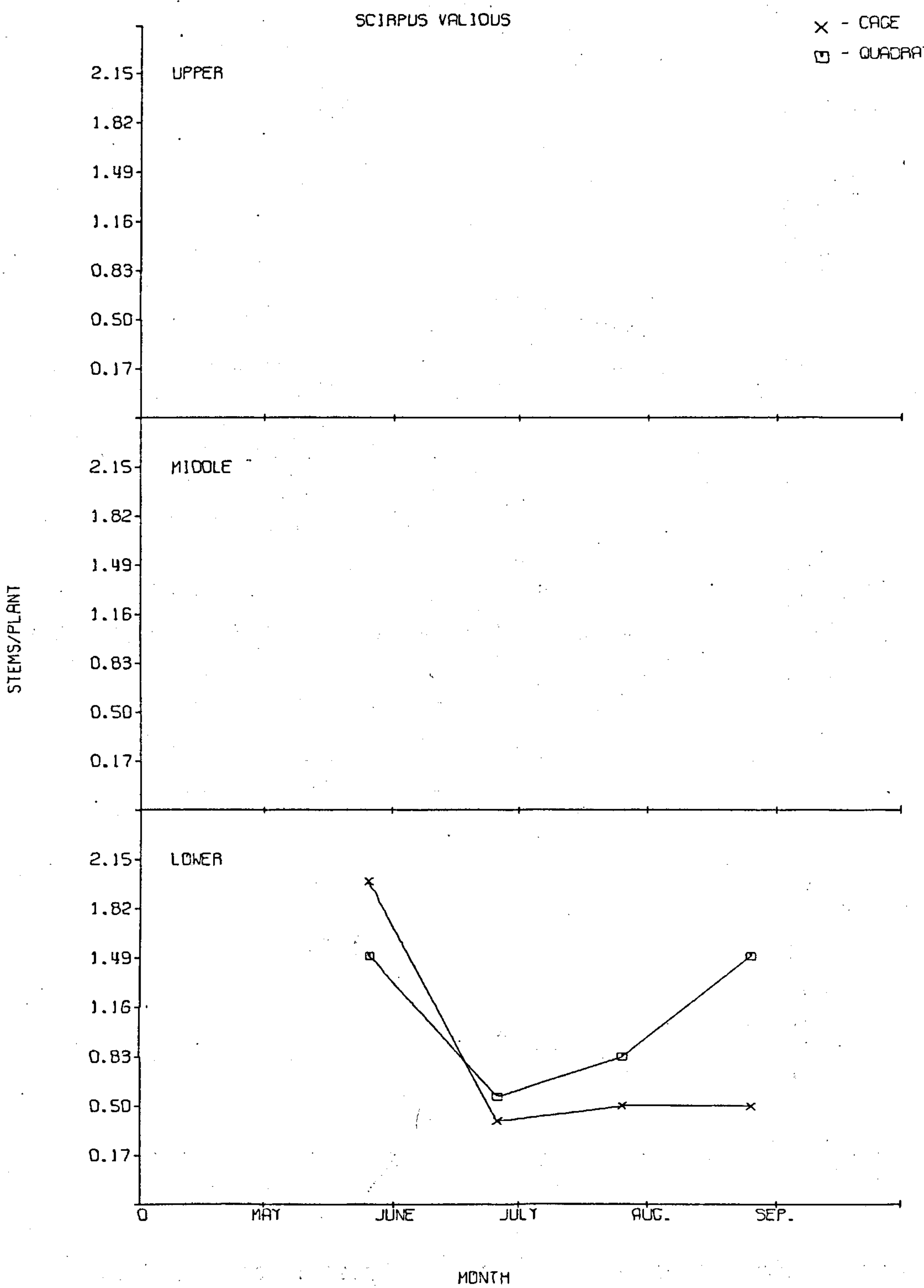

Figure A5. (Sheet 5 of 5).

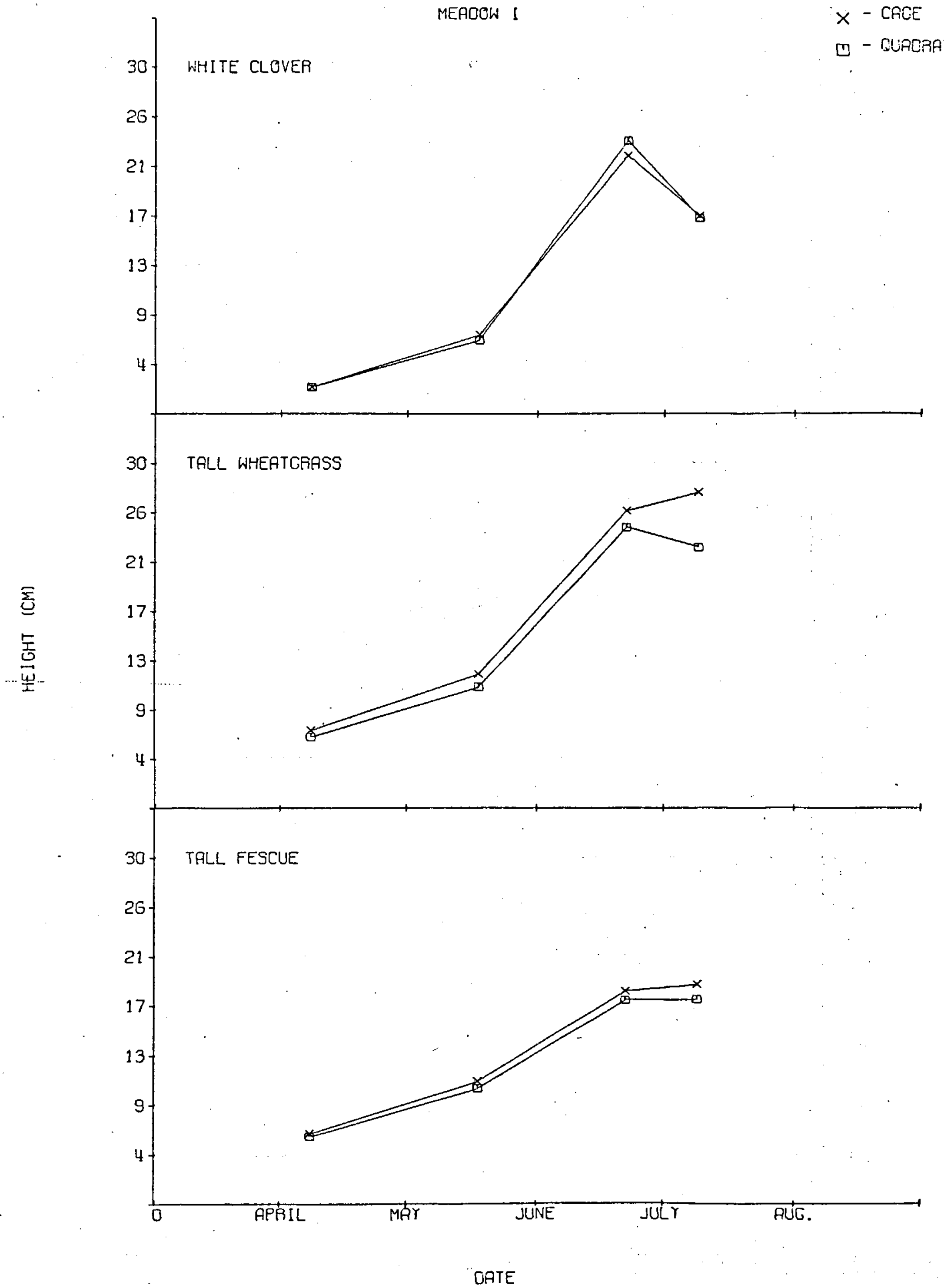

Figure A6. Average heights of planted species in caged and uncaged (quadrat) meadow I areas during the summer months of 1977

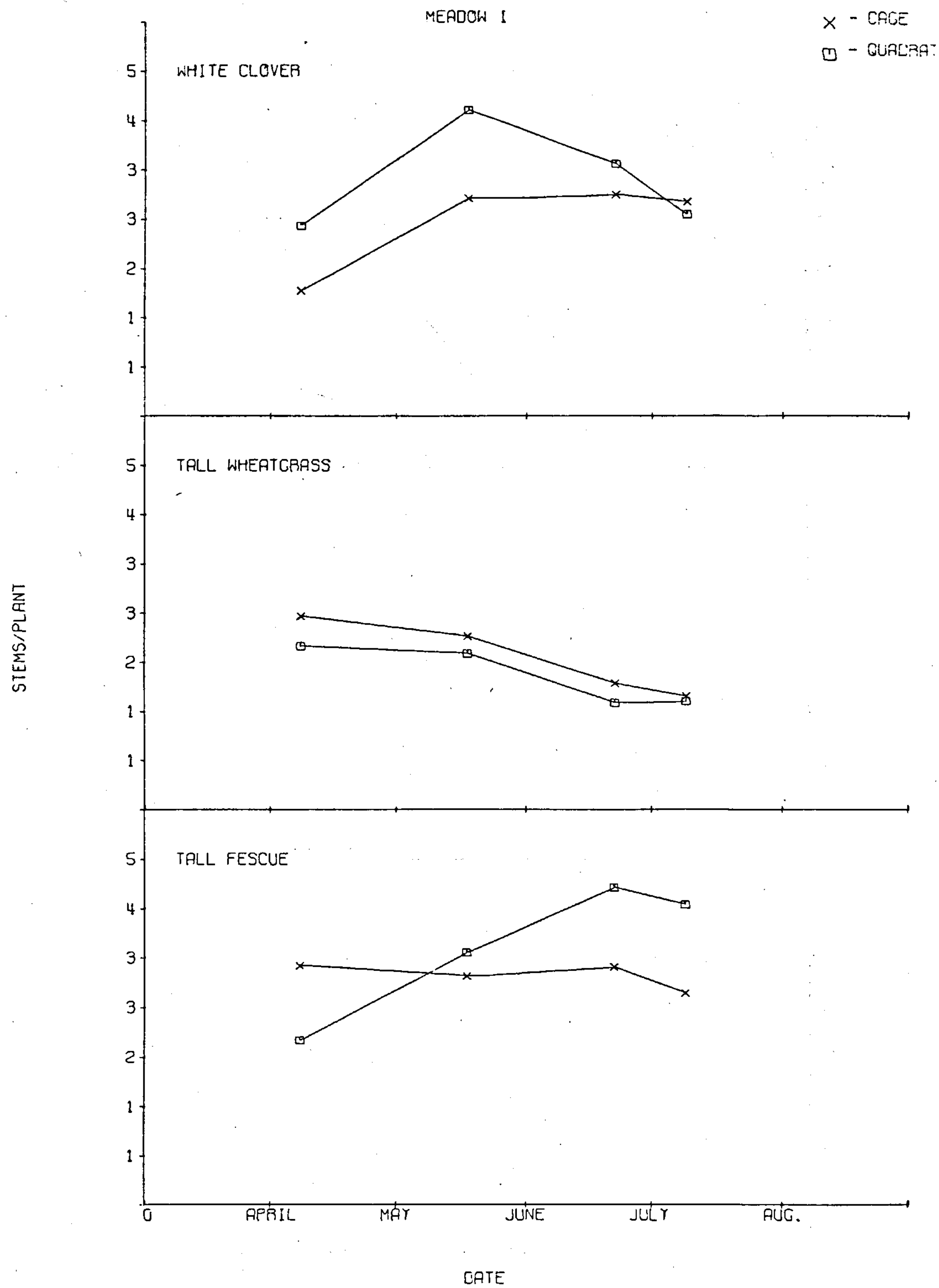

Figure A7. Average number of stems per plant of seeded species in caged and uncaged (quadrat) meadow I areas during the summer months of 1977

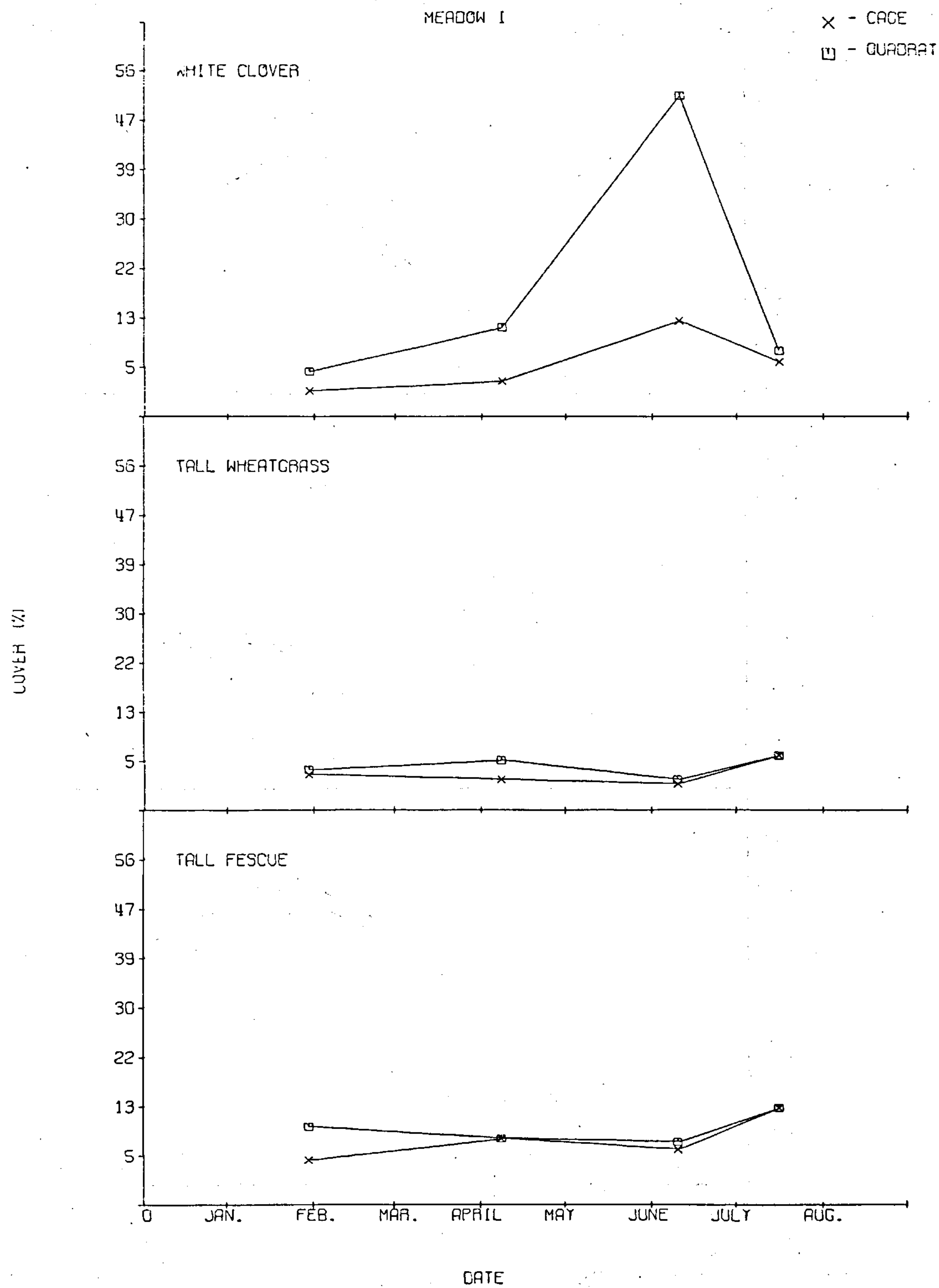

Figure A8. Percent of ground covered by planted species in caged and uncaged (quadrat) meadow I areas in 1977

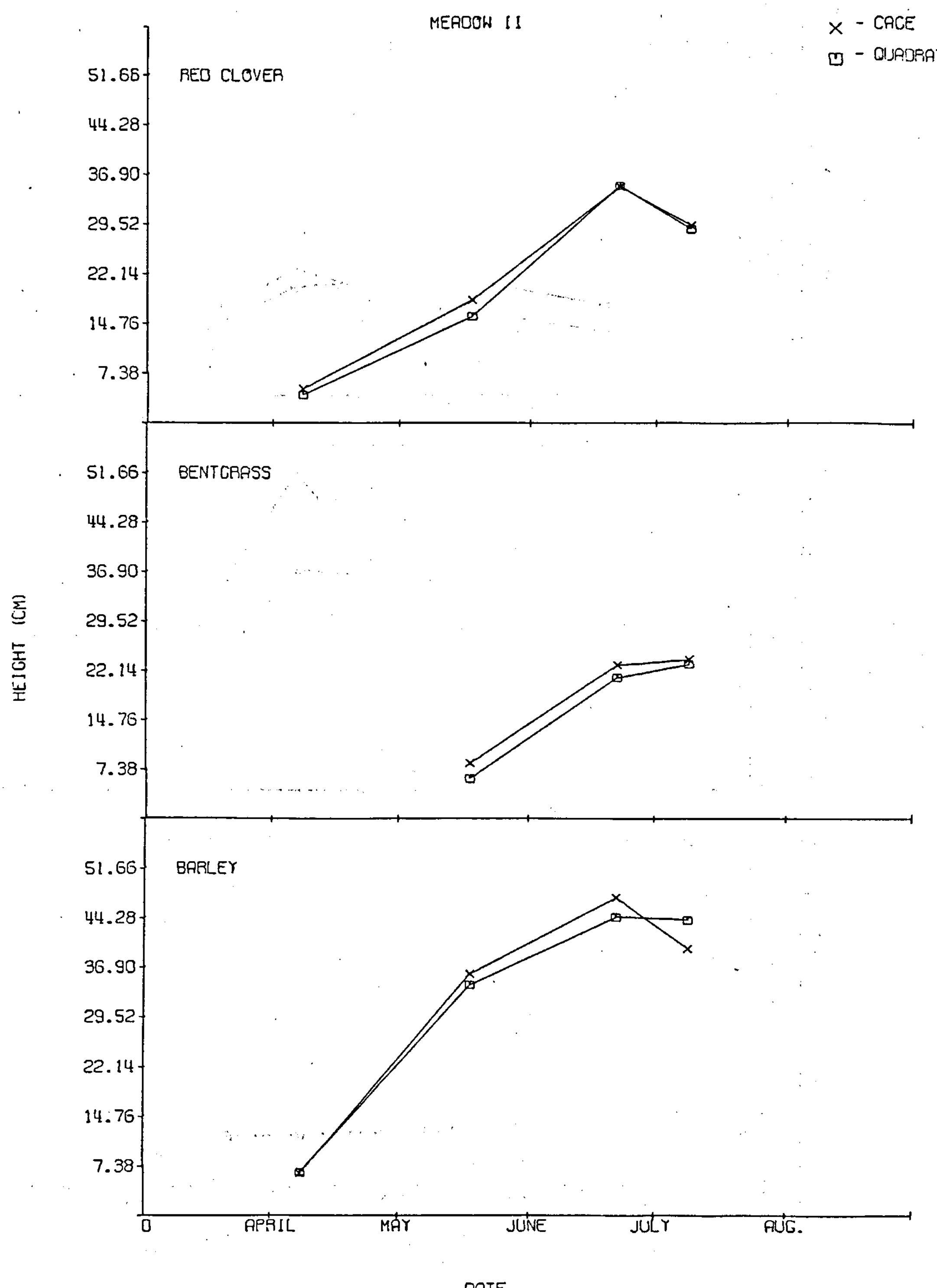

Figure A9. Average heights of planted species in caged and uncaged (quadrat) meadow II areas during the summer months of 1977

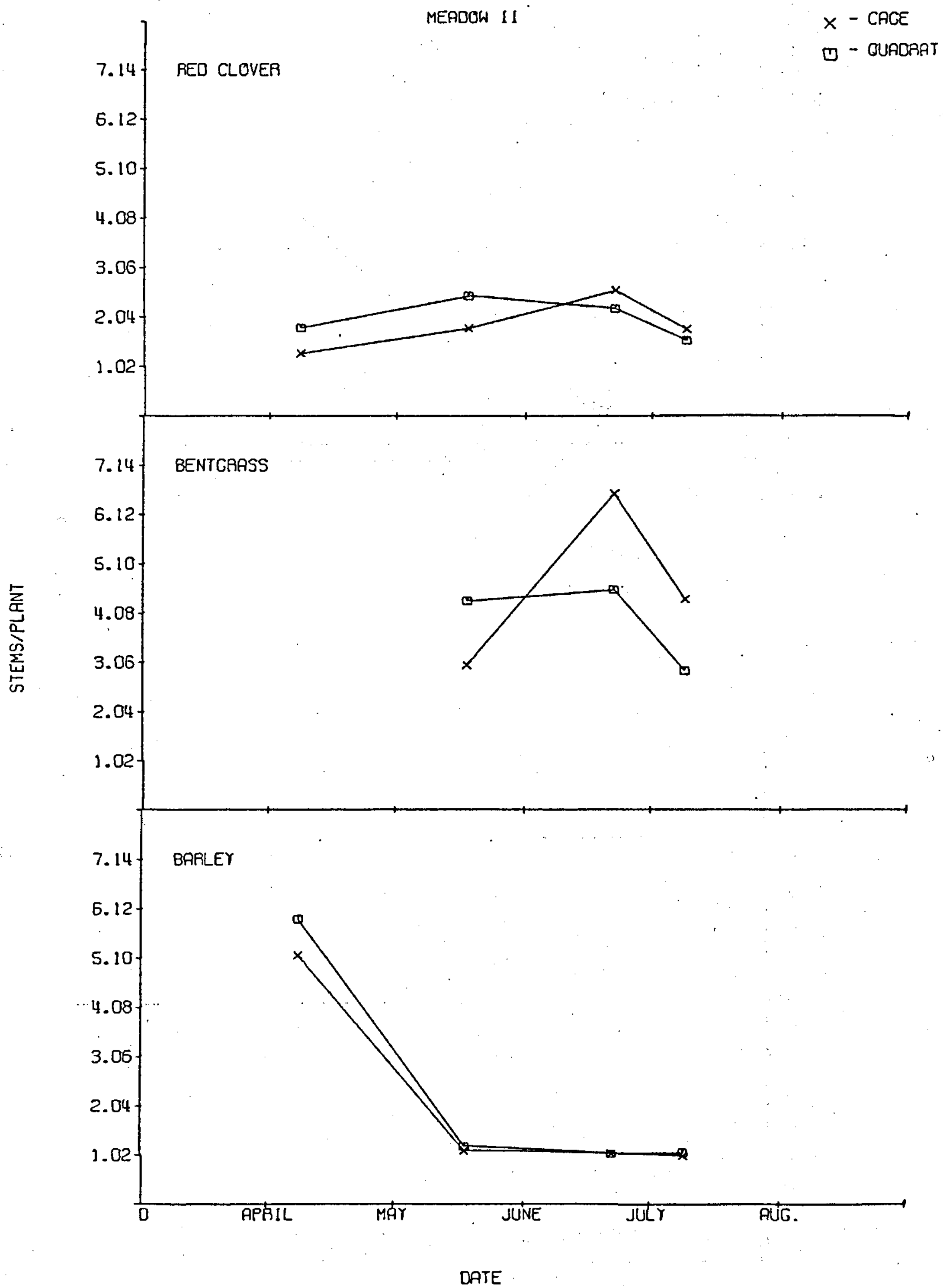

Figure A10. Average number of stems per plant of seeded species in caged and uncaged (quadrat) meadow II areas during the summer months of 1977

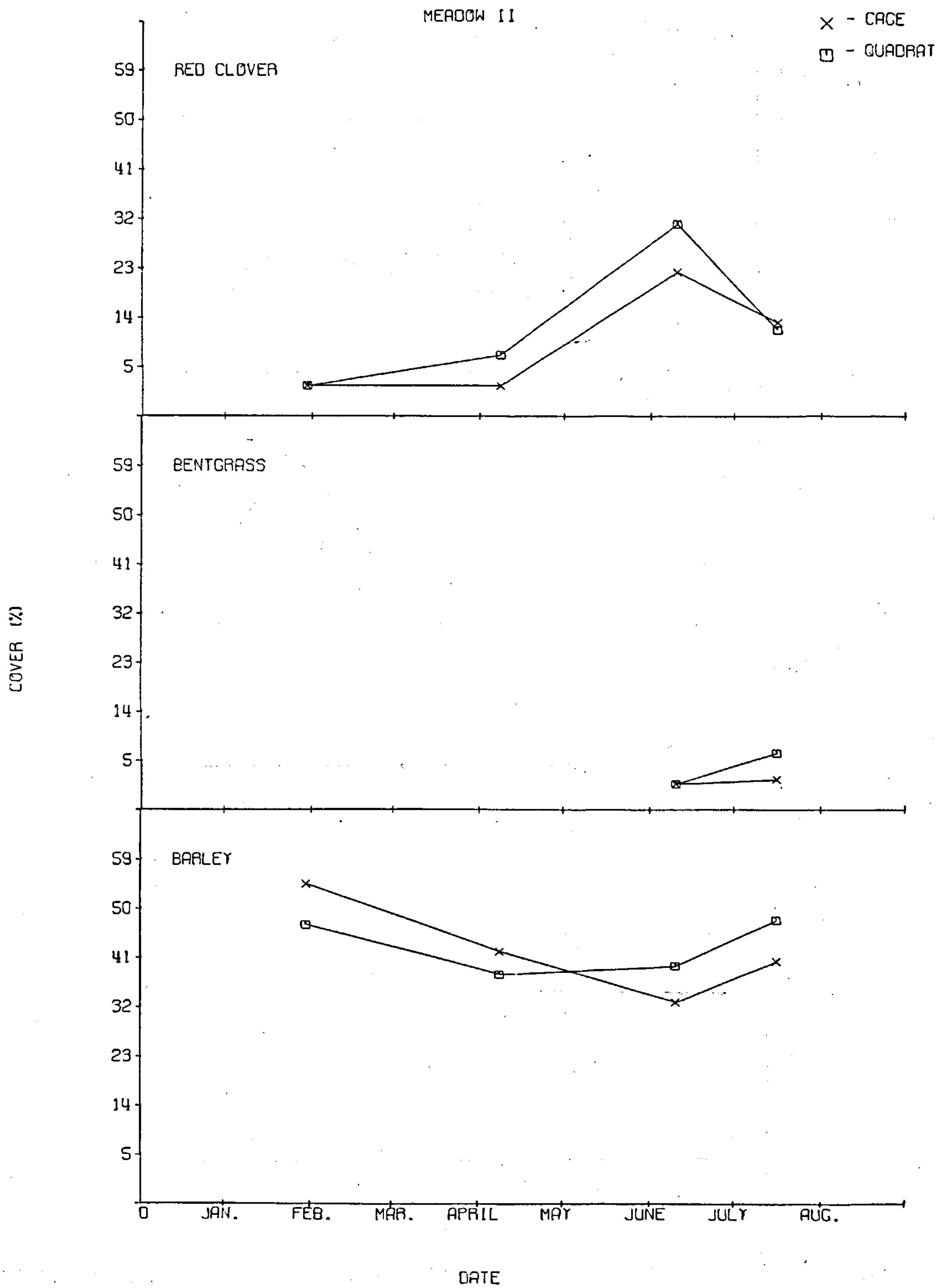

Figure A11. Percent of ground covered by planted species in caged and uncaged (quadrat) meadow II areas in 1977

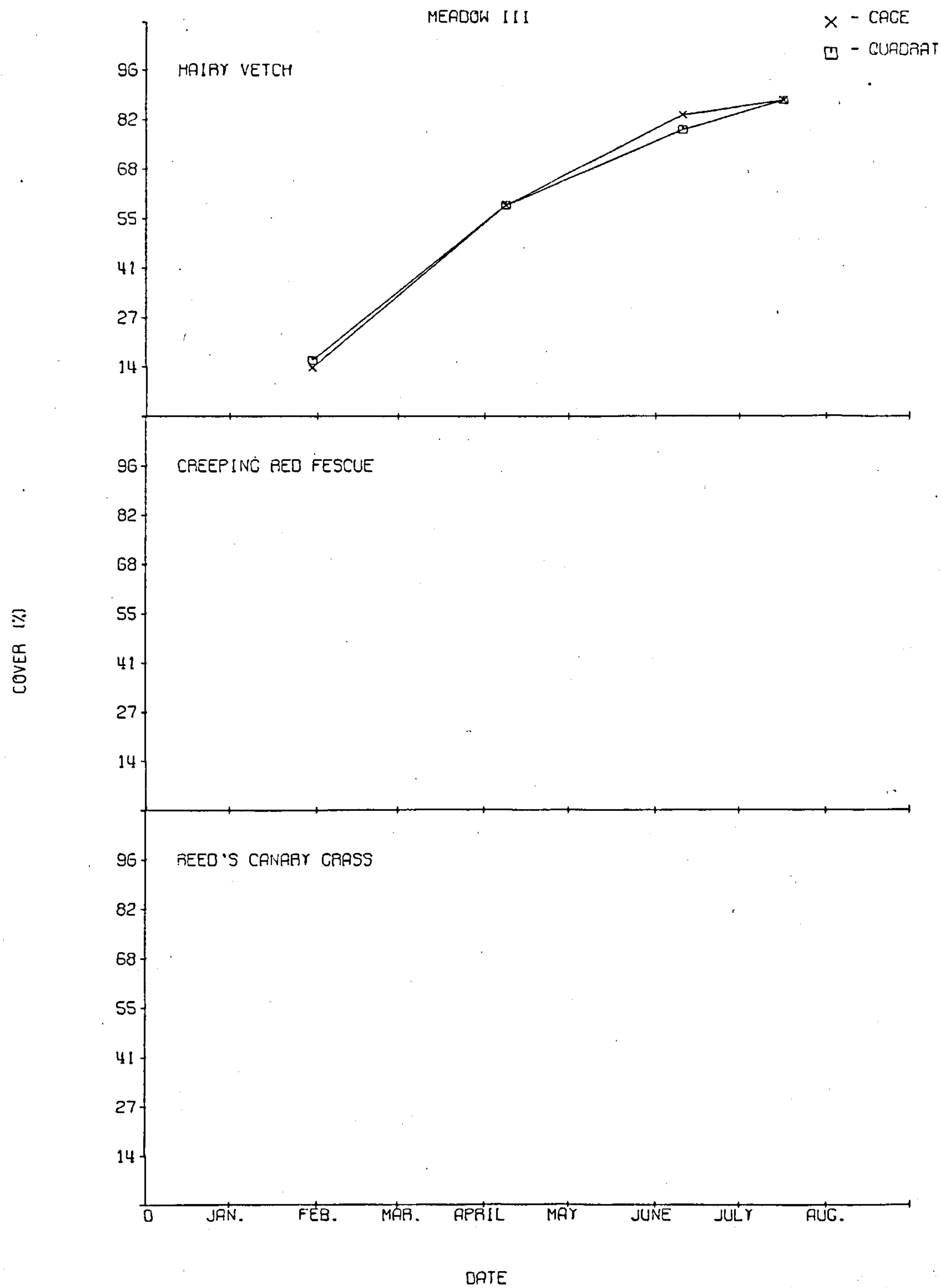

Figure A12. Percent of ground covered by planted species in caged and uncaged (quadrat) meadow III areas in 1977

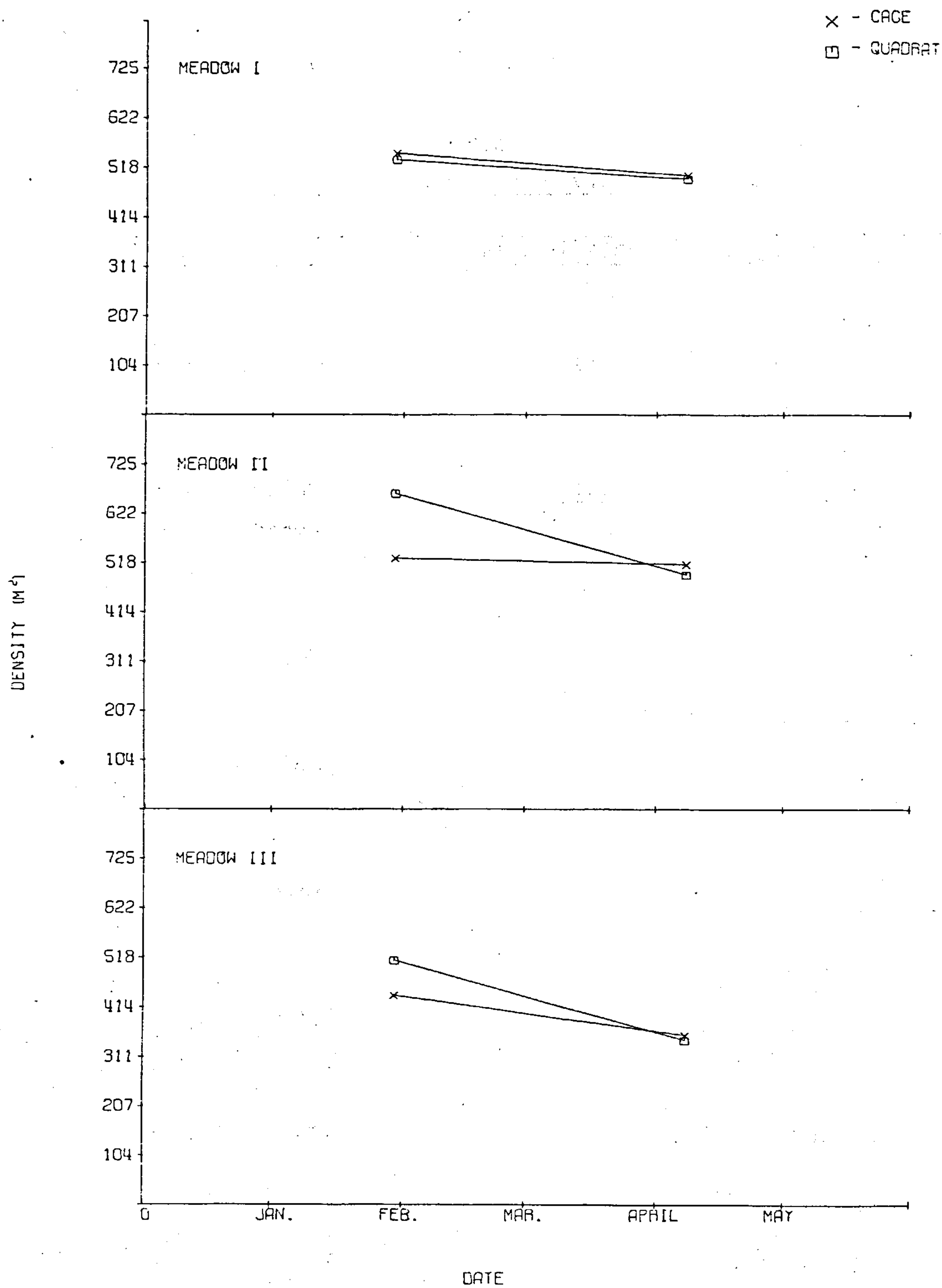

Figure A13. Comparisons of total plant density (includes invading species) in caged and uncaged (quadrat) locations of the 3 meadows in 1977

Table A1

Plant Species Observed on the Miller Sands Island Complex

Family and Scientific Name	Common Name
Aceraceae	
Acer macrophyllum Pursh.	Big-leaf maple
Alismataceae	
Alisma plantago-aquatica L.	Water plantain
Sagittaria latifolia Willd.	Broadleaf arrowhead
Aquifoliaceae	
Ilex sp.	Holly
Balsaminaceae	
Impatiens noli-tangere L.	Jewelweed
Betulaceae	
Alnus rubra Bong.	Oregon alder
Boraginaceae	
Myosotis discolor Pers.	Forget-me-not
Myosotis laxa Lehm.	Small-flowered forget-me-not
Myosotis scorpioides L.	Common forget-me-not
Callitrichaceae	
Callitriche verna L.	Spring water-starwort

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Caprifoliaceae	
Lonicera involucrata (Rich.) Banks var. *involucrata*	Black twinberry
Sambucus racemosa L. var. *arborescens* (T. & G.) Gray	Red elderberry
Symphoricarpos albus (L.) Blake var. *laevigatus* Fern.	Common snowberry
Caryophyllaceae	
Cerastium nutans Raf.	Nodding chickweed
Cerastium vulgatum L.	Mouse-ear chickweed
Lychnis dioica L.	Red campion
Compositae	
Achillea millefolium L. ssp. ssp. *lanulosa* (Nutt.) Piper	Common yarrow
Anaphalis margaritacea (L.) B. & H.	Pearly everlasting
Antennaria sp.	Everlasting
Bidens cernua L.	Nodding beggars-tick
Chrysanthemum leucanthemum L.	Marguerite
Crepis necaeensis Balb.	French hawksbeard
Erechtites prenanthoides (A. Rich) DC.	
Erigeron philadelphicus L.	Philadelphia daisy
Filago arvensis L.	Field filago
Hieracium albiflorum Hook.	White-flowered hawkweed
Hypochaeris radicata L.	Spotted cats-ear
Senecio jacoboca L.	Tansy ragwort

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Senecio sylvaticus L.	Wood groundsel
Sonchus asper (L.) Hill	Prickly sow-thistle
Taraxacum officinale Weber.	Common dandelion
Cornaceae	
Cornus stolonifera Michs. var. *occidentalis* (T. & G.) Hitchc.	Red-osier dogwood
Cruciferae	
Arabidopsis thaliana (L.) Schur	Thale cress
Cakile edentula (Bigel.) Hook.	American searocket
Cardamine pensylvanica Muhl.	Pennsylvania bittercress
Raphanus sativus L.	Wild radish
Rorippa nasturtium-aquaticum (L.) Schinz & Thell.	Water-cress
Teesdalia nudicaulis (L.) R. Br.	Shepherd's cress
Cupressaceae	
Thuja plicata Donn.	Western red cedar
Cyperaceae	
Carex densa Bailey	Dense sedge
Carex lyngbyei Hornem.	Lyngby's sedge
Carex obnupta Bailey	Slough sedge
Carex stipata Muhl.	Sawbeak sedge
Eleocharis palustris (L.) R. & S.	Common spike-rush
Scirpus americanus Pers.	American bulrush
Scirpus olneyi Gray	Olney's bulrush

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Scirpus validus Vahl.	Tule
Equisetaceae	
Equisetum arvense L.	Common horsetail
Equisetum hyemale L.	Common scouring-rush
Ericaceae	
Arctostaphylos columbiana Piper	Bristly manzanita
Arctostaphylos uva-ursi (L.) Spreng.	Kinnikinnick
Gaultheria shallon Pursh	Salal
Vaccinium ovatum Pursh	Evergreen huckleberry
Vaccinium parvifolium Smith	Red bilberry
Geraniaceae	
Erodium cicutarium (L.) L'Her	Filaree
Gramineae	
Agropyron elongatum	Tall wheatgrass
Agrostis alba L.	Red-top
Agrostis oregonensis	Oregon bentgrass
Aira caryophyllea L.	Silver hairgrass
Aira praecox L.	Early hairgrass
Alopecurus geniculatus L.	Water foxtail
Ammophilia arenaria (L.) Link.	European beachgrass
Anthoxanthum odoratum L.	Sweet vernalgrass

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Avena fatua L.	Wild oats
Bromus commutatus Schrad.	Meadow brome
Bromus rigidus Roth.	Ripgut
Bromus sterilis L.	Barren brome-grass
Bromus tectorum L.	Cheat grass
Deschampsia cespitosa (L.) Beauv. var. longifolia Beal	Tufted hairgrass
Elymus mollis Trin.	Dune wildrye
Festuca elatior Schreb. var. arundinacea	Tall fescue
Festuca myuros L.	Rat-tail fescue
Festuca rubra L. var. rubra	Red fescue
Festuca subulata Trin.	Bearded fescue
Holcus lanatus L.	Common velvetgrass
Hordeum vulgare L.	Barley
Lolium multiflorum Lam.	Italian ryegrass
Phalaris arundinacea L.	Reed canarygrass
Poa compressa L.	Canadian bluegrass
Poa nemoralis L.	Woods bluegrass
Poa palustris L.	Fowl bluegrass
Poa reflexa Vasey & Scribn.	Nodding bluegrass
Triticum aestivum L.	Wheat
Grimmlaceae	
Rhacomitrium heterostrichum	Moss
Hydrocharitaceae	
Elodea nuttalli (Planch.) St. John	Nuttall's waterweed

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Hypericaceae	
Hypericum perforatum L.	Klamath weed
Iridaceae	
Iris pseudocorus L.	Yellow flag
Juncaceae	
Juncus acuminatus Michx.	Tapered rush
Juncus balticus Willd. var. balticus	Baltic rush
Juncus effusus var. compactus Lejeune & Court	Common rush
Juncus effusus L.	Soft rush
Juncus oxymeris Engelm.	Painted rush
Juncus tenuis Willd.	Slender rush
Juncaginaceae	
Lilaea scilloides (Poir.) Hauman	Flowering quillwort
Labiatae	
Prunella vulgaris L.	Self-heal
Leguminosae	
Amorpha canascens Pursh	Lead plant
Cytisus scoparius (L.) Link	Scot's broom
Lathyrus japonicus Willd.	Maritime peavine

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Lathyrus palustris L.	Marsh peavine
Lathyrus sphaericus Retz.	Grass peavine
Lotus corniculatus L.	Birdsfoot-trefoil
Lotus purshiara (Berth.) Clements & Clements	Spanish clover
Lupinus rivularis Dougl.	Stream lupine
Medicago lupulina L.	Black medic
Melilotus alba Desr.	White sweet clover
Psoralea lanceolata Pursh	Lance-leaf scurf-pea
Trifolium dubium Sibth.	Suckling clover
Trifolium pratense L.	Red clover
Trifolium procumbens L.	Hop clover
Trifolium repens L.	White clover
Vicia cracca L.	Bird vetch
Vicia gigantea Hook.	Giant vetch
Vicia hirsuta (L.) S. F. Gray	Tiny vetch
Vicia sativa L. var. angustifolia (L.) Wahlb.	Common vetch
Vicia villosa Roth.	Hairy vetch
Liliaceae	
Veratrum californicum Durand	California hellebore
Lythraceae	
Lythrum salicaria L.	Purple loosestrife

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Oleaceae	
Fraxinus latifolia Benth.	Oregon ash
Onagraceae	
Epilobium angustifolium L.	Fireweed
Epilobium luteum Pursh.	Yellow willow-weed
Epilobium watsonii Barbey	Watson's willow-weed
Orchidaceae	
Goodyera oblongifolia Raf.	Western Rattlesnake plantain
Habenaria dilatata (Pursh) Hook. var. *dilatata*	White bog-orchid
Pinaceae	
Picea sitchensis (Bong.) Carr.	Sitka spruce
Pseudotsuga menziesii (Mirbel) Franco var. *menziesii*	Douglas-fir
Tsuga heterophylla (Raf.) Sarg.	Western hemlock
Plantaginaceae	
Plantago lanceolata L.	English plantain
Polygonaceae	
Polygonum punctatum Ell.	Water smartweed
Polygonum hydropiper L.	Marsh-pepper smartweed
Rumex acetosella L.	Sheep sorrel
Rumex occidentalis Wats.	Western dock

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Polypodiaceae	
Athyrium filix-femina (L.) Roth.	Lady-fern
Blechnum spicant (L.) Roth.	Deer-fern
Polypodium hesperium Maxon	Licorice fern
Polystichum munitum (Kaulf.) Presl var. munitum	Sword-fern
Pteridium aquilinum (L.) Kuhn	Bracken
Polytrichaceae	
Polutrichum juniperinum	Moss
Portulacaceae	
Montia fontana L. var. tenerrima (Gray) Fern. & Wieg.	Water chickweed
Montia sibirica (L.) Howell var. sibirica	Western springbeauty
Potamogetonaceae	
Potamogeton crispus L.	Curled pondweed
Ranunculaceae	
Caltha asarifolia DC.	Yellow marshmarigold
Ranunculus acris L.	Meadow buttercup
Ranunculus bulbosus L.	Bulbous buttercup
Ranunculus flammula L.	Creeping buttercup
Ranunculus cf. macounii Britt. var. oreganus Gray	Macoun's buttercup
Ranunculus orthorhynchus Hook. var. platyphyllus Gray	Straightbeak buttercup
Ranunculus uncinatus D. Don var. uncinatus	Little buttercup

(Continued)

Table A1 (Continued)

Family and Scientific Name	Common Name
Rosaceae	
Crataegus douglasii Lindl. var. suksdorfii Sarg.	Black hawthorn
Osmaronia cerasiformis (T. & G.) Greene	Indian plum
Physocarpus capitatus (Pursh)Kuntze	Pacific ninebark
Potentilla pacifica Howell	Pacific silverweed
Prunus avium L.	Sweet cherry (cultivated)
Rosa nutkana Presl var. nutkana	Nootka rose
Rubus discolor Weike & Ness	Himalayan blackberry
Rubus laciniatus Willd.	Evergreen blackberry
Rubus parviflorus Nutt.	Thimbleberry
Rubus spectabilis Pursh	Salmonberry
Rubiaceae	
Galium cymosum Wieg.	Pacific bedstraw
Salicaceae	
Populus trichocarpa T. & G.	Black cottonwood
Salix cf. drummondiana Barratt	Drummond willow
Salix exigua Nutt. ssp. exigua var. exigua	Coyote willow
Salix fluviatilis Nutt.	Columbia River willow
Salix cf. hookeriana Barratt	Hooker willow
Salix lasiandra Benth. var. lasiandra	Pacific willow

(Continued)

Table A1 (Concluded)

Family and Scientific Name	Common Name
Salix rigida Muhl. var. *mackenzieana* (Hook.) Cronq.	Mackenzie's willow
Scrophulariaceae	
Digitalis purpurea L.	Foxglove
Gratiola neglecta Torr.	Common American hedge-hyssop
Limosella aquatica L.	Mudwort
Linaria vulgaris Hill.	Butter and eggs
Mimulus guttatus DC. var. guttatus	Yellow monkey-flower
Solanaceae	
Solanum dulcamara L.	Bittersweet nightshade
Umbelliferae	
Daucus carota L.	Wild carrot
Eryngium petiolatum Hook.	Oregon coyote-thistle
Heracleum lanatum Michx.	Cow-parsnip
Lilaeopsis occidentalis Coult. & Rose	Lilaeopsis
Valerianaceae	
Valerianella locusta (L.) Betcke	Lamb's lettuce

Table A2

Classification of algae genera found in marsh area

Class, Family, and Genus
BACILLARIOPHYCEA
Monoraphidae
Achnanthes
Araphideae
Synedra
Fragillaria
Tabellaria
Naviculaceae
Navicula
Biraphideae
Pleurosigma
Cymbella
Nitzschia
Gomphonema
Coscinodiscaceae
Coscinodiscus
Melosira
Raphidioideae
Eunotia
XANTHOPHYCEA
Tribonemataceae
Tribonema
Vaucheriacea
Voucheria

(Continued)

Table A2 (Concluded)

Class, Family, and Genus
CYANOPHYCEA
Oscillatoriaceae
Oscillatoria
CLOROPHYCEA
Ulotrichacea
Ulothrix
Coelastraceae
Scenedesmus
Cladophoraceae
Cladophora
Rhizoclonium
Oedogoniaceae
Oedogonium

Table A3

Chemical Symbols and Names used in the Text

Symbols	Names
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
$Ca(OAc)_2$	Calcium acetate
Cl	Chlorine
H_3BO_3	Boric acid
HCl	Hydrochloric acid
HNO_3	Nitric acid
H_2O_2	Hydrogen perioxide
H_2SO_4	Sulfuric acid
K	Potassium
KCl	Potassium chloride
$K_2Cr_2O_7$	Potassium dichromate
K_2SO_4	Potassium sulfate
Mg	Magnesium
N	Nitrogen
Na	Sodium
Na_2CO_3	Sodium carbonate
NaF	Sodium fluoride
NaOAc	Sodium acetate
NH_3	Ammonia
NH_4F	Ammonium fluoride
NH_4-N	Ammonium nitrogen
NH_4OAc	Ammonium acetate
NO_3-N	Nitrate nitrogen
P	Phosphorus
SO_4-S	Sulfate sulfur

Table A4

Relationship of Soil pH in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and pH					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	6.75 a*	6.66 a	6.77 a	6.40 a	6.57 a	6.63 c
Middle	7.00 ab	6.90 ab	6.84 b	7.00 ab	7.08 a	6.96 b
Upper	7.22 a	7.23 a	7.08 a	7.10 a	7.26 a	7.18 a
Mean	6.99 a	6.93 a	6.90 a	6.83 a	6.97 a	6.92
Deschampsia Seeded						
Lower	6.68 ab	6.56 b	6.75 ab	6.76 ab	6.95 a	6.74 c
Middle	6.91 a	6.78 a	6.95 a	6.96 a	6.85 a	6.89 b
Upper	7.43 a	6.99 b	7.01 b	7.06 b	7.15 b	7.13 a
Mean	7.01 a	6.78 a	6.91 a	6.93 a	6.98 a	6.92
Carex obnupta Transplant						
Lower	6.68 a	6.71 a	6.54 ab	6.32 b	6.73 a	6.60 c
Middle	6.99 a	6.97 a	6.85 a	6.95 a	6.71 a	6.90 b
Upper	7.44 a	7.08 a	7.04 a	7.26 a	7.41 a	7.25 a
Mean	7.04 a	6.92 ab	6.81 b	6.84 b	6.95 ab	6.91
Carex obnupta Seeded						
Lower	6.70 a	6.56 a	6.61 a	6.77 a	6.79 a	6.69 b
Middle	6.83 a	6.80 a	6.88 a	6.88 a	7.06 a	6.89 ab
Upper	7.27 a	7.35 a	7.07 a	7.06 a	7.25 a	7.20 a
Mean	6.93 a	6.90 a	6.85 a	6.90 a	7.03 a	6.93
Control						
Lower	6.66 a	6.64 a	6.71 a	6.58 a	6.76 a	6.67 c
Middle	7.05 a	6.77 b	6.86 ab	6.92 ab	6.88 ab	6.90 b
Upper	7.42 a	7.08 ab	7.18 ab	7.29 ab	7.01 b	7.19 a
Mean	7.04 a	6.83 b	6.91 ab	6.93 ab	6.88 ab	6.92

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A5

Relationship of Soil pH in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and pH					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	6.95 a*	6.71 a	6.99 a	7.12 a	6.82 a	6.92 c
Middle	6.90 a	6.95 a	7.16 a	7.20 a	6.90 a	7.02 b
Upper	7.21 a	7.25 a	7.11 a	7.30 a	7.09 a	7.19 a
Mean	7.03 a	6.97 a	7.08 a	7.21 a	6.94 a	7.05
Deschampsia Seeded						
Lower	6.73 b	6.81 ab	6.87 ab	7.01 a	6.97 ab	6.88 a
Middle	7.10 a	7.29 a	7.07 a	7.22 a	6.85 a	7.11 a
Upper	7.08 a	6.67 b	6.54 b	7.07 a	7.26 a	6.93 a
Mean	6.97 abc	6.93 bc	6.83 c	7.10 a	7.03 ab	6.97
Carex obnupta Transplant						
Lower	6.97 a	6.97 a	6.70 a	6.97 a	6.98 a	6.92 b
Middle	6.93 a	6.93 a	6.97 a	7.18 a	6.95 a	6.99 ab
Upper	7.43 a	7.18 a	7.28 a	7.22 a	7.33 a	7.29 a
Mean	7.11 a	7.03 a	6.99 a	7.12 a	7.09 a	7.07
Carex obnupta Seeded						
Lower	6.79 a	6.98 a	6.96 a	6.90 a	6.98 a	6.92 a
Middle	7.00 ab	6.84 b	7.06 ab	7.18 a	6.93 b	7.00 a
Upper	7.15 a	7.18 a	7.05 a	6.82 a	7.20 a	7.08 a
Mean	6.98 a	7.00 a	7.02 a	6.97 a	7.04 a	7.00
Control						
Lower	7.03 a	6.97 a	6.90 a	6.72 a	6.95 a	6.93 a
Middle	7.39 a	7.11 b	7.02 b	7.05 b	7.06 b	7.13 a
Upper	7.35 a	6.99 a	7.29 a	6.98 a	7.02 a	7.13 a
Mean	7.26 a	7.02 b	7.07 b	6.94 b	7.01 b	7.06

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A6

Relationship of Soil pH in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and pH					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	6.96 a*	6.89 a	6.98 a	7.01 a	6.89 a	6.94 b
Middle	6.85 a	7.11 a	7.05 a	7.16 a	6.86 a	7.01 b
Upper	7.34 a	7.17 a	7.42 a	7.55 a	7.28 a	7.36 a
Mean	7.03 a	7.06 a	7.15 a	7.24 a	7.01 a	7.10
Deschampsia Seeded						
Lower	7.07 a	7.00 ab	6.99 ab	7.04 a	6.87 b	6.99 a
Middle	7.04 a	7.02 a	7.19 a	7.21 a	6.60 a	7.01 a
Upper	7.32 a	7.14 ab	7.03 ab	6.89 ab	6.83 b	7.04 a
Mean	7.14 a	7.06 a	7.07 a	7.05 a	6.77 b	7.02
Carex obnupta Transplant						
Lower	7.08 a	6.87 a	7.04 a	7.04 a	6.96 a	7.00 b
Middle	7.21 a	6.80 a	6.96 a	6.99 a	6.87 a	6.97 b
Upper	7.76 a	7.50 ab	7.38 b	7.36 b	7.73 ab	7.55 a
Mean	7.35 a	7.06 b	7.13 b	7.13 b	7.19 ab	7.17
Carex obnupta Seeded						
Lower	6.97 a	7.00 a	6.99 a	6.98 a	7.11 a	7.01 b
Middle	7.22 a	6.89 a	6.87 a	7.00 a	6.76 a	6.95 b
Upper	7.51 a	7.50 a	7.38 ab	6.98 bc	6.80 c	7.24 a
Mean	7.23 a	7.13 ab	7.08 ab	6.99 b	6.89 b	7.06
Control						
Lower	7.03 a	6.99 a	6.99 a	6.98 a	6.96 a	6.99 b
Middle	7.24 a	6.93 ab	6.98 ab	6.97 ab	6.89 b	7.00 b
Upper	7.49 a	7.47 a	7.49 a	7.35 a	7.38 a	7.43 a
Mean	7.25 a	7.13 ab	7.15 ab	7.11 ab	7.08 b	7.14

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A7

Relationship of Exchangeable K in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Exchangeable K (meq/100 g)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.14 a*	0.16 a	0.17 a	0.15 a	0.17 a	0.16 a
Middle	0.09 c	0.12 b	0.16 a	0.11 bc	0.11 bc	0.12 a
Upper	0.09 b	0.10 ab	0.15 ab	0.17 a	0.11 ab	0.12 a
Mean	0.11 c	0.12 bc	0.16 a	0.14 ab	0.13 bc	0.13
Deschampsia Seeded						
Lower	0.16 a	0.16 a	0.17 a	0.16 a	0.15 a	0.16 a
Middle	0.11 a	0.16 a	0.17 a	0.14 a	0.14 a	0.14 a
Upper	0.08 b	0.14 b	0.24 a	0.14 b	0.13 b	0.15 a
Mean	0.12 c	0.15 b	0.19 a	0.15 bc	0.14 bc	0.15
Carex obnupta Transplant						
Lower	0.18 a	0.15 a	0.16 a	0.17 a	0.16 a	0.16 a
Middle	0.10 a	0.12 a	0.17 a	0.10 a	0.15 a	0.13 b
Upper	0.10 a	0.14 a	0.16 a	0.10 a	0.10 a	0.12 b
Mean	0.12 b	0.14 ab	0.16 a	0.12 b	0.13 ab	0.14
Carex obnupta Seeded						
Lower	0.14 a	0.15 a	0.15 a	0.15 a	0.14 a	0.15 a
Middle	0.12 b	0.12 b	0.18 a	0.14 ab	0.10 b	0.13 a
Upper	0.08 b	0.10 b	0.18 a	0.13 ab	0.15 ab	0.13 a
Mean	0.12 b	0.13 b	0.17 a	0.14 ab	0.13 b	0.14
Control						
Lower	0.13 b	0.16 a	0.16 ab	0.15 ab	0.14 ab	0.15 a
Middle	0.10 b	0.14 ab	0.11 ab	0.11 ab	0.15 a	0.12 b
Upper	0.09 a	0.12 a	0.14 a	0.11 a	0.12 a	0.12 b
Mean	0.11 a	0.14 a	0.14 a	0.12 a	0.14 a	0.13

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A8

Relationship of Exchangeable K in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Exchangeable K (meq/100 g)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.15 a*	0.17 a	0.16 a	0.17 a	0.16 a	0.16 a
Middle	0.12 a	0.16 a	0.13 a	0.12 a	0.15 a	0.14 ab
Upper	0.10 b	0.11 b	0.10 b	0.14 a	0.14 a	0.12 b
Mean	0.12 a	0.14 a	0.13 a	0.15 a	0.15 a	0.14
Deschampsia Seeded						
Lower	0.16 a	0.19 a	0.16 a	0.17 a	0.17 a	0.17 a
Middle	0.14 ab	0.16 ab	0.21 a	0.13 b	0.18 ab	0.17 a
Upper	0.10 b	0.15 b	0.33 a	0.14 b	0.15 b	0.17 a
Mean	0.14 b	0.17 b	0.23 a	0.15 b	0.16 b	0.17
Carex obnupta Transplant						
Lower	0.20 a	0.17 a	0.17 a	0.19 a	0.17 a	0.18 a
Middle	0.11 a	0.13 a	0.14 a	0.13 a	0.15 a	0.13 b
Upper	0.11 a	0.12 a	0.11 a	0.13 a	0.12 a	0.12 b
Mean	0.14 a	0.14 a	0.14 a	0.15 a	0.15 a	0.14
Carex obnupta Seeded						
Lower	0.16 a	0.18 a	0.17 a	0.16 a	0.16 a	0.17 a
Middle	0.14 a	0.17 a	0.19 a	0.15 a	0.15 a	0.16 a
Upper	0.10 b	0.12 b	0.22 a	0.14 b	0.14 b	0.15 a
Mean	0.13 b	0.16 ab	0.19 a	0.15 ab	0.15 ab	0.16
Control						
Lower	0.16 d	0.18 c	0.18 b	0.15 e	0.19 a	0.17 a
Middle	0.13 bc	0.16 abc	0.12 c	0.16 ab	0.17 a	0.15 b
Upper	0.10 a	0.12 a	0.13 a	0.17 a	0.14 a	0.13 b
Mean	0.13 a	0.15 a	0.14 a	0.16 a	0.16 a	0.15

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A9

Relationship of Exchangeable K in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Exchangeable K (meq/100 g) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.14 a*	0.15 a	0.14 a	0.16 a	0.16 a	0.15 a
Middle	0.09 a	0.13 a	0.12 a	0.11 a	0.10 a	0.11 b
Upper	0.10 a	0.09 a	0.09 a	0.09 a	0.10 a	0.09 b
Mean	0.11 a	0.12 a	0.12 a	0.12 a	0.12 a	0.12
Deschampsia Seeded						
Lower	0.16 a	0.15 a	0.15 a	0.15 a	0.18 a	0.16 a
Middle	0.14 a	0.15 a	0.17 a	0.12 a	0.16 a	0.15 a
Upper	0.10 a	0.11 a	0.15 a	0.12 a	0.11 a	0.12 a
Mean	0.13 a	0.14 a	0.16 a	0.13 a	0.15 a	0.14
Carex obnupta Transplant						
Lower	0.16 a	0.16 a	0.16 a	0.17 a	0.16 a	0.16 a
Middle	0.10 b	0.10 b	0.13 ab	0.11 b	0.14 a	0.12 b
Upper	0.09 a	0.08 a	0.09 a	0.10 a	0.08 a	0.09 c
Mean	0.12 a	0.11 a	0.13 a	0.13 a	0.13 a	0.12
Carex obnupta Seeded						
Lower	0.16 a	0.16 a	0.15 a	0.15 a	0.16 a	0.16 a
Middle	0.12 a	0.12 a	0.12 a	0.13 a	0.14 a	0.13 b
Upper	0.10 bc	0.09 c	0.15 a	0.13 abc	0.14 ab	0.12 b
Mean	0.12 a	0.12 a	0.14 a	0.14 a	0.15 a	0.13
Control						
Lower	0.15 a	0.16 a	0.16 a	0.15 a	0.16 a	0.15 a
Middle	0.11 a	0.14 a	0.11 a	0.12 a	0.13 a	0.12 b
Upper	0.09 a	0.11 a	0.10 a	0.11 a	0.11 a	0.10 b
Mean	0.12 a	0.14 a	0.12 a	0.12 a	0.13 a	0.13

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A10

Relationship of Available P in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Available P (ppm)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	200 a*	241 a	185 a	219 a	229 a	215 a
Middle	197 a	200 a	195 a	182 a	204 a	196 ab
Upper	141 a	124 a	142 a	141 a	131 a	136 b
Mean	180 a	188 a	174 a	180 a	188 a	182
Deschampsia Seeded						
Lower	292 a	234 ab	167 b	215 ab	149 b	211 a
Middle	235 a	229 a	180 ab	132 b	223 a	200 ab
Upper	112 b	113 b	166 a	137 ab	135 ab	133 b
Mean	213 a	192 ab	171 b	162 b	169 b	181
Carex obnupta Transplant						
Lower	237 a	161 a	206 a	248 a	236 a	218 a
Middle	171 a	210 a	181 a	180 a	247 a	198 a
Upper	134 a	148 a	134 a	128 a	153 a	139 a
Mean	181 a	173 a	173 a	185 a	212 a	185
Carex obnupta Seeded						
Lower	231 a	206 a	233 a	199 a	191 a	187 a
Middle	224 a	240 a	233 a	231 a	205 a	227 a
Upper	122 b	147 ab	159 a	130 ab	150 ab	142 a
Mean	178 a	183 a	197 a	188 a	180 a	185
Control						
Lower	231 a	206 a	233 a	199 a	191 a	212 a
Middle	194 a	218 a	199 a	212 a	227 a	210 a
Upper	131 a	132 a	131 a	144 a	153 a	138 a
Mean	185 a	185 a	188 a	185 a	190 a	187

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A11

Relationship of Available P in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Available P (ppm)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	124 a*	171 a	139 a	169 a	133 a	149 a
Middle	85 a	130 a	99 a	91 a	116 a	104 b
Upper	71 a	79 a	61 a	94 a	92 a	79 c
Mean	89 c	126 a	100 bc	118 ab	114 ab	110
Deschampsia Seeded						
Lower	178 a	180 a	131 a	136 a	154 a	156 a
Middle	126 a	130 a	89 a	97 a	111 a	111 b
Upper	79 a	64 a	74 a	76 a	67 a	72 c
Mean	127 a	125 ab	98 c	103 bc	111 abc	113
Carex obnupta Transplant						
Lower	152 a	168 a	164 a	114 a	161 a	152 a
Middle	90 a	97 a	90 a	89 a	111 a	96 b
Upper	76 a	70 a	85 a	80 a	67 a	75 b
Mean	106 a	112 a	113 a	94 a	113 a	108
Carex obnupta Seeded						
Lower	154 a	157 a	165 a	116 a	160 a	150 a
Middle	118 a	124 a	112 a	102 a	102 a	112 b
Upper	69 a	66 a	68 a	50 a	68 a	64 c
Mean	114 a	116 a	115 a	89 a	110 a	109
Control						
Lower	132 a	180 a	139 a	146 a	167 a	153 a
Middle	103 a	118 a	101 a	113 a	120 a	111 b
Upper	70 a	51 a	56 a	71 a	70 a	64 c
Mean	102 a	116 a	99 a	106 a	119 a	108

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0,05) by DMRT.

Table A12

Relationship of Available P in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Available P (ppm)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	143 a*	183 a	154 a	198 a	211 a	180 a
Middle	100 a	137 a	115 a	102 a	100 a	111 b
Upper	103 ab	97 b	98 b	126 a	106 ab	106 b
Mean	112 a	139 a	122 a	142 a	139 a	131
Deschampsia Seeded						
Lower	189 a	199 a	162 a	166 a	157 a	174 a
Middle	128 a	134 a	126 a	108 a	115 a	122 b
Upper	109 b	107 b	109 b	118 ab	130 a	114 b
Mean	142 a	147 a	132 a	130 a	134 a	137
Carex obnupta Transplant						
Lower	187 a	178 a	196 a	175 a	189 a	185 a
Middle	108 ab	101 b	115 ab	102 ab	136 a	113 b
Upper	103 b	107 ab	104 ab	111 a	106 ab	106 b
Mean	133 a	122 a	138 a	130 a	144 a	135
Carex obnupta Seeded						
Lower	193 a	184 a	172 a	196 a	168 a	182 a
Middle	141 a	132 a	109 a	132 a	117 a	126 b
Upper	95 b	102 ab	120 a	106 ab	119 a	108 b
Mean	143 a	139 a	134 a	145 a	135 a	139
Control						
Lower	173 a	200 a	192 a	186 a	178 a	186 a
Middle	114 a	133 a	107 a	111 a	118 a	117 b
Upper	104 a	102 a	111 a	106 a	102 a	105 b
Mean	130 ab	148 a	137 ab	127 b	133 ab	135

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A13

Relationship of Ammonium N in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and NH_4-N (ppm) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	5.91 b*	11.99 ab	11.11 ab	10.13 ab	13.68 a	10.57 a
Middle	1.58 c	9.64 b	21.25 a	5.08 bc	8.27 bc	9.17 a
Upper	2.23 a	5.87 a	8.81 a	1.36 a	11.12 a	5.87 a
Mean	3.24 c	9.17 ab	13.72 a	5.52 bc	11.03 a	8.54
Deschampsia Seeded						
Lower	13.04 a	11.10 a	16.05 a	12.36 a	11.89 a	12.88 a
Middle	7.55 b	18.35 ab	31.84 a	4.60 b	18.60 ab	16.23 a
Upper	12.58 b	18.23 b	38.90 a	3.69 b	4.72 b	15.62 a
Mean	11.13 bc	15.89 b	28.93 a	6.88 c	11.73 bc	14.91
Carex obnupta Transplant						
Lower	8.33 a	14.57 a	14.04 a	8.70 a	13.84 a	11.90 a
Middle	1.92 c	7.54 bc	20.76 a	5.90 bc	11.06 b	9.43 ab
Upper	1.06 b	2.39 b	11.44 a	2.16 b	4.02 b	4.22 b
Mean	3.77 c	8.17 b	15.41 a	5.59 bc	9.64 b	8.52
Carex obnupta Seeded						
Lower	6.85 b	13.56 ab	16.95 a	9.90 ab	9.14 ab	11.28 a
Middle	7.84 b	11.15 ab	29.98 a	9.83 b	13.02 ab	14.36 a
Upper	1.28 b	6.96 b	32.86 a	4.20 b	6.23 b	10.31 a
Mean	5.32 b	10.56 b	26.60 a	7.98 b	9.46 b	11.98
Control						
Lower	6.88 c	15.00 a	12.74 ab	9.29 bc	12.14 ab	11.21
Middle	6.42 a	12.12 a	7.69 a	5.84 a	11.58 a	8.73 a
Upper	2.54 a	6.15 a	12.98 a	1.69 a	5.08 a	5.68 a
Mean	5.28 a	11.09 a	11.14 a	5.61 a	9.60 a	8.54

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A14

Relationship of Ammonium N in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and NH_4-N (ppm) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	9.28 ab*	11.55 ab	9.03 b	15.10 a	10.10 ab	11.14 a
Middle	1.59 b	16.97 a	4.49 ab	3.35 ab	8.25 ab	6.93 a
Upper	1.01 a	1.55 a	1.86 a	1.13 a	0.72 a	1.25 b
Mean	3.30 b	10.02 a	5.12 ab	6.53 ab	6.36 ab	6.33
Deschampsia Seeded						
Lower	14.47 a	12.20 a	10.07 a	12.65 a	9.81 a	11.84 a
Middle	6.74 a	11.80 a	19.28 a	4.20 a	14.57 a	11.32 a
Upper	0.98 b	9.95 b	37.64 a	2.11 b	2.54 b	10.64 a
Mean	7.40 bc	11.32 b	22.33 a	6.32 c	8.97 bc	11.27
Carex obnupta Transplant						
Lower	14.42 a	11.38 a	12.33 a	10.96 a	13.36 a	12.49 a
Middle	1.13 b	4.31 ab	6.53 ab	5.33 ab	11.10 a	5.68 b
Upper	0.95 ab	0.54 b	1.74 ab	3.85 a	1.05 ab	1.63 c
Mean	5.50 a	5.41 a	6.86 a	6.71 a	8.50 a	6.60
Carex obnupta Seeded						
Lower	6.07 b	10.44 ab	16.78 a	9.24 ab	9.83 ab	10.47 ab
Middle	8.67 b	10.22 ab	34.14 a	9.45 ab	12.81 ab	15.06 a
Upper	0.87 b	5.79 b	34.41 a	5.17 b	1.83 b	9.61 b
Mean	5.20 b	8.82 b	28.44 a	7.95 b	8.16 b	11.71
Control						
Lower	10.42 a	12.83 a	12.41 a	10.76 a	11.96 a	11.74 a
Middle	5.87 a	9.04 a	2.92 a	7.69 a	4.37 a	5.98 b
Upper	1.23 a	1.50 a	0.97 a	6.09 a	3.00 a	2.56 b
Mean	5.84 a	7.79 a	5.44 a	7.86 a	6.45 a	6.65

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A15

Relationship of Ammonium N in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and NH_4-N (ppm)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	6.74 b*	13.66 ab	8.67 ab	14.78 a	11.50 ab	11.38 a
Middle	2.53 a	9.85 a	5.48 a	4.63 a	2.96 a	5.09 b
Upper	2.06 a	1.96 a	0.93 a	1.16 a	1.45 a	1.51 b
Mean	3.41 a	8.49 a	5.03 a	6.86 a	5.30 a	5.87
Deschampsia Seeded						
Lower	12.53 a	13.58 a	9.10 a	12.50 a	15.37 a	12.62 a
Middle	8.54 a	9.19 a	15.70 a	12.09 a	17.65 a	12.64 a
Upper	1.30 a	5.15 a	2.10 a	2.56 a	3.12 a	2.85 b
Mean	7.46 a	9.31 a	8.97 a	9.05 a	12.05 a	9.37
Carex obnupta Transplant						
Lower	18.87 a	9.69 a	12.46 a	10.84 a	17.10 a	13.79 a
Middle	1.93 b	4.01 b	8.16 ab	4.03 b	16.88 a	7.00 b
Upper	0.77 a	1.65 a	1.91 a	2.95 a	1.27 a	1.71 c
Mean	7.19 a	5.12 a	7.51 a	5.94 a	11.75 a	7.50
Carex obnupta Seeded						
Lower	8.12 a	11.20 a	11.22 a	11.09 a	11.35 a	10.60 ab
Middle	8.48 ab	8.04 b	17.23 ab	10.47 ab	21.27 a	13.10 a
Upper	1.20 b	1.21 b	13.18 a	3.57 ab	13.09 a	6.45 b
Mean	5.93 b	6.82 b	13.87 a	8.38 b	15.24 a	10.05
Control						
Lower	11.47 a	10.94 a	11.88 a	9.78 a	10.60 a	11.02 a
Middle	8.69 a	9.99 a	5.73 a	8.00 a	7.99 a	8.08 ab
Upper	1.61 a	5.99 a	1.14 a	1.20 a	2.40 a	2.47 b
Mean	7.26 a	8.97 a	6.25 a	5.89 a	6.99 a	7.10

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A16

Relationship of Kjeldahl N in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Kjeldahl N (%)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.015 a*	0.022 a	0.015 a	0.019 a	0.022 a	0.019 a
Middle	0.005 a	0.007 a	0.008 a	0.009 a	0.006 a	0.007 b
Upper	0.003 a	0.004 a	0.004 a	0.003 a	0.004 a	0.004 b
Mean	0.008 a	0.011 a	0.009 a	0.011 a	0.011 a	0.010
Deschampsia Seeded						
Lower	0.022 ab	0.023 ab	0.023 ab	0.026 a	0.015 b	0.022 a
Middle	0.010 a	0.014 a	0.009 a	0.004 a	0.009 a	0.009 b
Upper	0.003 c	0.006 a	0.007 a	0.004 b	0.004 bc	0.005 b
Mean	0.012 ab	0.014 a	0.013 ab	0.012 ab	0.009 b	0.012
Carex obnupta Transplant						
Lower	0.021 a	0.022 a	0.022 a	0.021 a	0.021 a	0.021 a
Middle	0.005 a	0.007 a	0.008 a	0.005 a	0.011 a	0.007 b
Upper	0.003 a	0.003 a	0.004 a	0.004 a	0.004 a	0.004 b
Mean	0.010 a	0.010 a	0.011 a	0.010 a	0.012 a	0.011
Carex obnupta Seeded						
Lower	0.018 a	0.023 a	0.025 a	0.023 a	0.016 a	0.021 a
Middle	0.013 a	0.010 a	0.013 a	0.012 a	0.006 a	0.011 ab
Upper	0.003 b	0.004 b	0.007 a	0.004 b	0.003 b	0.004 b
Mean	0.012 a	0.013 a	0.015 a	0.012 a	0.008 a	0.012
Control						
Lower	0.017 b	0.024 a	0.021 ab	0.019 b	0.019 ab	0.020 a
Middle	0.006 a	0.011 a	0.006 a	0.009 a	0.010 a	0.008 b
Upper	0.003 a	0.004 a	0.004 a	0.003 a	0.004 a	0.004 b
Mean	0.009 a	0.013 a	0.010 a	0.010 a	0.011 a	0.011

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A17

Relationship of Kjeldahl N in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Kjeldahl N (%) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.015 a*	0.020 a	0.013 a	0.021 a	0.023 a	0.019 a
Middle	0.005 a	0.012 a	0.006 a	0.004 a	0.006 a	0.007 b
Upper	0.004 a	0.003 a	0.003 a	0.004 a	0.004 a	0.004 b
Mean	0.007 a	0.012 a	0.007 a	0.010 a	0.011 a	0.009
Deschampsia Seeded						
Lower	0.020 a	0.013 a	0.017 a	0.015 a	0.015 a	0.016 a
Middle	0.010 a	0.011 a	0.008 a	0.004 a	0.010 a	0.009 b
Upper	0.002 d	0.004 b	0.006 a	0.003 cd	0.004 bc	0.004 b
Mean	0.011 a	0.010 a	0.010 a	0.007 a	0.010 a	0.010
Carex obnupta Transplant						
Lower	0.025 a	0.021 a	0.021 a	0.023 a	0.020 a	0.022 a
Middle	0.003 b	0.007 ab	0.006 ab	0.006 ab	0.010 a	0.007 b
Upper	0.003 ab	0.003 b	0.004 ab	0.004 a	0.004 ab	0.004 b
Mean	0.011 a	0.010 a	0.010 a	0.011 a	0.011 a	0.011
Carex obnupta Seeded						
Lower	0.018 a	0.020 a	0.016 a	0.020 a	0.022 a	0.019 a
Middle	0.012 a	0.013 a	0.008 a	0.004 a	0.005 a	0.009 b
Upper	0.003 c	0.004 bc	0.007 a	0.004 b	0.003 c	0.004 b
Mean	0.011 a	0.012 a	0.010 a	0.010 a	0.010 a	0.011
Control						
Lower	0.019 a	0.022 a	0.022 a	0.019 a	0.020 a	0.020 a
Middle	0.008 a	0.011 a	0.006 a	0.009 a	0.009 a	0.009 b
Upper	0.003 a	0.003 a	0.004 a	0.004 a	0.004 a	0.004 b
Mean	0.010 a	0.012 a	0.010 a	0.010 a	0.011 a	0.011

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A18

Relationship of Kjeldahl N in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Kjeldahl N (%)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.015 a*	0.022 a	0.016 a	0.021 a	0.023 a	0.020 a
Middle	0.006 a	0.013 a	0.007 a	0.005 a	0.006 a	0.008 b
Upper	0.004 a	0.004 a	0.003 a	0.004 a	0.004 a	0.004 b
Mean	0.008 a	0.013 a	0.009 a	0.010 a	0.011 a	0.010
Deschampsia Seeded						
Lower	0.023 a	0.024 a	0.015 a	0.018 a	0.016 a	0.019 a
Middle	0.010 a	0.010 a	0.009 a	0.006 a	0.009 a	0.009 b
Upper	0.005 a	0.004 a	0.004 a	0.005 a	0.004 a	0.004 b
Mean	0.013 a	0.013 a	0.009 b	0.010 b	0.010 b	0.011
Carex obnupta Transplant						
Lower	0.021 a	0.025 a	0.025 a	0.021 a	0.024 a	0.023 a
Middle	0.008 a	0.007 a	0.009 a	0.006 a	0.012 a	0.008 b
Upper	0.003 ab	0.003 ab	0.004 ab	0.004 a	0.003 b	0.004 b
Mean	0.010 a	0.012 a	0.013 a	0.010 a	0.013 a	0.012
Carex obnupta Seeded						
Lower	0.022 a	0.023 a	0.019 a	0.024 a	0.019 a	0.021 a
Middle	0.012 a	0.009 a	0.008 a	0.010 a	0.008 a	0.009 b
Upper	0.004 a	0.004 a	0.006 a	0.004 a	0.004 a	0.004 b
Mean	0.013 a	0.012 a	0.011 a	0.013 a	0.011 a	0.012
Control						
Lower	0.019 a	0.027 a	0.024 a	0.023 a	0.020 a	0.022 a
Middle	0.008 a	0.011 a	0.006 a	0.008 a	0.008 a	0.008 b
Upper	0.004 a	0.005 a	0.004 a	0.003 a	0.005 a	0.004 b
Mean	0.010 a	0.014 a	0.011 a	0.010 a	0.011 a	0.011

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A19

Relationship of Nitrate N in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and NO_3-N (ppm) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.33 a*	0.00 a	0.17 a	0.00 a	0.28 a	0.16 a
Middle	0.08 ab	0.00 b	0.41 ab	0.00 b	0.66 a	0.23 a
Upper	0.25 a	0.41 a	0.10 a	0.33 a	0.97 a	0.41 a
Mean	0.22 b	0.14 b	0.23 b	0.11 b	0.64 a	0.27
Deschampsia Seeded						
Lower	0.11 a	0.03 a	0.89 a	0.00 a	0.00 a	0.21 a
Middle	1.07 a	0.25 a	1.07 a	0.12 a	0.37 a	0.58 a
Upper	0.25 b	0.95 ab	1.83 a	1.03 ab	0.49 ab	0.91 a
Mean	0.48 b	0.41 b	1.26 a	0.38 b	0.28 b	0.56
Carex obnupta Transplant						
Lower	0.08 b	0.71 a	0.03 b	0.00 b	0.49 ab	0.26 a
Middle	0.08 a	0.55 a	0.26 a	0.41 a	0.42 a	0.34 a
Upper	0.06 a	0.95 a	0.42 a	0.43 a	0.27 a	0.43 a
Mean	0.07 b	0.74 a	0.24 ab	0.28 ab	0.39 ab	0.34
Carex obnupta Seeded						
Lower	0.00 a	0.22 a	0.02 a	0.61 a	0.00 a	0.17 a
Middle	0.24 a	0.02 a	0.26 a	0.10 a	0.27 a	0.18 a
Upper	0.15 a	0.06 a	0.69 a	0.68 a	0.29 a	0.37 a
Mean	0.13 b	0.10 b	0.32 ab	0.46 a	0.19 ab	0.24
Control						
Lower	0.03 a	0.88 a	0.61 a	0.32 a	0.26 a	0.42 a
Middle	0.72 a	0.43 a	0.00 a	0.32 a	0.16 a	0.33 a
Upper	0.18 a	0.35 a	0.49 a	0.20 a	1.50 a	0.54 a
Mean	0.31 a	0.56 a	0.37 a	0.28 a	0.64 a	0.43

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A20

Relationship of Nitrate N in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and NO_3-N (ppm) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.60 a*	0.48 a	0.31 a	1.29 a	0.65 a	0.67 a
Middle	0.40 a	0.47 a	0.41 a	0.37 a	0.45 a	0.42 a
Upper	0.09 b	0.35 ab	0.32 ab	0.59 a	0.43 ab	0.36 a
Mean	0.33 a	0.43 a	0.34 a	0.75 a	0.51 a	0.48
Deschampsia Seeded						
Lower	0.60 ab	0.28 b	0.58 ab	0.51 ab	0.84 a	0.56 a
Middle	0.66 b	0.79 b	1.51 ab	0.68 b	2.72 a	1.27 a
Upper	0.27 b	1.42 ab	3.43 a	1.44 ab	1.42 ab	1.60 a
Mean	0.51 c	0.83 bc	1.84 a	0.88 bc	1.66 ab	1.43
Carex obnupta Transplant						
Lower	0.63 a	0.58 a	1.12 a	0.53 a	0.63 a	0.70 a
Middle	0.42 a	0.62 a	0.19 a	0.24 a	0.37 a	0.37 b
Upper	0.33 a	0.57 a	0.23 a	0.27 a	0.42 a	0.36 b
Mean	0.46 a	0.59 a	0.51 a	0.35 a	0.48 a	0.48
Carex obnupta Seeded						
Lower	0.53 a	0.45 a	0.71 a	0.48 a	0.50 a	0.54 a
Middle	0.32 a	1.62 a	0.63 a	0.47 a	0.74 a	0.76 a
Upper	0.30 a	0.76 a	1.61 a	1.06 a	0.54 a	0.86 a
Mean	0.38 a	0.95 a	0.99 a	0.67 a	0.59 a	0.72
Control						
Lower	0.72 a	0.93 a	0.61 a	0.52 a	0.55 a	0.68 a
Middle	0.79 a	0.54 a	0.42 a	0.27 a	0.58 a	0.52 a
Upper	0.51 a	0.37 a	0.25 a	1.63 a	0.50 a	0.65 a
Mean	0.68 a	0.62 a	0.43 a	0.84 a	0.54 a	0.62

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A21

Relationship of Nitrate N in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and NO_3-N (ppm) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.23 a*	0.04 a	0.31 a	0.57 a	0.76 a	0.39 a
Middle	0.75 a	0.93 a	0.51 a	0.71 a	0.90 a	0.76 a
Upper	0.54 a	0.81 a	0.88 a	0.51 a	1.21 a	0.79 a
Mean	0.54 a	0.59 a	0.57 a	0.60 a	0.96 a	0.65
Deschampsia Seeded						
Lower	0.29 a	0.68 a	0.65 a	0.70 a	0.33 a	0.53 a
Middle	0.93 a	0.43 a	1.27 a	0.45 a	1.80 a	0.98 a
Upper	0.65 a	1.03 a	0.67 a	2.77 a	1.90 a	1.40 a
Mean	0.63 a	0.71 a	0.86 a	1.31 a	1.34 a	0.97
Carex obnupta Transplant						
Lower	0.37 a	0.58 a	0.50 a	0.77 a	0.49 a	0.54 a
Middle	0.46 a	0.53 a	0.77 a	0.38 a	0.52 a	0.53 a
Upper	1.12 a	0.28 b	0.26 b	0.41 ab	0.86 ab	0.59 a
Mean	0.65 a	0.46 a	0.51 a	0.52 a	0.63 a	0.55
Carex obnupta Seeded						
Lower	0.58 a	0.29 a	0.61 a	0.94 a	0.68 a	0.62 b
Middle	0.84 b	1.05 b	1.25 b	0.53 b	3.36 a	1.41 a
Upper	0.85 b	0.80 b	0.70 b	3.98 a	3.36 ab	1.94 a
Mean	0.76 b	0.71 b	0.85 b	1.82 ab	2.47 a	1.32
Control						
Lower	0.51 b	0.62 b	0.55 b	0.97 a	0.49 b	0.60 a
Middle	1.12 a	0.53 a	0.70 a	0.34 a	0.74 a	0.69 a
Upper	0.94 a	0.62 a	0.59 a	1.08 a	0.68 a	0.78 a
Mean	0.86 a	0.59 a	0.61 a	0.77 a	0.64 a	0.69

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A22

Relationship of Organic Carbon in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Organic C (%) F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	0.31 ab*	0.43 a	0.28 b	0.27 b	0.32 ab	0.32 a
Middle	0.06 a	0.15 a	0.08 a	0.03 a	0.05 a	0.07 b
Upper	0.05 a	0.05 a	0.05 a	0.05 a	0.05 a	0.05 b
Mean	0.12 a	0.21 a	0.13 a	0.12 a	0.14 a	0.15
Deschampsia Seeded						
Lower	0.35 a	0.27 a	0.29 a	0.25 a	0.37 a	0.30 a
Middle	0.12 a	0.11 a	0.09 a	0.05 a	0.08 a	0.09 b
Upper	0.04 a	0.05 a	0.03 a	0.04 a	0.04 a	0.04 b
Mean	0.17 a	0.14 a	0.14 a	0.12 a	0.16 a	0.15
Carex obnupta Transplant						
Lower	0.55 a	0.30 b	0.26 b	0.38 ab	0.32 b	0.36 a
Middle	0.08 a	0.07 a	0.08 a	0.06 a	0.14 a	0.09 b
Upper	0.04 a	0.04 a	0.05 a	0.04 a	0.04 a	0.04 b
Mean	0.23 a	0.14 b	0.13 b	0.16 ab	0.17 ab	0.16
Carex obnupta Seeded						
Lower	0.26 a	0.25 a	0.28 a	0.23 a	0.25 a	0.25 a
Middle	0.13 a	0.10 a	0.07 a	0.12 a	0.07 a	0.10 b
Upper	0.05 a	0.05 a	0.06 a	0.05 a	0.04 a	0.05 b
Mean	0.15 a	0.13 a	0.14 a	0.13 a	0.12 a	0.13
Control						
Lower	0.41 a	0.34 ab	0.39 a	0.26 b	0.27 b	0.34 a
Middle	0.10 a	0.13 a	0.06 a	0.09 a	0.08 a	0.09 b
Upper	0.04 a	0.03 a	0.04 a	0.04 a	0.05 a	0.04 b
Mean	0.19 a	0.17 a	0.16 a	0.11 a	0.13 a	0.15

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A23

Relationship of Cation Exchange Capacity in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and CEC (meq/100 g)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	4.69 a*	6.15 a	5.25 a	5.62 a	6.24 a	5.65 a
Middle	3.25 a	4.26 a	3.52 a	3.33 a	3.33 a	3.54 b
Upper	3.29 ab	3.24 ab	3.11 b	3.53 a	3.20 b	3.27 b
Mean	3.63 a	4.55 a	3.96 a	4.16 a	4.26 a	4.12
Deschampsia Seeded						
Lower	6.12 a	6.02 a	5.31 a	5.68 a	5.24 a	5.67 a
Middle	4.26 a	4.21 a	3.68 a	3.33 a	3.54 a	3.81 b
Upper	3.49 a	3.48 a	3.45 a	3.53 a	3.55 a	3.50 b
Mean	4.63 a	4.57 a	4.15 a	4.18 a	4.11 a	4.33
Carex obnupta Transplant						
Lower	5.83 a	6.19 a	6.48 a	5.74 a	6.10 a	6.07 a
Middle	3.56 a	3.40 a	3.43 a	3.26 a	4.31 a	3.55 b
Upper	3.55 a	3.46 a	3.22 a	3.50 a	3.27 a	3.40 b
Mean	4.25 a	4.35 a	4.37 a	4.17 a	4.56 a	4.34
Carex obnupta Seeded						
Lower	6.35 a	6.01 a	5.31 a	6.14 a	5.41 a	5.85 a
Middle	4.46 a	3.98 a	3.28 a	4.48 a	3.31 a	3.90 b
Upper	3.28 a	3.26 a	3.24 a	3.40 a	3.11 a	3.26 b
Mean	4.70 a	4.42 b	3.94 a	4.67 a	3.95 b	4.33
Control						
Lower	5.58 b	6.64 a	6.27 ab	5.52 b	5.82 ab	6.00 a
Middle	3.72 a	4.17 a	3.51 a	3.47 a	3.74 a	3.72 b
Upper	3.54 a	3.38 a	3.47 a	3.51 a	3.20 a	3.42 b
Mean	4.28 ab	4.73 a	4.41 ab	3.99 b	4.25 ab	4.34

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A24

Relationship of Soil Moisture in the Marsh to Treatments and Elevation at the End of the 1976 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Moisture (%)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	27.67 a*	29.90 a	25.77 a	27.20 a	26.73 a	27.45 a
Middle	24.87 a	23.47 a	23.63 a	22.83 a	22.67 a	23.49 ab
Upper	20.67 a	17.90 a	19.87 a	18.80 a	20.03 a	19.45 b
Mean	24.40 a	23.76 a	23.09 a	22.94 a	23.14 a	23.47
Deschampsia Seeded						
Lower	28.97 a	29.93 a	25.30 a	29.23 a	27.33 a	28.15 a
Middle	24.00 a	26.07 a	20.30 a	22.37 a	25.67 a	23.68 b
Upper	20.03 a	20.40 a	17.93 a	21.60 a	12.77 b	18.55 c
Mean	24.33 a	25.47 a	21.19 a	24.40 a	21.92 a	23.46
Carex obnupta Transplant						
Lower	28.47 a	27.00 a	29.40 a	27.50 a	24.80 a	27.43 a
Middle	23.53 a	21.93 a	21.03 a	23.50 a	23.63 a	22.73 ab
Upper	17.80 a	18.50 a	19.07 a	17.33 a	18.40 a	18.22 b
Mean	23.27 a	22.48 a	23.17 a	22.78 a	22.28 a	22.79
Carex obnupta Seeded						
Lower	28.13 a	29.13 a	26.23 a	25.37 a	28.00 a	27.37 a
Middle	28.43 a	27.10 a	21.43 a	24.90 a	24.07 a	25.19 a
Upper	18.70 a	18.23 a	23.53 a	19.10 a	17.37 a	19.39 b
Mean	25.09 a	24.82 a	23.73 a	23.12 a	23.14 a	23.98
Control						
Lower	27.77 a	29.78 a	25.75 a	26.92 a	28.53 a	27.75 a
Middle	23.43 a	24.57 a	24.87 a	21.48 a	24.42 a	23.75 b
Upper	18.10 a	20.37 a	17.52 a	17.97 a	17.80 a	18.35 c
Mean	23.10 a	24.91 a	22.71 a	22.12 a	23.58 a	23.28

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A25

Relationship of Soil Moisture in the Marsh to Treatments and Elevation during the Middle of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Moisture (%)					
	F0	F1	F2	F3	F4	Mean
Deschampsia Transplant						
Lower	24.40 a*	28.80 a	26.40 a	28.17 a	31.43 a	28.09 a
Middle	24.47 ab	25.83 a	23.37 ab	21.53 a	25.80 a	24.20 a
Upper	25.03 a	21.93 a	24.50 a	24.87 a	23.87 a	24.04 a
Mean	24.66 a	25.52 a	24.76 a	24.86 a	27.03 a	25.38
Deschampsia Seeded						
Lower	30.20 a	33.00 a	26.43 b	26.30 b	26.50 b	28.49 a
Middle	27.23 a	23.57 c	23.73 c	24.77 bc	26.60 ab	25.18 ab
Upper	24.63 ab	24.37 ab	26.27 a	24.00 ab	22.97 b	24.45 b
Mean	27.36 a	26.98 ab	25.48 abc	25.02 c	25.36 bc	26.04
Carex obnupta Transplant						
Lower	26.23 a	31.03 a	27.80 a	27.57 a	26.33 a	27.79 a
Middle	24.27 a	25.13 a	25.30 a	25.17 a	25.80 a	25.13 ab
Upper	22.53 a	23.57 a	23.57 a	24.27 a	22.50 a	23.29 b
Mean	24.34 a	26.58 a	25.56 a	25.67 a	24.88 a	25.40
Carex obnupta Seeded						
Lower	28.63 a	30.70 a	27.03 a	29.03 a	27.23 a	28.53 a
Middle	25.87 a	26.63 a	24.20 a	25.87 a	24.73 a	25.46 ab
Upper	23.87 b	23.63 b	22.43 c	25.57 a	23.17 bc	23.73 b
Mean	26.12 ab	26.99 a	24.56 b	26.82 a	25.04 ab	25.91
Control						
Lower	27.97 a	28.93 a	28.42 a	28.00 a	27.92 a	28.26 a
Middle	26.33 a	25.73 a	25.57 a	26.42 a	25.07 a	25.82 ab
Upper	24.22 a	24.23 a	24.18 a	24.38 a	22.50 b	23.90 b
Mean	26.17 a	26.30 a	26.06 a	26.05 a	25.16 a	25.95

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A26

Relationship of Soil Moisture in the Marsh to Treatments and Elevation at the End of the 1977 Growing Season

Plot Identification and Elevation	Fertilizer Treatment and Moisture (%)					
	F0	F1	F2	F3	F4	Mean
<u>Deschampsia</u> Transplant						
Lower	27.45 a*	30.10 a	29.27 a	30.87 a	29.67 a	29.61 a
Middle	26.83 ab	27.97 a	23.70 b	23.33 b	25.40 ab	25.45 b
Upper	21.50 a	13.13 a	14.13 a	11.34 a	19.63 a	15.95 c
Mean	24.98 a	23.73 a	22.37 a	21.86 a	24.90 a	23.54
<u>Deschampsia</u> Seeded						
Lower	35.27 a	32.93 ab	30.63 ab	29.50 b	28.63 b	31.39 a
Middle	27.03 a	25.17 a	25.07 a	27.47 a	25.97 a	26.14 b
Upper	14.33 ab	20.87 a	18.20 a	14.77 ab	7.67 b	15.17 c
Mean	25.54 ab	26.32 a	24.63 ab	23.91 ab	20.76 b	24.23
<u>Carex</u> <u>obnupta</u> Transplant						
Lower	32.10 a	37.43 a	35.83 a	30.17 a	36.03 a	34.31 a
Middle	24.97 a	25.47 a	26.43 a	23.57 a	27.27 a	25.54 b
Upper	8.90 a	11.50 a	13.33 a	14.37 a	7.00 a	11.02 c
Mean	21.99 a	24.80 a	25.20 a	22.70 a	23.43 a	23.62
<u>Carex</u> <u>obnupta</u> Seeded						
Lower	34.20 a	30.60 ab	29.13 b	32.70 ab	30.57 ab	31.44 a
Middle	27.73 a	26.03 a	25.70 a	28.10 a	25.40 a	26.59 b
Upper	21.63 a	12.27 a	21.47 a	23.23 a	13.57 a	18.43 c
Mean	27.86 ab	22.97 b	25.43 ab	28.01 a	23.18 ab	25.49
Control						
Lower	31.70 a	33.35 a	30.75 a	30.88 a	31.10 a	31.60 a
Middle	25.48 a	26.32 a	25.57 a	25.47 a	27.20 a	26.01 b
Upper	14.87 a	16.75 a	13.40 a	13.03 a	18.52 a	15.31 c
Mean	24.02 a	25.47 a	23.24 a	22.16 a	25.61 a	24.14

* Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A27

Percent Cover of Plants Established in the Deschampsia cespitosa Transplant Plots During August 1977 Sampling Period

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Deschampsia cespitosa	Lower	0.00 a**	0.00 a	0.01 a	0.00 a	6.94 a	1.39 b
	Middle	17.06 b	35.28 ab	23.33 ab	51.11 a	39.44 ab	32.56 a
	Upper	33.61 b	44.17 b	62.50 ab	76.39 a	50.56 ab	53.44 a
	Mean	16.90 c	26.48 bc	28.62 bc	42.50 a	32.32 ab	29.18
Algae sp.*	Lower	0.61 b	1.19 b	2.28 b	0.64 b	7.27 a	2.40 b
	Middle	65.00 a	65.83 a	63.61 a	39.73 a	60.28 a	59.15 a
	Upper	4.48 a	18.09 a	4.19 a	0.61 a	11.13 a	7.70 b
	Mean	26.23 a	28.37 a	23.36 a	13.66 a	26.23 a	23.61
Callitriche verna	Lower	0.00 a	0.00 a	0.03 a	0.02 a	4.50 a	0.91 a
	Middle	0.01 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
	Upper	0.02 a	0.00 a	0.01 a	0.01 a	0.00 a	0.01 a
	Mean	0.01 a	0.00 a	0.02 a	0.01 a	1.50 a	0.30
Limosella aquatica	Lower	0.00 b	0.00 b	0.00 b	0.01 ab	0.03 a	0.01 a
	Middle	0.02 a	0.00 a	0.01 a	0.56 a	0.00 a	0.11 a
	Upper	0.00 a	0.57 a	0.00 a	0.00 a	0.00 a	0.11 a
	Mean	0.01 a	0.19 a	0.00 a	0.19 a	0.01 a	0.08

(Continued)

Table A27 (Continued)

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Polygonum sp.	Lower	0.00 a	0.00 a	0.00 a	0.01 a	0.01 a	0.00 a
	Middle	0.02 b	1.14 a	0.00 b	0.00 b	0.00 b	0.22 a
	Upper	0.02 a	1.12 a	0.58 a	0.01 a	0.57 a	0.46 a
	Mean	0.01 a	0.76 a	0.19 a	0.01 a	0.19 a	0.23
Eleocharis palustris	Lower	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a	0.00 b
	Middle	0.93 ab	1.12 ab	0.57 b	6.67 a	2.50 ab	2.30 a
	Upper	0.00 a	1.11 a	0.00 a	0.00 a	0.00 a	0.22 b
	Mean	0.35 b	0.75 ab	0.19 b	2.22 a	0.83 ab	0.86
Carex lyngbyei	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00 a	0.58 a	0.00 a	0.01 a	0.01 a	0.12 a
	Upper	0.00 a	0.57 a	4.17 a	0.01 a	8.07 a	2.56 a
	Mean	0.00 a	0.38 a	1.39 a	0.01 a	2.69 a	0.88
Elodea nuttalli	Lower	0.00 a	0.57 a	0.00 a	0.01 a	0.01 a	0.12 a
	Middle	0.00 a	0.57 a	0.00 a	0.00 a	0.00 a	0.11 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.38 a	0.00 a	0.00 a	0.00 a	0.08

(Continued)

Table A27 (Continued)

Species	Tier	Treatments and % Cover F0	F1	F2	F3	F4	Mean
Lilaea scilloides	Lower	0.00 a	0.00 a	0.00 a	0.00 a	0.56 a	0.11 a
	Middle	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a	0.00 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.00 a	0.00 a	0.00 a	0.19 a	0.04
Juncus validus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.03 a	0.00 a	0.56 a	0.00 a	0.00 a	0.11 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.01 a	0.00 a	0.19 a	0.00 a	0.00 a	0.04
Lilaeopsis occidentalis	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.46 a	3.06 a	0.00 a	1.94 a	1.94 a	1.44 a
	Upper	1.11 a	0.57 a	0.00 a	0.00 a	13.06 a	2.95 a
	Mean	0.52 a	1.21 a	0.00 a	0.65 a	5.00 a	1.46
Alopecurus geniculatus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.46 a	0.46 a	0.00 a	1.94 a	0.00 a	0.59 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.17 a	0.19 a	0.00 a	0.65 a	0.00 a	0.20

(Continued)

Table A27 (Concluded)

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Cakile edentula	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.01 a	1.12 a	0.02 a	1.12 a	0.00 a	0.46 a
	Mean	0.00 a	0.37 a	0.01 a	0.37 a	0.00 a	0.15
Juncus effusus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.02 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	0.00 a	0.00 a	0.56 a	1.11 a	0.33 a
	Mean	0.01 a	0.00 a	0.00 a	0.19 a	0.37 a	0.11
Mimulus guttatus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.83 a	0.01 a	0.00 a	0.00 a	0.00 a	0.17 a
	Mean	0.26 a	0.00 a	0.00 a	0.00 a	0.00 a	0.06
Epilobium angustifolium	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.56 a	0.00 a	0.00 a	0.00 a	0.11a
	Mean	0.00 a	0.19 a	0.00 a	0.00 a	0.00 a	0.04

* See Table A2 for list of algae species identified in marsh plot areas.
** Values in horizontal sequence and means not followed by same letters are significantly different ($p=0.05$) by DMRT.

Table A28

Percent Cover of Plants Established in the Carex obnupta Transplant Plots During August 1977 Sampling Period

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Deschampsia cespitosa	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	2.51 a†	0.00 a	0.00 a	0.00 a	0.00 a	0.61 a
	Upper	0.00 a	1.11 a	0.00 a	0.57 a	0.56 a	0.45 a
	Mean	0.84 a	0.37 a	0.19 a	0.19 a	0.19 a	0.35
Carex obnupta	Lower	0.01 a	1.12 a	0.00 a	1.12 a	0.02 a	0.46 a
	Middle	29.46 a	12.82 a	21.12 a	23.34 a	16.40 a	20.63 a
	Upper	10.28 a	25.00 a	15.58 a	20.84 a	7.52 a	15.84 a
	Mean	13.25 a	12.98 a	12.23 a	15.10 a	7.98 a	12.31
Algae sp.*	Lower	1.19 a	2.82 a	1.73 a	2.58 a	1.73 a	2.01 b
	Middle	63.61 ab	70.83 ab	87.50 a	43.33 b	73.61 ab	67.78 a
	Upper	0.58 a	0.03 a	9.47 a	11.16 a	0.04 a	4.26 b
	Mean	21.79 ab	24.56 ab	32.90 a	19.02 b	25.13 ab	24.58
Callitriche verna	Lower	0.01 a	1.13 a	0.07 a	0.59 a	0.02 a	0.36 a
	Middle	9.72 a	0.01 a	0.01 a	0.00 a	0.01 a	1.95 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	3.24 a	0.38 a	0.03 a	0.20 a	0.01 a	0.77

(Continued)

Table A28 (Continued)

Species	Tier	F0	F1	F2	F3	F4	Mean
		Treatments and % Cover					
Limosella aquatica	Lower	0.00 b	0.02 a	0.00 b	0.00 b	0.00 b	0.00 a
	Middle	6.69 a	0.00 b	0.03 b	0.56 b	0.00 b	1.46 a
	Upper	0.00 a	0.00 a	0.01 a	0.56 a	0.00 a	0.11 a
	Mean	2.23 a	0.01 b	0.02 b	0.37 ab	0.00 b	0.53
Polygonum punctatum	Lower	0.01 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 b
	Middle	1.13 a	0.00 a	0.02 a	1.94 a	0.00 a	0.62 a
	Upper	0.01 a	0.01 a	0.00 a	0.56 a	0.01 a	0.12 ab
	Mean	0.38 a	0.00 a	0.01 a	0.83 a	0.00 a	0.25
Eleocharis palustris	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	1.96 a	0.00 a	6.68 a	6.94 a	0.01 a	3.12 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.65 a	0.00 a	2.23 a	2.32 a	0.00 a	1.04
Carex lyngbyei	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.02 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	0.00 a	0.00 a	1.94 a	0.00 a	0.39 a
	Mean	0.01 a	0.00 a	0.00 a	0.65 a	0.00 a	0.13

(Continued)

Table A28 (Continued)

Species	Tier	Treatments and % Cover F0	F1	F2	F3	F4	Mean
Elodea nuttalli	Lower	0.02 a	0.00 a	0.56 a	0.00 a	0.57 a	0.23 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a	0.00 a
	Mean	0.01 a	0.00 a	0.19 a	0.00 a	0.19 a	0.08
Phalaris arundinacea	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.01 a	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a
	Upper	0.56 a	0.01 a	0.00 a	0.00 a	0.00 a	0.11 a
	Mean	0.19 a	0.00 a	0.00 a	0.00 a	0.00 a	0.04
Lilaea scilloides	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.03 a	0.00 a	0.01 a	0.00 a	0.00 a	0.01 a
	Upper	0.00 a	0.00 a	0.56 a	0.56 a	0.00 a	0.22 a
	Mean	0.01 a	0.00 a	0.19 a	0.19 a	0.00 a	0.08
Lilaeopsis occidentalis	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.56 a	0.00 a	0.56 a	0.01 a	0.00 a	0.22 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.19 a	0.00 a	0.19 a	0.00 a	0.00 a	0.08

(Continued)

Table A28 (Concluded)

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Patchgrass**	Lower	0.00 a	1.11 a	0.00 a	0.56 a	0.00 a	0.33 a
	Middle	1.94 a	0.00 a	0.00 a	0.00 a	0.00 a	0.39 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.65 a	0.37 a	0.00 a	0.19 a	0.00 a	0.24
Potamogeton crispus	Lower	0.00 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00	0.00	0.00	0.00	0.00	0.00
Cakile edentula	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.01 a	1.96 a	0.00 a	0.00 a	1.11 a	0.62 a
	Mean	0.00 a	0.65 a	0.00 a	0.00 a	0.37 a	0.21
Rumex sp.	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00 a	0.00 a	0.00 a	0.56 a	0.00 a	0.11 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.00 a	0.00 a	0.19 a	0.00 a	0.04

* See Table A2 for list of algae species identified in marsh plot area.

** Tentatively identified as *Limosella aquatica*.

† Values in horizontal sequence and means not followed by same letters are significantly different ($p=0.05$) by DMRT.

Table A29

Percent Cover of Plants Established in the Deschampsia cespitosa Seeded Plots During August 1977 Sampling Period

Species	Tier	Treatments & % Cover					
		F0	F1	F2	F3	F4	Mean
Deschampsia cespitosa	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.56 a†	5.83 a	5.56 a	1.11 a	4.20 a	3.45 a
	Upper	1.73 a	6.72 a	1.18 a	1.19 a	0.59 a	2.28 a
	Mean	0.76 a	4.19 a	2.24 a	0.77 a	1.60 a	1.91
Algae*	Lower	0.64 a	5.30 a	0.64 a	20.07 a	4.26 a	6.18 a
	Middle	66.68 a	44.47 a	31.13 a	35.84 a	37.80 a	43.18 a
	Upper	0.64 a	18.12 a	20.06 a	20.89 a	0.02 a	11.95 a
	Mean	22.66 a	22.63 a	17.28 a	25.60 a	14.03 a	20.44
Callitriche verna	Lower	0.01 a	5.87 a	0.02 a	0.61 a	0.01 a	1.30 a
	Middle	0.00 a	0.00 a	0.00 a	0.01 a	0.01 a	0.00 a
	Upper	0.00 a	0.56 a	0.00 a	0.00 a	0.00 a	0.11 a
	Mean	0.00 a	2.14 a	0.01 a	0.21 a	0.01 a	0.47
Limosella aquatica	Lower	0.00 a	0.57 a	0.00 a	0.00 a	0.00 a	0.11 a
	Middle	0.00 a	0.00 a	0.00 a	0.56 a	0.00 a	0.11 a
	Upper	0.00 a	0.58 a	0.00 a	0.00 a	0.00 a	0.12 a
	Mean	0.00 a	0.38 a	0.00 a	0.19 a	0.00 a	0.11

(Continued)

Table A29 (Continued)

Species	Tier	F0	F1	F2	F3	F4	Mean
		Treatments & % Cover					
Polygonum sp.	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00 a	0.00 a	0.00 a	0.00 a	1.94 a	0.38 a
	Upper	4.18 a	0.56 a	0.56 a	0.01 a	0.00 a	1.06 a
	Mean	1.39 a	0.19 a	0.19 a	0.00 a	0.65 a	0.48
Eleocharis palustris	Lower	0.00 b	0.03 a	0.00 b	0.00 b	0.00 b	0.01 a
	Middle	0.01 a	0.00 a	1.96 a	0.56 a	4.18 a	1.34 a
	Upper	0.01 a	2.50 a	0.00 a	0.00 a	0.00 a	0.50 a
	Mean	0.01 a	0.84 a	0.65 a	0.19 a	1.39 a	0.62 a
Carex lyngbyei	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.56 a	1.96 a	0.00 a	0.00 a	0.00 a	0.50 a
	Mean	0.19 a	0.65 a	0.00 a	0.00 a	0.00 a	0.17
Elodea nuttalli	Lower	0.03 a	0.01 a	0.01 a	0.01 a	0.01 a	0.02 a
	Middle	2.50 a	0.01 a	0.00 a	0.00 a	0.00 a	0.50 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.84 a	0.01 a	0.00 a	0.00 a	0.00 a	0.17

(Continued)

Table A29 (Concluded)

Species	Tier	Treatments & % Cover F0	F1	F2	F3	F4	Mean
Phalaris arundinacea	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.01 a	1.94 a	0.00 a	0.00 a	0.00 a	0.39 a
	Mean	0.00 a	0.65 a	0.00 a	0.00 a	0.00 a	0.13 a
Patchgrass**	Lower	0.00 a	0.58 a	0.00 a	0.00 a	0.00 a	0.12 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.19 a	0.00 a	0.00 a	0.00 a	0.04
Juncus effusus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.57 a	0.00 a	0.00 a	0.00 a	0.11 a
	Mean	0.00 a	0.19 a	0.00 a	0.00 a	0.00 a	0.04

* See Table A2 for list of Algae species identified in marsh plot areas.

** Tentatively identified as Limosella aquatica.

† Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A30

Percent Cover of Plants Established in the Carex obnupta Seeded Plots During August 1977 Sampling Period

Species	Tier	Treatments and % Cover F0	F1	F2	F3	F4	Mean
Deschampsia cespitosa	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	6.96 a**	4.74 a	0.57 a	0.02 a	2.50 a	2.96 a
	Upper	0.03 a	9.51 a	8.40 a	10.30 a	0.62 a	5.77 a
	Mean	2.33 a	4.75 a	2.99 a	3.44 a	1.04 a	2.91
Carex obnupta	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 b	0.01 ab	0.01 ab	0.01 ab	0.04 a	0.01 a
	Mean	0.00 a	0.00 a	0.00 a	0.00 a	0.01 a	0.00
Algae sp.*	Lower	0.64 a	0.10 a	0.63 a	0.64 a	0.10 a	3.59 b
	Middle	79.17 a	46.67 ab	32.24 b	38.89 b	65.83 ab	52.56 a
	Upper	0.62 a	5.86 a	4.73 a	6.16 a	0.60 a	0.42 b
	Mean	26.81 a	17.54 a	12.54 a	15.23 a	22.18 a	18.86
Callitriche verna	Lower	0.02 a	0.07 a	0.58 a	0.02 a	0.01 a	0.14 a
	Middle	0.01 a	0.00 a	0.00 a	0.00 a	0.00 a	0.00 a
	Upper	0.00 a	0.00 a	0.01 a	0.02 a	0.00 a	0.01 a
	Mean	0.01 a	0.02 a	0.20 a	0.02 a	0.00 a	0.05

(Continued)

Table A30 (Continued)

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Limosella aquatica	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.02 a	0.00 a	0.00 a	0.00 a	1.96 a	0.40 a
	Upper	0.00 a	0.57 a	0.02 a	0.57 a	0.00 a	0.23 a
	Mean	0.01 a	0.19 a	0.01 a	0.19 a	0.65 a	0.21
Polygonum sp.	Lower	0.00	0.00	0.00	0.00	0.00	0.00 b
	Middle	1.94 a	0.56 a	0.56 a	0.00 a	0.11 a	0.61 b
	Upper	0.00 a	5.28 a	2.59 a	4.46 a	0.00 a	2.45 a
	Mean	0.65 a	1.94 a	1.02 a	1.49 a	0.00 a	1.02
Eleocharis palustris	Lower	0.00 a	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a
	Middle	0.01 a	0.00 a	3.06 a	0.01 a	4.18 a	1.45 a
	Upper	0.00 a	10.83 a	2.50 a	0.00 a	0.00 a	2.67 a
	Mean	0.00 a	3.61 a	1.86 a	0.00 a	1.39 a	1.37
Carex lyngbyei	Lower	0.00	0.00	0.00	0.00	0.00	0.00 b
	Middle	0.01 a	0.00 a	0.02 a	0.00 a	1.94 a	0.40 b
	Upper	1.94 b	0.58 b	0.00 b	10.00 a	0.00 b	2.50 a
	Mean	0.65 b	0.19 b	0.01 b	3.33 a	0.65 b	0.97

(Continued)

Table A30 (Continued)

Species	Tier	Treatments and % Cover F0	F1	F2	F3	F4	Mean
Elodea nuttalli	Lower	0.01 a	0.00 a	0.56 a	0.01 a	0.00 a	0.12 a
	Middle	1.11 a	0.00 a	0.00 a	0.01 a	0.00 a	0.22 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.37 a	0.00 a	0.19 a	0.01 a	0.00 a	0.11
Phalaris arundinacea	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	1.95 a	0.02 a	0.00 a	0.00 a	0.39 a
	Mean	0.00 a	0.65 a	0.00 a	0.01 a	0.00 a	0.13
Lilaeopsis occidentalis	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.00 a	0.02 a	0.56 a	0.00 a	0.12 a
	Mean	0.00 a	0.00 a	0.01 a	0.19 a	0.00 a	0.04
Alopecurus geniculatus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	1.94 a	0.00 a	0.00 a	0.00 a	0.39 a
	Mean	0.00 a	0.65 a	0.00 a	0.00 a	0.00 a	0.13

(Continued)

Table A30 (Concluded)

Species	Tier	Treatments and % Cover F0	F1	F2	F3	F4	Mean
Potamogeton crispus	Lower	0.00 a	0.00 a	0.00 a	0.57 a	0.00 a	0.11 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.00 a	0.00 a	0.19 a	0.00 a	0.04
Cakile edentula	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.56 a	0.00 a	0.00 a	0.00 a	0.11 a
	Mean	0.00 a	0.19 a	0.00 a	0.00 a	0.00 a	0.04
Mimulus guttatus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.00 a	0.00 a	0.83 a	0.00 a	0.17 a
	Mean	0.00 a	0.00 a	0.00 a	0.28 a	0.00 a	0.06
Rumex sp.	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.56 a	0.00 a	0.00 a	0.00 a	0.00 a	0.11 a
	Mean	0.19 a	0.00 a	0.00 a	0.00 a	0.00 a	0.04

* See Table A2 for list of Algae species identified in marsh plot areas.

** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A31

Percent Cover of Plants Established in the No Plant Plots During August 1977 Sampling Period

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Deschampsia cespitosa	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.01 a**	0.33 a	1.26 a	2.37 a	0.29 a	0.87 a
	Upper	2.66 a	0.01 a	1.27 a	0.58 a	1.02 a	1.11 a
	Mean	0.89 a	0.10 a	0.84 a	0.98 a	0.44 a	0.66
Carex obnupta	Lower	0.29 a	0.05 a	0.00 a	0.00 a	0.00 a	0.07 a
	Middle	0.01 a	0.01 a	0.00 a	0.01 a	0.00 a	0.01 a
	Upper	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a	0.01 a
	Mean	0.10 a	0.02 a	0.00 a	0.00 a	0.00 a	0.03
Algae*	Lower	0.34 a	0.59 a	0.92 a	1.31 a	2.43 a	1.12 b
	Middle	40.01 ab	61.25 ab	62.79 ab	68.77 a	35.17 b	53.42 a
	Upper	2.14 a	9.48 a	5.18 a	0.34 a	6.85 a	4.80 b
	Mean	14.17 a	22.34 a	22.96 a	23.47 a	14.82 a	19.53
Callitriche verna	Lower	0.02 a	0.04 a	0.02 a	0.98 a	0.02 a	0.22 a
	Middle	0.00 a	0.01 a	0.00 a	4.87 a	0.00 a	1.00 a
	Upper	0.00 a	0.01 a	0.00 a	0.00 a	0.01 a	0.00 a
	Mean	0.01 a	0.02 a	0.01 a	1.95 a	0.01 a	0.40

(Continued)

Table A31 (Continued)

Species	Tier	F0	F1	F2	F3	F4	Mean
		Treatments and % Cover					
Limosella aquatica	Lower	0.00 a	0.01 a	0.01 a	0.00 a	0.00 a	0.00 a
	Middle	0.01 a	0.31 a	1.81 a	0.00 a	0.00 a	0.43 a
	Upper	0.00 a	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a
	Mean	0.00 a	0.10 a	0.61 a	0.00 a	0.00 a	0.14
Polygonum sp.	Lower	0.00	0.00	0.00	0.00	0.01	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.28 a	0.02 a	0.28 a	0.00 a	0.28 a	0.17 a
	Mean	0.09 a	0.01 a	0.09 a	0.00 a	0.10 a	0.06 a
Eleocharis palustris	Lower	0.00 a	0.01 a	0.00 a	0.01 a	0.00 a	0.00 b
	Middle	0.97 a	0.31 a	0.02 a	0.56 a	0.01 a	0.38 a
	Upper	0.00 a	0.28 a	0.00 a	0.00 a	0.00 a	0.06 b
	Mean	0.34 a	0.20 a	0.01 a	0.19 a	0.00 a	0.14
Carex lyngbyei	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00 a	0.00 a	0.00 a	0.28 a	0.01 a	0.06 a
	Upper	0.28 a	0.00 a	0.00 a	0.28 a	0.00 a	0.11 a
	Mean	0.09 a	0.00 a	0.00 a	0.19 a	0.00 a	0.06

(Continued)

Table A31 (Continued)

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Elodea nuttalli	Lower	0.00 a	0.01 a	0.01 a	0.56 a	0.28 a	0.17 a
	Middle	2.36 a	0.31 a	0.00 a	0.01 a	0.00 a	0.54 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.79 a	0.10 a	0.00 a	0.19 a	0.09 a	0.24
Lilaea scilloides	Lower	0.00 a	0.01 a	0.00 a	0.00 a	0.00 a	0.00 a
	Middle	0.01 a	0.00 a	0.29 a	0.01 a	0.00 a	0.06 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.00 a	0.10 a	0.00 a	0.00 a	0.02
Alopecurus geniculatus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.28 a	0.97 a	0.00 a	0.00 a	0.00 a	0.25 a
	Mean	0.09 a	0.34 a	0.00 a	0.00 a	0.00 a	0.08
Mimulus guttatus	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.00 a	0.00 a	0.28 a	0.00 a	0.00 a	0.06 a
	Mean	0.00 a	0.00 a	0.09 a	0.00 a	0.00 a	0.02

(Continued)

Table A31 (Concluded)

Species	Tier	Treatments and % Cover					
		F0	F1	F2	F3	F4	Mean
Trifolium repens	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00	0.00	0.00	0.00	0.00	0.00 a
	Upper	0.28 a	0.00 a	0.00 a	0.00 a	0.00 a	0.06 a
	Mean	0.09 a	0.00 a	0.00 a	0.00 a	0.00 a	0.02 a
Grass sp.	Lower	0.00	0.00	0.00	0.00	0.00	0.00 a
	Middle	0.00 a	0.31 a	0.00 a	0.00 a	0.00 a	0.06 a
	Upper	0.00	0.00	0.00	0.00	0.00	0.00 a
	Mean	0.00 a	0.10 a	0.00 a	0.00 a	0.00 a	0.02

* See Table A2 for list of Algae species identified in marsh plot area.

** Values in horizontal sequence and means not followed by same letters are significantly different (p=0.05) by DMRT.

Table A32

Performance of Planted Species in Cage-Quadrat Comparisons
In Meadow I During July 1977 Sampling Period

Parameter	Cage 1	Cage 2	Cage 3	Cage $\bar{x}$	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat $\bar{x}$
				White Clover				
No. stems	3.14	2.71	3.43	3.10	4.33	3.14	3.14	3.50
Height (cm)	13.56	22.91	23.85	20.11	10.66	14.65	22.69	16.26
No. flowering stems	1.29	0.14	0.14	0.52	0.50	0.00	0.57	0.35
Root length (cm)	12.93	17.06	10.07	13.35	20.90	11.00	14.86	15.32
Shoot weight (g)	0.41	0.25	0.40	0.35	0.39	0.27	0.27	0.31
Root weight (g)	0.13	0.07	0.07	0.09	0.16	0.19	0.06	0.14
Total weight (g)	0.54	0.32	0.47	0.44	0.55	0.46	0.33	0.44
Root/Shoot ratio	0.37	0.40	0.19	0.32	0.50	0.80	0.29	0.53
				Tall Fescue				
No. stems	4.43	3.14	2.86	3.48	7.57	3.43	3.14	4.71
Height (cm)	18.75	21.01	18.94	19.56	17.37	17.78	22.39	19.18
No. flowering stems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Root length (cm)	12.79	11.54	10.26	11.53	11.14	11.49	12.71	11.78
Shoot weight (g)	0.56	0.35	0.18	0.37	0.93	0.28	0.25	0.49
Root weight (g)	0.18	0.07	0.05	0.10	0.30	0.06	0.10	0.15
Total weight (g)	0.74	0.42	0.23	0.47	1.22	0.34	0.35	0.64
Root/Shoot ratio	0.32	0.24	0.42	0.29	0.30	0.31	0.42	0.34
				Tall Wheatgrass				
No. stems	2.29	2.29	1.43	2.00	2.00	1.86	1.29	1.71
Height (cm)	20.73	22.13	27.83	23.34	19.30	25.22	20.95	21.83
No. flowering stems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Root length (cm)	19.11	16.81	12.56	16.16	16.81	18.19	10.61	15.20
Shoot weight (g)	0.30	0.18	0.18	0.22	0.27	0.14	0.12	0.18
Root weight (g)	0.14	0.09	0.04	0.09	0.14	0.05	0.03	0.07
Total weight (g)	0.44	0.27	0.23	0.31	0.41	0.20	0.15	0.30
Root/Shoot ratio	0.28	0.50	0.30	0.44	0.63	0.44	0.25	0.45

Table A33

Performance of Planted Species in Cage-Quadrat Comparisons in Meadow II During July 1977 Sampling Period

Parameter	Cage 1	Cage 2	Cage 3	Cage $\bar{x}$	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat $\bar{x}$
				Red Clover				
No. stems	2.86	1.14	1.57	1.86	2.40	1.29	2.43	2.00
Height (cm)	25.35	19.83	32.11	25.76	24.04	19.02	30.33	24.51
No. flowering stems	0.29	0.00	0.71	0.33	0.00	0.00	1.29	0.47
Root length (cm)	14.63	14.33	14.58	14.51	17.24	17.33	20.21	18.37
Shoot weight (g)	0.82	0.47	1.76	1.02	0.26	0.27	1.78	0.82
Root weight (g)	0.36	0.17	0.35	0.29	0.17	0.21	0.57	0.33
Total weight (g)	1.18	0.64	2.11	1.31	0.43	0.47	2.34	1.15
Root/Shoot ratio	1.13	0.47	0.34	0.61	0.61	0.75	0.39	0.58
				Oregon Bentgrass				
No. stems	5.33	1.00	7.29	6.18	9.80	2.40	2.00	4.41
Height (cm)	21.28	12.20	17.93	18.32	13.21	20.41	15.78	16.39
No. flowering stems	0.33	0.00	0.14	0.18	1.00	0.00	0.14	0.35
Root length (cm)	10.17	9.80	11.57	10.94	11.90	9.86	8.41	9.86
Shoot weight (g)	0.11	0.01	0.36	0.26	0.41	0.06	0.04	0.16
Root weight (g)	0.06	0.00	0.07	0.07	0.10	0.02	0.03	0.05
Total weight (g)	0.17	0.01	0.44	0.33	0.51	0.08	0.08	0.21
Root/Shoot ratio	0.68	0.00	0.27	0.36	0.45	0.39	1.11	0.70
				Barley				
No. stems	1.17	1.00	1.14	1.10	1.29	1.00	1.00	1.10
Height (cm)	35.03	37.30	39.09	37.25	32.09	40.60	42.20	38.30
No. flowering stems	1.00	1.00	1.00	1.00	1.29	1.00	0.86	1.05
Root length (cm)	10.42	13.41	12.11	12.06	8.33	15.86	13.39	12.52
Shoot weight (g)	0.71	0.63	0.72	0.68	0.82	0.99	1.12	0.98
Root weight (g)	0.15	0.27	0.13	0.19	0.18	0.19	0.20	0.19
Total weight (g)	0.86	0.90	0.85	0.87	1.00	1.17	1.32	1.17
Root/Shoot ratio	0.22	0.45	0.18	0.29	0.24	0.21	0.24	0.23

Table A34

Performance of Planted Species in Cage-Quadrat Comparisons in Meadow III During July 1977 Sampling Period

Parameters	Cage 1	Cage 2	Cage 3	Cage $\bar{x}$	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat $\bar{x}$
				Hairy Vetch				
No. stems	1.57	1.86	1.57	1.67	2.00	1.00	1.71	1.57
Height (cm)	104.07	166.37	141.66	137.37	106.06	131.14	160.72	132.64
No. flowering stems	0.00	1.71	0.57	0.76	0.00	0.29	6.00	2.10
Root length (cm)	16.91	15.36	16.46	16.24	15.41	15.14	16.81	15.79
Shoot weight (g)	1.60	2.86	3.03	2.50	1.88	1.60	3.59	2.35
Root weight (g)	0.09	0.07	0.09	0.08	0.11	0.09	0.18	0.13
Total weight (g)	1.68	2.93	3.12	2.58	1.99	1.68	3.77	2.48
Root/Shoot ratio	0.06	0.02	0.03	0.04	0.07	0.05	0.06	0.06

Table A35

Measurements of Soil Parameters during the Midgrowing Season (1977) in Monotypic Plots of Meadow I

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
White Clover				
Moisture (%)	8.80 a*	7.00 a	7.87 a	7.89
pH (water)	5.91 a	5.83 a	5.92 a	5.89
Exchangeable K (meq/100 g)	0.20 a	0.21 a	0.25 a	0.22
Kjeldahl N (%)	0.023 a	0.013 a	0.020 a	0.019
NH_4-N (ppm)	0.55 a	0.42 a	0.50 a	0.49
NO_3-N (ppm)	0.50 a	0.30 a	0.87 a	0.56
P (ppm)	6.57 a	5.80 a	8.00 a	6.79
Tall Wheatgrass				
Moisture (%)	7.30 a	8.43 a	8.70 a	8.14
pH (water)	6.11 a	5.87 b	5.94 b	5.97
Exchangeable K (meq/100 g)	0.19 a	0.22 a	0.24 a	0.22
Kjeldahl N (%)	0.014 b	0.021 a	0.017 ab	0.017
NH_4-N (ppm)	0.85 a	0.53 a	0.97 a	0.78
NO_3-N (ppm)	0.41 a	0.51 a	0.33 a	0.42
P (ppm)	6.03 b	7.17 a	7.30 a	6.83
Tall Fescue				
Moisture (%)	9.50 a	8.50 a	8.60 a	8.87
pH (water)	5.92 a	5.80 ab	5.56 b	5.76
Exchangeable K (meq/100 g)	0.21 a	0.21 a	0.22 a	0.21
Kjeldahl N (%)	0.020 b	0.019 b	0.024 a	0.021
NH_4-N (ppm)	0.70 a	0.92 a	0.74 a	0.79
NO_3-N (ppm)	0.24 a	0.31 a	0.21 a	0.25
P (ppm)	6.77 a	6.83 a	7.93 a	7.18

(Continued)

Table A35 (Concluded)

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Control				
Moisture (%)	6.77 b	7.43 b	9.13 a	7.78
pH (water)	5.90 a	5.71 a	5.74 a	5.78
Exchangeable K (meq/100 g)	0.18 a	0.20 a	0.23 a	0.20
Kjeldahl N (%)	0.016 b	0.017 b	0.023 a	0.019
NH_4-N (ppm)	0.96 a	0.85 a	1.56 a	1.12
NO_3-N (ppm)	0.30 a	0.57 a	0.26 a	0.37
P (ppm)	6.43 a	6.50 a	7.37 a	6.77

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A36

Measurements of Soil Parameters during the Midgrowing Season (1977) in Monotypic Plots of Meadow II

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Red Clover				
Moisture (%)	6.67 a*	6.30 a	6.13 a	6.37
pH (water)	6.07 a	5.72 ab	5.67 b	5.82
Exchangeable K (meq/100 g)	0.11 a	0.11 a	0.13 a	0.12
Kjeldahl N (%)	0.006 a	0.015 a	0.006 a	0.009
NH_4-N (ppm)	0.17 a	0.23 a	0.06 a	0.15
NO_3-N (ppm)	0.42 a	0.59 a	0.43 a	0.48
P (ppm)	5.53 a	6.10 a	6.47 a	6.03
Oregon Bentgrass				
Moisture (%)	7.00 ab	7.60 a	6.40 b	7.00
pH (water)	4.47 a	6.04 a	5.73 a	5.42
Exchangeable K (meq/100 g)	0.12 a	0.16 a	0.13 a	0.14
Kjeldahl N (%)	0.009 a	0.010 a	0.014 a	0.011
NH_4-N (ppm)	0.18 a	0.75 a	0.58 a	0.50
NO_3-N (ppm)	0.20 a	0.90 a	0.50 a	0.53
P (ppm)	5.33 b	6.30 a	6.50 a	6.04
Barley				
Moisture (%)	7.20 a	6.93 a	6.40 b	6.84
pH (water)	6.08 a	6.01 a	5.94 a	6.01
Exchangeable K (meq/100 g)	0.12 b	0.11 b	0.16 a	0.13
Kjeldahl N (%)	0.005 a	0.006 a	0.007 a	0.006
NH_4-N (ppm)	0.60 a	0.95 a	1.06 a	0.87
NO_3-N (ppm)	0.82 a	0.86 a	1.25 a	0.98
P (ppm)	5.50 a	5.40 a	5.90 a	5.60

(Continued)

Table A36 (Concluded)

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Control				
Moisture (%)	7.67 a	7.77 a	7.73 a	7.72
pH (water)	6.17 a	6.07 a	5.91 b	6.05
Exchangeable K (meq/100 g)	0.20 a	0.18 a	0.20 a	0.19
Kjeldahl N (%)	0.012 a	0.012 a	0.013 a	0.012
NH_4-N (ppm)	0.85 a	0.66 a	0.84 a	0.78
NO_3-N (ppm)	1.37 a	1.54 a	1.12 a	1.34
P (ppm)	5.43 c	8.67 a	6.63 b	6.91

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A37

Measurements of Soil Parameters during the Midgrowing Season (1977) in Monotypic Plots of Meadow III

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Hairy Vetch				
Moisture (%)	7.80 a*	7.43 a	26.37 a	13.87
pH (water)	5.93 a	5.63 a	5.67 a	5.75
Exchangeable K (meq/100 g)	0.16 b	0.18 a	0.18 a	0.17
Kjeldahl N (%)	0.019 a	0.020 a	0.023 a	0.021
NH_4-N (ppm)	0.70 a	1.87 a	1.66 a	1.41
NO_3-N (ppm)	0.52 a	0.66 a	0.65 a	0.61
P (ppm)	4.83 b	5.90 ab	6.97 a	5.90
Red Fescue				
Moisture (%)	7.10 a	6.97 a	7.10 a	7.06
pH (water)	6.04 a	5.97 a	6.17 a	6.06
Exchangeable K (meq/100 g)	0.18 a	0.19 a	0.20 a	0.19
Kjeldahl N (%)	0.015 a	0.018 a	0.017	0.017
NH_4-N (ppm)	1.02 a	0.62 ab	0.41 b	0.68
NO_3-N (ppm)	0.28 a	0.46 a	0.37 a	0.34
P (ppm)	5.07 a	6.83 a	14.60 a	8.83
Reed Canarygrass				
Moisture (%)	7.10 a	6.83 a	6.33 a	6.76
pH (water)	6.14 a	5.82 a	5.87 a	5.94
Exchangeable K (meq/100 g)	0.14 a	0.16 a	0.18 a	0.16
Kjeldahl N (%)	0.016 a	0.019 a	0.020 a	0.019
NH_4-N (ppm)	0.74 a	0.99 a	1.21 a	0.98
NO_3-N (ppm)	0.62 a	0.92 a	0.67 a	0.74
P (ppm)	5.53 a	6.33 a	7.73 a	6.53

(Continued)

Table A37 (Concluded)

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Control				
Moisture (%)	7.60 a	7.00 a	6.83 a	7.14
pH (water)	5.94 a	5.78 ab	5.67 b	5.80
Exchangeable K (meq/100 g)	0.15 a	0.16 a	0.14 a	0.15
Kjeldahl N (%)	0.015 a	0.014 a	0.017 a	0.015
NH_4-N (ppm)	1.30 a	1.97 a	1.36 a	1.54
NO_3-N (ppm)	1.23 a	0.94 a	1.23 a	1.13
P (ppm)	5.70 a	5.73 a	6.60 a	6.01

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A38

Measurements of Soil Parameters at the End of the 1977 Growing Season in Monotypic Plots of Meadow I

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
White Clover				
Moisture (%)	19.23 a*	17.87 a	16.07 a	17.72
Organic C	0.16 b	0.41 a	0.28 ab	0.28
pH (water)	6.17 a	5.90 ab	5.69 b	5.92
CEC (meq/100 g)	4.40 a	4.20 a	4.22 a	4.27
Exchangeable K (meq/100 g)	0.16 a	0.21 a	0.18 a	0.18
Kjeldahl N (%)	0.013 a	0.025 a	0.016 a	0.018
NH_4-N (ppm)	0.56 a	0.98 a	1.07 a	0.87
NO_3-N (ppm)	0.17 b	0.16 b	0.41 a	0.25
P (ppm)	6.53 a	9.10 a	10.13 a	8.59
Tall Wheatgrass				
Moisture (%)	17.40 a	15.40 a	15.47 a	16.09
Organic C	0.23 b	0.33 a	0.29 a	0.29
pH (water)	6.25 a	5.95 b	5.92 b	6.04
CEC (meq/100 g)	4.02 a	4.20 a	4.13 a	4.12
Exchangeable K (meq/100 g)	0.19 a	0.20 a	0.19 a	0.19
Kjeldahl N (%)	0.014 a	0.019 a	0.019 a	0.017
NH_4-N (ppm)	0.67 b	0.70 ab	1.13 a	0.83
NO_3-N (ppm)	0.80 a	0.06 a	0.23 a	0.36
P (ppm)	7.43 a	8.60 a	8.57 a	8.20

(Continued)

Table A38 (Concluded)

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Tall Fescue				
Moisture (%)	16.60 a	16.20 a	16.47 a	16.42
Organic C	0.28 a	0.28 a	0.34 a	0.30
pH (water)	6.09 a	5.96 a	5.69 b	5.91
CEC (meq/100 g)	4.18 a	4.43 a	4.25 a	4.29
Exchangeable K (meq/100 g)	0.19 a	0.19 a	0.18 a	0.19
Kjeldahl N (%)	0.018 a	0.018 a	0.020 a	0.018
NH_4-N (ppm)	0.68 a	0.99 a	1.14 a	0.94
NO_3-N (ppm)	0.54 a	0.42 a	0.25 a	0.40
P (ppm)	7.10 c	9.13 b	10.63 a	8.96
Control				
Moisture (%)	15.93 a	16.13 a	16.37 a	16.14
Organic C	0.27 a	0.28 a	0.35 a	0.30
pH (water)	6.15 a	5.93 b	5.91 b	6.00
CEC (meq/100 g)	4.31 a	4.41 a	4.54 a	4.42
Exchangeable K (meq/100 g)	0.16 a	0.20 a	0.21 a	0.19
Kjeldahl N (%)	0.017 a	0.017 a	0.019 a	0.017
NH_4-N (ppm)	1.11 a	2.67 a	1.25 a	1.68
NO_3-N (ppm)	0.42 a	0.91 a	0.73 a	0.69
P (ppm)	5.93 b	8.27 a	7.90 a	7.37

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A39

Measurements of Soil Parameters at the End of the 1977 Growing Season in Monotypic Plots of Meadow II

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Red Clover				
Moisture (%)	23.20 a*	18.93 a	15.80 a	19.31
Organic C	0.07 b	0.11 a	0.10 a	0.09
pH (water)	6.27 a	5.87 b	5.59 c	5.91
CEC (meq/100 g)	3.27 b	3.53 a	3.46 ab	3.42
Exchangeable K (meq/100 g)	0.10 b	0.12 a	0.12 ab	0.11
Kjeldahl N (%)	0.004 b	0.007 a	0.006 a	0.006
NH_4-N (ppm)	1.07 a	1.44 a	1.02 a	1.18
NO_3-N (ppm)	0.11 a	0.39 a	0.32 a	0.28
P (ppm)	6.13 b	7.13 a	7.50 a	6.92
Oregon Bentgrass				
Moisture (%)	21.17 a	16.30 b	15.10 b	17.52
Organic C	0.13 a	0.15 a	0.12 a	0.13
CEC (meq/100 g)	6.41 a	6.00 ab	5.89 b	6.10
pH (water)	3.36 a	3.41 a	3.42 a	3.40
Exchangeable K (meq/100 g)	0.13 a	0.15 a	0.14 a	0.14
Kjeldahl N (%)	0.007 a	0.012 a	0.008 a	0.009
NH_4-N (ppm)	1.56 a	1.54 a	1.33 a	1.48
NO_3-N (ppm)	0.28 a	0.47 a	0.24 a	0.33
P (ppm)	5.77 a	7.40 a	6.67 a	6.61

(Continued)

Table A39 (Concluded)

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Barley				
Moisture (%)	33.73 a	17.93 b	19.43 b	23.70
Organic C	0.08 a	0.08 a	0.11 a	0.09
pH (water)	6.53 a	6.31 ab	6.12 b	6.32
CEC (meq/100 g)	3.59 a	3.59 a	3.70 a	3.62
Exchangeable K (meq/100 g)	0.11 a	0.11 a	0.13 a	0.12
Kjeldahl N (%)	0.006 a	0.005 a	0.007 a	0.006
NH_4-N (ppm)	1.28 b	1.57 ab	2.38 a	1.74
NO_3-N (ppm)	0.32 a	0.67 a	0.66 a	0.55
P (ppm)	7.20 a	6.40 a	7.70 a	7.10
Control				
Moisture (%)	18.93 a	19.33 a	17.73 a	18.67
Organic C	0.21 a	0.20 a	0.19 a	0.20
pH (water)	6.46 a	6.36 a	6.33 a	6.38
CEC (meq/100 g)	4.18 a	4.13 a	4.08 a	4.13
Exchangeable K (meq/100 g)	0.19 ab	0.18 b	0.20 a	0.19
Kjeldahl N (%)	0.012 a	0.013 a	0.015 a	0.013
NH_4-N (ppm)	1.48 a	2.30 a	1.51 a	1.76
NO_3-N (ppm)	0.48 a	0.48 a	0.31 a	0.42
P (ppm)	6.40 a	9.37 a	8.73 a	8.17

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A40

Measurements of Soil Parameters at the End of the 1977 Growing Season in Monotypic Plots of Meadow III

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Hairy Vetch				
Moisture (%)	18.00 a*	21.10 a	18.77 a	19.29
Organic C	0.32 a	0.36 a	0.31 a	0.33
pH (water)	5.90 a	5.83 ab	5.71 b	5.81
CEC (meq/100 g)	4.05 a	3.84 a	4.13 a	4.01
Exchangeable K (meq/100 g)	0.16 a	0.17 a	0.19 a	0.17
Kjeldahl N (%)	0.023 a	0.024 a	0.023 a	0.023
NH_4-N (ppm)	2.62 a	4.69 a	5.76 a	4.36
NO_3-N (ppm)	1.72 b	1.98 ab	3.34 a	2.35
P (ppm)	7.03 b	7.47 b	8.33 a	7.61
Red Fescue				
Moisture (%)	14.23 a	15.47 a	15.60 a	15.10
Organic C	0.23 a	0.28 a	0.31 a	0.27
pH (water)	5.95 a	5.87 a	5.91 a	5.91
CEC (meq/100 g)	3.87 a	3.89 a	3.93 a	3.90
Exchangeable K (meq/100 g)	0.17 ab	0.15 b	0.18 a	0.17
Kjeldahl N (%)	0.013 a	0.018 a	0.023 a	0.020
NH_4-N (ppm)	1.36 ab	1.91 a	0.81 b	1.36
NO_3-N (ppm)	1.15 a	0.98 a	0.95 a	1.03
P (ppm)	5.47 c	7.00 b	8.37 a	6.95

(Continued)

Table A40 (Concluded)

Monotypic Plot and Parameter	Fertilizer Treatment F0	F1	F2	Mean
Reed Canarygrass				
Moisture (%)	13.53 a	14.13 a	14.70 a	14.12
Organic C	0.26 a	0.29 a	0.31 a	0.29
pH (water)	5.96 a	5.83 a	5.64 a	5.81
CEC (meq/100 g)	3.84 a	3.79 a	3.77 a	3.80
Exchangeable K (meq/100 g)	0.13 a	0.13 a	0.12 a	0.12
Kjeldahl N (%)	0.020 a	0.017 a	0.021 a	0.019
NH_4-N (ppm)	0.72 a	1.06 a	1.12 a	0.96
NO_3-N (ppm)	1.47 a	1.80 a	1.50 a	1.59
P (ppm)	7.23 a	8.27 a	8.37 a	7.96
Control				
Moisture (%)	15.97 a	15.70 a	14.23 a	15.30
Organic C	0.17 a	0.25 a	0.22 a	0.21
pH (water)	6.01 a	5.99 a	5.72 b	5.91
CEC (meq/100 g)	3.96 a	4.35 a	3.95 a	4.09
Exchangeable K (meq/100 g)	0.12 a	0.14 a	0.13 a	0.13
Kjeldahl N (%)	0.013 a	0.015 a	0.014 a	0.014
NH_4-N (ppm)	0.99 a	1.17 a	1.03 a	1.06
NO_3-N (ppm)	1.14 a	1.07 a	0.97 a	1.06
P (ppm)	5.77 b	7.20 a	7.30 a	6.76

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A41

Measurements of Soil Parameters in Cage-Quadrat Locations in Upland Meadow Areas at the End of the 1977 Growing Season

Parameter and Meadow No.	Cage (Inside)	Quadrat (Outside)	Mean
Kjeldahl N (%)			
I	0.010 a*	0.009 a	0.009 a
II	0.009 a	0.009 a	0.009 a
III	0.014 a	0.017 a	0.015 a
Reference Area	0.020 a	0.010 a	0.015 a
NH_4-N (ppm)			
I	0.35 a	0.83 a	0.59 b
II	3.10 a	1.35 a	2.23 b
III	9.81 a	6.26 a	8.04 a
Reference Area	1.17 a	1.28 a	1.23 b
NO_3-N (ppm)			
I	2.60 a	2.03 a	2.31 a
II	0.32 a	0.12 a	0.22 b
III	0.98 a	0.73 a	0.86 ab
Reference Area	0.56 a	0.47 a	0.52 b
P (ppm)			
I	6.95 a	7.36 a	7.15 ab
II	9.17 a	8.15 a	8.66 a
III	9.34 a	8.45 a	8.90 a
Reference Area	4.81 a	4.95 a	4.88 b
Exchangeable K (ppm)			
I	0.12 a	0.14 a	0.13 c
II	0.17 a	0.16 a	0.17 ab
III	0.21 a	0.17 a	0.19 a
Reference Area	0.15 a	0.14 a	0.14 bc

(Continued)

Table A41 (Concluded)

Parameter and Meadow No.	Cage (Inside)	Quadrat (Outside)	Mean
pH			
I	5.74 a	5.62 a	5.68 a
II	5.54 a	5.60 a	5.57 ab
III	5.52 a	5.39 a	5.46 b
Reference Area	5.68 a	5.76 a	5.72 a
Moisture (%)			
I	12.00 a	12.83 a	12.42 b
II	14.27 a	12.70 a	13.48 b
III	18.60 a	17.60 a	18.10 a
Reference Area	18.50 a	18.03 a	18.27 a
Organic C (%)			
I	0.14 a	0.13 a	0.14 a
II	0.14 a	0.13 a	0.13 a
III	0.05 a	0.26 a	0.15 a
Reference Area	0.22 a	0.25 a	0.24 a
CEC (meq/100 g)			
I	3.67 a	3.89 a	3.78 ab
II	3.70 a	3.68 a	3.69 ab
III	4.04 a	4.18 a	4.11 a
Reference Area	3.30 a	3.59 a	3.45 b

* Values in horizontal sequence and means not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A42

Nutrient Concentration in Shoot Parts of Monotypic Species Located in Cage-Quadrat Pairs of Upland Meadow I - July 1977 Harvest

Species and Nutrient	Nutrient Concentration (%) Cage (Inside)	Quadrat (Outside)	Mean
White Clover			
N	2.07 a*	2.20 a	2.13
P	0.32 a	0.24 a	0.29
K	1.40 a	1.54 a	1.46
Tall Wheatgrass			
N	0.62 a	0.71 a	0.67
P	0.12 a	0.09 a	0.10
K	0.96 a	0.90 a	0.92
Tall Fescue			
N	0.94 a	0.78 a	0.86
P	0.13 a	0.13 a	0.13
K	1.29 a	1.24 a	1.27

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A43

Nutrient Concentration in Shoot Parts of Monotypic Species Located in Cage-Quadrat Pairs on Upland Meadow II - July 1977 Harvest

Species and Nutrient	Nutrient Concentration (%) Cage (Inside)	Quadrat (Outside)	Mean
Red Clover			
N	2.00 a*	1.67 a	1.84
P	0.20 a	0.19 a	0.19
K	1.34 a	1.28 a	1.31
Oregon Bentgrass			
N	1.48 a	1.23 a	1.33
P	0.29 a	0.35 a	0.32
K	1.33 a	1.52 a	1.44
Barley			
N	0.53 a	0.65 a	0.59
P	0.10 a	0.14 a	0.12
K	0.68 a	0.64 a	0.66

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A44

Nutrient Concentration in Shoot Parts of Monotypic Species Located in Cage-Quadrat Pairs of Upland Meadow III - July 1977 Harvest

Species and Nutrient	Nutrient Concentration (%) Cage (Inside)	Quadrat (Outside)	Mean
Hairy Vetch			
N	1.98 a*	1.99 a	1.98
P	0.23 a	0.27 a	0.25
K	1.37 a	1.16 a	1.26

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A45

Nutrient Uptake in Shoot Parts of Monotypic Species Located in Cage-Quadrat Pairs on Upland Meadow I - July 1977 Harvest

Species and Nutrient	Nutrient Uptake (mg/Plant) Cage (Inside)	Quadrat (Outside)	Mean
White Clover			
N	7.1 a*	7.3 a	7.2
P	1.2 a	0.8 a	1.0
K	4.7 a	4.9 a	4.8
Tall Wheatgrass			
N	1.4 a	1.3 a	1.3
P	0.3 a	0.2 a	0.2
K	2.1 a	1.4 a	1.7
Tall Fescue			
N	3.4 a	3.6 a	3.5
P	0.5 a	0.7 a	0.6
K	4.5 a	5.0 a	4.8

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

Table A46

Nutrient Uptake in Shoot Parts of Monotypic Species Located in Cage-Quadrat Pairs on Upland Meadow II - July 1977 Harvest

Species and Nutrient	Nutrient Uptake (mg/Plant) Cage (Inside)	Quadrat (Outside)	Mean
Red Clover			
N	20.7 a*	12.1 b	16.4
P	1.9 a	1.2 b	1.5
K	12.1 a	8.7 a	10.4
Oregon Bentgrass			
N	2.8 a	1.7 a	2.2
P	0.4 a	0.4 a	0.4
K	2.1 a	1.7 a	1.9
Barley			
N	3.6 a	6.6 a	5.1
P	0.7 a	1.5 a	1.1
K	4.6 b	6.5 a	5.6

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

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Table A47

Nutrient Uptake in Shoot Parts of Monotypic Species Located in Cage-Quadrat Pairs on Upland Meadow III - July 1977 Harvest

Species and Nutrient	Nutrient Uptake (mg/Plant) Cage (Inside)	Quadrat (Outside)	Mean
Hair Vetch			
N	48.5 a*	44.6 a	46.6
P	5.3 a	5.7 a	5.5
K	34.4 a	26.1 a	30.3

* Values in horizontal sequence not followed by the same letters are significantly different (p=0.05) by DMRT.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Heilman, Paul E

Habitat development field investigations, Miller Sands marsh and upland habitat development site, Columbia River, Oregon; Appendix E: Postpropagation assessment of botanical and soil resources on dredged material / by Paul E. Heilman ... [et al.], Washington State University, Pullman, Wash. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

289, 101 p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-77-38, Appendix E)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW57-76-C-0195 (DMRP Work Unit No. 4B05K)

References: p. 89-91.

1. Columbia River. 2. Dredged material. 3. Field investigations. 4. Habitat development. 5. Habitats. 6. Marsh development.

(Continued on next card)

Heilman, Paul E

Habitat development field investigations, Miller Sands marsh and upland habitat development site, Columbia River, Oregon; Appendix E: Postpropagation assessment of botanical and soil resources on dredged material ... 1978. (Card 2)

7. Marshes. 8. Miller Sands Island. 9. Plants (Botany). 10. Soil analysis. 11. Vegetation establishment. 12. Waste disposal sites. I. United States. Army. Corps of Engineers. II. Washington (State). State University, Pullman. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-77-38, Appendix E.

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