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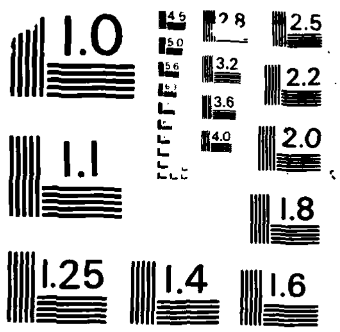

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AD-A189 837

BUHNE POINT SHORELINE EROSION DEMONSTRATION PROJECT

FINAL

APPENDICES VOL. I
A-D

SAN FRANCISCO AND LOS ANGELES DISTRICTS
CORPS OF ENGINEERS

LOCAL SPONSOR
HUMBOLDT BAY HARBOR, RECREATION AND CONSERVATION DISTRICT

AUGUST 1987

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REPORT DOCUMENTATION PAGE

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18. SUPPLEMENTARY NOTES

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

Beach restoration	Shoreline erosion control
Dune restoration	Native plants

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

This report provides detailed information on the rebuilding of the Buhne Point marine beach, the construction of retaining structures, and the establishment of native dune vegetation to prevent wind erosion. The various appendices which are part of the report thoroughly document physical and numerical model studies done at the Waterways Experimentation Station (WES) in Vicksburg Mississippi for the structures and beach, as well as the post-construction and post-planting monitoring programs.

(continued)

20. Abstract, continued.

Buhne Point is located about 250 ~~air~~ miles north of San Francisco, on the east shore of Humboldt Bay, Humboldt County, California. A natural sand spit was located on the western face of the point, but the area lies directly in line with wind and waves entering Humboldt Bay from the Pacific Ocean. Reports of erosion there have been recorded since the mid-19th century. By the late 1970s, erosion had become so severe that the beach had disappeared, and the shoreline had eroded back to the roadway, threatening the road and underground water, gas and sanitary sewer lines. Storm waves 10' in height are common, and were sending rock flying across the road and against adjacent homes of the community of King Salmon.

In 1982, Congress included the area in an authorization to the Federal Highway Administration to undertake a demonstration project to apply "state-of-the-art methods for repairing damage to highways and preventing damage to highways resulting from shoreline erosion." A four-year, four-phase program was implemented, and is described in this final report.

The First Phase consisted of designing and constructing a 1,250' timber groin and a 200' long rubble-mound head to prevent sand from being transported south, downcoast.

Phase II consisted of placing 600,000 yds^3 of fine-to-medium grain sand to reform the almost-24-acre beach.

In Phase III, a 1,050' shore-connected, rubble-mound breakwater was constructed on the northerly face of the beach. The Phase I timber groin and breakwater was given an additional 425' arched extension.

Phase IV consisted of vegetating the sandfill with native plants. The vegetation program included experimental collecting and growing of 20 different native and naturalized species for a two-year period, and then extensive plantings and monitoring.

APPENDIX A

SECTION 1 PROJECT AGREEMENT BETWEEN FHWA AND COE

SECTION 2 PROJECT AGREEMENT BETWEEN COE AND HBHRCD

SECTION 1

PROJECT AGREEMENT BETWEEN FHWA AND COE

Project Agreement
Between the Federal Highway Administration
and the Corps of Engineers

Shoreline Erosion Demonstration Project

Humboldt Bay, California

Pursuant to Section 131(c) of the
Surface Transportation Assistance Act of 1982

THIS AGREEMENT, entered into by the DEPARTMENT OF THE ARMY, SAN FRANCISCO DISTRICT CORPS OF ENGINEERS (CORPS) and by the DEPARTMENT OF TRANSPORTATION, acting through the FEDERAL HIGHWAY ADMINISTRATION (FHWA), WITNESSETH THAT:

WHEREAS, the Congress of the United States has authorized the appropriation of funds for a project to demonstrate state-of-the-art methods for repairing damage to highways and preventing damage to highways, resulting from shoreline erosion, and

WHEREAS, such project is to be carried out in the vicinity of Buhne Point, Humboldt Bay, California, and

WHEREAS, the Corps of Engineers is recognized as having technical expertise and facilities as needed to carry out design studies and to construct the shoreline protection project;

NOW THEREFORE, in consideration of the faithful performance of each party of the mutual convenants and agreements hereinafter set forth, it is mutually agreed as follows:

Article 1 - Project Description

Humboldt Bay is a natural harbor on the coast of northern California about 200 miles north of San Francisco. Within the bay area, about 3 miles south of the city of Eureka, and directly opposite the bay entrance, is a prominent bluff known as Buhne Point. To the southwest of Buhne Point is a small sand spit known as Buhne Spit (sometimes also referred to as Buhne Point). Directly east of the spit is the community of King Salmon. Buhne Drive, the only public access to King Salmon, runs along west side of King Salmon forming a bay side boundary between the shoal area and King Salmon.

Over the past decade, Buhne Spit shoal has eroded to the point where Buhne Drive is threatened. When strong northly winds coincide with a high tide, waves break on to the roadway, disrupting traffic. To prevent Buhne Drive and underlying utilities from destruction, Humboldt County has reveted the bayside of the road with large rock. The revetment has protected the roadway during recent storms, but is not designed as a permanent structure to withstand large breaking waves. This project is for permanent stabilization of the eroding shoreline along Buhne Drive.

Article 2 - Responsibilities of the Corps of Engineers

The Corps of Engineers shall assume charge of the project and take all steps necessary to accomplish design and construction of a shoreline protection facility at Buhne Point, Humboldt Bay, California.

The principal items of work to be performed are:

- Prepare environmental documents.
- Carry out public involvement process and Coastal Zone Management requirements.
- Coordinate all project activities.
- Conduct design studies.
- Prepare Plans, Specifications and Estimate.
- Solicit bids.
- Award construction contracts.
- Administer construction contracts.
- Monitor construction.
- Monitor performance.
- Prepare final report.

Provisions

Eligible Work - Eligible work under this project is that which is necessary for the prevention and repair of damage to highways or access roads resulting from wave action in the vicinity of Buhne Point. Except as required for construction of erosion protection facilities, the reconstruction or repair of highways or access roads or relocation of utilities are excluded as work items under this agreement. This work will be performed by Humboldt County, under a separate agreement. Project work schedules shall be developed cooperatively with Humboldt County.

Environmental Studies - Environmental studies and documentation shall be in accordance with NEPA and all other applicable Federal and State requirements. The FHWA California Division shall be included as a cooperating agency in the environmental process.

Maintenance Agreement - In advance of construction, the Corps shall obtain a maintenance agreement with the appropriate responsible agency or agencies for maintenance of the completed shore protection facility over its design life in accordance with established Corps procedures. It is understood that the Corps, by obtaining this agreement, assumes no obligation for maintenance of the project.

Work Plan - The Corps shall prepare a comprehensive work plan for the project within 60 days from the date of this agreement. The work plan including future revisions thereof shall be approved by FHWA in writing and become a part of this agreement. The work plan shall include a description of the items of work to be performed, and a time schedule for accomplishing each item of work, as well as an estimate of the costs of design and construction.

Design Studies - Design studies shall focus on the following objectives.

1. Define an environmentally acceptable and cost-effective shoreline protection scheme which utilizes state-of-the-art methods.

2. Minimize adverse impacts outside the project limits.

3. Document the design and analysis procedures for demonstration purposes.

Design studies shall consider alternative shore protection measures. The detail of studies shall be sufficient to define the hydrodynamics of the existing system and to evaluate design alternatives.

The outcome of the design studies, including alternatives considered, shall be summarized in a design report.

FHWA Concurrence - The Corps of Engineers shall obtain written concurrence from FHWA in the following:

- Initial work plan and revisions
- Design studies to be performed
- Selection of protection scheme
- Final acceptance of the project
- Final report

Performance Monitoring Period - The performance monitoring period shall begin with completion of shore protection construction and shall continue over a 1 year period, plus time extensions approved in writing by FHWA. The FHWA final acceptance of the project shall take place at the completion of performance monitoring.

Final Report - The final report should include (1) a general overview of the project and a description of activities and studies which were accomplished and the outcome and (2) a detailed description of the engineering design study.

The final report shall be submitted to FHWA no later than 120 days after FHWA's final acceptance of the project. Part 1 should be presented in a non-technical form, augmented with a slide-tape or movie presentation as appropriate to accomplish the demonstration aspect of the project.

Article 3 - Funding and Financial Reporting

The FHWA shall transfer obligational (contract) authority and obligational ceiling to the Corps via allocation letter from Director, Office of Fiscal Services, FHWA. The total amount of authority transferred shall be the estimated costs of design and construction as stated in the approved comprehensive work plan required by Article 2 of this agreement, not to exceed $8.375 million. Upon execution of this agreement, obligational authority and obligational ceiling in the amount of $500,000 will be transferred for preliminary investigations and coordination. The Corps will request cash on an as needed basis and such requests for cash will be directed to Chief, Finance Division.

The Corps shall submit a monthly SF-133, Report on Budget Execution, to the FHWA reflecting specific budgetary data. Because FHWA transfers other allocations to the Corps under the same treasury symbol ((96-20 X 8102) i.e., (a) Bridges over Dams and (b) Shoreline Erosion Demo), the SF-133 must be brokendown to reflect each specific fund allocation and overall total. In addition, a TFS-2108, Year-End Closing Statement shall be submitted to FHWA.

Cost Overrun

If the Corps, at any time, has reason to believe that the cost to the Government for performance of this agreement will exceed the estimated cost established in the work plan approved by FHWA, it shall promptly notify FHWA to that effect, giving the revised estimate of such total cost.

Should the total cost exceed the estimated cost (per work plan) for reasons beyond the control and without negligence of the parties to this agreement, FHWA shall bear the responsibility for seeking any additional funding that may be required. In no event shall commitments be made to exceed the total cost available at $8.375 million without consent of FHWA and establishment of a source of funds for such overrun.

Project Steering Committee

The FHWA shall provide a chairman for a project steering committee made up of representatives from local governmental agencies and citizen groups. The purpose of the committee shall be to provide the views of local interests concerning the project. The views of the commitee shall be considered advisory in nature with the Corps and FHWA having final decision authority. The Corps may be invited to attend meetings of the group and make presentations.

General

The agreement may be amended by the mutual concurrence of both parties and it will be in force and effect upon the date of signature by the appropriate parties.

U.S. Department of the Army
Corps of Engineers

By: Edward M. Lee, Jr.
LTC, CE

Date: 6/13/83

U.S. Department of Transportation
Federal Highway Administration

By: [illegible signature]

Date: 6/13/83

SECTION 2

PROJECT AGREEMENT BETWEEN COE AND HBHRCD

AGREEMENT BETWEEN
THE UNITED STATES OF AMERICA
AND
THE HUMBOLDT BAY HARBOR RECREATION AND CONSERVATION DISTRICT
FOR
CONSTRUCTION
OF BUHNE POINT SHORELINE EROSION DEMONSTRATION PROJECT,
HUMBOLDT BAY, CALIFORNIA.

This Agreement, entered into this 24th day of August, 1983, by and between the UNITED STATES OF AMERICA (Hereinafter called the "Government") represented by the District Engineer executing this Agreement, and the Humboldt Bay Harbor Recreation and Conservation District, (hereinafter called the "DISTRICT").

WITNESSETH THAT:

WHEREAS, the Government is prepared to commence construction of the Buhne Point Shoreline Demonstration Project at Humboldt Harbor, California, authorized by the Federal Highway Administration under authority of Section 131(C) of the Surface Transportation Assistance Act of 1982.

NOW THEREFORE, the parties agree as follows:

1. The DISTRICT agrees that, if the Government shall commence construction of Buhne Point Shoreline Demonstration Project in accordance with the plans and specifications, the DISTRICT shall, in consideration of the Government commencing construction of the Project, fulfill the requirements of non-Federal cooperation applicable thereto, to wit:

a. Provide, without cost to the United States, all lands, easements and rights-of-way necessary for the construction of the project.

b. Hold and save the United States, and its agents and employees, free and harmless from any and all manner of actions, liability and claims to persons or property as a result of the construction work performed by the United States, its agents or employees, but not including damages due to the construction, operation and maintenance which are due to the fault or negligence of the United States, its agents and employees, or its contractors.

c. Maintain and operate the shoreline erosion portion of the project, to include all structures and fills constructed on the bay side of Buhne Drive, in a manner satisfactory to the District Engineer, San Francisco District and to the Federal Highway Administration, and to perform all repair or restoration work after completion of construction and the project monitoring program.

d. Provide Assistance of Compliance with Department of Defense Directive 5500.11, Non-discrimination in Federally Assisted Programs, published in the Federal Register, 31 December 1964, and any amendments thereto or implementation thereof, as may be required by the Secretary of the Army.

e. Assure that, in conjunction with acquiring rights-of-way, affected persons will be adequately informed of the benefits, policies, and procedures described in the Uniform Relocation Assistance and Real Property Policies Act of 1970 (Public Law 91-464) and in accordance with Sections 210 and 305 of said Act and implementing regulations, assure that:

(1) Fair and reasonable and relocation payments and assistance shall be provided to or for displaced persons, as are required to be provided by a Federal agency under Section 202, 203 and 204 of the Act;

(2) Relocation assistance programs offering the services described in Section 205 of said Act shall be provided to such displaced persons;

(3) Within a reasonable period of time prior to displacement, decent, safe, and sanitary replacement dwellings will be available to displaced persons in accordance with Section 205 (c) (3) of said Act;

(4) In acquiring real property, it will be guided, to the greatest extent practicable under State Law, by the land acquisition policies in Section 301 and the provisions of Section 302 of said Act.

2. The DISTRICT hereby gives the Government a right to enter at reasonable times and in a reasonable manner, upon lands which the DISTRICT owns or controls for access to the Project for the purpose of inspection of the completed work.

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the day and year first above written.

THE UNITED STATES OF AMERICA

BY: ________________
for EDWARD M. LEE, JR.
Lieutenant Colonel,
Corps of Engineers
District Engineer

For the Secretary of the Army

Date: 22 August 1983

HUMBOLDT BAY, HARBOR,
RECREATION & CONSERVATION DISTRICT.

BY: ________________

Date: August 11, 1983

I am the Legal Counsel for the Humboldt Bay Harbor, Recreation and Conservation District. The District is a legally constituted public body with the powers provided for pursuant to Appendix 2 of the California Harbors and Navigation Code. In my opinion the District has full authority and capability to perform the terms of the above Agreement between the United States and the Humboldt Bay Harbor, Recreation and Conservation District in connection with the pertinent work requested and that the persons who have executed this Agreement have acted within their statutory authority.

August 11, 1983 Jeremiah R. Scott Jr.

Jeremiah R. Scott, Jr.
Attorney at Law
Counsel, Humboldt Bay Harbor, Recreation and Conservation District

APPENDIX B

SECTION 1 PHASE I: SEED COLLECTION

SECTION 2 PHASE I PLANTING: METHODS AND COST ANALYSIS

SECTION 3 PHASE I: VEGETATION MONITORING REPORT

SECTION 4 A REVIEW OF CALIFORNIA COASTAL DUNE RESTORATION/REVEGETATION PROJECTS

SECTION 1

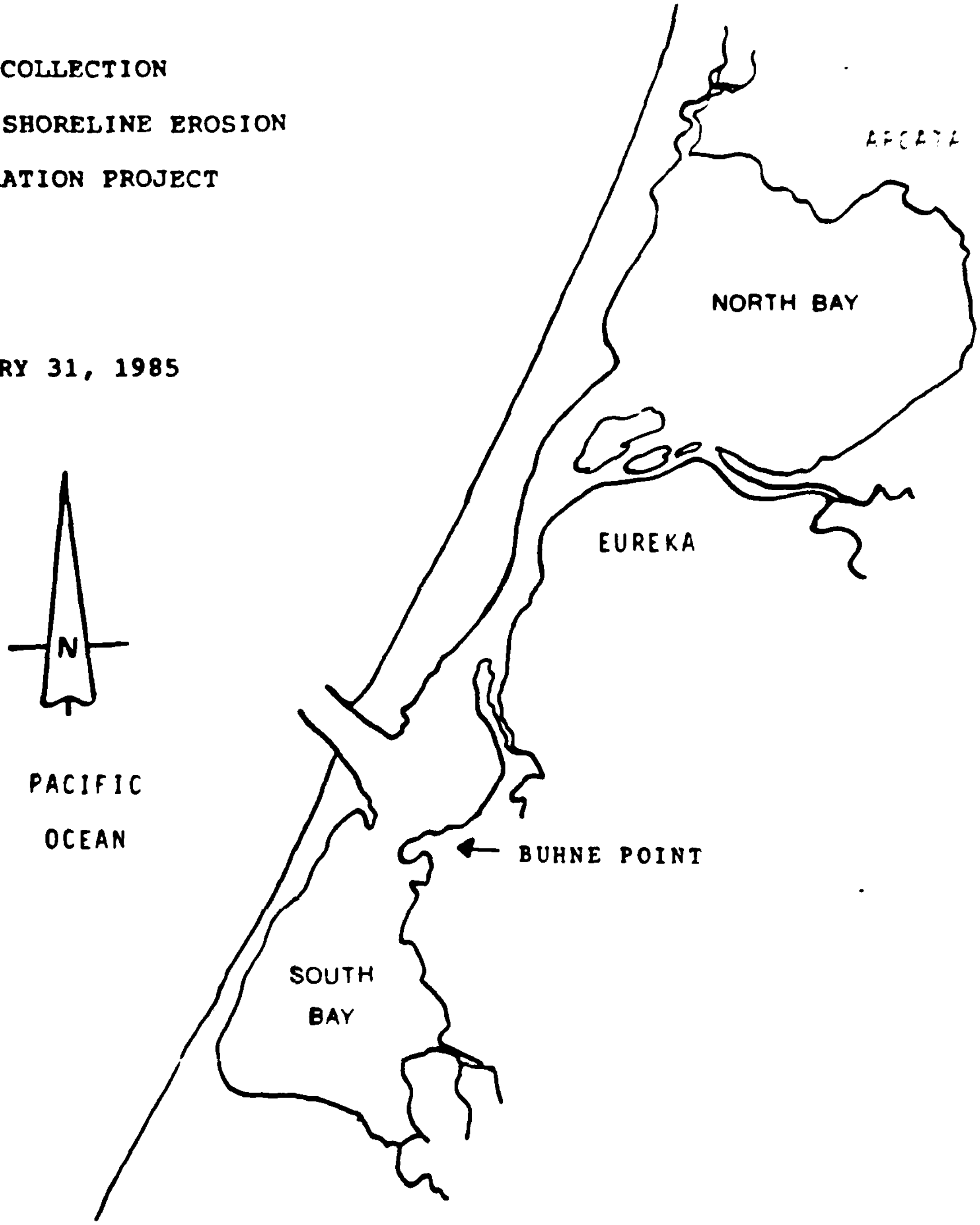
PHASE I: SEED COLLECTION

SEED COLLECTION

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

JANUARY 31, 1985



Gail A. Newton
Botanical Consultant
P.O. Box 234 • Arcata, CA 95521

SEED COLLECTION

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

LOCATION:	HUMBOLDT BAY, HUMBOLDT COUNTY, CALIFORNIA
SUBMITTED TO:	COUNTY OF HUMBOLDT DEPARTMENT OF PUBLIC WORKS 1106 SECOND STREET EUREKA, CALIFORNIA 95501
DATE:	JANUARY 31, 1985
SUBMITTED BY:	GAIL A. NEWTON BOTANICAL CONSULTANT P.O. BOX 234 ARCATA, CALIFORNIA 95521
PROJECT DIRECTOR:	GAIL A. NEWTON
COLLECTORS:	LORRIE BOTT STEVEN HARRIS CHARLOTTE HAYES LINDA LETTON LAUREN PHILBRICK RIC SCHLEXER

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INTRODUCTION

In the past, stabilization of dunes along the north coast of California was accomplished by the introduction of species that bind the sand. Bush lupine (*Lupinus arboreus*), native to Mendocino County, California, and south, and European beach grass (*Ammophila arenaria*), native to Europe, have been used extensively in Humboldt County for this purpose. Only in recent years have the ecological problems of using these introduced species for stabilization become apparent. Not only do they outcompete the native species, but they also destroy the natural dune structure of ridges, hollows and deflation plains.

A native dune system is to be artificially created at Buhne Point to protect an area known as King Salmon from tidal erosion. The dunes will be constructed and appropriate species planted in hopes that a stable and self-propagating dune system will emerge.

The purpose of this contract was to document the cost, manhours, and procedures necessary for the collecting, processing, and storaging of seeds from local, native dune plants that could be used to vegetate the artifical dunes. The section on "Species" describes the processes in detail for each species investigated. (See Table 1 for a list of the species.) This report documents the time spent on each species and on each task in the process. An attempt is made to predict the time needed for a full-scale project.

TABLE 1
Species List

Scientific Name	Plant Family	Common Name
Abronia latifolia	Nyctaginaceae	yellow sand verbena
Ambrosia chamissonis	Compositae	beach bur
Armeria maritima var. californica	Plumbaginaceae	thrift
Artemisia pycnocephala	Compositae	beach sagewort
Baccharis pilularis var. consanguinea	Compositae	coyote brush
*Cakile maritima	Cruciferae	sea rocket
Calystegia soldanella	Convolvulaceae	beach morning glory
Camissonia cheiranthifolia	Onagraceae	beach evening primrose
Erigeron glaucus	Compositae	seaside daisy
Eriogonum latifolium	Polygonaceae	seaside buckwheat
Lathyrus littoralis	Leguminosae	beach pea
Orthocarpus purpurascens var. latifolius	Scrophulariaceae	owl's clover
Plantago hookeriana var. californica	Plantaginaceae	dune plantain
Polygonum paronychia	Polygonaceae	no common name
Solidago spathulata	Compositae	goldenrod
Tanacetum douglasii	Compositae	dune tansy

* Cakile maritima is naturalized from Europe. This species binds sand on the littoral strip and does not compete with the native dune species.

SITE SELECTION

Due to the lateness of the season, the initial period of time allotted to site selection was limited so that the field crew could begin collecting. Later, when time constraints were not so tight, other more remote sites were visited to ascertain the quantities of fruits available for a species at that site. Also, in order to stay within the budget, and to attempt to reach the goal of 100 pounds of processed seed, sites within the Humboldt Bay dune areas were preferred. Table 2 is a overview of the abundance of species at each site visited.

The sites surveyed from north to south were Stone Lagoon, Dry Lagoon, Big Lagoon, Clam Beach, The Nature Conservancy (TNC) at Lanphere-Christiansen Dune Preserve, Samoa Peninsula, Elk River Wildlife Area, Elk River Spit, and South Spit. Areas on Samoa Peninsula were more specifically identified by local landmarks such as the Louisiana-Pacific Mill (LP), the Simpson Mill (Simp.), and the Coast Guard Station (CG). The sites were chosen for variability of habitats, accessibility to collection spots, and proximity to the Eureka-Arcata area (see Maps 1 & 2).

From the abundance indices presented in Table 2, the relative importance of a site is evident. The Lanphere-Christiansen Dune Preserve, owned by The Nature Conservancy, is an extremely valuable resource for fruit production of native dune species. Without the use of this resource, four of the species listed in Table 1 would be difficult to collect in quantity: *Camissonia cheiranthifolia* (beach evening primrose), *Erigeron glaucus* (seaside daisy), *Eriogonum latifolium* (seaside buckwheat), and *Lathyrus littoralis* (beach pea). If continued collection on the preserve is not allowed, new sites for these species will have to be found.

The poundage of *Calystegia soldanella* (beach morning glory) could be easily increased by securing access to state parklands, namely Big Lagoon and Dry Lagoon. (Only the first few yards of the Big Lagoon Spit are county owned, most of the morning glory population is on state parklands.) Access to these areas was not secured for this contract.

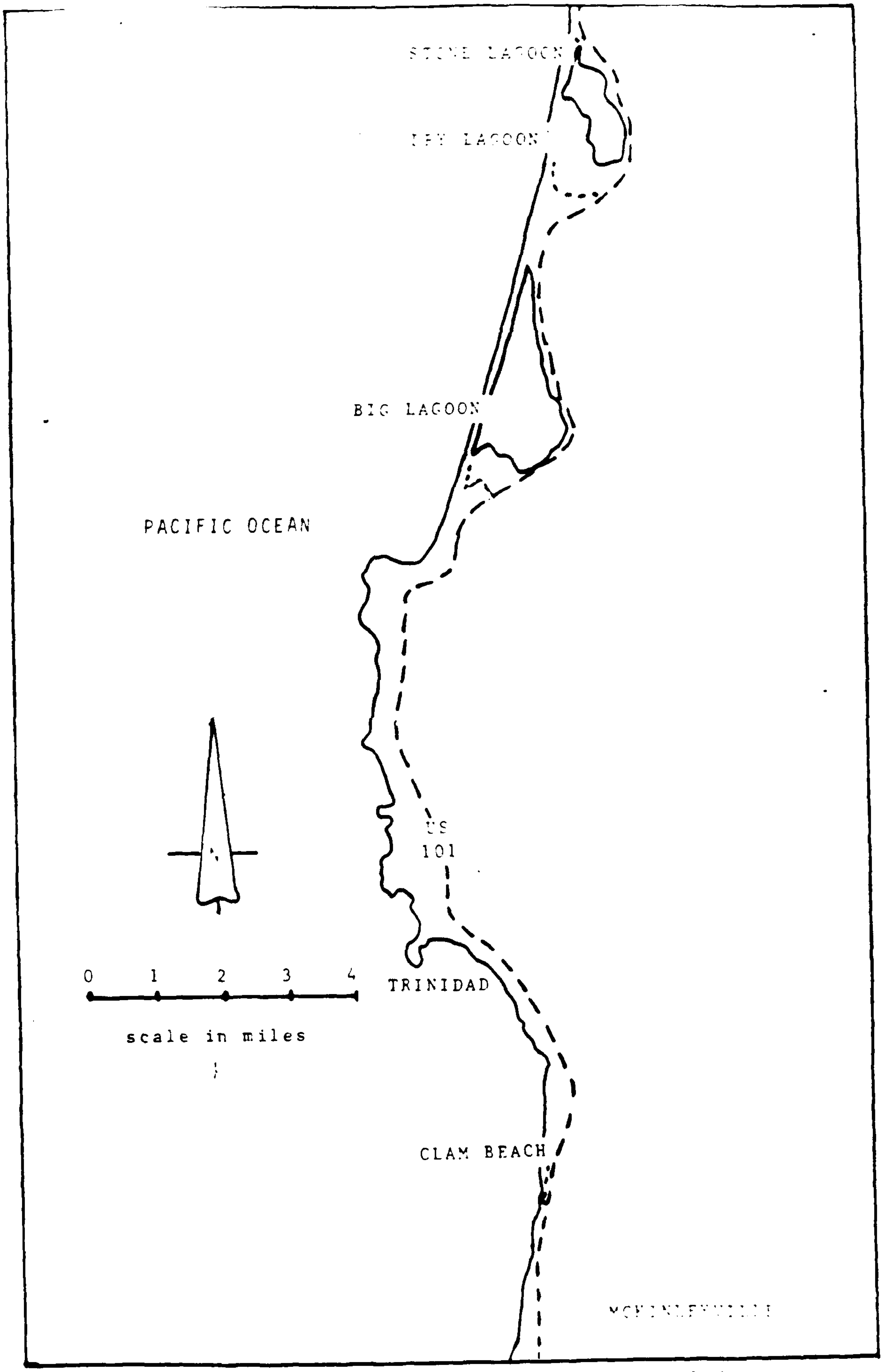
TABLE 2
SPECIES ABUNDANCE BY SITE

SPECIES CODE	TNC	SAMOA -LP	SAMOA SIMP.	SAMOA -CG	ELK R. SPIT	ELK R. WA	SOUTH SPIT	BIG LAGOON	DRY LAGOON	STONE LAGOON	CLAM BEACH
(collected)											
ABLA	A	+	A				-				
AMCH	-	-	+	-	-		A	+	-		
ARMA	+		+	+		+					
ARPY	+	A	-	+							
BAPL	-	-		+		+					A
CAMA	+	-		A	-			+	-		
CASO		+			+	+	+	A	A	+	
CACH	A	-			-						
ERGL	A	+	-								
ERLA	A	+	-				-				
LALI	A				+[1]		-	-			
ORPU	A	A	-	+			+				
PLHO	A			A		+					
POPA	+			+	A	+	-				
SOSP	A	+	-			+	+				
TADO				A		+	-	-	+	-	
(not collected)											
ELMO	-	-			+						
FRCH	+				+					A	

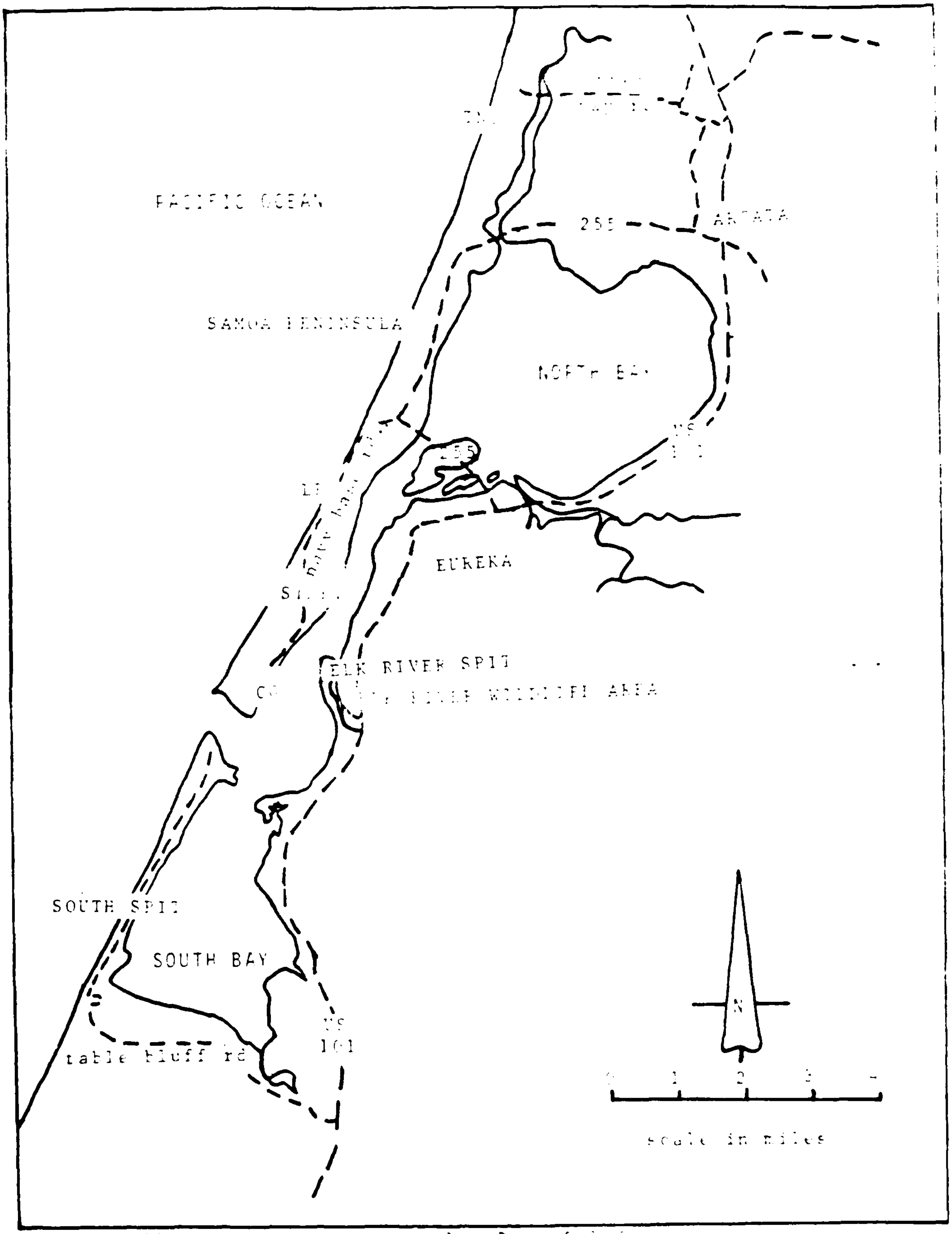
A- very abundant, best site for collection of the species.
+- abundant, good site for collection of the species.
-- common, species may be collected at the site, optimal areas elsewhere

[1]species abundant on site but virtually no viable seeds found.

A key to the species codes used above can be found in Appendix 1.



MAP 1. Collection sites north of McKinleyville, California



MAP 2: Collection Sites on Humboldt Bay, California

MATERIALS

A variety of equipment was necessary during different phases of the contract. For collecting large quantities of plant material, plastic garbage bags (10 gallon) or ziplock bags (1 gallon), were used. Each collector had to carry a pack to store the bags in once they became full, since areas of collection were often remote from the car. A data card was filled out for each collection bag. For some species collectors had to wear leather gloves. For the collection of yellow sand verbena, a common kitchen strainer was used. See the "Species" section for particulars on collecting techniques.

Drying the large quantities of plant material before processing was a problem. The driers at Humboldt State University to which we were given access did not have functional thermostats; hours of collected fruits were burnt before this was known.

One of the collectors owned a large capacity food drier. The drier was designed by Dale E. Kirk, Agricultual Engineer at Oregon State University. The heat source in a set of six light bulbs. The drier consists of five shelves totaling approximately 13.5 square feet. Without access to this personal property, drying of the literaly hundreds of bags of plant material would have been impossible. The cost of the drier is estimated at $500.00.

Sun drying involved the use of carboard boxes and a series of flexible screens. Sun drying produced [illegible] because of Humboldt County weather and winds.

Various kitchen utencils were used for processing the seeds. For example different sized sieves, collanders, sifters, and strainers were used. A rolling pin was used for breaking up the inflorescences and a multitude of pans were used for rolling seeds out of the chaff.

Four sampling screens were borrowed from Humboldt State University. These screens were USA Standard Sieve Series, ASTM Designation, with openings of 0.5 mm, 1.0 mm, 2.0 mm, and 4.0 mm. The screens were used in combination with a blower (hand held hair drier) and manual agitation in an attempt to mimic large industrial processors. Plastic goggles and face masks had to be worn during most of the processing to prevent dust inhalation and allergic reactions.

The end products were stored in a cold room at Humboldt State University. Before storage the seeds and fruits were weighed with a balance, provided by the University, and treated with a fungicide and an insecticide. Plastic gloves, a face mask, and goggles had to be worn during fumigation.

Most of the seeds were stored in glass jars, of which four dozen were supplied by the University and many more by the staff from their private collections. Three large plastic buckets were purchased for storage of the bulkier fruits. These proved to be too expensive. Bulky fruits and fruits in large quantities were stored in paper bags and boxes. Each container was labeled with a code (key in Appendix 2) on both the inside and the outside.

It should be apparent from the preceding description of necessary equipment that by far the majority of equipment was either donated or loaned to the project by Humboldt State University or the staff of the pilot project. There was only a $100.00 equipment budget. This money was spent on data cards, time cards, plastic bags, insecticide, and fungicide.

COST ANALYSIS

Pilot Project Cost

Each collector/processor was asked to keep a detailed record of her/his time for each task. The task categories were defined as follows:

Collect: Time spent in actual collection of plant material.
Data : Time spent filling out data cards and taking pertinent notes.
Process: Time spent processing plant material to end product, includes drying and handling.
Walk : Time spent walking from plant to plant within a site.
Prep & Training: Time spent organizing and training or being trained for a task.
Travel : Vehicle travel time to and from a collection site.
Scouting: Time spent searching for good population from which to collect.
Misc. : Includes paid breaks, and any other task not covered by above categories.

When possible, the time spent at a task was assigned to the species that was being worked on. This was not always possible due to more than one species being dried, handled, processed, or collected within a given time frame. The resultant data is presented in units of hours in a summary chart of tasks and species (See Appendix 3).

Collecting and processing time was also recorded on the field data card that accompanied each collection bag. This system of double recording was used for increased accuracy. Each field data card and the information contained on it is listed in Appendix 4 by scientific name.

Future Cost Estimation

The data used for predicting costs for a larger scale collection project are obtained by modifying data from the summary table and from the data cards. For purposes of prediction, processing time does not include the time spent in the pilot project on experimentation with various processing methods. Time involved in data collection and analysis and site surveying is also deleted. In all, approximately 20% of the hours of this pilot study were spent on learning processes that will not need to be repeated for these species in future projects.

The following table (Table 3) predicts the cost in pounds/hours for each of the species collected, given similar end products, and the collection and processing techniques of the pilot study. Due to the large number of hours not directly applicable to a particular species, the total number of hours for collecting and processing should be increased by 50% to cover these costs. Examples of non-specific costs are drying, handling, walking within a site, preparation and training, paid breaks, travel to the collection site, and minimal office time. <u>In this predictive chart there is no equipment budget, overhead, profit margin, or funds for development and research.</u> Using the information in this chart, the pounds collected of each species during the pilot project, and an hourly rate of $6/hour (rather than $8/hour), a minimum of $33.00/pound is obtained for this species mixture.

Table 3: Table of Predicted Costs in Pounds/Hour for Each Species.

This table includes direct costs for each species only, total hours should be increased by 50% for non-specific costs (for examples of "non-specific" costs refer to the previous paragraph).

An example of dollars/pound is given for each "End Product" using an hourly rate of $8/hour.

Species Code	Pounds	End Product Not Processed lbs./hr.	=	$/lb.	End Product Processed lbs./hr.	=	$/lb.	Notes
ABLA	33.423	1.128	=	7.09	1.019	=	7.85	not processed--just cleaning time.
AMCH	17.680	0.742	=	10.78	0.615	=	13.01	not processed--just cleaning time.
ARMA	0.084	0.0179	=	446.92	---			not processed.
ARPY	0.541	0.0396	=	202.02	0.0115	=	695.65	easy to collect, hard to process.
CAMA	0.079	0.0485	=	164.95	---			based on few samples.
CASO	2.584	0.0955	=	83.77	0.0734	=	108.99	increase ratio by collecting in season.
CACH	0.156	0.0632	=	126.58	0.0135	=	592.59	
ERGL	2.004	0.146	=	54.79	---			not processed
FRLA	1.629	0.0968	=	82.64	0.0442	=	181.00	
LALI	2.536	0.0897	=	89.19	---			processing done on site (i.e. included)
ORPU	1.779	0.409	=	19.56	0.0804	=	99.50	
PLHO	0.142	0.0294	=	272.11	0.0251	=	318.72	increase ratio by collecting in season.
POPA	4.236	0.116	=	68.96	0.0952	=	84.03	achenes incompletely processed.
SOSP	3.573	0.276	=	28.99	---			not processed
TADO	7.448	0.602	=	13.29	0.225	=	35.56	

A key to the species codes used above can be found in Appendix 1.

[illegible]

A list of the dune species collected for seed can be found in Table 1. Information on species collected and/or considered, follows. The species are arranged in alphabetical order by their scientific names.

Abronia latifolia (yellow sand verbena)

End product: fruit--an achene
Best site: Samoa Peninsula--near the Simpson Plant
Total hours: 32.82
Total pounds: 33.423

Biology and Ecology

Yellow sand verbena is in the Nyctaginaceae--the four-o'clock family. This species is a perennial herb with prostrate stems and clustered yellow flowers. The fruit of this species is an achene, a one-seeded, indehiscent fruit. This fruit is oblong, 8-15mm long with five wing-like lobes. The seed located in this fruit is medium brown, 4-5mm long, and can be collected from August to the end of September. This species forms mats on tops of stable mounds located in areas of active sand movement.

Collecting

Since the plant forms large mats usually distant from other species, it was easiest to collect quantities of yellow sand verbena by straining the fruits from the sand around the mounds. The strainers used for this contract were common large mesh kitchen strainers. Time was needed to locate large mature populations of this species. It is common in the dunes of this area, but not always in stands large enough to allow for more-effective collecting.

Processing

Straining of sand for fruits can introduce contamination into the seed collection, therefore, some cleaning of the fruits was necessary, especially in areas near stands of the highly invasive bush lupine (*Lupinus arboreus*). Rabbit pellets were commonly included in the collections; most were picked out. With the exception of the aforementioned cleaning, no processing of the fruits was done. This species was handled only during drying and storage procedures.

Propagating

Germination is irregular and often slow for this species. A higher rate of germination can be attained by planting in greenhouse flats but transplants tend to die; therefore, planting should be done on the exact site (Schmidt 1980). It is not clear whether the low germination data was based on seeds or fruits. Approximately 40% of the fruits collected in the pilot study were found to be empty. A large quantity of yellow sand verbena fruits should be collected to compensate for this species' low rate of germination and high percentage of empty fruit.

Notes

This species was the easiest to collect; it was not processed. Processing of the fruits into pure seed would be extremely time consuming, and unless germination studies show that the germination increases significantly using pure seed versus fruits, there is no reason to process this species.

Different techniques were tried to attempt to separate the empty fruits from the ones containing seeds. There was no consistent size or shape to indicate which fruits were empty. The sizes of the fruits vary enough that it would also be difficult to separate the fruits based on weight.

No one site was found to contain a higher percentage of seeds in the fruits; more variation was found within sites than between sites.

<u>Ambrosia</u> <u>chamissonis</u> (beach bur)

End product: fruit--a one seeded bur.
Best site: South Spit.
Total hours: 31.47
Total pounds: 17.680

<u>Biology</u> <u>and</u> <u>Ecology</u>

Beach bur is a perennial herb with horizontal branching stems that form loose mats. The flowers of this species are unisexual located on a spike with the male flowers on top, rather different from the usual inflorescences of the composite family (daisy family). The burs are one seeded, 8-10mm long. The larger populations of this species were found in areas of moving sand.

This species can be collected from mid-October to mid-November. Since beach bur ripened after most of the other species that were collected during this contract, drying and traveling time occurring during the latter half of the contract relates directly to this species.

Collecting

The burs were stripped off the plants while wearing heavy leather gloves (gloves are necessary!). As a result of the method of collection, a considerable amount of leaves and twigs were collected along with the burs.

Processing

Drying of the burs was difficult due to handling problems. The burs stuck to the drying screens, and once again, heavy leather gloves had to worn.

After the burs were dried, several different large-meshed screens were tried in an attempt to separate the leaves and twigs from the seeds. However, the burs were so spiny that many of them stuck to the screens and considerable agitation of the screens was required to force them through the mesh. This agitation also caused most of the debris to fall through the screen as well, and the goal of separating the seeds from the larger debris was abandoned. A kitchen strainer with a relatively small mesh (about 1 mm) was used to separate the small particle and sand from the seeds.

Notes

It is fairly easy to collect large quantities of this species as long as hand protection is used. Most sites have enough of this species to warrant collection; however large status were found only on the South spit.

<u>Armeria</u> <u>maritima</u> var. <u>californica</u> (thrift)

End product: fruit--an achene enclosed by calyx
Best site: The Nature Conservancy
Total hours: 4.70
Total pounds: 0.084

<u>Biology</u> <u>and</u> <u>Ecology</u>

Thrift, a member of the Plumbaginaceae (thrift family), is a perennial herb with a long, tough taproot. The leaves are linear and basal. The pink flowers are in a head at the end of a scape. The seed of this species is an achene tightly enclosed by the calyx, and ripened during the month of September. Thrift is found in dune hollows at The Nature Conservancy and near roadsides on Samoa Peninsula.

<u>Collecting</u>

Ripe fruits were collected by flicking the head over a collection bag. Thrift is sparsely distributed, but the major problem in collecting quantities of this species was insect damage. Insect infestation of collected fruits varied from 50% to almost total infestation. Before an inflorescence was collected, the head was checked for signs of damage by larvae. This slowed collection considerably.

<u>Propagation</u>

Thrift requires sun and moisture for optimal growth (Schmidt 1980).

Notes

The seeds of this species are extremely small, and tightly held by the calyx. No reasonable means of processing was found, so this species was not processed.

Artemisia pycnocephala (beach sagewort)

End product: fruit--an achene
Best site: Samoa Peninsula near Louisiana-Pacific Drive
Total hours: 27.02
Total pounds: 0.541

Biology and Ecology

Beach sagewort is in the composite family--the daisy family. The flowers and seeds of this species are very small. The inflorescence is a narrow, erect cluster of flowers rising about 1/3 meter above the rest of the plant. The flower heads are small. (Flowers of the composite family are grouped into heads.) The fruit is an achene 1.5mm in size, tightly enclosing the small seed. This species can be collected from mid-August to the end of September. The best populations are located on stable sand dunes.

Collecting

Collection of beach sagewort was best accomplished by stripping heads off ripe inflorescences or by collecting the whole inflorescence. The hairs present on the leaves and stems of this species were extremely irritating to the nose and eyes of the collectors.

Processing

The inflorescences were then dried in the sun or in a drier. The plants dried in the drier produced an odor that caused headaches in the people attending the drier. Once dried, the flower stalks were put into a large screen and with a gloved hand, pulverized into small pieces. The debris was put through successively smaller screens, which removed most of the debris except for sand, flowers, and fruits.

In small amounts the small debris and fruit mixture was put on a large metal pan. The pan was held at an angle and lightly shaken. The achenes rolled more easily than the plant debris, so given the right amount of shaking and angle, the product at the end of the metal pan was sand and achenes.

A dust mask and plastic goggles had to be worn at all times while handling this species. Inhalation of airborne particles given off by this species caused a mild to severe reaction in the processors' respiratory systems.

An attempt to separate the sand from the achenes by weight was somewhat successful. Basically, after agitation, the seeds were blown off the top of the sand. The achenes and sand were about the same size so screening did not help.

Other attempts at processing techniques included pulverizing the inflorescences using a blender. This was found to be too hard on the blender. Watei was added to facilitate blending,and the resultant mixture of ground- up plant and seeds was put through successive water columns. The achenes and sand tend to sink, while the rest of the debris floats. However, drying of the sand and achene soup was difficult given the facilities, and once again the sand was difficult to separate from the achenes. This method was found to produce slightly better results than the shaking method, but it was also extremely time consuming and we lacked adequate facilities for major steps in the wet process.

Propagating

This species grows best in sunny and dry conditions (Schmidt 1980). Propagation of this species can be accomplished by either seed or cuttings (Labadie 1978). Seeds germinate in two weeks, and grow rapidly (Lenz 1956). There is an estimated 3,000,000 seeds per pound for this species (Robin 1983). A application rate of 15 pounds/acre was suggested by Clyde Robin Seed Company which offers this species for $36.00/pound.

Notes

It was rather easy to collect large amount of inflorescences from this species. However, processing of the species was time consuming and yielded few fruits for our labor. Given the bulk of the inflorescences processed, extremely few fruits were yielded. A closer look at heads of this species revealed an average of two mature achenes per head, an extremely small number. It was certain that the majority of the heads were mature when they were collected because older heads on the plant were already disintegrating. In another year or another site, seed set might be better.

Baccharis pilularis ssp. consanguinea (coyote brush)

Biology and Ecology

Coyote brush is a much-branched erect shrub of the composite family. This shrub is dioecious (male and female flowers found on separate plants). The flowers are in heads; numerous heads are found at the end of branches and in their axils. The fruit of this species is an achene 1.3-1.5 mm in length. Coyote brush is found in abundance throughout this area along berms in wetland areas and on older dune ridges. Large stands can be found at the southern tip of the Samoa Peninsula, along U.S. 101 just north of Eureka, and on the Elk River Wildlife Area.

Propagating

Coyote brush can be grown from seeds or cuttings, but cuttings are the best (Labadie 1978).

Notes

This species blooms extremely late in our area, Sept. - Jan. It was not collected due to the late ripening date and to its availability from native seed suppliers.

Cakile maritima (sea rocket)

End product: fruit--a corky silicle
Best Site: Samoa Peninsula--south of Coast Guard Station
Total hours: 6.20
Total pounds: 0.079

Biology and Ecology

Sea rocket is in the Cruciferae (mustard family) that grows on the beach near the water line. This species is a robust annual with pink to purplish flowers. The fruits of this species are called silicles. They are short fleshy/corky fruits about 15 mm long. These silicles are two jointed with a seed in each half. The upper half is rocket shaped. It falls off the plant and is carried away by the surf. The lower half remains attached to the plant longer, and finally falls to the ground in the vicinity of the parent.

Notes

Sea rocket was monitored throughout the duration of the study. A single inflorescence per plant ripens at a time. Plants are also very sparsely distributed, with the exception of the Coast Guard site. Therefore, this species yielded few fruits per attempt to collect. As soon as the inflorescence was ripe, the top cell was dropped. It was not possible to collect these cells from the sand due to daily tidal action washing them away. Many of the cells were also infected with a fungus.

Calystegia soldanella (beach morning glory)

End product: seed
Best site: Dry Lagoon
Total hours: 35.23
Total pounds: 2.584

Biology and Ecology

Beach morning glory is in the Convolvulaceae--the morning glory family. This perennial herb has prostrate, fleshy stems and long, deep-seated rootstocks. The flowers are large, from rose to purplish. The fruits are round capsules containing four dull black obovoid seeds, 5 mm in diameter. Beach morning glory is usually found in areas of moving sand, though the Elk River Wildlife Site is an exception. This species is one of the early bloomers; therefore the fruits can be collected beginning early in August until early September.

Collecting

At the time this contract began, many of the pods had already dehisced their seeds onto the sand. Once on the sand the seeds are more time consuming to collect and became infested by insects. Collection of this species included picking the pods off the plants and well as picking seeds off the sand. The pods were later processed.

Processing

Processing of the pods entailed crumbling the pods between the hands until the seeds were released. Then this mixture of seeds and bits of pods was dropped by handfuls onto the top of a 28" X 48" plywood board. One end of the board was propped about 20" high with a thicker board at the other end to catch the seeds. Using a gloved hand the mixture was rubbed letting the seeds roll to the bottom of the board.

If too much chaff remained with the cleaned seeds at the bottom of the board, the seeds and chaff were dropped down the slant board again. The seeds were then picked up, some of the pieces of the pods that rolled down the board were picked out by hand, and the seeds were placed in a jar.

Notes

Seeds that were not round, and probably not viable, did not roll well and were easily excluded. But the seeds that were only slightly infested by fungus did roll down the board with the good seeds. Separation of infested seeds by hand in the field would be too time consuming. Fungicide prevented the spread of the fungus in storage.

This species can produce four seeds per pod; however, rarely were there more than 3 seeds per pod. And of these three seeds, usually two would be viable. This species is prone to a rust fungus that infects about 50% of the seeds, plus abortion of one or more of the ovules was common.

The poundage per hour of collection for this species would easily be increased by collecting at the appropriate time of year and on the state parklands.

Camissonia cheiranthifolia (beach evening primrose)

End product: seed
Best site: The Nature Conservancy
Total hours: 14.00
Total pounds: 0.156

Biology and Ecology

Beach evening primrose, in the Convolvulaceae (evening primrose family), is a perennial herb with several prostrate stems. The flowers of this species are bright yellow, aging red, and long blooming. The fruit is a capsule that becomes coiled when mature. The capsule is about 12-21 mm long and contains many dark brown 1 mm long seeds. This species was most abundant in areas with beach pea, areas of moving sand. The fruits are ripe for collecting beginning in August until late September.

Collecting

Collection of this species was easy once quantities were located. Whole inflorescences were clipped off the plants and put into bags.

Processing

The inflorescences were dried. Drying was a problem because the extremely small seeds would fall through the screens in the drier. They were dried either in an oven with just the pilot light on or in the sun. Once the inflorescences were dry, they were twisted and crumbled over a large cloth, releasing the seeds onto the cloth along with small debris. The debris and seeds was placed through successively smaller screens until a single sized mixture was attained.

The seeds were then collected from the cloth. Beetles about the same size as the seeds and similar sized sand particles could not be separated by use of the screens. Some separation was possible by weight, but the end product still contained many beetles. The containers were heavily fumigated.

Propagating

Beach primrose is propagated from seed, but does not always germinate well. Once established in a proper situation of sun, sandy soil, and very little water, plants thrive and produce a few seedlings (Schmidt 1980). There are approximately 4,[illegible],000 seeds per pound for this species; and a recommended rate of application of 1/2 pound per acre (ESP, Inc. 1984). Environmental Seed Producers, Inc. sells this species for $85.00 per pound.

Notes

The seeds of this species are extremely small, but collection of the inflorescences is quick and easy. Plants of this species tend to grow distant from each other. Processing of the inflorescences is not hard, but because of the seed size, yields very little poundage. The beetle infestation is a problem that has to be promptly dealt with after collecting.

Erigeron glaucus (seaside daisy)

End product: fruit--an achene
Best site: The Nature Conservancy
Total hours: 13.74
total pounds: 2.004

Biology and Ecology

Seaside daisy is in the composite family--the daisy family. The violet flowers of this species are clustered in heads. There is one head per branch, and numerous flowers per head. The dispersal unit of this species is the fruit (an achene) plus the feathery pappus. Quantities of this species were found at The Nature Conservancy on the side of older ridges, and at other sites in areas of stable sand. Seaside daisy can be collected during the months of August and September.

Collecting

A delicate hand is needed to collect this species in order to separate out the larvae infested heads. The head was plucked from the involucre gently and then turned over. If the clump of achenes did not puff up, that indicated that there was some amount of larvae damage and the head was discarded. About 50% to 70% of the inflorescences were damaged by insects at the sites collected.

Processing

Separation of the seed from the achene and pappus in composite species is an unnecessary and impossible task. This species was not processed to pure seed.

Sorting of viable seeds from damaged seeds was done in the field as much as possible. To rid the collections of the worms that did make it into the bags, the fruits were thinly spread between two sheets of screening. The screening was placed on a sidewalk during a sunny day. As the sidewalk reflected heat through the fruits, the worms escaped through the screening and fled. This process saved us the labor of picking the worms out of the fruits.

Propagating

Seaside daisy can be grown from seeds or from cuttings; seeds take one week to germinate (Lenz 1956).

Eriogonum latifolium (seaside buckwheat)

End product: seed
Best site: The Nature Conservancy
Total hours: 36.86
Total pounds: 1.629

Biology and Ecology

Seaside buckwheat is in the Polygonaceae--the buckwheat family. This species is a perennial, somewhat woody, herb to shrub. The flowers of this species are pink, ripening brown. The fruit of this species is a brown achene, about 4 mm long, enclosed by the calyx. The fruit and calyx fall together or separately when the fruits are ripe. This species grows in areas of newer sand dune ridges. This species has a staggered ripening time between plants and within inflorescences and can be collected during August and September.

Collecting

Collection of this species was easily accomplished by rubbing the ripe inflorescences over a bag. The ripe fruits and their calyces dropped into the bag, the immature fruits remained on the plant. The collection of this species was limited by seasonality. Most of the inflorescences, aided by the strong winds and rains of the late fall, had completely dispensed their achenes by the end of September. The fruit should be collected during August and September.

Processing

The collection of seaside buckwheat yielded large quantities of chaff and fruits for processing. Processing was accomplished by first mashing the mixture into small particles. A large screen was used to remove the large pieces of debris. Then the mixture was put into a screen that was too small for the seeds to pass through. A gloved hand was used to stir the mixture around in the screen until most of the chaff was crushed into small pieces and had fallen through the screen.

The remaining chaff was removed by shifting the mixture to one end of the screen and slowly moving it back and forth. This agitation caused the heavier seeds to stay near the bottom of the pile and the lighter chaff to be near the top. The top of the mixture was blown out of the screen with a common hair dryer. Thus, the chaff was blown out of the screen (along with some of the seeds) leaving almost pure seed behind in the screen.

Propagating

Seaside buckwheat can be grown from seed or from cuttings. This species of buckwheat is not offered by any of the native plant suppliers; however, other species of buckwheat are offered. The range for number of seeds per pound for various species of buckwheats is from 218,000 to 571,000, and the suggested rate of application is from 8 to 20 pounds per acre (Clyde Robin 1983). Clyde Robin Seed Company offers various species of buckwheats for between $4.50 to $115.00 per pound.

Notes

The processing of this species involved a great deal of learning time. All of the above steps are by feel; mixing too hard caused you to damage the seeds, blowing too hard causes too great a loss of seeds. Once learned, the process was not nearly as time consuming. Face masks and goggles had to be worn at all times while processing this species due to the large amount of dust produced.

Lathyrus littoralis (beach pea)

End product: seed
Best site: The Nature Conservancy
Total hours: 28.13
Total pounds: 2.511

Biology and Ecology

Beach pea is in the Fabaceae--the pea family. This species is a perennial herb with typical, pink-colored pea flowers. Beach pea blooms very early and therefore the fruits are also ready quite early. At the time of this contract the pods were ripe and some had already dehisced. The fruits of this species are like a dry and leathery pea pod. The pod contains 1 to 5 seeds; rarely 3 or more seeds per pod were found in these populations. Seeds of this species are 5 mm in diameter. The best populations of this species are located on the edge of hollows and deflation plains.

Collecting and Processing

Collection of the seeds from this species was very time consuming. A good deal of the time was spent walking from patch to patch. The best patches to collect from were located well within the boundaries of the dune preserve and were most often isolated from one another.

Of the pods that were not obviously empty (flat pods were obviously empty) only 10% of the remaining pods contained viable seeds. The low viability of the seeds was due in part to abortion but mainly to insect damage. The infecting insect bores a hole into the pod and lays its eggs. The offspring hatch out, ingest the seeds, and eat their way out of the pod.

Due to the large amount of insect damage, it proved to be cost-effective to process in the field. Processing involved shucking the peas by hand. The infection did tend to be localized; therefore, the collector could move a few feet away and begin collecting again if the previous spot was too badly infected.

Propagating

Beach pea can be grown from seed or from cuttings. This species of pea is not offered by any native plant suppliers. Another species of pea, Lathyrus latifolius, has a suggested application rate of 20 pounds per acre, and an estimated 9,000 seeds per pound (ESP, Inc. 1984).

Notes

Usually only one seed per pod was viable. Rarely were more than two seeds untouched by the insects. Seeds that had already been shed onto the sand were also collected. Pods both on the plant and on the ground were checked. There was no difference in the amount of insect damage between the pods still held by the plant and those already on the sand.

<u>Orthocarpus purpurascens</u> var.<u>latifolius</u> (owl's clover)

End product: seed--encased in loose, netted coat.
Best site: The Nature Conservancy
Total hours: 30.29
Total pounds: 1.779

Biology and Ecology

Owl's clover is a member of the Scrophulariaceae--the figwort family. This species of owl's clover is an annual herb that is highly branched from the base. The flowers of this species are lavender,pink, and purple. The fruits of this species are in a ovoid capsule 10-15 mm long containing many seeds that are less than 1mm long. Each seeds is encased by a loose fitting, netted seed coat. This species was found on old, stable ridges and dune systems. Collection is best during August and September.

Collecting

The ripe plants were easy to spot. When the fruits are ripe the entire plant turns brown. Since the species is an annual, it is quite easy to pull the whole plant up. However, because this is an annual species, collection of the total seed source from a plant is not ecologically sound. An attempt was made to collect only half the inflorescences per plant and to leave the remaining. This was clumsy and not always successful since the plants pull up easily. Large garbage bags were used for collection of this species due to the large quantities available and the bulk of the inflorescences.

Processing

The large quantities of plant material were dried in a pilot oven and in the sun. After drying the plants were crushed on newspaper by hand to break up the branches. The plants were then crushed further by rolling them on newspaper using a rolling pin to break apart the fruits and release the seeds.

The crushed plant material was then put through a large-meshed screen (approx. 1 mm) to separate the large-sized debris from the seeds. The seeds and small sized debris that passed through the screen were then put through one or two small-meshed screens (0.5 mm and slightly larger than 0.5 mm) to remove sand, dust, and small debris from the seeds. The screens used for processing most of the owl's clover were kitchen strainers and only a small amount of seeds/debris could be put through a screen at one time. Small black beetles about the same size as the seeds remained mixed in with the final product.

Propagating

Orthocarpus purpurascens is offered for $60.00 per pound by Clyde Robin Seed Company. The variety of the species is not specified. There is an estimated 900,000 seeds per pound for this species, and a suggested application rate of four pounds per acre (Robin 1983).

Plantago hookeriana var. *californica* (dune plantain)

End product: seed
Best site: Samoa Peninsula--near the Coast Guard Station
Total hours: 5.66
Total pounds: 0.142

Biology and Ecology

Dune plantain is in the Plantaginaceae--the plantain family. This species is a small annual herb with linear leaves. The small flowers are densely clustered along a spike. The fruit of this species is a capsule that is two-celled and two-seeded. The dull brown seeds are 2-2.5 mm long. This species grows in stable, protected hollows and flats. The best time to collect quantities of dune plantain is from mid July to late August.

Collecting

At the time of this study, most of the plants had already dehisced. The inflorescences of dune plantain were stripped while being held over a bag. Many of the capsules dehisced during the collection process.

Processing

The mixture of capsules and seeds was crumpled between the hands and placed through various sized screens. First a large screen was used to get rid of stems and leaves and large pieces of the capsules. Then the mixture was put into a small screen to get rid of the sand and small debris--the seeds did not pass through. The remaining mixture of even-sized particles was then separated by weight. The mixture was agitated and the lighter chaff blew off the top.

Propagating

A closely related species of plantain is offered by Clyde Robin Seed Company for $1.50 per pound. This related species was estimated as having 250,000 seeds per pound, with a suggested application rate of 50 pounds per acre (Robin 1983).

Notes

•Dune plantain is an annual species; therefore, collection of seed from this species will impact its seed reservoir. Collection of the species should be over as large an area as possible so that there is minimum impact on localized populations.

Polygonum paronychia (no common name)

End product: fruit (an achene) plus most of the attached calyx
Best site: Elk River Spit
Total hours: 44.39
Total pounds: 4.236

Biology and Ecology

Polygonum paronychia is a member of the Polygonaceae--the buckwheat family. This species is a perennial shrub that sprouts from large woody rootstocks. The shrub is highly branched with short, linear leaves that are crowded near the tips of the branches. The small pink flowers are located in the axils of the leaves and in terminal spikes. The fruit of this species is a black, shining achene about 4.5 mm long, surrounded by the persistent calyx. This shrub is most abundant in stabilized sand and is best collected during the months of August and September.

Collecting

The largest seeds seemed to be those located away from the tip of the branch. The branches were stripped while being held over a collection bag. Most of the mature achenes either fell into the bag or came off easily in the hand. The immature achenes remained on the branch.

Processing

The mixture of fruits and bits of debris were placed in a large mesh screen to separate the leaves, stems, etc. from the fruits. The fruits at this point usually consisted of the achenes and their attached calyces.

Different methods were experimented with for removing the calyces from the black achenes. Rubbing of the fruits through a screen did not adequately remove the calyces. The fruits were then lightly scrubbed with a sponge that was covered with sand paper. Some calyces did detach, but not a majority. After this last attempt, processing was abandoned.

Propagating

Though no reference could be found on growing this species, I believe that it could be easily propagated by cutting or digging up the rootstocks.

Notes

Approximately 1/4 of the Polygonum paronychia collected was killed by overdrying in Humbolt State University driers.

Solidago spathulata (goldenrod)

End product: fruit--an achene plus pappus
Best site: The Nature Conservancy
Total hours: 14.44
Total pounds: 3.573

Biology and Ecology

Goldenrod is a member of the composite family--the daisy family. The stems of this perennial herb arise from a caudex or woody rhizome. The leaves of this species are bright green and mostly basal. The yellow flowers of goldenrod are arranged in heads along compound, spike-like inflorescences. The dispersal unit of this species is the short achene with attached pappus. Goldenrod is found on established ridges and protected flats. The fruits can be collected during the months of September and October.

Collecting

One method of collecting this species was to strip the whole inflorescence. Using this method, the involucre was collected along with the achenes. The involucre was difficult to separate from the achenes while off the plant. To get a cleaner product, a method of collecting similar to the seaside daisy method was used. The achenes were pulled off the involucre head by head. The heads did not have to be as closely inspected as those of seaside daisy, since insect damage was not usually a major problem with goldenrod.

Processing

An attempt was made to clean the collections of goldenrod that included the involucre and pieces of the stem. It was found that such cleaning was extremely difficult and later collections included only the achenes and attached pappus. No processing of the achenes was attempted.

Propagating

Though no information was found on this particular species of goldenrod, other species of goldenrod are well known for their easy cultivation and rapid growth (Taylor 1955). Goldenrod can be grown from seed or cuttings.

Notes

This species has an extremely staggered ripening time. Though some insect damage was found; it was not a problem with this species of goldenrod.

Tanacetum douglasii (dune tansy)

End product: fruit--an achene
Best site: Samoa Peninsula--near the Coast Guard Station
Total hours: 37.41
Total pounds: 7.448

Biology and Ecology

Dune tansy is in the composite family--the daisy family. This species is an aromatic perennial herb that is highly rhizomatous. The leaves of dune tansy are highly divided. Flowers and fruit of this species are very small, typical of the daisy family. The achenes are about 3-4 mm long. Dune tansy is found in areas of stabilized dunes and flats that are usually well vegetated. Collection of the fruits from this species is best between mid-September to mid-November.

Collecting

Occurrence of this species is highly localized; therefore, a large amount of ripe inflorescences are available at one time at a site. Collection of the whole inflorescence caused problems with processing. The best way to collect this species is to break off the inflorescence just below the involucre, then lightly rub the decaying flowers off the top of the achenes. The achenes are later separated from the involucre. Most of the heads had some amount of insect damage; lightly damaged heads were collected.

Processing

This species was dried in the sun and in the drier. When dried in closed quarters, the odor of this species causes headaches in some people. After drying, the achenes were pulled off the involucre by hand. This was actually very easy to do and not very time consuming. Successively smaller screens were used to separate any included debris from the ripe achenes.

Propagating

The closely related species of common tansy (*Tanacetum vulgare*) has a similar creeping rhizome and is most commonly propagated from cuttings of this rhizome. Common tansy spreads rapidly from these cuttings to form large colonies (Sperka 1973). Common tansy and dune tansy both grow in colonies.

Notes

Dune tansy tends to dominate the areas where it grows. This species is also found at the upper edges of dune areas, near upland grasslands.

DISCUSSION

The methods used in this pilot project were very labor-intensive. All aspects of collecting and processing fruits/seeds was done by hand. One way to decrease the cost of species per pound is to mechanize the collecting and processing.

Commercial seeds companies rarely collect in the field. Seed is brought back to the greenhouse and grown for stock. If a large amount of seed is needed from natural sources, a vacuum is used to suck the fruits off the plant.

Processing of the plant material by commercial operations is usually done with a blower and a series of sieves. The blower has fine calibrations such that chaff, aborted, and non-viable seeds can be easily separated from the viable seeds. Therefore, the end product from a commercial operation is purer than our end product and is obtained with quite a bit less labor.

Some basic rules for processing seeds/fruits:

1) Seeds are heavier than chaff.
2) Seeds are smaller than leaves and stems.
3) Seeds are larger than dust and some sand.
4) Seeds roll easier than chaff and sand.
5) Seeds are lighter than sand.

One way to decrease costs would be to decrease or omit processing. However, for most species, the purer the seed, the higher the percentage of germination. A study of germination of seeds in fruits versus naked seeds for each species would help determine whether processing is necessary.

After processing, the seeds need [illegible] they are to be stored for any length of time. The desired dryness of a seed is measured by its percent water content. As little as, but no less than, 7% water content is best for storage. The process required to measure the water content is an involved scientific procedure. Once dried, storage should be at a low temperature and low humidity until the seeds are to be used.

For this pilot project, weight was used as the quantity index for all species collected. This index is extremely artificial; it has no ecological significance. The size of the seeds collected under this contract vary from the size of a pin head to the size of a pea. An appropriate index would be based on the percentage of germination of a species coupled with the number of seeds per pound. When the information was available, the number of seeds per pound and the recommended rate of application were noted for each species (see "Species" section); this information was not known for the majority of species. Of the 77.869 combined pounds collected of seeds and fruits, two species with large fruits made up 66% of the weight.

Besides the use of seeds/fruits for propagation of native dune species, many of these species can be easily propagated by cuttings. Perhaps a combination of seeding and propagation by cutting should be employed to get the desired results.

The habitat for each species is more specific than just "dunes". Each species is particular to a certain microhabitat.

When planting, each species should be [illegible] to insure successful germination and a stable population.

The use of local races of native dune species for revegetation of local dunes is an excellent idea. The lack of a local, commercial operation makes the acquisition of large amounts of seed quite expensive. The only way to reduce the overall cost per pound for collecting and processing local species is to invest in equipment. Such equipment would greatly decrease the woman-hours and therefore the cost/pound. A list of other native dune species that may be included for a similar seed collection project are found in Table 4.

TABLE 4
OTHER SPECIES TO BE CONSIDERED

Scientific Name	Common name
Carex pansa	sand dune sedge
Elymus mollis	native beach grass
Erysimum menziesii	Menzie's wallflower
Fragaria chiloensis	beach strawberry
Garrya elliptica	silktassel
Gilia millefoliata	dune gilia
Glehnia leiocarpa	no common name
Holodiscus discolor	ocean spray
Juncus lesueurii var. *tracyi*	Tracy's salt rush
Lonicera involucrata	twinberry
Lupinus littoralis	lupine
Lupinus variicolor	lupine
Myrica californica	wax myrtle
Orthocarpus erianthus var. *micranthus*	butter and eggs
Salix piperi	dune willow
Sanicula arctopoides	footsteps-of-spring

identification of the species of the dead culms was difficult. Therefore, mortality rates for the dune and beach grass plantings were determined without regard to species. The mortality rates for the grasses varied widely between shipments and dunes (see Table 6). The mortality estimates were calculated by dividing the number of dead hills per dune by the number of hills planted on that dune.

The different mortality rates between shipments was due, at least in part, to the watering problems associated with the first plantings. The irrigation system was not completed before the first shipment arrived and Dune IV was planted. Therefore, the area was planted according to the original plans. Many of the hills on Dune IV were never reached by the irrigation (see Map 4a). Also, the plants on Dune IV experienced periods of drought immediately after planting due to the problems associated with the operation of the irrigation system. In some areas on Dune IV, groups of dead hills are surrounded by live plants, indicating adequate irrigation. Mortality of these areas is more likely linked to the low vigor of the stock supplied than the irrigation system.

Difference in mortality rates between dunes within shipment 2 is associated with the irrigation system and the percentage of European beach grass planted on that dune. When the identity of the dead culm was possible to determine, I observed that there were more dead European beach grass hills than dead native beach grass hills. Therefore, a dune comprised largely of European

APPENDIX 1
Species List

Scientific Name	Species Code	Common Name
Abronia latifolia	ABLA	yellow sand verbena
Ambrosia chamissonis	AMCH	beach bur
Armeria maritima var. *californica*	ARMA	thrift
Artemisia pycnocephala	ARPY	beach sagewort
Baccharis pilularis var. *consanguinea*	BAPI	coyote brush
Cakile maritima	CAMA	sea rocket
Calystegia soldanella	CASO	beach morning glory
Camissonia cheiranthifolia	CACH	beach evening primrose
Elymus mollis	ELMO	native beach grass
Erigeron glaucus	ERGL	seaside daisy
Eriogonum latifolium	ERLA	seaside buckwheat
Fragaria chiloensis	FRCH	beach strawberry
Lathyrus littoralis	LALI	beach pea
Orthocarpus purpurascens var. *latifolius*	ORPU	owl's clover
Plantago hookeriana var. *californica*	PLHO	dune plantain
Polygonum paronychia	POPA	no common name
Solidago spathulata	SOSP	goldenrod
Tanacetum douglasii	TADO	dune tansy

APPENDIX 2
KEY TO COLLECTOR CODES AND SITE CODES USED ON LABELED CONTAINERS

Each container was labeled with a two codes. First the species code (see Appendix 1), then the collection code. The collection code contains the date, collector, site, and jar number, in that order.

EXAMPLE: ABLA
09/09/84-1B-1

COLLECTORS

1 = Newton
2 = Bott
3 = Harris
4 = Hayes
5 = Letton
6 = Schlexer
7 = Philbrick

SITES

A = The Nature Conservancy
B = Samoa Peninsula--LP
C = Samoa Peninsula--Simpson
D = Samoa Peninsula--Coast Guard
E = Elk River Spit
F = Elk River Wildlife Area
G = South Spit
H = Big Lagoon

APPENDIX 3
HOURS BY TASK AND SPECIES

TASK	ABLA	AMCH	ARMA	ARPY	BAPI	CAMA	CASO	CACH	ERGL	ERLA
COLLECTING	24.30	21.37	4.00	7.70		.99	24.69	2.02	12.07	14.33
DATA	1.21	.74	.42	.27			.43	.37	.67	1.02
PROCESSING	3.16[a]	6.90[a]	N/P	17.36		.96[a]	8.16	11.50	N/P	20.03
WALKING	3.62	.95		.50			1.70	.08	1.00	1.48
PREP & TRAINING	.50	.75				.28	.25			
SCOUTING SITES	.03	.76	.28		.25	3.72		.03		
MISC.				1.19		.25				
OFFICE & DATA ANALYSIS										
TRAVEL TO SITE										
TOTAL HOURS	32.82	31.47	4.70	27.02	0.25	6.20	35.23	14.00	13.74	36.86
RAW MATERIAL (GAL.)	87	84	2	56		3	18	8	13	54
TOTAL POUNDS (PROPAGULE)	33.423	17.680	0.084	0.541		0.079	2.584	0.156	2.004	1.629
MILEAGE										

[a] time shown is only for cleaning, species was not processed.
[b] species was not completely processed.
INCL-species processed at site, therefore processing included in collecting hours.
A key to the species codes can be found in Appendix 1.

APPENDIX 3 CONTINUED
HOURS BY TASK AND SPECIES

TASK	LALI	ORPU	PLHO	POPA	SOSP	TADO	N/SP.	TOTALS	%
COLLECTING	24.08	3.49	4.37	32.82	10.82	11.48	3.45	201.98	34.2
DATA	.54	.46	.13	.35	.57	.41	.32	7.91	1.3
PROCESSING	INCL	25.61	.83	8.00[b]	1.50[a]	24.86	61.18	190.05	32.2
WALKING	3.38	.40	.33	3.22	1.35	.41	7.01	25.43	4.3
PREP & TRAINING						.08	18.49	20.35	3.4
SCOUTING SITES	.13				.20	.17	17.00	22.57	3.8
MISC.		.33					12.43	14.20	2.4
OFFICE & DATA ANALYSIS							57.91	57.91	9.8
TRAVEL TO SITE							50.89	50.89	8.6
TOTAL HOURS	28.13	30.29	5.66	44.39	14.44	37.41	228.68	591.29 hr.	100.0
RAW MATERIAL (GAL.)	8	110	3	9	15	17		532 gal.	
TOTAL POUNDS (PROPAGULE)	2.536	1.779	0.142	4.236	3.573	7.448		77.869 lbs.	
MILEAGE								1288.60mi.	

CARD INFORMATION BY SPECIES: ABRONIA LATIFOLIA (YELLOW SAND VERBENA)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ABLA	09/09/84	1	A	1	0.226	0.33	N/P	used strainer, ripe now
ABLA	09/09/84	1	A	2	0.080			see other card for info
ABLA	09/13/84	3	A	1	0.229	0.50	N/P	dried 12 hrs @ 100 F
ABLA	09/13/84	4	A	1	0.268	0.33	N/P	
ABLA	09/13/84	4	A	2	0.545	0.33	N/P	
ABLA	09/13/84	4	A	3	0.981	1.00	N/P	open dune areas, sifted seeds from sand, dried 14h @ 110 F
ABLA	09/14/84	3	A	1	0.120			see other jar for info
ABLA	09/14/84	3	A	2	0.479	0.33	0.50	sifted through sand
ABLA	09/14/84	3	A	3	0.832	0.75	N/P	sifted seeds from sand
ABLA	09/14/84	4	A	1	2.479	2.17	N/P	sifted through sand for seeds, dried for 14 hrs @ 100 F.
ABLA	09/16/84	3	A	1	5.960	1.92	N/P	sift through sand for seeds, sun dried
ABLA	09/16/84	4	A	1	4.547	3.08	N/P	about 40% dispores are empty, lots of beetles, dried 14hrs @ 100 F
ABLA	09/19/84	5	A	1	0.109	0.42	N/P	dried 14 hrs @ 100 F
ABLA	09/11/84	3	B	1	0.440	0.50	0.25	dried 12 hrs @ 100 F
ABLA	09/12/84	4	B	1	0.535	1.00	N/P	black beetles in with seeds, sifted through sand
ABLA	09/20/84	7	C	1	1.280	0.52	N/P	sifted through sand for seeds, includes some rabbit pellets
ABLA	09/22/84	4	C	1	4.313	2.95	N/P	sifted through sand for seeds, many rabbit pellets and beetles
ABLA	09/24/84	4	C	1	3.700	2.17	N/P	sifted through sand for seeds, dried for 16 hrs @ 100 F
ABLA	09/28/84	4	C	1	0.941	0.42	N/P	dried 16 hrs @ 100 F

CARD INFORMATION BY SPECIES: ABRONIA LATIFOLIA (CONTINUED)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ABLA	09/28/84	4	C	2	3.695	1.42	N/P	sifted through sand for seeds, est. 40% dispores empty, dried 16h @ 110 F
ABLA	09/17/84	3	E	1	1.664	1.25	N/P	beetles infested, sift through sand for seeds, dried 12 hrs @ 110 F

CARD INFORMATION BY SPECIES: AMBROSIA CHAMISSONIS (BEACH BUR)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
AMCH	09/24/84	4	C	1	0.477	0.67	YES	some ABRONIA seeds mixed in, striped stems with gloves
AMCH	09/24/84	4	C	2	1.448		N/P	not processed but fairly clean dried 14 hrs @ 100F
AMCH	10/22/84	4	C	1	1.442	0.83	N/P	sand wet--couldn't use strainer, pulled seeds off stems w/ gloves
AMCH	10/24/84	4	C	1	0.412	0.58	N/P	collected by straining through sand & striping stems w/ gloves
AMCH	10/25/84	1	G	1	1.450	1.50	N/P	dried 17 hrs @ 100 F
AMCH	10/25/84	2	G	1	1.153	1.50	N/P	in scattered patches in various stages of ripeness, some dehisced
AMCH	10/30/84	2	G	1	2.037	3.25	YES	most plants dehisced, dried 14 hrs @ 100 F
AMCH	10/30/84	3	G	1	2.759	3.90	N/P	dried 22 hrs @ 100 F, striped seeds from stem
AMCH	10/31/84	2	G	1	0.568	0.92	N/P	info for all three jars, dried 16 hrs @ 100 F
AMCH	11/01/84	2	G	1	2.155	2.00	YES	weather has made seeds wet and sandy, dried 17 hrs @ 100 F
AMCH	11/01/84	3	G	1	0.382	0.50	N/P	dried 22 hrs @ 100 F
AMCH	11/01/84	3	G	2	0.605	0.42	N/P	dried 14 hrs @ 100 F
AMCH	11/01/84	3	G	3	0.474	0.58	N/P	dried 22 hrs @ 100 F
AMCH	11/01/84	3	G	4	0.544	0.80	N/P	dried 22 hrs @ 100 F
AMCH	11/11/84	2	G	1	0.422	0.92	yes?	most seeds have been blown off infl during recent storm
AMCH	11/15/84	2	G	1	0.382	0.92	YES	most seeds blown off plants, plants not very abundant
AMCH	10/22/84	7	H	1	0.255	1.50	1.25	slightly wet, not completely processed
AMCH	10/22/84	7	H	2	0.270			see info on jar #1

CARD INFORMATION BY SPECIES: AMBROSIA CHAMISSONIS (BEACH BUR) CONTINUED

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
AMCH	10/22/84	7	H	3	0.260			see info on jar #1
AMCH	10/22/84	7	H	4	0.185	0.58	1.25	sand too large to strain out, striped stem w/ leather gloves

CARD INFORMATION BY SPECIES: ARMERIA MARITIMA VAR. CALIFORNICA (THRIFT)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ARMA	09/16/84	6	A	1	0.032	1.50	N/P	90% ripe, 50% insect damage, only undamaged fruits taken
ARMA	09/17/84	6	F	1	0.052	2.50	N/P	60-70% ripe, plants scattered, almost total insect infestation

CARD INFORMATION BY SPECIES: ARTEMISIA PYCNOCEPHALA (BEACH SAGEWORT)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ARPY					0.018		1.52	unlabeled
ARPY	09/09/84	1	B	1	0.024	0.17	0.78	sand present in final product
ARPY	09/12/84	2	B	1	0.072	1.50	0.92	see 09/13/2B1
ARPY	09/12/84	3	B	1	0.077	3.00	4.47	striped panicle with fingers
ARPY	09/12/84	4	B	1	0.008	1.50	2.43	striped panicle with fingers, dried 14 hrs @ 100 F
ARPY	09/13/84	2	B			1.50		killed by overdrying
ARPY	09/13/84	2	B	1	0.012		0.65	mislabeled, see 9/12/84 2B1 for coll time
ARPY	09/19/84	2	B	1	0.063	1.03	1.42	
ARPY	10/22/84	2	B	1	0.267	0.50	N/P	most infl completely dehisced, dried 22 hrs @ 100 F

CARD INFORMATION BY SPECIES: CAMISSONIA CHEIRANTHIFOLIA (BEACH EVENING PRIMROSE)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
CACH	09/13/84	1	A	1	0.081	0.50	4.50	collected whole infl, capsules somewhat dehisced, dried in sun
CACH	09/13/84	2	A	1	0.007	0.13	0.42	whole infl collected, dried in pilot oven
CACH	09/14/84	2	A	1	0.007	0.30	0.83	whole infl collected, dried in pilot oven
CACH	09/16/84	2	A	1	0.011	0.17	0.25	
CACH	09/19/84	4	A	1	0.005	0.50	0.75	collected whole infl
CACH	09/20/84	2	A	1	0.023	0.22	0.92	dried 24 hrs @ 100 F
CACH	09/20/84	2	A	2	0.022	0.20	0.67	

CARD INFORMATION BY SPECIES: CAKILE MARITIMA (SEA ROCKET)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
CAMA					0.024			unlabeled
CAMA	09/09/84	1	A	1	0.038	0.33	N/P	not completely dry, most not ripe, plants sparse--lots of walking
CAMA	11/15/84	4	D	1	0.017	0.33	N/P	dried 14 hrs @ 100 F

CARD INFORMATION BY SPECIES: CALYSTEGIA SOLDANELLA (BEACH MORNING GLORY)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
CASO	09/11/84	1	B	1	0.101		INCL	pilot collection, in barren area east of fore dunes
CASO	09/12/84	4	B	1	0.382	1.50	0.58	plants widely separated, picked pods, dried @100 F
CASO	09/19/84	2	B	1	0.009	0.50	0.08	most processing included, dried 14 hrs @ 100 F
CASO	09/21/84	6	B	1	0.077	1.00	1.00	picked off sand and plants, rust fungus, highly localized
CASO	09/20/84	7	D	1	0.218	1.77	0.88	collected pods and loose seeds, dried 4 days in pilot oven
CASO	09/27/84	2	D	1	0.129	1.20	0.50	most pods dehisced, insect damage, sun dried
CASO	09/04/84	1	E	1	0.048	1.00	INCL	seeds often dehisced, rust fungus common, scattered plants
CASO	09/17/84	2	E	1	0.048	0.42	0.30	
CASO	09/17/84	3	E	1	0.086	3.50	0.50	pods collected
CASO	09/17/84	4	E	1	0.053	1.50	0.33	collected pods off ground
CASO	09/24/84	1	E	1	0.249	1.75	1.00	rust fungus, pick earlier in season-many dehisced, good spot
CASO	09/24/84	2	E	1	0.239	1.97	0.83	
CASO	09/25/84	2	E	1	0.278	1.58	0.83	most pods dehisced
CASO	09/22/84	1	F	1	0.135	1.00	0.75	good population, easy access, many already dehisced
CASO	09/22/84	2	F	1	0.122	2.00	0.50	dried in sun
CASO	10/15/84	1	G	1	0.033	1.00	INCL	test collection for site
CASO	11/11/84	2	G	1	0.073	0.67	0.08	seeds on surface, some sprouting collected while scouting
CASO	11/31/84	2	G	1	0.304	1.83		dried 22 hrs @ 100F

CARD INFORMATION BY SPECIES: ERIGERON GLAUCUS (SEASIDE DAISY)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ERGL	09/10/84	5	A	1	0.029	0.33	N/P	heavily infested with larvae
ERGL	09/13/84	3	A	1	0.280	1.50	INCL	pappus and achenes, 80% in fruit, dried 10 hrs @ 100 F
ERGL	09/13/84	3	A	2	0.087	0.75	INCL	plucked pappus with achenes
ERGL	09/13/84	3	A	3	0.300	2.00	N/P	collected pappus with achene
ERGL	09/13/84	3	A	4	0.184	1.00	N/P	pluck pappus with achenes
ERGL	09/13/84	4	A	1	0.343	0.75	N/P	dried 10 hrs @ 100F
ERGL	09/13/84	4	A	2	0.216	1.00	N/P	plants located on dune slopes, dried 10 hrs @ 100 F
ERGL	09/14/84	1	A	1	0.020	0.25	INCL	60-70% of heads insect damaged, picked only undamaged achenes
ERGL	09/14/84	3	A	1	0.078	0.33	INCL	dried 13 hrs @ 110 F
ERGL	09/16/84	3	A	1	0.049	0.17	INCL	pluck achenes and pappus off infl, dried 12 h @ 100 F
ERGL	09/16/84	6	A	1	0.178	2.00	INCL	heavily infested with insects, only undamaged seeds collected
ERGL	09/11/84	1	B	1	0.069	0.17	INCL	dried 14 hrs @ 100 F
ERGL	09/12/84	2	B	1	0.171		N/P	50% infl damaged by insects, dried for 10 h @ 100 F

CARD INFORMATION BY SPECIES: ERIOGONUM LATIFOLIUM (SEASIDE BUCKWHEAT)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ERLA	09/13/84	1	A	1	0.059	0.50	0.50	spiders included, some other species contaminated bag
ERLA	09/13/84	3	A	1	0.035	0.33	0.43	may be missing some processing time
ERLA	09/13/84	4	A	1	0.208	2.00	3.35	includes exper processing time, many larvae in infl
ERLA	09/13/84	4	A	2	0.023	0.67	1.00	larvae in seeds, dried in sun for 2 hrs
ERLA	09/14/84	2	A	1	0.096	0.83	0.25	processing time ont correct, insect damage,
ERLA	09/14/84	2	A	2	0.061	0.42	1.50	stopped due to rain, seeds wet, dried in pilot oven
ERLA	09/16/84	2	A	1	0.068	0.50	1.75	very wet, dried 14 hrs @ 100 F
ERLA	09/16/84	6	A	1	0.124	3.20	1.92	about 90% ripe, some larvae, dried 3 hrs @ 100 F
ERLA	09/19/84	5	A	1	0.267	1.42	1.25	sorted through heads due to insect damage
ERLA	09/24/84	2	A	1	0.213	0.97	3.83	dried in low oven
ERLA	09/25/84	5	A	1	0.210	0.92	0.75	
ERLA	09/11/84	1	B	1	0.061	0.17	1.33	use this pro time as est of learned time
ERLA	09/12/84	2	B	1	0.184	1.83	0.75	seeds damp when collected
ERLA	09/17/84	4	E	1	0.020	0.50	0.25	dried 15 hrs @ 100 F

CARD INFORMATION BY SPECIES: LATHYRUS LITTORALIS (BEACH PEA)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
LALI	09/09/84	1	A	1	0.455	4.25	INCL	ripe now, large amount of seeds with insect damage
LALI	09/13/84	1	A	1	0.596	5.00	INCL	10% seeds viable, usually 1 seed per pod, many pods without seeds
LALI	09/16/84	2	A	1	0.536	4.08	INCL	lots of insect damage, insect eggs laid in pods
LALI	09/19/84	4	A	1	0.025	1.50	INCL	insect damage
LALI	09/19/84	5	A	1	0.010	0.33	INCL	approx 1 in 20 pods had a seed undamaged by insects
LALI	09/20/84	2	A	1	0.524	6.00	INCL	
LALI	09/20/84	5	A	1	0.390	4.42	INCL	

CARD INFORMATION BY SPECIES: ORTHOCARPUS PURPURASCENS VAR. LATIFOLIUS
(OWL'S CLOVER)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ORPU	09/16/84	1	A	1	0.014	0.17	0.68	lots on preserve
ORPU	09/21/84	2	A	1	0.335	0.40	2.35	dried in pilot oven and sun,
ORPU	09/21/84	2	A	2	0.108	0.10	1.42	dried in pilot oven
ORPU	09/25/84	5	A	1	0.090	0.83	0.42	
ORPU	09/17/84	2	B	1	0.182	0.20	2.42	infl damp, dried in sun and in pilot oven
ORPU	09/19/84	2	B	1	0.071	0.30	0.75	infested by small black beetles about the same size of the seeds
ORPU	09/27/84	2	B	1	0.247	0.18	2.58	foggy day--collected damp, dried in pilot oven
ORPU	09/27/84	2	B	2	0.202	0.38	7.65	collected damp, dried in sun, used large collection bags
ORPU	11/15/84	2	B	1	0.056	0.50		plants mostly dehisced--contain few seeds
ORPU	09/20/84	7	D	1	0.078	0.10	0.75	easier to pick whole plant, foggy day--hard to collect
ORPU	11/11/84	2	G	1	0.396	0.33	0.92	dried in pilot oven, check on processing time and wt.

CARD INFORMATION BY SPECIES: PLANTAGO HOOKERIANA VAR. CALIFORNICA
(DUNE PLANTAIN)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
PLHO	09/16/84	1	A	1	0.074	2.75	0.50	50%+ dehisced, highly localized, striped infl with fingernail
PLHO	09/21/84	2	A	1	0.065	1.10	0.33	most plants already dehisced, dried 12 hrs a 100 F
PLHO	09/21/84	5	A	1	0.003	0.50		wind makes collection difficult, most already dehisced

CARD INFORMATION BY SPECIES: POLYGONUM PARONYCHIA

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
POPA	09/14/84	1	A	1	0.277	1.17	0.50	large patches sparsely spaced, 50% ripe, striped infl
POPA	09/16/84	5	A	1	0.469	5.75	N/P	KILLED by overdrying
POPA	09/19/84	5	A	1	0.020	0.25	N/P	dried 14 hrs @ 100F
POPA	09/17/84	2	E	1	2.972	21.4	6.33	not completely processed, mixed: 9/17-9/25 & Bott, Newton, Hayes
POPA	09/17/84	5	F	1	0.498	4.25	N/P	KILLED by overdrying

CARD INFORMATION BY SPECIES: SOLIDAGO SPATHULATA (GOLDENROD)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
SOSP	09/14/84	1	A	1	0.099	0.33	N/P	
SOSP	09/14/84	1	A	2	0.116			no insect damage, some areas ripe, others not ripe, see #1
SOSP	09/14/84	6	A	1	0.024	1.60	N/P	20-30% ripe, collected during light rain--difficult
SOSP	09/21/84	2	A	1	0.312	0.18	N/P	dried 12h @ 110 F, wind-difficult collection, includes involucre
SOSP	09/21/84	2	A	2	0.391	0.83	N/P	dried for 12 hrs @ 110 F
SOSP	09/21/84	2	A	3	0.313	0.50	N/P	wind-collection difficult, dried 14 h@ 110 F, insect damage
SOSP	09/21/84	2	A	4	0.474	0.35	N/P	dried for 14h @ 110 F
SOSP	09/21/84	2	A	5	0.170			see other jar for time info
SOSP	09/21/84	2	A	6	0.148			see other jar for time info
SOSP	09/21/84	5	A	1	0.246	0.75	N/P	
SOSP	09/21/84	5	A	2	0.400	1.08	N/P	
SOSP	09/28/84	2	A	1	0.162			see other jar for time info
SOSP	09/09/84	1	B	1	0.124	0.17	N/P	
SOSP	09/12/84	3	B	1	0.066	1.00	0.50	
SOSP	09/12/84	3	B	2	0.077	1.00	1.00	dried 13 hrs @ 110 F
SOSP	09/20/84	7	D	1	0.319	0.23	N/P	damp day, insect damage
SOSP	09/17/84	6	F	1	0.132	2.80	N/P	30-40% ripe, some insect damage, dried 4 hrs @ 100 F

CARD INFORMATION BY SPECIES: TANACETUM DOUGLASII (DUNE TANSY)

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
TADO	09/20/84	3	D	1	3.451	3.60	9.08	dried 18 hrs @ 100 F picked whole infloresence
TADO	09/20/84	4	D	1	2.822	3.50	4.00	involucre pulled off, sun dried one day
TADO	09/27/84	2	D	1	0.257	1.77	2.25	most heads with some insect damage, processed longer--stems
TADO	11/15/84	4	D	1	0.424	1.58	0.75	most infl gone with rain storms dried 14 hrs @ 100 F, in 3 jars
TADO	11/16/84	4	D	1	0.458	0.83	0.50	dried 14 hrs @ 100 F, most processing done at site
TADO	09/22/84	2	F	1	0.036	0.20		large amount of insect damage, too windy to collect,

N/P - not processed

William [illegible]
Ecologist
SPLPD-RL
19 Feb 1985

MEMORANDUM FOR RECORD

Subject: Comments on Seed Collection Report (DACW07-84-M-0640)

1. General: The draft report is generally well done and is acceptable under the specifications of the contract.

2. Specific comments: The following comments are provided to finalize the report:

a. Lupinus arboreus may not be endemic to the site but it is certainly native to northern california and should be distinguished from the naturalized European species Ammophila arenaria (P1.7).

b. P1 p3: One purpose of this contract was to determine cost...

c. P3 p2: Please provide a map showing site locations and access routes.

d. P10 p2: Please provide estimates of overhead, profit margin. Please provide an estimate of the total cost of collection including overhead, profit, necessary expenses, for each species in table 3. It is not clear what the "50%" added costs includes. There should be no costs included for developement, research or equipment, these costs are investments made by the contractor to increase his efficiency in performing the work over and above that which can be done by hand. Simple equipment, seives, blowers, frames and simple drying overs can be legitamately included. Total costs of pounds of seed will be compared with that available from commercial sources and from commercial wild harvestors where comparisons exist. While the Corps Biologist recognizes that a premium is justified for the collection of endemic varieties, this additional cost should not exceed by 30% the cost of commercial wild harvest of the same species.

e. P12 p2: Pounds per hour collected, and total cost per pound of seed should be collected and displayed. The estimated cost per pound in future collection should also be shown and should reflect cost savings resulting from better information on collection sites, more appropriate collection times, more efficient processing techniques.

f. P44 Table 4: Please identify the species which may be considered pioneer or early colonizers of sand dunes. Two are apparent,
Elymus mollis and Fragaria chiloensis, though the latter invades bare sand from established areas.

g. P48 A3: Please add the pounds of seed collected per species, and some estimate of the bulk of material collected befor processing.

RESPONSES TO COMMENTS RECEIVED

Response to Comments by
William Van Peters
U.S. Army Corps of Engineers:

2a. Distinction made per your request, page 1, paragraph 1.

2b. Change was made Page 1, paragraph 3, sentence 1.

2c. Per your request, see Maps 1 & 2.

2d. "Overhead" and "Profit Margin" are best determined by the individual companies according to their costs, goals, and the scope of the project. The seed collection contract (DACW07-84-M-0840) budget contained neither overhead nor profit margin; each of these costs can range from 10-50% of the total contract price. Overhead includes a price for the use of equipment by the associated project, and profit margins help cover costs of business equipment/expansion and research and development. The costs for each species provided in Table 3 page 13, can be increased by the appropriate overhead and profit margin.

Other necessary expenses cannot be divided by species and are included in the "50% non-specific costs". Examples of these non-specific costs were given on page 12, paragraph 2, sentence 2 & 3. More explicitly:

1) walking between plants or areas within a site that were not directly accountable to a particular species.

2) daily preparation and briefing was minimal (averaged 10 minutes per collecting day per person).

3) training varies widely according to the knowledge of the employees (very little was necessary for the crew used on this project).

4) paid breaks (two 10 minute breaks per 8 hours for each collector/processor).

5) travel time to a collection site is usually not assignable to a particular species and varied from 10 minutes to 45 minutes.

6) office time directly applicable to the project includes budgeting, accounting, payroll, bookkeeping, and correspondence.

7) each bag of plant material had to be thinly spread over the drying surface by hand and later retrieved by hand (an average of 10 minutes per 1 gal bag).

8) each collection had to be placed in storage container(s), time varies according to container size and opening as well as propagule.

The "non-specific" (=not assignable to a specific species) category for hours worked would increase the predicted man-hours necessary for the collecting, processing, and storage of a species by 50%.

The hours attributed to "learning processes" necessary, for this pilot project are not included in any of the future cost analysis, see page 12, paragraph 1.

Necessary equipment for a larger scale seed collection project would exceed the "simple equipment" category. Necessary equipment should include:

- large capacity drying oven(s)
- calibrated blowers with sieves
- calibrated sieves
- field vacuums
- dry storage room
- cold storage room
- fumigation room
- accurate balance

The equipment used by the pilot project included:

- "simple" drying oven...............$ 500--donated use
- calibrated sieves (4 @ $100 each)..$ 400--donated use
- balance............................$1800--donated use
- dry storage room...................$ 500--donated use
- cold storage room..................$?--donated use
- airtight storage containers (200)..$ 150--donated use
- ....$ 18--purchased
- hand held blower...................$ 20--donated use
- collection bags.................. $ 30--purchased (reused)
- pack (1/field person @ $20 ea.)....$ 140--donated use
- leather gloves (pr/person @ $10 ea.)$ 70--donated use
- screens ($10 for 8')...............$ 10--donated
- slant boards (metal and wood)......$ 50--donated
- goggles (1 per person @ $5 ea.)....$ 35--donated
- data cards (200)...................$ 25--purchased
- incidentals:
    - face masks--donated
    - collanders--donated use
    - sifters--donated use
    - strainers--purchased and donated use
    - office supplies--purchased and donated

Commercial companies prices are not based on wild harvest, see page 42, paragraph 2.

2e. Pounds per hour by species was given in Table 3, page 13. The predicted cost per pound of seed can be found by dividing the desired poundage by the pounds per hour found in Table 3 then multiplying by the desired hourly rate. Table 3 has been expanded to display examples of dollars/pound for each species.

2f. *Elymus mollis* and *Fragaria chiloensis* are the only early colonizers found in Table 4.

2g. The pounds collected per species can be found in Table 3 in the Cost Analysis Section, as well as, under each species collected in the Species Section. 192 one gallon bags and

14 ten gallon bags of plant material were collected, or approximately 71 cubic feet. This information has been added to Appendix 3, per your request.

SECTION 2

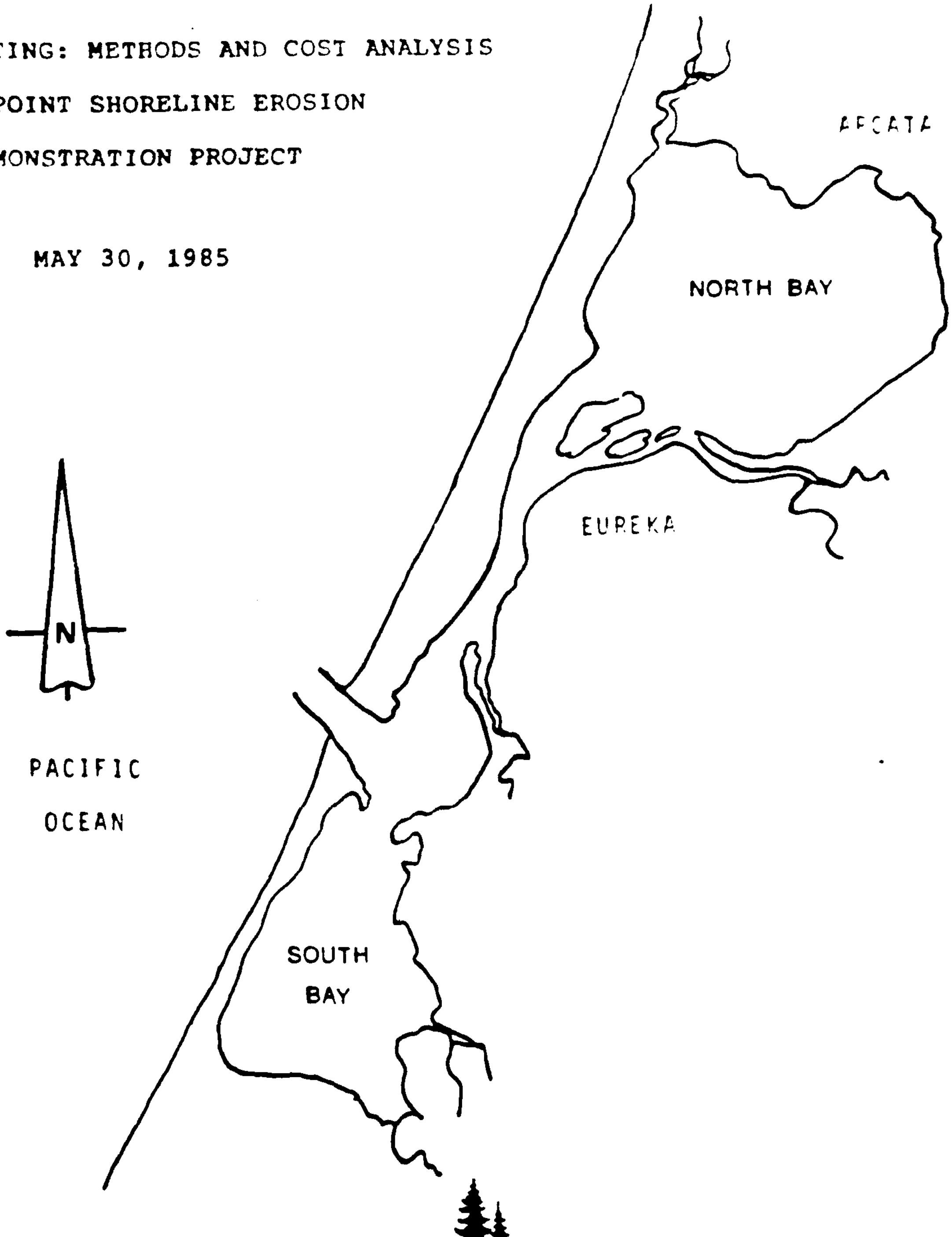
PHASE I PLANTING: METHODS AND COST ANALYSIS

PHASE ONE PLANTING: METHODS AND COST ANALYSIS

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

MAY 30, 1985



Gail A. Newton
Botanical Consultant
P.O. Box 234 • Arcata, CA 95521

PHASE ONE PLANTING: METHODS AND COST ANALYSIS

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

LOCATION: HUMBOLDT BAY, HUMBOLDT COUNTY, CALIFORNIA

SUBMITTED TO:
COUNTY OF HUMBOLDT
DEPARTMENT OF PUBLIC WORKS
NATURAL RESOURCES DIVISION
1106 SECOND STREET
EUREKA, CALIFORNIA 95501

DATE: MAY 30, 1985

SUBMITTED BY:
GAIL A. NEWTON
BOTANICAL CONSULTANT
P.O. BOX 234
ARCATA, CALIFORNIA 95521

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ANGELES CA AUG 87

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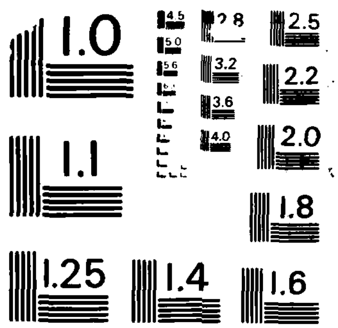


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

INTRODUCTION

In the past, stabilization of dunes along the north coast of California has been accomplished by the introduction of species that bind the sand. Bush Lupine (*Lupinus arboreus*), native to Mendocino County, California, and south, and European beach grass (*Ammophila arenaria*), native to Europe, have been used extensively in Humboldt County for this purpose. Only in recent years have the ecological problems of using these introduced species for stabilization become apparent. Not only do they out-compete the native species, but they also destroy the natural dune structure of ridges, hollows, and deflation plains that is typical of the Humboldt County coastline.

A dune system was created from dredge spoils at Buhne Point to protect an area known as King Salmon from tidal erosion. A limited, experimental planting was designed cooperatively by the Humboldt County Department of Public Works (Natural Resources Division) and the Los Angeles District Corps of Engineers, for implementation in Spring 1985. Full scale planting of 10-15 acres of the total 23 acres of fill is scheduled for November 1985.

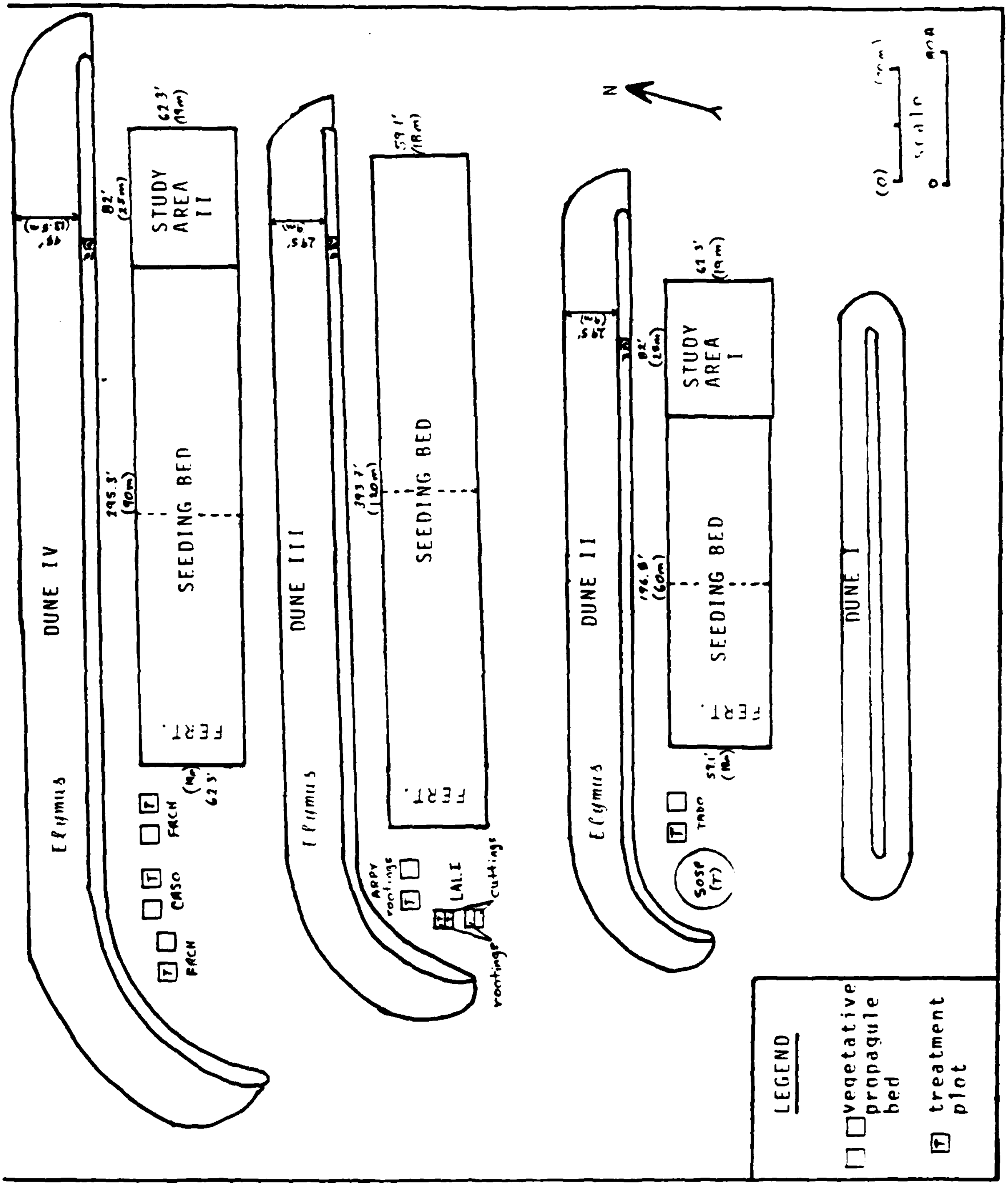
The experimental planting was carried out by Humboldt County Department of Public Works under contract to the San Francisco District, Corps of Engineers. The County subcontracted with botanical consultant Gail Newton for supervision of the planting and other tasks documented in this report. The experimental plantings comprised seeds and vegetative propagules from native dune species that were planted in the areas outlined on Maps 1a and 1b. The seeds were collected in the Fall of 1984 under a previous contract; the details of the seed collection and processing can be found in "Seed Collection, Buhne Point Shoreline Erosion Demonstration Project" by Gail A. Newton, Botanical Consultant (Army Corps of Engineers #DACW07-84-M-0840).

One purpose of this planting was to determine the cost, man-hours, procedures, and equipment necessary to establish a cover of native dune species sufficient to stabilize the artificial dunes. The results of the contract are presented in this report.

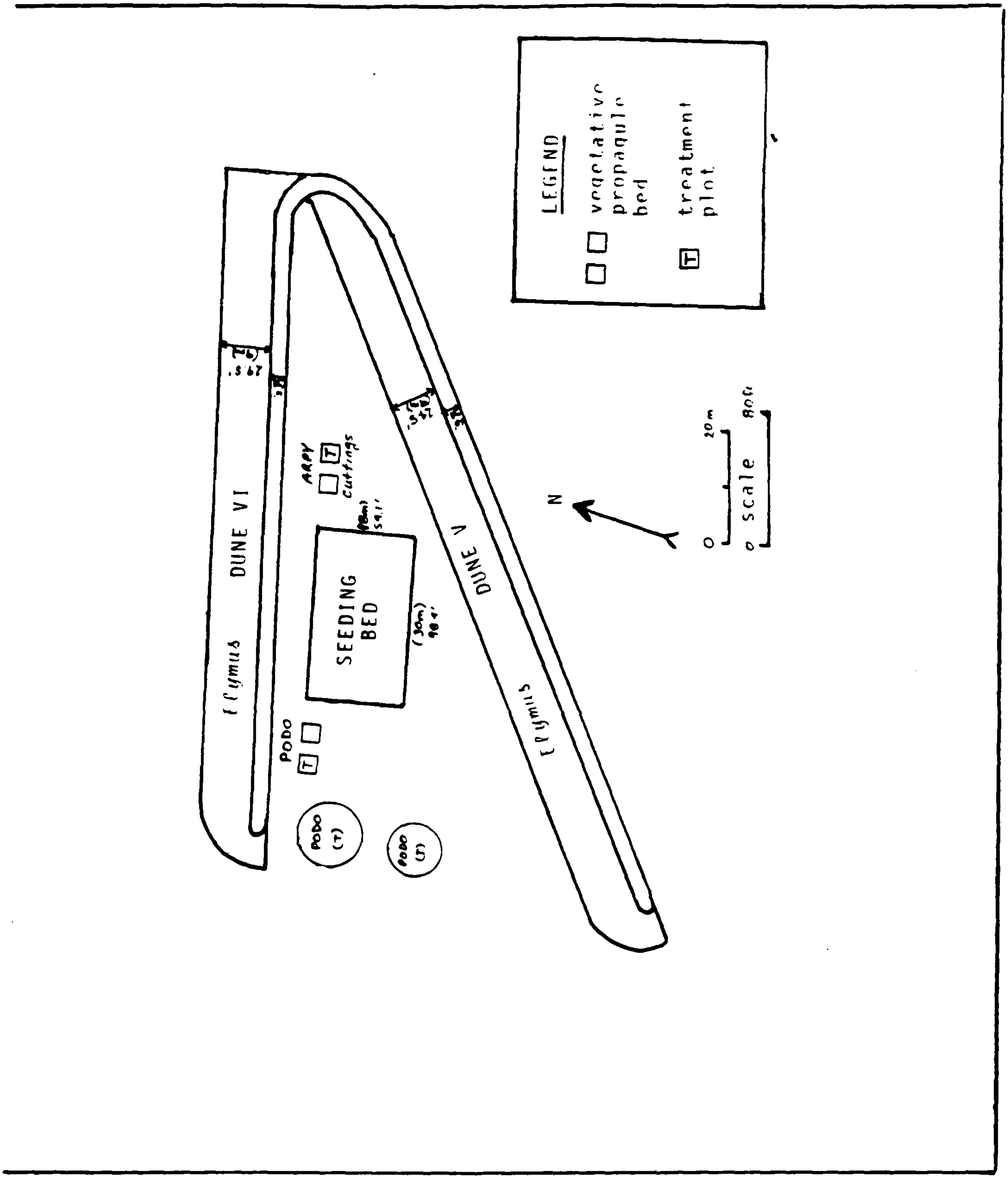
Three major plantings were undertaken using the species listed in Table 1. First, large seeding beds were sowed with a calculated mixture of locally collected seeds. Next, small areas were identified for vegetative propagation. These propagules were also collected from local stock. The last segment of the dune vegetation was the planting of culms from the native dune grass (Elymus mollis). Native dune grass was planted on the windward side of six of the seven dunes that were created on the project site. Since large beds of dune grass are rare in our area, the stock was imported from Oregon.

TABLE 1
Species List

Scientific Name	Code	Plant Family	Common Name
SEEDING BEDS:			
Abronia latifolia	ABLA	Nyctaginaceae	yellow sand verbena
Ambrosia chamissonis	AMCH	Compositae	beach bur
Calystegia soldanella	CASO	Convolvulaceae	beach morning glory
Camissonia cheiranthifolia	CACH	Onagraceae	beach evening primrose
Erigeron glaucus	ERGL	Compositae	seaside daisy
Eriogonum latifolium	ERLA	Polygonaceae	seaside buckwheat
Lathyrus littoralis	LALI	Leguminosae	beach pea
Orthocarpus purpurascens var. *latifolius*	ORPU	Scrophulariaceae	owl's clover
Polygonum paronychia	POPA	Polygonaceae	no common name
Solidago spathulata	SOSP	Compositae	goldenrod
Tanacetum douglasii	TADO	Compositae	dune tansy
VEGETATIVE PROPAGULES:			
Artemisia pycnocephala	ARPY	Compositae	beach sagewort
Calystegia soldanella	CASO	Convolvulaceae	beach morning glory
Elymus mollis	ELMO	Poaceae	native dune grass
Fragaria chiloensis	FRCH	Rosaceae	beach strawberry
Lathyrus littoralis	LALI	Leguminosae	beach pea
Poa douglasii	PODO	Poaceae	beach bluegrass
Solidago spathulata	SOSP	Compositae	goldenrod
Tanacetum douglasii	TADO	Compositae	dune tansy



Map 1a: Schematic Drawing of the Eastern Portion of the Project Plan. Refer to Table 1 for species codes.



Map 1b: Schematic Drawing of the Western Portion of the Project Plan. Refer to Table 1 for Species Codes

GENERAL COST ANALYSIS

Table 2 outlines, in general terms and dollar values, the costs involved with each of the three plantings on the project site: seeding, vegetative propagation, and dune grass planting. All laborer hours are estimated at \$8/hour (estimated employer's cost for a \$5/hour to \$6/hour employee). The hours worked by the California Conservation Corps (CCCs) are also included in this estimate at \$8/hour to give a realistic idea of the cost, even though there was no charge for their services. All supervision and planning hours are charged at \$15/hour. The total cost for the Phase I planting was \$35,382.01; paying for the labor donated by the CCCs would have increased the cost to \$42,062.01. In both of these estimates, \$26,892.60 is due to the cost of the irrigation system.

The overall cost per acre for seeding of the area using the species mix in Table 3, was \$2,842.38 (\$0.70/m^2). If paid labor had been used in place of CCCs, the total cost of seeding would have been \$4,309.95 per acre (\$1.06/m^2). This cost per area can vary depending on the proportion of each species used in the seed mix and the application rate used for sowing the mix.

The cost for planting the vegetative propagules using CCC labor was a total of \$600.90, or \$20,030.00/acre (\$4.95/m^2). Without CCC labor the total cost would have been \$1,522.90, or \$50,763.33/acre (\$12.54/m^2). This high cost is due, in part, to the large amount of travel time coupled with the small number of divisions (rootings and cuttings) collected at a site. The cost could be easy reduced by 50% if more divisions were taken per site.

When the cost of seeding versus the cost of vegetative propagation are compared, seeding appears to be much less expensive. However, in evaluating the cost per acre, neither the comparative density nor the survival of the plants was taken into account. The seedlings have just begun to germinate and grow; therefore, the density and survival rate of the seeding beds are not available at the time of this report. To truly compare the cost of the two processes, the seeding beds and the vegetative propagation beds should be evaluated after a year's growth for the density of surviving plants.

The comparative cost analysis between the seeding beds and the vegetative propagation beds should also be calculated by species. The results would determine the most efficient method for propagating an individual native dune species.

The cost to plant one acre with native dune grass (*Elymus mollis*) was \$2,605.92 (\$0.64/m^2). If CCC labor had not been used, this planting cost would have been \$4,710.43/acre (\$1.16/m^2). This figure is based on a rate of \$0.05/culm. After the supplier realized the time and expense involved with digging this species, he requested that future orders be billed at \$0.07/culm. The price of the grass was 80% of the total cost, using CCC labor, for the planting of native dune grass. With the increased price per culm, the grass will become 84% of the total cost.

The projected total cost of the irrigation system is $26,892.60 which is 76% of the total cost, using CCC labor, of all aspects of the Planting Phase I; using paid labor, the irrigation represents 64% of the total. The total cost of this planting is approximately $35,382.01 with CCC labor, $42,062.01 with paid labor. Without the irrigation system, the total cost would have been $8,489.41 with CCC labor or $15,169.41 with paid labor. Planting during the winter months would significantly lower costs.

TABLE 2:
GENERAL COST ANALYSIS

Propagule	Area Acres	Area (m^2)	Man-hours Collection	Cost of Collection	Man-hours Planting	Cost of Planting	Man-hour/Area m-h/acre	Man-hour/Area (m-h/m^2)
SEEDS	0.74	(3000)	167.12	$1,336.96	135.75*	$1,086.00*	409.3	(0.10)
VEGETATIVE	0.03	(120)	71.25*	$ 570.00*	44.00*	$ 352.00*	3,841.7	(0.96)
ELYMUS	2.22	(9000)	N/A	$4,600.00	584.00*	$4,672.00*	263.1[a]	(0.065)[a]

continued below

Propagule	Additional Man-hour $	Supervision Cost	Equipment	Mileage	Total Cost w/o CCCs	Total Cost w/ CCCs	$/Acre w/o CCCs	$/Acre w/ CCCs
SEEDS	$15.50	$480.90	$250.00	$20.00	$ 3,189.36	$ 2,103.36	$ 4,309.95	$ 2,842.38
VEGETATIVE		$360.90	$200.00	$40.00	$ 1,522.90	$ 600.90	$50,763.33	$20,030.00
ELYMUS	$88.00	$777.15	$300.00	$20.00	$10,457.15	$ 5,785.15	$ 4,710.43	$ 2,605.92
SUBTOTAL					$15,169.41	$ 8,489.41	$ 5,073.38	$ 2,839.27
IRRIGATION					$26,892.60	$26,892.60	$ 8,994.18	$ 8,994.18
TOTAL					$42,062.01	$35,382.01	$14,067.56	$11,833.45

* =Labor hours supplied free of charge by the California Conservation Corps (CCCs)
N/A-not applicable, collection of *Elymus* done by another contractor; charge was by the piece.
a -hours based on planting only, hours for collecting are not applicable.

<u>MAINTENANCE RECOMMENDATIONS</u>

Great effort was put into the Buhne Point Demonstration Project to create a beach vegetated with native dune species. I have three recommendations that need to be followed to assure the successful establishment of the dune mat vegetation and dune grass plantings.

To maintain the native plant community of this beach, a regularly scheduled program for the eradication of exotic species will be necessary. Bush Lupine (<u>Lupinus</u> <u>arboreus</u>) and European beach grass (<u>Ammophila</u> <u>arenaria</u>), which occur in areas around the project site, are introduced species that out-compete the natives. Two seedlings of bush lupine have already been found (and destroyed) on the project site. These seedlings were found among driftwood brought on the site with the dredge spoils. Since neither of these species are presently on the site, a small number of man-hours per growing season could prevent establishment of these invasive species. The perimeter fencing needs to be maintained until a dense dune mat community has fully developed. Off-road vehicle use of the area would destroy the vegetative cover; vehicles should never be allowed on the site.

Preliminary results from the monitoring contract associated with this project show that the substrate is deficient in nitrogen. Therefore, all areas need to be fertilized annually with ammonium sulfate until adequate organic matter has accumulated and nitrogen is no longer limiting.

SEEDING

The seeds from native dune species collected under a previous contract were planted by the California Conservation Corps (CCCs) at the Buhne Point Demonstration Project. The large seeding beds (see Maps 1a and 1b) were raked to remove as much of the large debris in and on the soil as possible. Seed mixes were weighed and put into bags, each to cover 215.28 square feet (20 m^2). The seeds were raked into the sand in the large seeding beds. A portion of the seeding beds were later fertilized with 21-0-0 (coarse particle ammonium sulfate) at a rate of 400 pounds per acre. The specifications and details of the seed planting follow. An overview of the planting scheme can be found on Map 1a and 1b.

SEED TREATMENTS

Two common types of seed dormancy are physical dormancy and chemical dormancy. Species in the pea family (Leguminosae), such as beach pea (*Lathyrus littoralis*), and in the morning glory family (Convolvulaceae), such as beach morning glory (*Calystegia soldanella*) commonly have seeds that are physically dormant. Physical dormancy means that the seed coverings are impermeable to water. Scarification or acid treatment counteracts physical dormancy by damaging the seed coat and allowing the seed to imbibe water. The length of time for treating seeds with sulfuric acid is either not known or has not been published for most species. For this contract, scarification (scratching the seed coast with abrasives) was done by rubbing the seeds between two sheets of coarse-grained sandpaper.

Another type of seed dormancy, common in the buckwheat family (Polygonaceae) which includes seaside buckwheat (Eriogonum latifolium) and Polygonum paronychia, is chemical dormancy. A chemical found in the seed inhibits germination. Until this chemical has leached sufficiently, the seed will not germinate. Stratification and/or water soaking can be used to accelerate the leaching process. Stratification consists of surrounding the seeds in wet peat moss which increases the rate of leaching, and allows for germination of the seed. Also, chemical treatments can be used to counteract the inhibiting chemicals of the seed; however, the treatments are species-specific.

Other investigators have researched the problem of seed dormancy in native dune species. According to Susan A. Trent, author of the Pismo Revegetation Propagation Report, the best germination rates for beach bur (Ambrosia chamissonis) resulted from scarification + 36 hour water soaking + 45 day stratification. She found that scarification was necessary for the germination of beach morning glory (Calystegia soldanella); for beach pea (Lathyrus littoralis), scarification and a water soak were suggested. None of the other species that were planted at Buhne Point have a suggested treatment or belong to a plant family that is known for seed dormancy.

Due to the large area to be seeded, the damage that could result from the handling of seeds that had begun to germinate, and the difficulty of spreading wet seeds, all seeds were either left untreated or were scarified. The following species were scarified: *Polygonum paronychia*, beach bur (*Ambrosia chamissonis*), beach morning glory (*Calystegia soldanella*), and beach pea (*Lathyrus littoralis*).

Legume seeds are often inoculated with a bacteria culture that is specific to that legume species. In response to the symbiotic nitrogen-fixing bacteria, the host plant forms nodules on its roots. There is no documented inoculant for beach pea (*Lathyrus littoralis*), and nodules were not found on this species at the site where it was dug up. The nitrogen-fixing bacteria are not necessary for germination or survival of the species; however, growth is often greatly enhanced by the presence of such bacteria. Since no information was available on a specific inoculant, no attempt was made to inoculate the beach pea seeds or the soil of the seed beds.

A special note about the beach pea (*Lathyrus littoralis*) seeds: beach pea seeds collected after the pods had dehisced the seeds onto the sand had a brick-red colored seed coat that was easily scarred by the sandpaper treatment. Seeds that were shucked from ripe pods that had fallen from the plant, but had not dehisced the seeds onto the sand, generally had a tan to grey-green colored coat. During the drying process the seed coat did not turn red. The lighter colored seed coat was very hard to scarify. The difference in color and texture of the seed coat may be a response to sunlight that allows for easier and more consistent scarification and, therefore, better germination.

SEED APPLICATION RATES AND PLANTING

The rate at which the seeds are sown is critical. If the rate is too low, there will be too few plants to cover the area. If the rate is too high, competition among plants may reduce the size and quality of surviving plants. The rate of sowing can be estimated if the percent germination, percent purity, and the number of seeds per pound are known. Since these parameters are not known for most of the native dune species planted, the application rate for each species was based on:

1) Application rate suggested by commercial seed companies for the same or closely related species or subspecies.
2) Application rate suggested by commercial seed companies for similar sized seeds.
3) General information on germination rates.
4) Pounds of seeds collected for planting.

Application proportions for each species in the seed mix are derived from the application rate for monoculture of that species. Eleven species were included in the mix. These species and their monoculture application rates are listed in Table 3. The sources of these seeds are listed in Appendix 1. The poundage of seed per species for the mix was calculated as a ratio of the suggested species application rate to the combined monoculture application rate of all species, multiplied by the combined total poundage. For example, the poundage of a species with a monoculture application rate of 15 pounds/acre (such as seaside daisy, *Erigeron glaucus*) would be calculated as follows:

$$\text{lbs. of species in mix} = \frac{\text{mono. application rate}}{\text{combined mono. application rate of all species}} \times \text{total lbs. of mix}$$

$$\text{lbs. of } \underline{\text{Erigeron}} \text{ in mix} = \frac{15 \text{ lbs./acre}}{201 \text{ lbs./acre}} \times 14.82645 \text{ lbs. of mix} = 1.1064 \text{ lbs.}$$

The combined total poundage of seed in the mix was 14.82645 pounds. This figure is based on a total application rate of 20 pounds/acre for 0.741 acres. The calculated poundage of each species (see Table 3) was then put into a large trash can. The seeds were thoroughly mixed to prevent the carry-over of any collection site variation into the seeding beds. Then the mix was divided into seed caches of 0.0988 pounds, which will cover 215.28 square feet (20 m^2) at a total application rate of 20 pounds per acre.

TABLE 3

SEED APPLICATION RATES AND POUNDAGE IN SEED MIX

SPECIES	MONOCULTURE APPLICATION RATE LBS/ACRE	POUNDAGE IN MIX
Abronia latifolia yellow sand verbena	40	2.9505 lbs.
Ambrosia chamissonis beach bur	30	2.2129 lbs.
Calystegia soldanella beach morning glory	20	1.4753 lbs.
Camissonia cheiranthifolia beach evening primrose	1	0.0738 lbs.
Erigeron glaucus seaside daisy	15	1.1064 lbs.
Eriogonum latifolium seaside buckwheat	15	1.1064 lbs.
Lathyrus littoralis beach pea	20	1.4753 lbs.
Orthocarpus purpurascens var. latifolius owl's clover	5	0.3688 lbs.
Polygonum paronychia no common name	20	1.4753 lbs.
Solidago spathulata goldenrod	15	1.1064 lbs.
Tanacetum douglasii dune tansy	20	1.4753 lbs.

The areas to be seeded were raked to remove the large shell fragments and rocks that covered the surface of the planting site. Each seeding bed (see Maps 1a and 1b) was measured and staked out. Guide-lines were set up to mark the rows to be seeded. Guide-lines consisted of two stakes tied together with a string which has specific intervals marked on it. Within each bed, five rows were seeded, each 2 meters wide. Seeded rows were 6.56 feet (two meters) apart, except where the plan was altered to give a right-of-way for the irrigation system.

The planting scheme of the three largest seeding beds was altered to include some fertilization. This alteration was suggested by the preliminary data gathered from Study Areas I and II (see Map 1a and report on Monitoring). Germination of the seeds was somewhat inhibited by the addition of fertilizer to the beds at the time of sowing. However, those seeds that did germinate had noticeably greater growth rate and produced robust plants. It was concluded that fertilization might have a more beneficial effect after germination had occurred.

Therefore, the western one-half of the three largest seed beds were fertilized approximately 8 1/2 weeks after the beds were planted, which was three to six weeks after germination, depending on the species. Ammonium sulfate (21-0-0) was applied at a rate of 400 pounds/acre. The fertilizer was spread over the entire western one-half of the seed bed, including the areas between the seed rows. The areas between the seed rows were also fertilized because seeds can be found outside the original seed beds due to the high winds that occurred after the rain planting and due to disturbance of the beds during the installation of the irrigation system.

The results of this fertilization should be visually evident after one years growth. If the plants on the western one-half of each bed are indeed larger and more numerous, then this scheme of germination followed by a later fertilization could be used with good success.

The cost of this fertilization was $30.00 for three bags of ammonium sulfate + 5.0 man-hours in labor (3.5 hours for fertilizing area and 1.5 hours for gathering materials and approximate staking of original seed rows) + $3.25 for mileage. The total area fertilized was 0.67 acres (2700 meters square). These figures yield a total cost of $113.80/acre for the fertilization.

MAN-HOURS FOR SEEDING

The actual processes included in the seeding task are the staking of the seeding beds (8 man-hours), the set-up of the guide strings (4 man-hours), raking debris from top layer of sand (32 man-hours), actual seeding (81.75 man-hours), and quality control--making sure the seeds are covered--(4 man-hours). The sum of these man-hours (135.75 man-hours) divided by the total seeded area of 0.74 acres (3000 meters square) yields the man-hours required to seed a unit area: 183.45 man-hours/acre (0.045

man-hours/meter square).

NOTES

An even dispersion of the seeds was difficult due the wide range in seed size, the cohesion between seeds, the wet and windy weather conditions, the experience of the spreaders, and the tendency certain species had for sticking to the plastic cache bags. This resulted in closely clumped plants which may increase between-plant competition.

The raking process did not always adequately cover all the seeds; "quality controllers" were used to cover these seeds. High winds occurred after the seeding; these winds eroded the sand out from under the larger seeds. Therefore, beach pea (*Lathyrus littoralis*) and beach morning glory (*Calystegia soldanella*) seeds were commonly found on top of the substrate after the wind storm. Where possible, these seeds were replanted, but many remained on top of the sand.

Seedlings were trampled by the numerous dogs that roam the area unleashed and by the crew that installed the irrigaiton system. Foot access to the area needs to be restricted to the areas that were not planted, and barriers should be installed that would restrict all access to the area by dogs.

VEGETATIVE PROPAGATION

The collection, treatment, and planting of the sprigs are outlined in this section for all species except the native dune grass (*Elymus mollis*).

COLLECTION

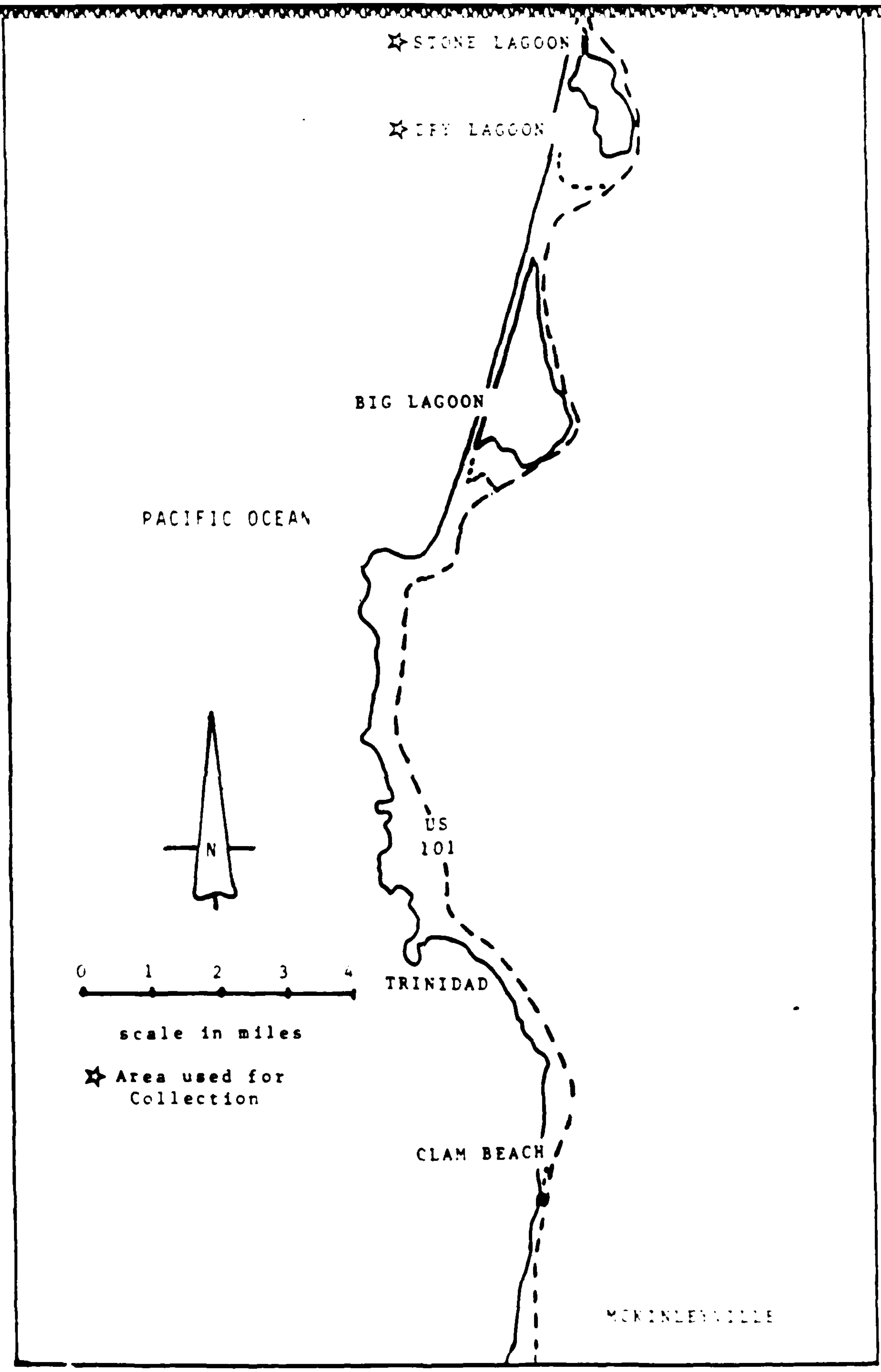
Sites identified during the seed collection phase were used for the collection of vegetative propagules. Sites were chosen based on the vigor of the population at that site. A variety of sites were used so as not to over-collect from one site, and to add variation to the stock used on the demonstration site. A permit from the California State Parks was required to collect off Dry and Stone Lagoons. The site used for the collection of each of the propagules, as well as the type of division collected, is listed in Table 4 by species. These sites are also located on Maps 2 and 3.

TABLE 4.

COLLECTION SITES AND TYPE OF DIVISION COLLECTED

SPECIES	DIVISION	COLLECTION SITE
Artemisia pycnocephala beach sagewort	rootings and cuttings	Samoa Peninsula—near the Louisiana-Pacific Mill
Calystegia soldanella beach morning glory	rootings	Dry Lagoon
Fragaria chiloensis beach strawberry	rootings	Stone Lagoon
Lathyrus littoralis beach pea	rootings and cuttings	Elk River Spit
Poa douglasii beach bluegrass	rootings	Elk River Spit
Solidago spathulata goldenrod	cuttings	Elk River Spit
Tanacetum douglasii dune tansy	rootings	Samoa Peninsula—near the Coast Guard Station

Beach strawberry (*Fragaria chiloensis*), beach morning glory (*Calystegia soldanella*), beach pea (*Lathyrus littoralis*), and beach bluegrass (*Poa douglasii*), were all collected in the morning of March 26 and planted later that afternoon. Dune tansy (*Tanacetum douglasii*) and beach sagewort (*Artemisia pycnocephala*) were collected in the morning on March 27 and planted later that afternoon. It rained heavily all day March 26 and into the morning of through March 27. Necessary equipment for collection and planting of the propagules includes shovels, trowels, knifes, large garbage bags, and guide-lines.



MAP 2 Collection Sites North of McKinleyville, California

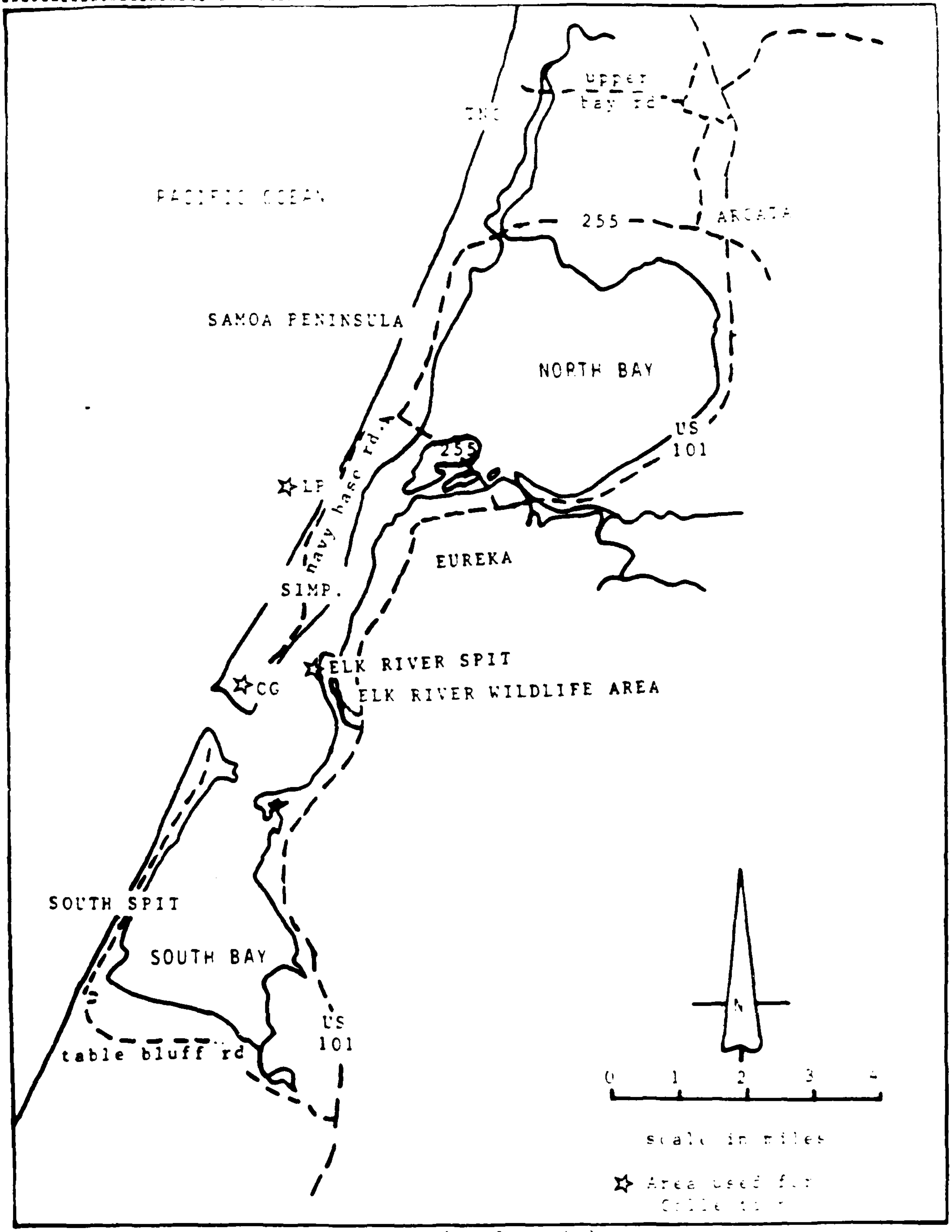


FIG. 3 Collection Sites in Humboldt Bay, California

VEGETATIVE PROPAGULE PLANTING AND TREATMENTS

The planting scheme of these rootings and cuttings can be found on Map 1a and 1b. Each vegetative propagule bed consisted of 50 plants with the specified treatment and 50 plants without the treatment. There is one bed per species except for beach sagewort (Artemisia pycnocephala) and beach strawberry (Fragaria chiloensis), each with two beds. Behind Dune IV there is a bed of beach strawberry on either side of the beach morning glory (Calystegia soldanella) bed. Behind Dune III lies a bed of beach sagewort rootings and a bed of beach pea (Lathyrus littoralis). The bed of beach pea is arranged such that 25 rootings and 25 cuttings, both with treatment, are located in one plot and 25 rooting and 25 cuttings, both without treatment, are found in the other plot. These two plots make up the beach pea bed. Dune tansy (Tanacetum douglasii) rootings are planted behind Dune II. Beach bluegrass (Poa douglasii) culms and beach sagewort cuttings are planted either side of the seed bed behind Dune VI. Additional beds of beach bluegrass are located between Dune V and Dune VI, all with treatment. Two beds of goldenrod (Solidago spathulata) are located behind Dune II, all with treatment. The additional beds of bluegrass and the beds of goldenrod were planted to utilize available CCC labor after all the native dune grass (Elymus mollis) stock had been planted.

For all the above vegetatively propagated species the treatment used on 50% of the divisions was a rooting hormone (Rootone), except for beach bluegrass (Poa douglasii). Half of the beach bluegrass was treated at the time of planting with ammonium sulfate (21-0-0) applied at a rate of 400 pounds per acre. When appropriate, the division was prepared for planting by making an angle cut on the end of the stem or root. These divisions were planted to a depth corresponding to the length of the stem or root, and the sand was compacted around the newly planted division. Spacing of all the divisions was 18 inches (0.45 meters) X 18 inches (0.45 meters), in plots that were approximately 6 feet (1.83 meters) X 13.5 feet (4.12 meters). Two plots are planted per bed, one with the treatment, one without the treatment. The same spacing was used for all species to reduce the time spent retraining the CCCs and re-marking the guide strings.

VEGETATIVE PROPAGATION MAN-HOURS

The man hours involved in the vegetative propagation portion of this contract can be divided into three categories: travel (14.5 man-hours), collecting (56.75 man-hours), and planting (44 man-hours). The sum of these figures yields a total of 115.25 hours for this process.

Approximately 0.0298 acres (120.4 meters square) were planted. (This figure for the area planted does not include the additional plantings of dune bluegrass or goldenrod.) The average number of man-hours per unit area for the vegetative propagation portion of this planting, based on a spacing of 18 inches (0.45 meters) was 3867.45 man-hour/acre (or 0.96 man-hours/meter square). This estimate is extremely conservative. A large amount of time was spent traveling, and very few sprigs were collected at each site. If the amount of sprigs collected per site was increased, then the amount of area planted per unit time would significantly increase.

NOTES

Two problems were encountered with the vegetative propagation portion of this contract. Collection and planting of the divisions was difficult in the heavy rains and winds. Also, due to inexperience or haste on the part of the CCCs, detrimental J-rooting (placing the rooting in the hole with the root portion curving upwards) was common in the beach morning glory (Calystegia soldanella) bed. Each beach morning glory planting was inspected and many had to be redone. The rootings of beach morning glory collected were long; they included the season's new leaves, roots, and a portion of the large perennial root stock. All vegetative propagation beds were inspected during the planting. No other problems with the planting techniques were found.

None of the vegetative propagation beds received regular and/or even watering by the installed irrigation system, except the beach sagewort (Artemisia pycnocephala) cuttings. Therefore, accessory lines were added to the system to evenly cover these beds. For more information on this subject, see the section on irrigation.

DUNE GRASS PLANTING*

The native dune grass (Elymus mollis) was planted in approximately the areas outlined on the original planting scheme. Grass supplied by Wilbur Ternyik of the Wave Beachgrass Nursery in Florence, Oregon, was planted by two different teams of the CCCs. After a dune was planted the area was fertilized. Details of the planting follow.

SUPPLIER

Mr. Wilbur Ternyik supplied most of the dune grass planted on the demonstration site. The grass was priced by the piece, five cents per culm. The schedule originally arranged with the first CCC crew for all the seeding, vegetative propagation, and dune grass planting covered the last two weeks in March. Just prior to the scheduled starting date, Mr. Ternyik alerted us that he would not be able to make his deadline. The two week period originally arranged for CCC labor was cut to three days and limited to seeding and collecting and planting of other vegetative propagules.

The next scheduled deadline for delivery by Mr. Ternyik was April 22. This date gave him ample time and was acceptable to the CCC crew. Mr. Ternyik delivered approximately 25,000-30,000 culms, out of the expected 135,000 culms. These culms were collected while dormant; collecting during dormancy increases the survival rate of the plants. The CCC labor scheduled for the

* See Addendum concerning extensive Ammophila arenaria contamination.

week planted beachgrass until Thursday morning, at which point the stock ran out. To fill in the remaining time, additional local dune grass stock and incidental divisions of goldenrod (Solidago spathulata) and beach bluegrass (Poa douglasii) were collected and planted by the CCCs. All of this additional stock was collected from Elk River Spit.

Mr. Ternyik was to deliver the remaining stock by May 6. Due to the prior difficulties in obtaining stock from this supplier, the spacing on the guide lines was increased overall to 24 inches (0.61 meters) X 24 inches (0.61 meters). To increase the survival rate of the plants, the total area to be planted was reduced to only the areas that could be reached by the irrigation system. The total order of dune grass was reduced to 80,000 culms from 135,000 culms. On May 6, Mr. Ternyik delivered the final 50,000 culms. However, most of these culms had already broken dormancy. Due to the reduced planting area and the increased spacing, not all of the supplied stock was planted. The unplanted stock remains heeled-in on the site.

DUNE GRASS PLANTING

The CCCs were trained in the art of native dune grass (Elymus mollis) planting by Mr. Ternyik and the consulting botanist. The planters worked in pairs. A tile spade held backwards was used by one member of the pair to make a deep hole, and a person following along inserted the culms and closed the hole. Tile spades did prove to be faster than shovels for making the holes. A total of eight tile spades were purchased at a cost of $20 each.

Back-lines were set up along the back edge of the dune with markings every 18 inches (0.45 meters) for Dune IV, and 24 inches (0.61 meters) for all other dunes. Each pair of planters had a guide-line, marked every 24 inches (0.61 meters), which they placed at right angles to the back-line for the rows. The lines were flared near the base of Dune IV to not more than 24 inches (0.61 meters) between rows.

The hills were planted at 2 culms per hill. The first shipment of stock was from obviously older plants and was collected while dormant. The stock was shipped in plugs of approximately 1 to 10 culms. The CCCs had a problem identifying the presence of more than two culms in a plug with this stock. Therefore, Dune IV has a highly variable number of culms per hill. Fifty hills from this dune were randomly sampled: the mean number of culms per hill was 2.76.

The number of culms per plug was easier to identify in the later shipment. Closer attention was paid by the CCC supervisor and the consulting botanist, and more numerous inspections were conducted to regulate the number of culms per hill. These factors resulted in all other dunes being planted at a consistent 2 culms/hill.

The actual depth of the hole was determined by the compactness of the substrate and the plant stock. The substrate on the windward side of the front dunes (Dunes IV & VI) is rather hard below a depth of approximately six inches; therefore, the recommended depth of 8-12 inches could not be readily attained. Also, the stock that was supplied at the latter date had shorter culms and did not need to be planted at greater than six inches. The plantings were regularly inspected; culms not planted deep enough were replanted.

DUNE GRASS MAN-HOURS

The hills/man-hour for the planting of native dune grass (*Elymus mollis*) is divided into two sections corresponding to the two shipments and the two different CCC crews. The number of members per crew per day was similar for both crews and ranged from nine to thirteen.

TABLE 5
MAN-HOURS NECESSARY FOR *ELYMUS* PLANTING

ACTIVITY	SHIPMENT & CREW #1	SHIPMENT & CREW #2
Prep, Training, Heeling-in	12 man-hours	27 man-hours
Elymus planting—range	35-39 hills/man-hour	57-83 hills/man-hour
Elymus planting—mean	38 hills/man-hour	64 hills/man-hour

The differences between shipment and crew #1 and shipment and crew #2 are obvious in the above table. The differences between the two values for preparation, training, and heeling-in man-hours are explained by the facts that crew #2 had twice the amount of native dune grass (Elymus mollis) to heel-in and the dunes planted by crew #2 were on the average farther removed from the area were the native dune grass was unloaded.

Differences between the hills/man-hour planted are also obvious. High winds were common during the week that crew #1 planted, making eyewear necessary and planting more difficult and uncomfortable. Crew #1 planted only on Dune IV, one of the dunes with firmly packed substrate at a depth of approximately six inches on the windward side. Some of the holes dug in this area had to be shoveled out to attain the necessary depth, rather than just "punched in". This extra amount of shoveling was very time consuming. Crew #2 had the same problem on Dune VI but to a much lesser extent. Crew #2 planted Dune II, III, V, and VI.

The number of hills planted per man-hour for this project were lower than has been reported by other revegetation projects. Woodhouse reported a rate of 130 to 150 hills per man-hour. Redwood Community Action Agency (RCAA) reported 60 to 100 hills per man-hour. Our values of 38 and 64 hills per man-hour are obviously at the low end of the reported ranges or below.

Our low values are in part due to the substrate of the area. Certain locations on the project, especially the area in front of Dunes IV and VI, are hard packed sand and gravel below about 6 inches. Two tile spades were broken on large rocks located below the surface; all of the tile spades were bent to a certain extent.

Other reasons for the low amount of hills per man-hour are connected to the prevalent windy conditions on the site. The high winds encountered during the first planting made conditions miserable and necessitated the use of guide-lines rather than markings in the sand. The use of guide lines slowed the crews. The crews could probably have increased the hills planted per man-hour by 50% if markings had been used. A combination of strings and markings should be used; strings on the extremely windy days and markings on the calm days.

After the dunes were completely planted, the areas were fertilized at a rate of 400 pounds/acre. Approximately 11 bags (at 80 pounds each) of fertilizer were spread. The cost of the fertilization was $110 for the fertilizer, $11 for the spreader (whirly-bird), 2 man-hours for organization of materials and training, and 9 man-hours for actual spreading of fertilizer. See Table 2 for a cost analysis.

NOTES

It was determined during this contract that with the native dune grass (Elymus mollis), unlike the European beach grass (Ammophila arenaria), the outer leaves do not need to be stripped away from the culms to expose the nodes. The robust native dune grass produces roots that can penetrate the outer leaves. These outer leaves help to protect the delicate nodes from physical damage during planting.

IRRIGATION

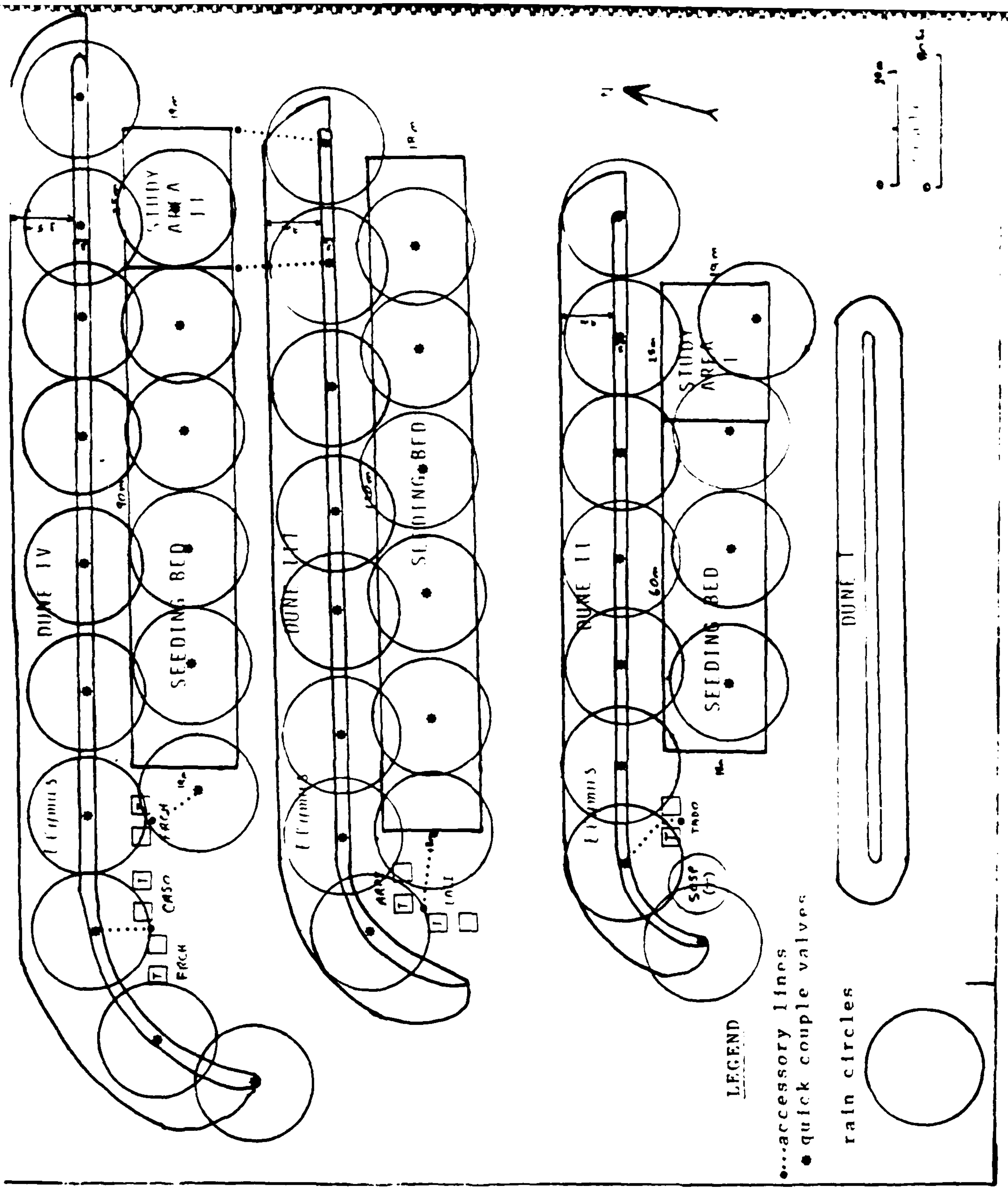
To increase the survival rate of seedlings and sprigs, planting should be done in the early winter months (i.e. November). The Buhne Point Phase I planting was experimental in nature and was not started until late March, and not completed until mid-May. Therefore, all areas required watering for germination and growth. While this section of the report outlines the high costs and frequent problems involved with the irrigation system, one must keep in mind that without the system the survival rate of the plants would have been near zero.

The irrigation system was designed by the Army Corps of Engineers to water the plants and to minimize sand movement under extreme wind conditions. Miller Farms installed the system. The irrigation system consists of pulsating sprinkler heads attached to quick coupler keys. The keys fit the head into the permanently installed system. Most of the system is below ground (about 3 feet), with only the quick coupler valves above the surface. This design of a below-ground permanent system with aboveground, removable sprinkler heads was used to minimize vandalism.

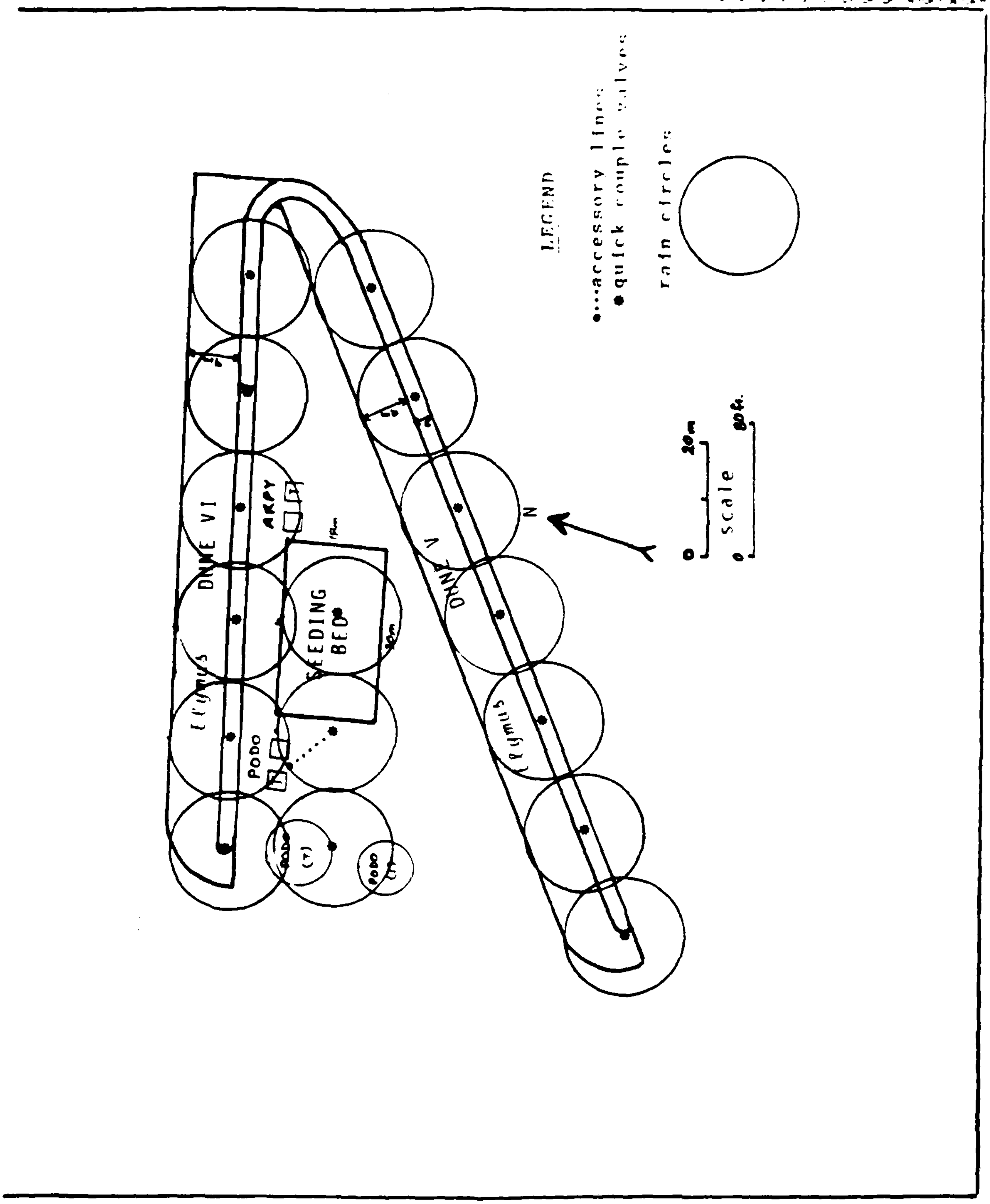
The system was designed to water the large seed beds, study areas, and native dune grass (Elymus mollis) plantings, using the specification of a 35-foot radius per sprinkler head. However, the design failed to take into account the windy conditions that are the norm on the site due its exposed location directly across from Entrance Bay. The calmest hours are in the very early morning (until 8 or 9 am.). To achieve the maximum coverage, the site has to be watered before the winds pick up.

Once the system was installed, it became apparent that even in a rare zero-wind condition, the system did not provide adequate coverage of the area. The irregular spacing of the heads (anywhere from 57.4 to 77.1 feet apart) and the 35 foot radius produced non-overlapping rain patterns, resulting in wet circles with dry areas between (see Maps 4a and 4b for the system layout). Only 75% of the large seed beds received water. Wind stretched the rain circles into ellipses and widened the dry gaps between rain circles. Some of the vegetative propagating areas receive uneven coverage and other areas received almost no water at all. The dune grass plantings are on the windward side of all the dunes; therefore, even a light wind had a large effect on the amount of water the grass receives. Except for the dune grass on Dune IV which was planted prior to the completion of the system, the planned planting of dune grass on all other dunes was rearranged to minimize the effect of the non-overlapping irrigation system.

The results from the study areas, Study Area I, II, and designated vegetative propagules, are to be statistically analyzed; therefore, these areas need to be evenly and consistently watered. The lack of even watering introduce extraneous factors into the tests that can not be blocked out. The vegetative propagation areas were planted prior to the installation of the irrigation system and so had to be watered by hand until the system was installed (30 man-hours). $225 worth



Map 4a: Schematic Drawing of the Eastern Portion of the Irrigation Plan, with 35' radius heads and zero wind conditions.



Map 4b: Schematic Drawing of the Western Portion of the Irrigation Plan, with 35' radius heads and zero wind conditions.

of hose was purchased to reach these areas with water. The temporary water source was a fire hydrant located on the street. Once installed, the irrigation system did not evenly water these propagules; therefore, hand watering was still necessary to achieve consistent results. Great effort was undertaken to keep these areas watered consistently and evenly.

Larger heads (50 foot range) were exchanged for some of the smaller heads (35 foot range), for an added fee, and accessory lines were added in strategic locations for the purpose of even coverage, adding 25 man-hours for installation + parts to the tally. The accessory lines, which do not always function correctly, are more visible and more vulnerable to vandalism. These lines consist of a hose buried about one foot below the surface to which a quick coupler key can be attached at one end with the other end wired to a piece of re-bar to which a sprinkler head can be attached.

Another problem with the irrigation system was the large number of line breakages that occurred during the first few weeks of operation, rendering portions of the system non-operational for periods of time. When a study area was located near a down line, the study area had to watered by hand, thereby doubling the man-hours necessary to completely water the area.

The large seed beds were the lowest priority; therefore, they experienced erratic watering during the first few weeks of operation due to breakages and lack of parts needed to completely use the system. Erratic watering may have had an adverse effect on the seedlings. If a seed has initiated germination and then is allowed to become desiccated, the embryo will be killed. Differential germination rates between the hand-watered study areas and the large seed beds will demonstrate how much of an effect the erratic watering schedule had on the seeds.

The seed beds were also affected by the disturbance associated with the placement and repair of the lines. Some areas had to be restaked to add the extra area necessary to open a three-meter wide corridor for the placement of the lines. The lines did not follow parallel to the seeding rows and so dug up more of the seed beds than was necessary (one area has most of one row gone). The disturbance was not restricted to the specified three-meter corridor; study plots were disturbed. The installation and repair crew did not restrict their foot access to the corridors as directed. As a result, seedlings were trampled.

COST

The total cost for the installation and operation of the irrigation system is estimated to be $26,892.60. Installation of the irrigation system by Miller Farms of Mckinleyville cost approximately $18,300. The cost of connecting the irrigation system to a large meter was $1,540. A minimum monthly service charge of $54.70 for eight months equals a total of $437.60 in service charges. Water is estimated to cost $1200 for the season (April-November). The difference in price between the eight smaller sprinkler heads for the eight large heads is approximately $16.50 per head resulting in an added cost of $[illegible]. The number of man-hours necessary to put the heads in place and turn the system on for the full season is projected to be around 660 man-hours. This figure is based on the following information:

1) documented hours from 4/27-5/15—botanical consultant 110 m-h*
2) ± documented hours from 5/16-6/10—Army Corps 82 m-h
3) estimated hours for contractor 6/11-11/1 240 m-h
4) estimated hours for maintenance—contractor 100 m-h
5) estimated hours for emergency operation—contractor 128 m-h

*includes hours for hand watering where necessary, due to line breakage and inadequate coverage by heads.

Using an estimate of $8/hour for the 660 man-hours, a total of $5280 is obtained for operation of the irrigation system per the following schedule.

IRRIGATION SCHEDULE

Normal Operation	Irrigation Frequency	Irrigation Duration	Number of Days
4/27-5/15	7 days/week	15 minutes	19
5/16-6/26	6 days/week	15 minutes	26
6/27-8/21	3 days/week	30 minutes	24
8/22-11/1	2 days/week	30 minutes	20

SUMMARY

A dune system was created from dredge spoils at Buhne Point to protect an area known as King Salmon from tidal erosion. The dune system is to be vegetated to stabilize the sand. Prior to the full scale planting, an experimental planting took place to evaluate different methods and specifications that could be used for the full scale planting. This document details all methods and costs involved with the different aspects of the experimental dune vegetation plan.

Three major plantings were included in the vegetation plan. First, large seed beds were planted using a calculated seed mix applied at a rate of 20 pounds/acre. Next, areas were selected for sprigging. Finally, native dune grass culms were placed at calculated distances on the windward side of on all but one of the man-made dunes.

The seeds included in the seed mix were collected under a separate contract the preceding fall. Four of the species were treated for seed coat dormancy: beach bur (*Ambrosia chamissonis*), beach morning glory (*Calystegia soldanella*), beach pea (*Lathyrus littoralis*), and *Polygonum paronychia*. Seed mixtures were raked into five two-meter wide rows per seed bed; seed beds varied in length. High winds immediately followed the seeding of these beds and many plants can presently be found outside of the original seeding areas.

The western one-half of the three largest seed beds were fertilized approximately 8-1 2 weeks after the beds were planted,

which was three to six weeks following germination, depending on the species. Vigorous growth followed this fertilization; therefore, the rest of the seed beds (except for one control row) was fertilized on August 19, approximately 3-1/2 to four months following germination.

Rootings and cuttings of the species listed in Table 1 under vegetative propagules were collected locally and planted usually on the same day. Treatment of these propagules included root hormone or fertilization. Very few propagules were collected at each locality; accordingly, few were planted at the site. Therefore, the cost of sprigging as estimated by this report overestimates the projected cost of a full scale project.

The dune grass (Elymus mollis) was supplied by Mr. Wilbur Ternyik of Wave Beachgrass Nursery, Florence Oregon. Mr. Ternyik had a hard time sticking to the supply schedule, and in August, after the plants had become somewhat mature, it became apparent that approximately 40% of his second shipment was actually the highly invasive, European beach grass (Ammophila arenaria).

The dune grass was planted at 2 culms/hill and fertilized within two weeks after planting. The man-hours required for the planting of the dune grass on Buhne Point was lower than that reported by other projects and varied with the weather and the crew (ranged from 35 to 83 hills/man-hour). Two reasons for the low number of hills planted per man-hour are: the use of guidelines rather than markings in the sand and, the presence of a hard substrate that made digging difficult in some areas on

Buhne Point.

The cost per acre for each of the three different plantings was calculated using CCC labor (at no cost to the county) and using paid labor (estimated at $8/hour). Using the CCC labor, the cost of seeding the large seed beds was $2,842.38/acre; the cost of sprigging for all species except dune grass (Elymus mollis) was $20,030.00/acre; and the cost for planting the dune grass was $2,605.92/acre.

If paid labor had been used in place of the CCCs, the cost of seeding would have been $4,309.95/acre; the cost of sprigging would have been $50,763.33/acre; and the cost for planting dune grass would have been $4,701.43/acre. This extrapolation is based on the assumption, perhaps unwarranted, that a private crew (non-CCCs) would have taken the same amount of time to complete all tasks included in each planting.

To be able to compare the costs involved with seeding a species versus sprigging that species, density and survival data need to be calculated. Such data is beyond the scope of this contract and report; however, in August (1985), mortality estimates were calculated for the dune grass. This information can be found in the Addendum.

This experimental planting occurred in the spring of 1985, after the rainy season. Therefore, irrigation was necessary to insure the survival of the plantings and to stablize roving sand under extreme wind conditions. The total cost of the irrigation is estimated to be $26,892.60, which is 76% of the total cost of the Phase I Planting.

In order to assure the survival of these plantings, the perimeter fencing will have to be maintained until the plants have become permanently established at the site. Annual fertilizing will be necessary until a soil develops on the site that contains essential elements, particularly nitrogen. To maintain the native species dominance of the area, annual maintenance should include eradication of exotic species.

ADDENDUM

This addendum was added to the Phase One Planting Report in August, 1985, during the printing of the final draft. The purpose of this addendum is to document two significant developments and to estimate mortality for the dune grass plantings (Elymus mollis).

The first development is that, in the seeding beds, much more robust growth occurred in the areas that received fertilizer (21-0-0) than in the unfertilized areas. Therefore, in August, the remaining areas of the seed beds were fertilized, with the exception of one control row located behind Dune II.

The second development is the discovery that a large portion of the grass supplied by Mr. Wilbur Ternyik of Wave Beachgrass Nursery, Florence, Oregon, was actually the highly invasive European beach grass (Ammophila arenaria). To estimate the amount of European beach grass supplied, each live hill was counted and the species composing that hill noted.

The results of the counts on the dunes confirmed that both shipments from Mr. Ternyik contained European beach grass. The first shipment was only slightly contaminated. A total of 10 hills of European beach grass were found, representing 0.09% of the total first shipment. The second shipment contained an estimated 20,717 European beach grass culms out of the total 50,000 culms supplied. This figure for European beach grass represents 41.4% of the second shipment.

At the time of dune grass planting, there was little difference detectable in the two different species. The European beach grass culms that had broken dormancy had slightly lighter green leaves than the native dune grass; however, the leaves of the European beach grass were uncharacteristically wide (resembling native dune grass).

As the culms matured, the color difference became much more apparent. When the inflorescences developed, I was able to determine that the lighter color grass was indeed European beach grass. A sample of the grass has been supplied to Dr. James P. Smith, an agrostologist at Humboldt State University, Arcata, for final determination.

The removal of all European beach grass from the project site is scheduled for August. The effect on the project will be significant. Dunes III and VI are almost all European beach grass. Removal of the beach grass from these two dunes will expose these areas to wind erosion. Emergency operation of the irrigation system may be needed to prevent sand movement.

I suggest that all dead hills be dug-up. Since positive identification is not always possible for the dead hills, all dead root stock should also be removed to insure against future growth. Any live rootstocks or rhizomes of the European beach grass left on the site may sprout new plants during future seasons. This includes the rootstock that remains heeled-in at the site.

Dead hills were counted to estimate mortality; however, the identification of the species of the dead culms was difficult. Therefore, mortality rates for the dune and beach grass plantings were determined without regard to species. The mortality rates for the grasses varied widely between shipments and dunes (see Table 6). The mortality estimates were calculated by dividing the number of dead hills per dune by the number of hills planted on that dune.

The different mortality rates between shipments was due, at least in part, to the watering problems associated with the first plantings. The irrigation system was not completed before the first shipment arrived and Dune IV was planted. Therefore, the area was planted according to the original plans. Many of the hills on Dune IV were never reached by the irrigation (see Map 4a). Also, the plants on Dune IV experienced periods of drought immediately after planting due to the problems associated with the operation of the irrigation system. In some areas on Dune IV, groups of dead hills are surrounded by live plants, indicating adequate irrigation. Mortality of these areas is more likely linked to the low vigor of the stock supplied than the irrigation system.

Difference in mortality rates between dunes within shipment 2 is associated with the irrigation system and the percentage of European beach grass planted on that dune. When the identity of the dead culm was possible to determine, I observed that there were more dead European beach grass hills than dead native beach grass hills. Therefore, a dune comprised largely of European beach grass will generally have a higher mortality rate, all other factors held constant. The mortality counts for Dune V were affected by the irrigation scheme. Dune V has generally high mortality. The counts for this dune include the v-section, an area that does not receive adequate irrigation.

TABLE 6:
PERCENT EUROPEAN BEACH GRASS (AMMOPHILA ARENARIA) AND MORTALITY ESTIMATES

DUNE NUMBER	TOTAL HILLS PLANTED	TOTAL HILLS DEAD	TOTAL PERCENT AMMOPHILA	TOTAL HILL MORTALITY
SHIPMENT 1: (planted @ 2.7 culms/hill)				
IV	10,610	5,000	0.09%	47.1%
SHIPMENT 2: (planted @ 2 culms/hill)				
II	3,664	474	8.2%	12.9%
III	5,524	1,273	80.9%	23.0%
V	5,001	2,032	7.3%	40.6%
VI	3,462	2,292	97.8%	66.2%
TOTALS	28,261	11,071	41.4%*	39.2%

* total includes estimate of *Ammophila* in heeled-in material.

APPENDIX 1:
CARD INFORMATION BY SPECIES FOR SPECIES INCLUDES IN SEED MIX

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
ABLA	09/09/84	1	A	1	0.226	0.33	N/P	used strainer, ripe now
ABLA	09/13/84	4	A	1	0.268	0.33	N/P	
ABLA	09/13/84	4	A	2	0.545	0.33	N/P	
ABLA	09/14/84	3	A	2	0.479	0.33	0.50	sifted through sand
ABLA	09/11/84	3	B	1	0.440	0.50	0.25	dried 12 hrs @ 100 F
ABLA	09/12/84	4	B	1	0.535	1.00	N/P	black beetles in with seeds, sifted through sand
ABLA	09/28/84	4	C	1	0.941	0.42	N/P	dried 16 hrs @ 100 F
ABLA	09/28/84	4	C	2	3.695	1.42	N/P	sifted through sand for seeds, est. 40% dispores empty, dried 16h @ 110 F
ABLA	09/17/84	3	E	1	1.664	1.25	N/P	beetles infested, sift through sand for seeds, dried 12 hrs @ 110 F
AMCH	10/25/84	1	G	1	1.450	1.50	N/P	dried 17 hrs @ 100 F
AMCH	10/25/84	2	G	1	1.153	1.50	N/P	in scattered patches in various stages of ripeness, some dehisced
ARPY	09/09/84	1	B	1	0.024	0.17	0.78	sand present in final product
ARPY	09/12/84	2	B	1	0.072	1.50	0.92	see 09/13/2B1
ARPY	09/12/84	4	B	1	0.008	1.50	2.43	striped panicle with fingers, dried 14 hrs @ 100 F
ARPY	09/13/84	2	B	1	0.012		0.65	mislabeled, see 9/12/84 2B1 for coll time
ARPY	09/19/84	2	B	1	0.063	1.03	1.42	
CACH	09/13/84	1	A	1	0.081	0.50	4.50	collected whole infl, capsules somewhat dehisced, dried in sun
CACH	09/20/84	2	A	1	0.023	0.22	0.92	dried 24 hrs @ 100 F
CACH	09/20/84	2	A	2	0.022	0.20	0.67	
CASO	09/12/84	4	B	1	0.382	1.50	0.58	plants widely separated, picked pods, dried @100 F
CASO	09/20/84	7	D	1	0.218	1.77	0.88	collected pods and loose seeds, dried 4 days in pilot oven

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
CASO	09/24/84	1	E	1	0.249	1.75	1.00	rust fungus, pick earlier in season-many dehisced, good spot
CASO	09/25/84	2	E	1	0.278	1.58	0.83	most pods dehisced
CASO	09/22/84	1	F	1	0.135	1.00	0.75	good population, easy access, many already dehisced
CASO	09/22/84	2	F	1	0.122	2.00	0.50	dried in sun
CASO	11/31/84	2	G	1	0.304	1.83		dried 22 hrs @ 100F
ERGL	09/13/84	3	A	1	0.280	1.50	INCL	pappus and achenes, 80% in fruit, dried 10 hrs @ 100 F
ERGL	09/13/84	3	A	3	0.300	2.00	N/P	collected pappus with achene
ERGL	09/13/84	4	A	1	0.343	0.75	N/P	dried 10 hrs @ 100F
ERGL	09/16/84	3	A	1	0.049	0.17	INCL	pluck achenes and pappus off infl, dried 12 h @ 100 F
ERGL	09/16/84	6	A	1	0.178	2.00	INCL	heavily infested with insects, only undamaged seeds collected
ERGL	09/12/84	2	B	1	0.171		N/P	50% infl damaged by insects, dried for 10 h @ 100 F
ERLA	09/13/84	1	A	1	0.059	0.50	0.50	spiders included, some other species contaminated bag
ERLA	09/13/84	4	A	1	0.208	2.00	3.35	includes exper processing time, many larvae in infl
ERLA	09/13/84	4	A	2	0.023	0.67	1.00	larvae in seeds, dried in sun for 2 hrs
ERLA	09/14/84	2	A	1	0.096	0.83	0.25	processing time ont correct, insect damage,
ERLA	09/14/84	2	A	2	0.061	0.42	1.50	stopped due to rain, seeds wet, dried in pilot oven
ERLA	09/16/84	2	A	1	0.068	0.50	1.75	very wet, dried 14 hrs @ 100 F
ERLA	09/16/84	6	A	1	0.124	3.20	1.92	about 90% ripe, some larvae, dried 3 hrs @ 100 F
ERLA	09/19/84	5	A	1	0.267	1.42	1.25	sorted through heads due to insect damage
ERLA	09/24/84	2	A	1	0.213	0.97	3.83	dried in low oven
ERLA	09/25/84	5	A	1	0.210	0.92	0.75	
ERLA	09/11/84	1	B	1	0.061	0.17	1.33	use this pro time as est of learned time
ERLA	09/12/84	2	B	1	0.184	1.83	0.75	seeds damp when collected
ERLA	09/17/84	4	E	1	0.020	0.50	0.25	dried 15 hrs @ 100 F

SPECIES	DATE	PERSON	AREA	JAR	LBS	COLL TIME	PROC TIME	NOTES
LALI	09/09/84	1	A	1	0.455	4.25	INCL	ripe now, large amount of seeds with insect damage
LALI	09/13/84	1	A	1	0.596	5.00	INCL	10% seeds viable, usually 1 seed per pod, many pods without seeds
LALI	09/19/84	4	A	1	0.025	1.50	INCL	insect damage
LALI	09/19/84	5	A	1	0.010	0.33	INCL	approx 1 in 20 pods had a seed undamaged by insects
LALI	09/20/84	2	A	1	0.524	6.00	INCL	
LALI	09/20/84	5	A	1	0.390	4.42	INCL	
ORPU	09/21/84	2	A	1	0.335	0.40	2.35	dried in pilot oven and sun,
ORPU	09/19/84	2	B	1	0.071	0.30	0.75	infested by small black beetles about the same size of the seeds
POPA	09/17/84	2	E	1	2.972	21.4	6.33	not completely processed, mixed: 9/17-9/25 & Bott, Newton, Hayes
SOSP	09/14/84	1	A	1	0.099	0.33	N/P	
SOSP	09/14/84	1	A	2	0.116			no insect damage, some areas ripe, others not ripe, see #1
SOSP	09/21/84	2	A	1	0.312	0.18	N/P	dried 12h @ 110 F, wind-difficult collection, includes involucre
SOSP	09/21/84	2	A	4	0.474	0.35	N/P	dried for 14h @ 110 F
SOSP	09/17/84	6	F	1	0.132	2.80	N/P	30-40% ripe, some insect damage, dried 4 hrs @ 100 F
TADO	09/20/84	4	D	1	2.822	3.50	4.00	involucre pulled off, sun dried one day
TADO	09/27/84	2	D	1	0.257	1.77	2.25	most heads with some insect damage, processed longer--stems
TADO	11/15/84	4	D	1	0.424	1.58	0.75	most infl gone with rain storms dried 14 hrs @ 100 F, in 3 jars
TADO	11/16/84	4	D	1	0.458	0.83	0.50	dried 14 hrs @ 100 F, most processing done at site
TADO	09/22/84	2	F	1	0.036	0.20		large amount of insect damage, too windy to collect,
TADO	11/11/84	2	G	1	0.134			

N/P = not processed

APPENDIX 2

KEY TO COLLECTOR CODES AND SITE CODES USED IN APPENDIX 1 AND IN LABELED CONTAINERS

Each container was labeled with two codes: the species code (see Table 1), and the collection code. The collection code contains the date, collector, site, and jar number, in that order.

EXAMPLE: ABLA
09/09/84-1B-1

COLLECTORS	SITES
1 = Newton	A = The Nature Conservancy
2 = Bott	B = Samoa Peninsula--LP
3 = Harris	C = Samoa Peninsula--Simpson
4 = Hayes	D = Samoa Peninsula--Coast Guard
5 = Letton	E = Elk River Spit
6 = Schlexer	F = Elk River Wildlife Area
7 = Philbrick	G = South Spit
	H = Big Lagoon

SECTION 3

PHASE I: VEGETATION MONITORING REPORT

PHASE I
VEGETATION MONITORING
REPORT
BUHNE POINT SHORELINE
EROSION DEMONSTRATION PROJECT

Prepared By:

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Natural Resources Division
Humboldt County
Department of Public Works

March 1986

Submitted To:

U.S. Army Corps of Engineers
San Francisco District
Contract No. DACW07-85-C-0037

ABSTRACT

An eroded 23-acre sand spit was restored through jetty construction and fill (using dredge spoils) by the Corps of Engineers at King Salmon on Humboldt Bay, California. An experimental planting designed to test revegetation methods using native plants was initiated on the spit in March, 1985 by Humboldt County Public Works Department under contract to the Corps. The experimental planting included both quantitative and qualitative investigations of the success of different species and treatments.

Two study plots were used to quantitatively examine the effect of nine treatments on the germination, survival and first-year cover of nine native dune species. Treatments consisted of soluble and slow release fertilizers, compost, jute matting, hydromulch/ fertilizer, and three different seed application rates in a control situation. All trials were irrigated. Treatments were applied to the following species: *Abronia latifolia, Camissonia cheiranthifolia* ssp. *cheiranthifolia, Ambrosia chamissonis, Eriogonum latifolium, Calystegia soldanella, Erigeron glaucus, Tanacetum douglasii, Lathyrus littoralis, Artemisia pycnocephala.*

Monitoring occurred over one growing season. Germination was highest under control situations (due to fertilizer-induced toxicity occurring in fertilized treatment plots); however, cover was greatly enhanced under compost, fertilizer (particularly slow-release) and hydromulch/fertilizer treatments. Survival was not directly affected by treatment to a significant extent.

Species were compared under control conditions to evaluate stabilization suitability as a function of germination, survival and cover. Germination of small seed types (*Tanacetum, Camissonia* and *Artemisia*) exhibited low germination relative to larger seed types (*Ambrosia, Abronia* and *Lathyrus*). Low germination in small-seeded species was attributed to excess planting depth (preventing light infiltration necessary to overcome dormancy). *Calystegia, Erigeron* and *Eriogonum* (large-medium sized) also exhibiting low germination, were found to exhibit a high degree of dormancy.

Qualitative experiments consisted of comparison of control and root hormone-treated cuttings and divisions of five species: *Artemisia pycnocephala, Lathyrus littoralis, Fragaria chiloensis, Tanacetum douglasii* and *Calystegia soldanella*. *Poa douglasii* divisions were tested for the effect of adding nitrogen fertilizer. No significant differences were found among treatments for various growth characteristics such as plant height, number of leaves and rosette diameter. Overall, survival did not differ significantly among treatment. However, comparisons among species revealed that *Fragaria, Artemisia, Poa* and *Tanacetum* exhibited high survival rates relative to *Calystegia* and *Lathyrus*.

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INTRODUCTION AND PURPOSE

The Buhne Point sand spit, located west of the community of King Salmon on Humboldt Bay (see Figure 1), has historically been the focal point of wave energy passing through the Humboldt Bay jetties. Erosion of the spit accelerated in 1973, culminating in its complete disappearance in 1982. The resulting exposure of Buhne Drive and the King Salmon community to storm waves and flooding prompted a 1983 Congressional allocation of $9 million for use in a shoreline erosion control "demonstration project". The purpose of the project was two-fold: to replace and protect the spit from further erosion, and to demonstrate state-of-the-art methods which could be applied to other projects. The newly created spit was completed in August 1984, using dredge spoils from the Humboldt Bay entrance channel. In keeping with the "demonstration" nature of the project, stabilization of the spit surface was intended to exemplify revegetation techniques using native plants--thus avoiding the detrimental ecological impacts associated with non-native introductions.

A review of the literature and visits to the major dune revegetation projects on the California coast revealed that very little published or unpublished data on dune revegetation using native plants exist, and to date no large scale projects have been successfully completed (Pickart, 1985). Information generated by past projects is largely site specific due to the differing goals of revegetation attempts and wide variation in climatic, edaphic and floristic characteristics. For this reason, an on-site experimental planting was designed cooperatively by Humboldt County Public Works Department and the Los Angeles District Corps of Engineers. The experimental planting, initiated in March 1985, consisted of qualitative and quantitative tests to examine the suitability of selected dune species and the effectiveness of various planting techniques. Qualitative portions consisted of small scale plantings (2.5 acres) of dune grass (*Elymus mollis*) and meter-wide strips of a manually sown mix of native species. Details of the planting methods are contained in the report: Phase One Planting: Methods and Cost Analysis, Buhne Point Shoreline Erosion Demonstration Project (Newton, 1985). This portion of the planting was monitored qualitatively through a descriptive and photographic record, and results are not included in this report. Photographs are on file with the Natural Resources Division, Humboldt County Public Works Department and the S.F. District Corps of Engineers.

Quantitative experiments tested two classes of "treatments" or planting techniques. The first class consisted of artificial manipulations of two environmental parameters that greatly influence germination and development of dune plants: substrate mobility and nutrient availability. Water availability, a third influencing factor, was not tested but was held constant at a non-limiting level through irrigation.

The second class of treatments consisted of seed application rates. Three application rates were examined under a control situation in an attempt to determine an optimum range falling between inadequacy (insufficient substrate stabilization) and overabundance (detrimental competitive effects).

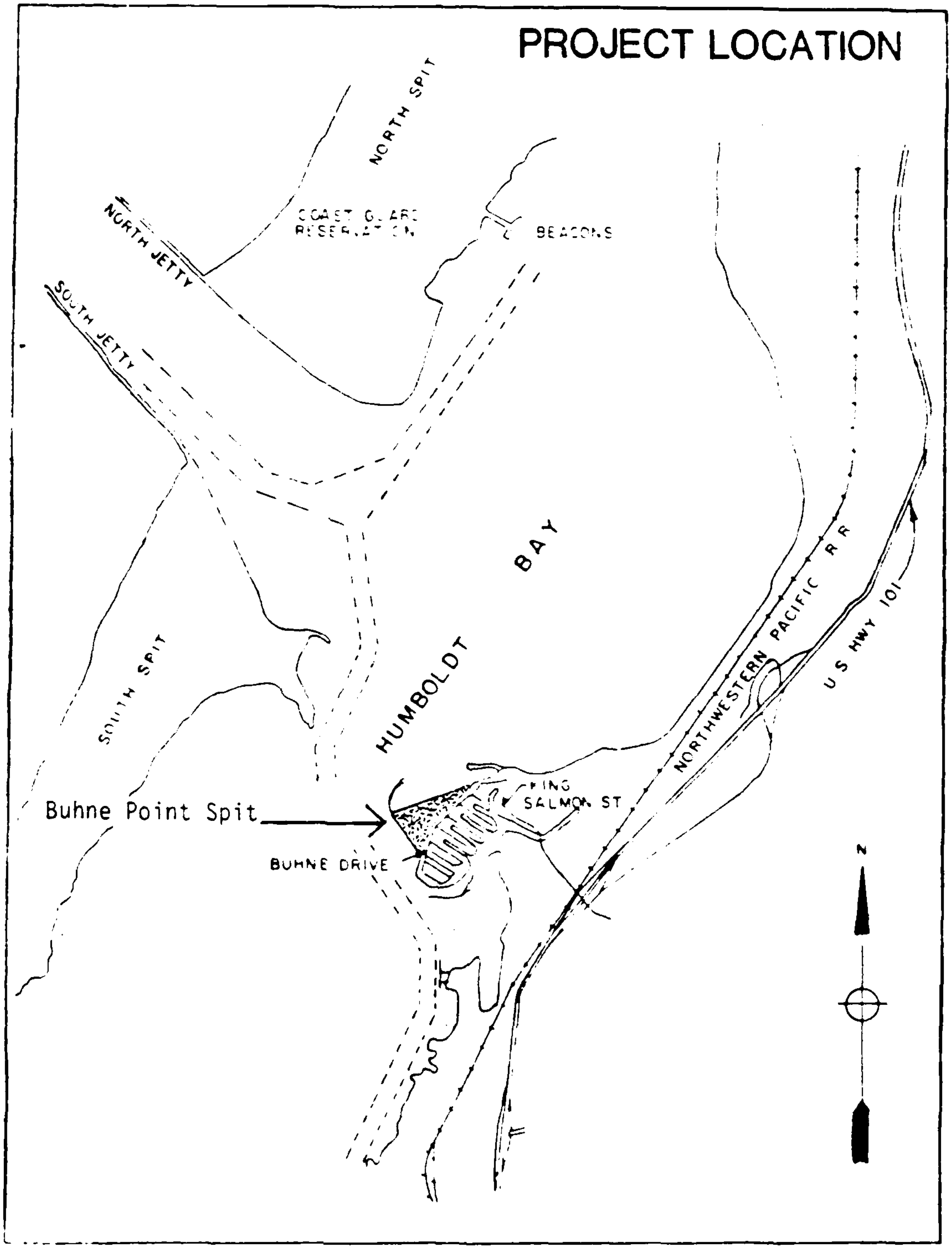


Figure 1: Project Site Location

The experiment was designed to address the question of whether the treatments can increase, as compared to the control situation, the stabilization potential of selected species by enhancing one or more of the following growth characteristics: germination, survival and cover. Secondarily, the investigation compares the nine species selected for their suitability for stabilization based on the above growth characteristics. The nine species and nine treatments tested are listed in Table 1.

A second series of quantitative test plots examined the effectiveness of a rooting compound applied to vegetative propagules of six species, and compared these species for suitability as propagules based on development and survival. The species tested and propagule types are listed in Table 2.

TABLE 1: Species and Treatments Monitored Quantitatively in Study Areas 1 and 2.

Species

Abronia latifolia	sand verbena
Ambrosia chamissonis	beach bur
Artemisia pycnocephala	beach sagewort
Calystegia soldenella	beach morning glory
Camissonia cheiranthifolia	beach evening primrose
Erigeron glaucus	seaside daisy
Eriogonum latifolium	beach buckwheat
Lathyrus littoralis	beach pea
Tanacetum douglasii	tansy

Treatments

Control (seeds sown at 2 inch depth)
2 times control application rate
1/2 control application rate
Compost (with added nitrogen)
Slow release fertilizer (14:14:14)
Soluble fertilizer (21:0:0)
Jute matting
Hydromulch/fertilizer (16:20:0)

TABLE 2: Species monitored quantitatively as vegetative propagules subjected to a rooting compound:

Species		Progagule
Artemisia pycnocephala	beach sagewort	Divisions (rooted) and cuttings
Calystegia soldenella	beach morning glory	Rhizomes
Fragaria chiloensis	beach strawberry	Divisions (rooted)
Lathyrus littoralis	beach pea	Divisions (rooted) and cuttings
Poa douglasii	seashore blue grass*	Divisions (rooted)
Tanacetum douglasii	tansy	Divisions (rooted)

*Monitored by photographic record only.

SITE DESCRIPTION AND ENVIRONMENTAL PARAMETERS

The Buhne Point Spit was created from 600,000 cubic yards of sand dredged from the entrance channel of Humboldt Bay. The spit is approximately 23 acres in size and is stabilized by groins at its east and west ends. The fill was completed in August 1984, and in Spring 1985 was graded to create a series of "dune" ridges roughly parallel with the beach face. Dune crests are at +14 MLLW, three feet above the main fill (see Figure 2).

The results of a seive analysis of fill samples taken in January 1985 show that approximately 85% of the sand component of the fill is fine to medium grained (USDA particle size classes). Table 3 contains the results of the analysis and the USDA particle size limits. A unique feature of the spit is the high fractional percent of rock and shell fragments resulting from its creation from dredge spoils. Rock and shell fragments constituted 1.3% of the total sample by weight, and ranged in size from 4.76 to 19mm in effective diameter. The effect of the rock and shell component is to create a lag layer after fine sediments blow off. The lag layer, reestablished after every disturbance, proved to be a significant factor in revegetation success as it provided an effective means of temporary substrate stabilization enhancing seedling establishment (see Figure 3).

The fill was subjected to the leaching action of rainfall through the 84-85 rainy season. However, prior to planting, soil samples were tested for conductivity to ensure that salinity was not a limiting factor in plant establishment. Replicate samples were taken at 2 inch and 4 inch in three locations, yielding average readings of .258 and .345 millimohs/cm. respectively. This level is well below limiting salinity concentrations.

The freshwater table was located by sinking PCV pipe to a depth of 15 feet. Depth to the water table ranged seasonally from 1 to 5 feet. Wind records for the area, summarized in Table 4, indicate a NNW direction for prevailing wind. The artificial dunes of the fill are situated slightly offset from the direction perpendicular to prevailing wind.

Temperatures for the project area, obtained from the U.S. Weather Service located at 5th and H Streets in the City of Eureka, are summarized in Table 5 for the period covered by the experimental planting (April - November 1985). Rainfall data was not collected because the system was irrigated regularly throughout the experimental phase. The irrigation schedule is presented in Table 6. Frequency of irrigation was initially high to prevent dessication of seedlings (daily), but was reduced as the season progressed in order to encourage deeper root penetration. Frequency had decreased to two times per week in November, when irrigation was concluded due to the onset of winter rains.

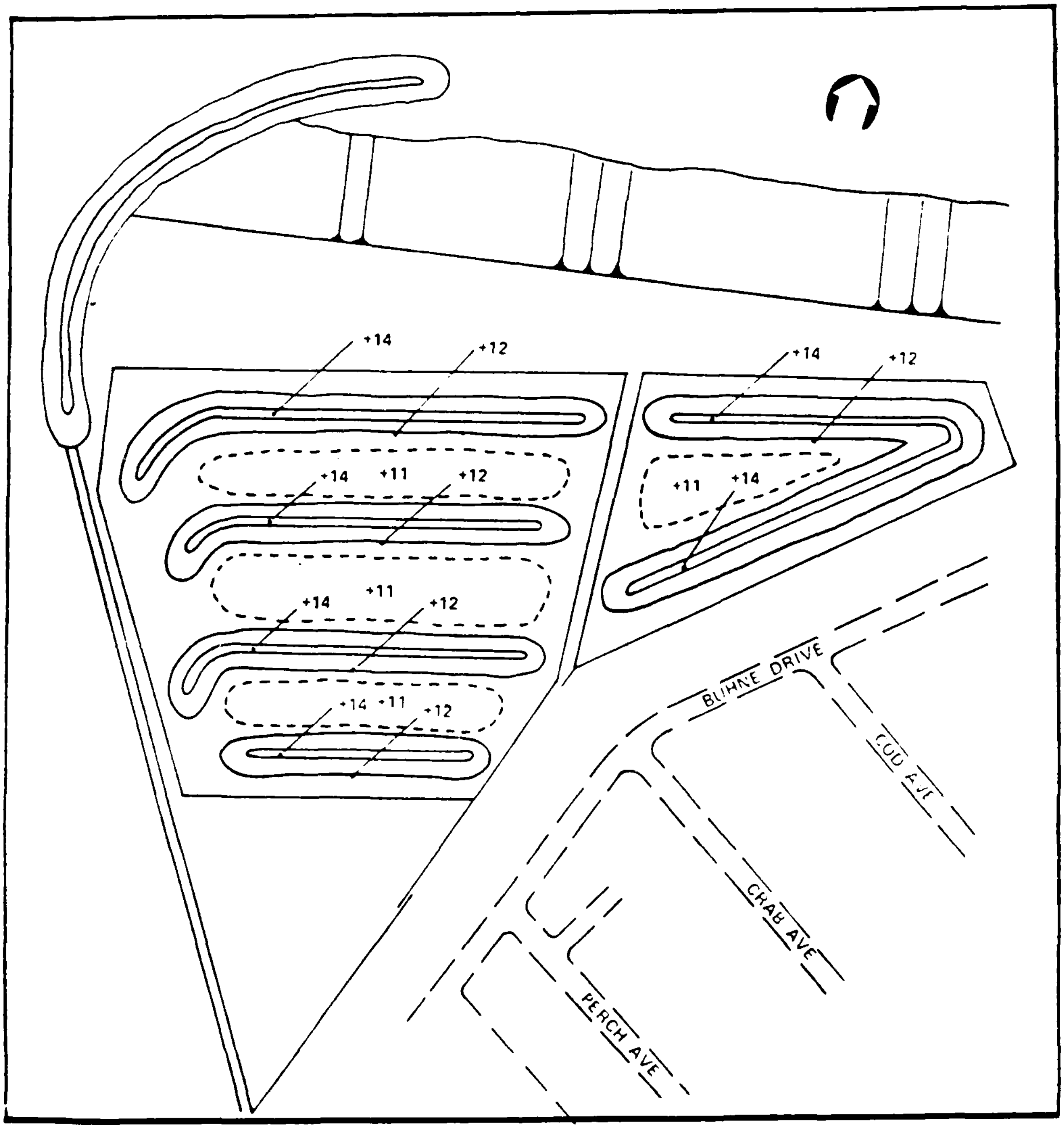


Figure 2: Site Plan Showing Surface Features and Elevations (MLLW)
(Corps of Engineers, 1964)

TABLE 3: Results of a Sieve Analysis for Burnt Point Sand Sediment.

Particle Size	Fractional
2:3.62 - 4.75 mm	0.6
1.18 - 2.362	2.2
600m - 1.18 mm	3.7
300 m - 600 m	22.4
152m - 300m	63.2
75m - 152m	5.3
less than 75m	2.6

USDA Particle Size Classes

Very fine sand	50m-100m
Fine sand	100m-250m
Medium sand	250m-500m
Coarse sand	.5m-1mm
Very coarse sand	1-2mm
Fine gravel	2-12mm

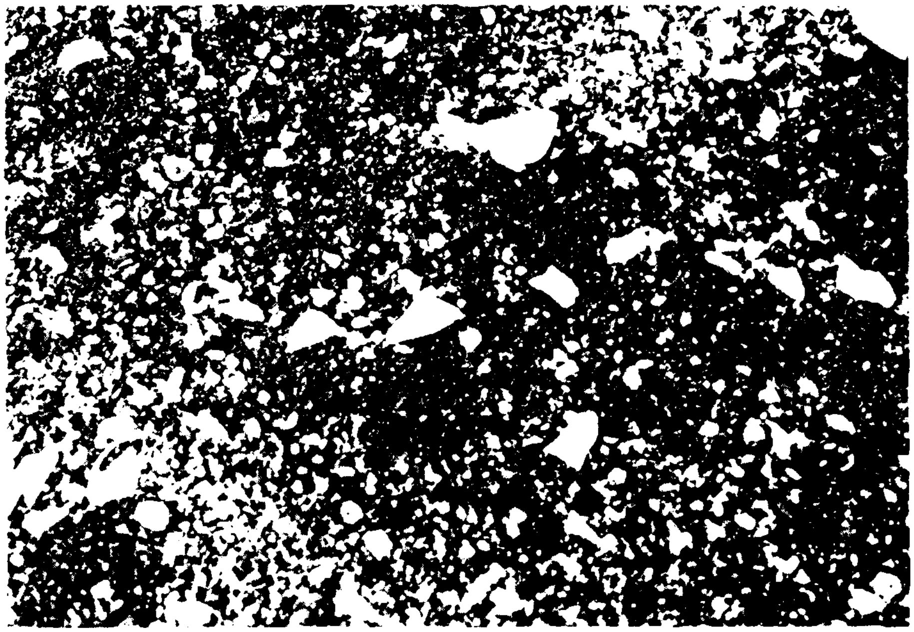


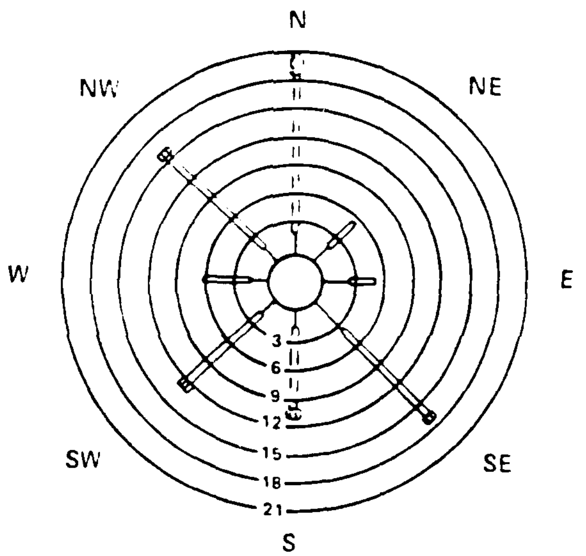
Figure 3: Lag layer of coarse shell and rock fragments overlying fine to medium sand.

TABLE No. 4: Monthly average and maximum winds, and hourly average surface winds (MPH) and frequency of occurrence (U.S. Army Corps of Engineers [illegible])

MONTHLY AVERAGE AND MAXIMUM WINDS

MONTH	MEAN WIND SPEED (MPH)	PREVAILING DIRECTION	MAXIMUM WIND SPEED (MPH)	MAXIMUM WIND SPEED DIRECTION
JANUARY	6.9	SE	54	S
FEBRUARY	7.2	SE	48	SW
MARCH	7.5	N	48	SW
APRIL	8.0	N	49	N
MAY	7.9	N	40	NW
JUNE	7.4	N	39	NW
JULY	6.8	N	35	N
AUGUST	5.8	NW	34	N
SEPTEMBER	5.5	N	44	N
OCTOBER	5.6	N	56	SW
NOVEMBER	6.0	SE	43	S
DECEMBER	6.4	SE	56	S
ANNUAL	6.8	N	56	SW
LENGTH OF RECORD (YRS)	54	54	67	67

(FROM U.S. DEPARTMENT OF COMMERCE, 1977)



INCLUSIVE DATES
July 1939-Dec 1942

TOTAL OBSERVATIONS
9002

MILES PER HOUR

1-3, 4-15, 16-31

Table 5: Maximum and Minimum Temperatures for Eureka for the Period [illegible] through November 2, 1985. (From the records of the National [illegible] and Atmospheric Administration).

Week	Max (°F)	Min (°F)
3/31 - 4/06/85	69	44
4/07 - 4/13/85	62	45
4/14 - 4/20/85	58	41
4/21 - 4/27/85	58	43
4/28 - 5/04/85	60	43
5/05 - 5/11/85	60	40
5/12 - 5/18/85	72	40
5/19 - 5/25/85	74	47
5/26 - 6/01/85	63	44
6/02 - 6/08/85	71	44
6/09 - 6/15/85	67	49
6/16 - 6/22/85	66	48
6/23 - 6/29/85	65	45
6/30 - 7/06/85	60	45
7/07 - 7/13/85	76	51
7/14 - 7/20/85	63	48
7/21 - 7/27/85	68	49
7/28 - 8/03/85	67	52
8/04 - 8/10/85	68	52
8/11 - 8/17/85	71	50
8/18 - 8/24/85	69	50
8/25 - 8/31/85	67	49
9/01 - 9/07/85	68	49
9/08 - 9/14/85	68	47
9/15 - 9/21/85	66	48
9/22 - 9/28/85	65	47
9/29 -10/05/85	81	48
10/06 -10/12/85	61	39
10/13 -10/19/85	62	40
10/20 -10/26/85	64	46
10/27 -11/02/85	66	41

TABLE 6: Irrigation Schedule for Study Areas

Period	Irrigation Frequency	Irrigation Duration
4/27-05/15/85	daily	15 min.
5/16-06/26/85	6 days/week	15 min.
6/27-08/21/85	3 days/week	30 min.
8/22-11/01/85	2 days/week	30 min.

METHODS

I. STUDY AREAS I AND II (SEEDS)

A. Establishing Study Areas

Two large study areas were created to test nine native dune species planted as seeds. The location of these plots is shown in Figure 4. Locations were selected to optimize homogeneity of environmental parameters (substrate, drainage, wind/salt spray exposure). The study areas each consisted of a rectangular block 19m by 24m delineated into a grid pattern using ground level guidelines of yellow nylon string tied to perimeter rebar (Study Area 1) or wood stakes (Study Area 2). The resulting grid consisted of one meter wide by 24m long rows (with the exception of a central 3m wide corridor for the irrigation line) divided into 1m x 1m "plots". Alternating rows (running E-W) represented different treatments, and each 1m x 1m "plot" within the row represented a single replicate of a species. Each row was blocked into five sets of 4 plots separated by an empty plot. This arrangement created empty corridors for walking the length or width of the Study Area. Five species were planted in each row (in Study Area 1, four species plus a mix) and each species plot was replicated four times within the row. Species and replicates were randomized across the row, although the pattern of four-plot "blocks" was maintained. The resulting design for Study Areas 1 and 2 is shown in Figures 5 and 6.

B. Control Seed Application Rates

The application rate for each species was that utilized in the qualitative experimental planting areas as discussed in the Phase 1 Planting Report (Newton 1985). These "monoculture" rates (i.e. based on revegetation using a single species) were derived from the literature or followed commercial seed company recommendations. In some cases the rate was based on recommendations for a closely related taxon or one with a similar seed size. Table 7 lists monoculture application rates and approximate number of seeds per 1m plot.

The monoculture application rate was used for all treatments and the control row, and varied for the two application rate rows to one half and double the monoculture rate. Seeds were weighed and packaged for individual plots and sown by hand to a depth approximately two inches (with the exception of the depth test treatment). For small seeds, random distribution was attempted but, in general, seeds were more concentrated towards the center of the plots. For larger seeds (e.g. *Calystegia* and *Lathyrus*) seeds were evenly distributed throughout the plot. Treaements were applied before or after sowing as appropriate. Planting occurred during the period 3/28 to 4/5/85.

C. Treatments

Specification for treatments are discussed in detail below. The hydromulch, jute mat and soluble fertilizer treatments are illustrated in Figures 7 and 8.

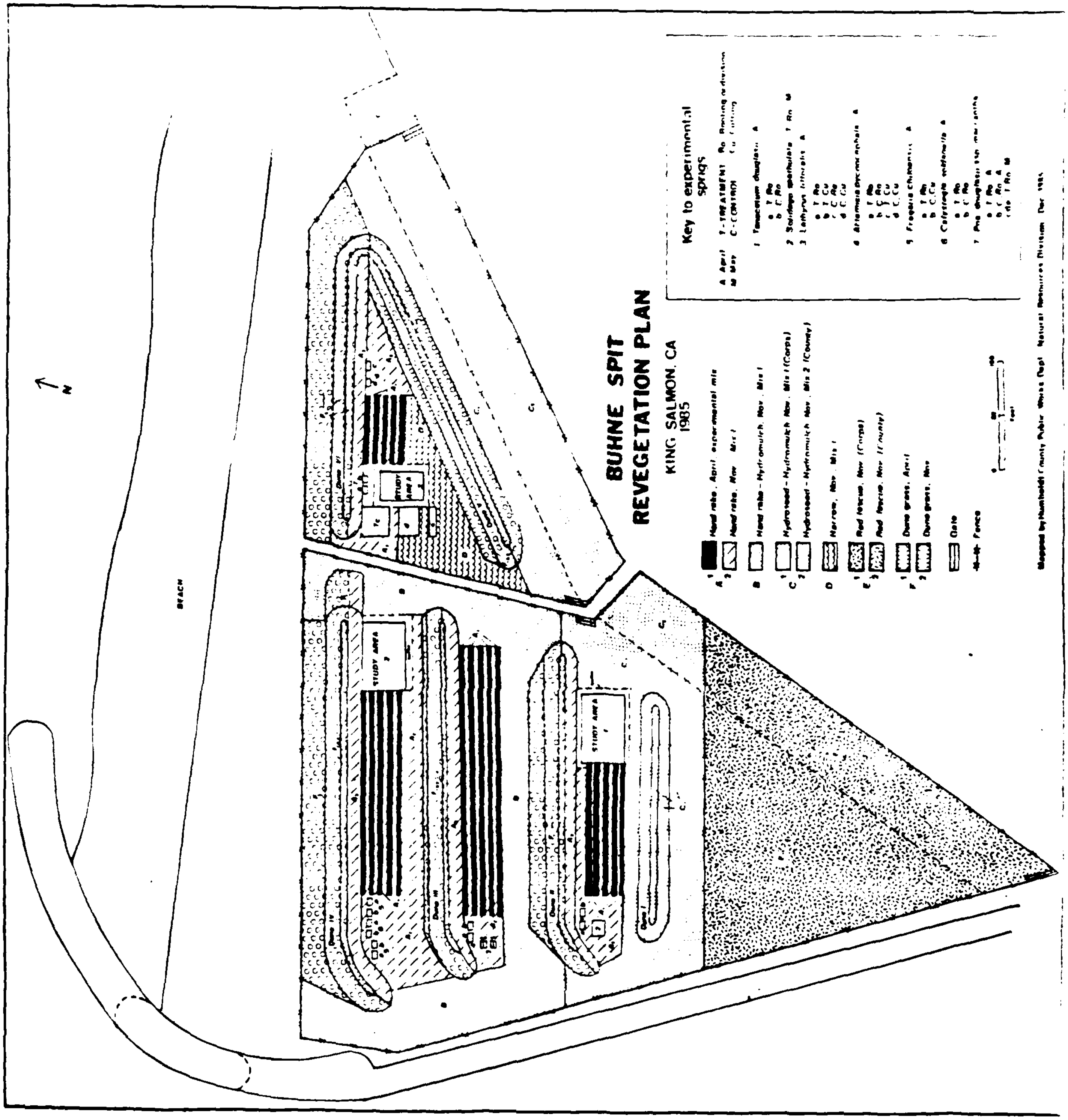


Figure 4: Revegetation Plan Showing Locations of Study Areas 1 and 2, and Vegetative Propagule Treatment Plots.

Figure 5: Layout of Study Area 1 (irrigation corridors not shown).

2x Control Rate	1/2 Control Rate	Control	Compost	Slow Release Fertilizer	Soluble Fertilizer	Jute Matting	Hydromulch/fertilizer
MX	AC	AC	CC	EL	EL	AC	MX
CC	AC	MX	CC	EL	AL	EL	EL
AC	EL	AL	MX	MX	MX	CC	AL
MX	MX	MX	AL	AC	AC	EL	AC
AL	CC	AL	EL	AC	MX	MX	AL
AL	MX	EL	CC	CC	CC	EL	EL
EL	MX	AL	AC	AL	AC	CC	AC
CC	EL	EL	MX	AL	AC	CC	CC
AL	CC	AC	AC	AL	EL	MX	AC
CC	EL	EL	MX	EL	CC	CC	AL
AC	CC	CC	AC	EL	EL	AL	CC
AL	AC	EL	EL	MX	MX	AC	EL
EL	AL	CC	EL	AL	AL	AC	CC
MX	AC	CC	AL	CC	AC	AL	EL
EL	MX	MX	AL	MX	CC	AL	MX
AC	EL	AC	CC	AC	AL	AC	CC
MX	AL	MX	AC	AC	MX	EL	AC
CC	AL	CC	EL	MX	AL	MX	MX
AC	CC	AC	MX	CC	EL	AL	AL
EL	AL	AL	AL	CC	CC	MX	MX

SPECIES CODES

AL *Abronia latifolia*
AC *Ambrosia chamissonis*
CC *Camissonia cheiranthifolia*
EL *Eriogonum latifolim*
MX Mix

Figure 6: Layout of Study Area 2 (irrigation corridors not shown).

Depth Test	2x Control Rate	1/2 Control Rate	Control	Compost	Slow Release Fertilizer	Soluble Fertilizer	Jute Matting	Hydromulch/fertilizer
AP	TD	LL	AP	LL	CS	LL	EG	TD
EG	CS	AP	CS	AP	CS	EG	LL	AP
TD	EG	AP	TD	LL	LL	LL	AP	CS
EG	CS	CS	TD	TD	TD	AP	TD	EG
LL	TD	LL	CS	AP	TD	TD	CS	TD
AP	LL	CS	EG	AP	LL	EG	EG	TD
LL	AP	AP	AP	LL	CS	EG	EG	EG
LL	EG	LL	EG	CS	EG	TD	AP	LL
CS	CS	EG	CS	LL	LL	TD	AP	AP
EG	LL	TD	AP	TD	AP	EG	TD	CS
CS	TD	EG	EG	CS	AP	CS	LL	LL
AP	AP	TD	TD	AP	EG	LL	TD	EG
TD	AP	CS	LL	TD	EG	CS	LL	LL
AP	EG	TD	EG	EG	EG	CS	TD	AP
CS	CS	AP	TD	CS	CS	AP	CS	CS
LL	AP	CS	LL	EG	TD	LL	AP	EG
CS	TD	LL	LL	TD	TD	AP	EG	AP
TD	LL	EG	CS	EG	LL	CS	LL	CS
TD	LL	TD	LL	CS	AP	AP	CS	TD
EG	EG	EG	AP	EG	AP	TD	CS	LL

<u>SPECIES CODES</u>

AP *Artemisia pycnocephala*
CS *Calystegia soldanella*
EG *Erigeron glaucus*
LL *Lathyrus littoralis*
TD *Tanacetum douglasii*

TABLE 7: Monoculture Application Rate and Approximate Number of Seeds Per Plot

Species	Monoculture Rate lbs/acre	Approximate Seeds Per 1m2 Plot
Abronia latifolia sand verbena	40	200
Ambrosia chamissonis beach bur	30	250
Artemisia pycnocephala beach sagewort	10	6800
Calystegia soldanella beach morning glory	20	44
Camissonia cheiranthifolia beach evening primrose	1	930
Erigeron glaucus seaside daisy	15	5500
Eriogonum latifolium beach buckwheat	15	5540
Lathyrus littoralis beach pea	20	30
Tanacetum douglasii tansy	20	3760

Figure 7: Application of hydromulch treatment.

Figure 8: Jute matting treatment (soluble fertilizer treatment on left, bottom).

(1) Control. Seeds sown at monoculture application rate at approximately 2 inches, soil compressed by hand to reduce erosion.

(2) 1/2 Control. Seeds sown at one half the monoculture application rate at 2 inches, soil compressed by hand to reduce erosion.

(3) 2x Control. Seeds sown at twice the monoculture application rate at 2 inches, soil compressed by hand to reduce erosion.

(4) Compost. Redwood compost, 1/2 bale per plot, (25 lbs/plot) incorporated 4 to 6 inches per manufacturer's recommendation (contains approximately 1% added nitrogen). Seeds sown at monoculture application rate at 2 inches.

(5) Slow Release Fertilizer. Osmocote 14:14:14 3 to 4 month formulation applied at 10 lbs/100 ft. (mid-range of manufacturer's suggested rate) and incorporated to 3 inches. Seeds were sown at approximately 2 inches at monoculture application rate.

(6) Soluble Fertilizer. Coarse-particle ammonium sulfate (21:0:0) applied at .7 lbs/100 sq.ft., incorporated into top 2 inches. Seeds sown to approximately 2 inches at monoculture application rate.

(7) Jute Matting. Coarse fiber netting designed to provide substrate stabilization. One strip covered an entire row, fastened with wood stakes. Applied after seeds sown to 2 inches at monoculture application rate.

(8) Hydromulch. 1500 lbs/acre spra-mulch (wood fiber) applied with 1 lb/100 square feet soluble fertilizer (ammonium phosphate 16:20:0) after seeds sown to a depth of approximately 2 inches at monoculture application rate.

(9) Depth Test. Study Area 2 only. Seeds for each replicate plot (control application rate) were divided into five approximately equal parts and planted in rows within the plot at depths of 1, 2, 3, 6 and 9 inches.

D. <u>Monitoring</u>

Monitoring consisted of counts of individuals on a fixed schedule between March and November to yield germination and survival, and computation of plot cover at the end of the monitoring period. Counting was accomplished using a 1 square meter quadrat sectioned into 16 equal parts. For the final count in November, dense growth in some treatment plots necessitated digging up plants to distinguish individuals. Monitoring was initiated when the first cotyledons appeared in late April and was repeated once per week in May, every other week in June, once per month in July, August and September, and once in November. This schedule allowed a greater sampling frequency during germination and early seedling development, stages, when the highest mortality rates were expected. Seedling mortality occurring simultaneously with new germination could then be distinguished. In addition to counts of individuals, notes were made on development and condition of plants. One replicate of each species/treatment were photographically documented twice per month in May and once per month thereafter. This schedule enabled the detection of possible mortality causes (mortality was expected to be higher in the first month). Final cover was calculated in November by taking vertical slides of each plot at a fixed scale. Slides were then projected and plant outlines delineated and planimetered.

II. VEGETATIVE PROPAGULES

A. Establishing Plots

Details of propagule planting are presented in the Phase I Planting Report (Newton 1985). Six native dune species were collected as vegetative propagules and planted on the project site in March. Propagule locations were selected to optimize environmental homogeneity. All propagules were located in the lee of dunes to reduce salt spray and wind stresses. Locations are shown in Figure 4. Propagules consisted of rooted divisions, cuttings, or rhizomes as shown in Table 8. The propagules were randomly divided into control and treatment groups. Treatment consisted of application of a rooting compound (Rootone) for all species except *Poa douglasii*, which was tested for effects of fertilizer (21:0:0) and was monitored photographically. All vegetative propagules were irrigated on the same schedule as the study plots.

B. Monitoring

Five individuals per species/treatment were randomly chosen, tagged, and monitored four times between March and November. Aluminum tags encircled the base of main stem of the plants. The tags do not appear to effect plant development. Appropriate growth characteristics were recorded. Table 8 lists the characteristics monitored for each species. All monitored individuals were photographed at each monitoring interval.

TABLE 8: Vegetative Propagules Monitored

Species	Propagule Type	Characteristics Monitored
Artemisia pycnocephala beach sagewort	rooted divisions	height, no. leaves
Calystegia soldanella morning glory	rhizomes	no. leaves beach
Fragaria chiloensis beach strawberry	rooted divisions	rosette diameter, no. leaves, no. runners
Lathryus littoralis beach pea	rooted divisions/ cuttings	no. branches
Poa douglasii seashore bluegrass	rooted divisions	photographs only
Tanacetum douglasii tansy	rooted divisions/ cuttings	plant height, no. leaves

RESULTS AND DISCUSSION

I. STUDY AREAS I AND II

A. Germination

Germination was calculated by taking the maximum live individuals over time as a proportion of the number of seeds planted. The number planted was determined from mean seed counts per unit weight of planting material calculated from four replicate samples. Table 9 shows results of seed counts for each species.

It was observed that in addition to affecting total germination, certain treatments caused a delay in germination. Due to variable rates of germination, the median date was selected to contrast germination times (i.e. the date at which at least 50% of the final individuals had germinated.) The results of this comparison were not statistically tested; however, average values (number of weeks from planting date) were calculated for each species/treatment. Results are shown in Table 10.

1. Results

A one-way analysis of variance (ANOVA) was performed separately on each species to identify significant differences between treatments. Data was first transformed using the arcsine of the square root to meet the test assumption of homoscedasticity (homeogenecus variances). The one-way ANOVA indicated a significant difference among means for all species and the T-method of multiple comparison was performed to locate specific differences. Results of this test are presented in graphical form in Figures 9-17. Each graph ranks the treatments by plotting comparison limits about the treatment means. Comparison limits represent the minimum significant difference between means. Where comparison limits of two means overlap, there is no statistically significant difference in germination between treatments ($P > .05$). Any two intervals that do not overlap represent a significant difference in germination rate. By viewing the graphs, every possible pair of means can be compared at the 5% significance level, experiment-wise.

The five species in Study Area 2 were subjected to a tenth treatment referred to as Depth Test and described under Methods. To test for significant differences in germination rates between planting depths, a one-way ANOVA was performed separately on each species. Data was first transformed using the arcsine square root to meet the assumption of homoscedasticity. The results of the ANOVA showed no significant differences among planting depths for [illegible] and [illegible]. *Artemisia*, *Erigeron* and [illegible] were further tested using the T-method of multiple comparison to locate differences. Results are graphically depicted in Figures 18-22 as ranked means and comparison limits.

TABLE 9: Seed Counts

Species	Mean Seeds per 1 gram	Standard Deviation
Abronia latifolia sand verbena	44.86	5.85
Ambrosia chamissonis beach bur	75.55	3.55
Artemisia pycnocephala beach sagewort	4034.4	213
Calystegia soldanella beach morning glory	19.64	.502
Camissonia cheiranthifolia beach evening primrose	8222.5	1560
Erigeron glaucus seaside daisy	3277.5	484
Eriogonum latifolium beach buckwheat	847.0	83.2
Lathyrus littoralis beach pea	12.92	.476
Tanacetum douglasii tansy	1650	263

TABLE 11: Average Median Germination Time

Species	Hydromulch/ fertilizer	Slow Release Fertilizer	Soluble Fertilizer	Jute Matting	Compost	Control	1/2 Control Rate	2x Control Rate
	No. Weeks from Plant Date to 50% Germination							
Abronia latifolia sand verbena	11	7	6	10	8	8	9	9
Ambrosia chamissonis beach bur	11	11	9	10	9	8	8	9
Artemisia pycnocephala beach sagewort	9	6	7	6	7	5	5	6
Calystegia soldanella beach morning glory	5	8	7	8	7	6	7	6
Camissonia cheiranthifolia beach evening primrose	9	7	8	7	13	7	8	7
Erigeron glaucus seadside daisy	9	7	12	11	13	7	7	8
Eriogonum latifolium beach buckwheat	4	4	6	7	11	4	4	4
Lathyrus littoralis beach pea	8	6	10	10	9	7	6	7
Tanacetum douglasii tansy	8	8	8	7	10	6	8	8

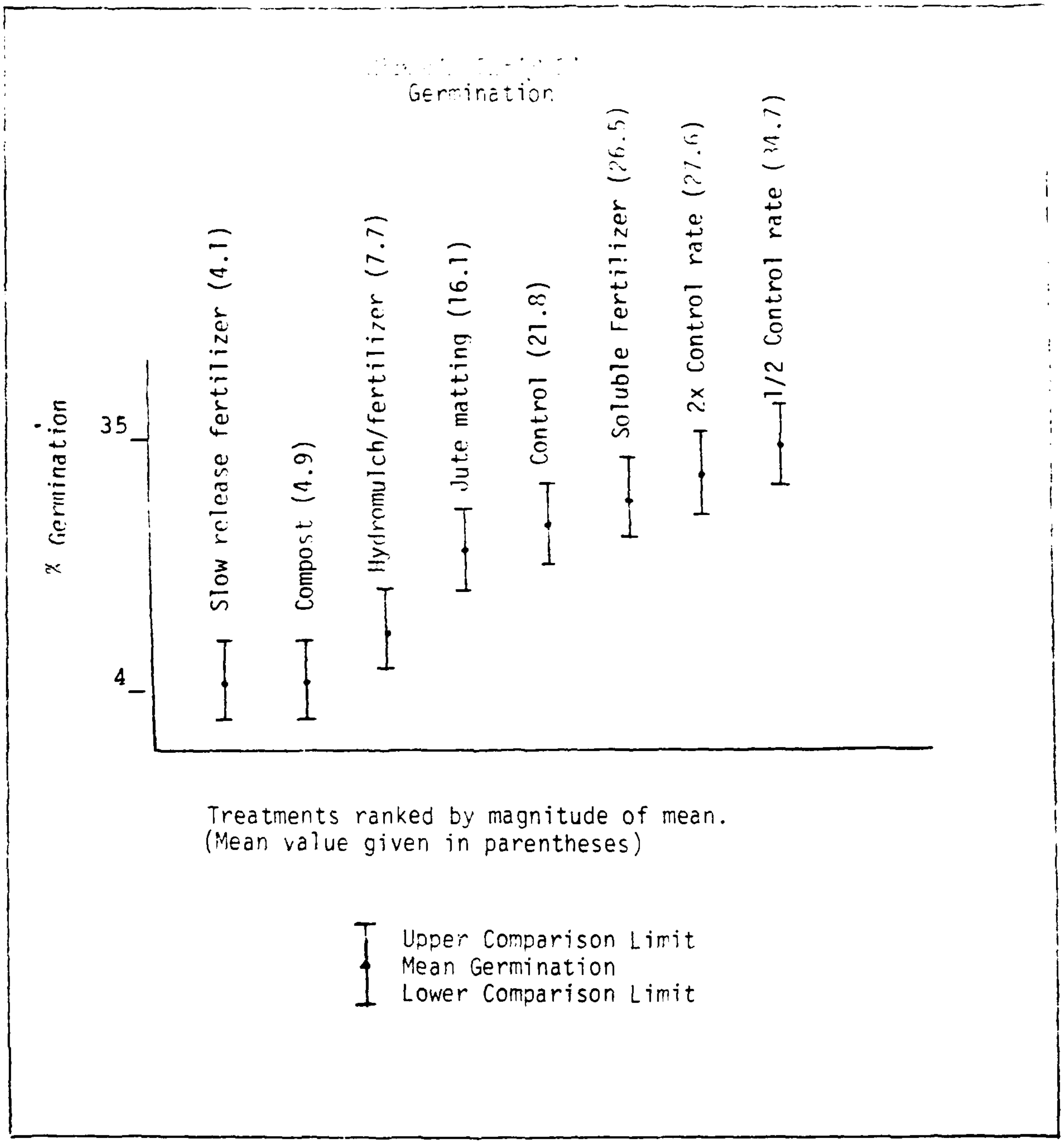


Figure 9: 95% Comparison Limits for *Abronia* Germination by Treatment. (Treatments whose intervals do not overlap are significantly different)

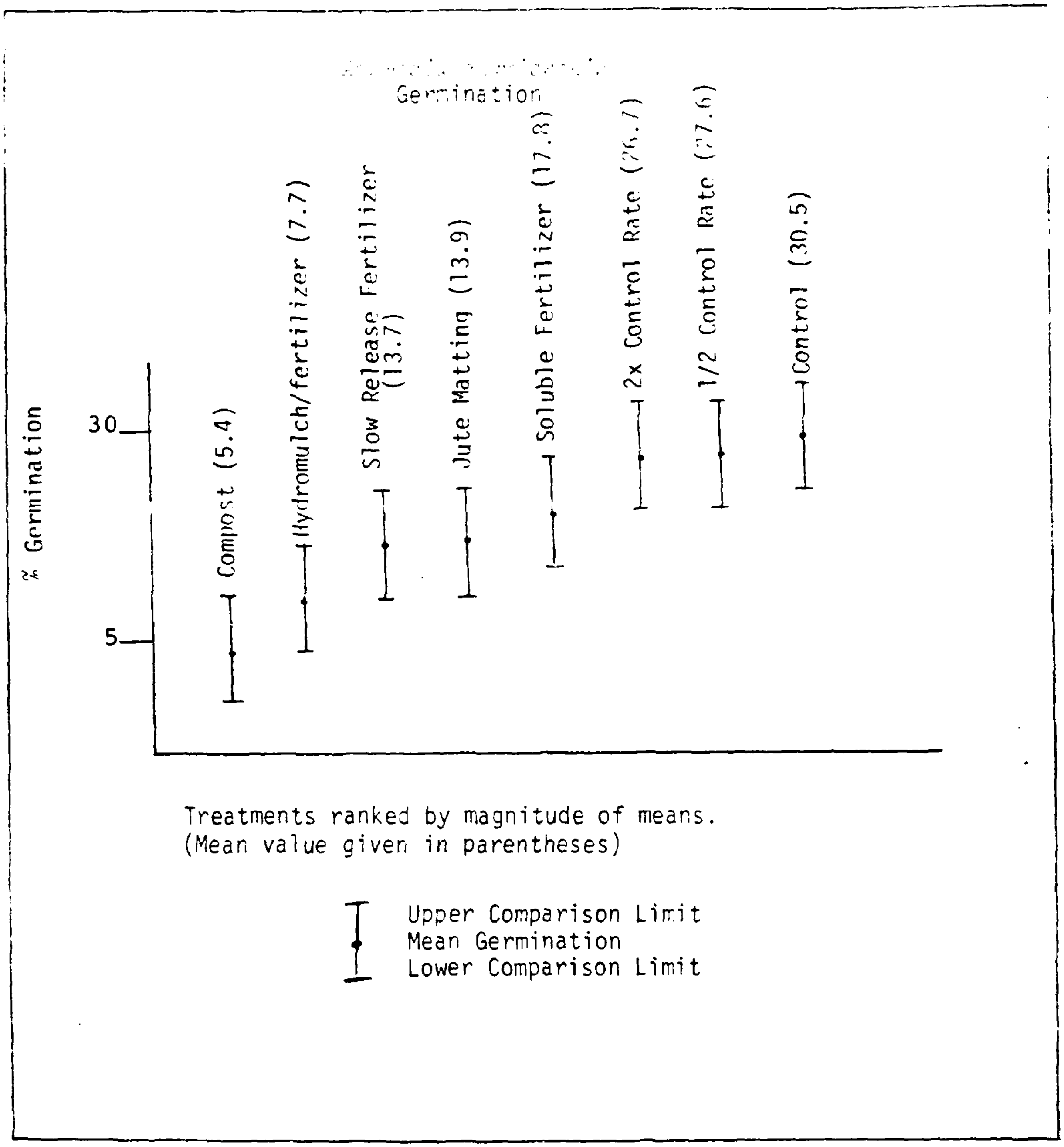


Figure 10: 95% Comparison Limits for *Ambrosia* Germination by Treatment. (Treatments whose intervals do not overlap are significantly different)

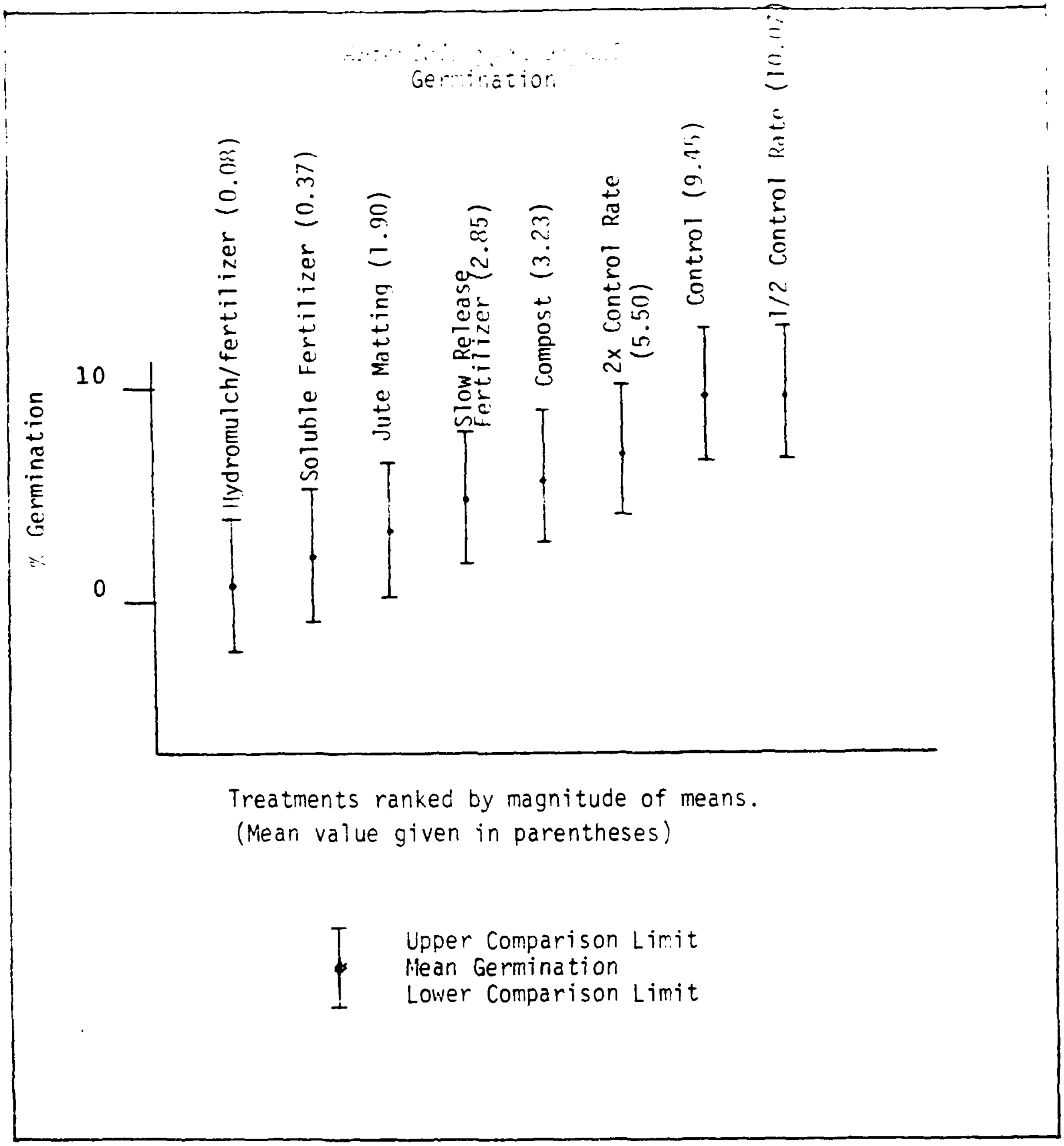


Figure 11: 95% Comparison Limits for *Artemisia* Germination by Treatment. (Treatments whose intervals do not overlap are significantly different)

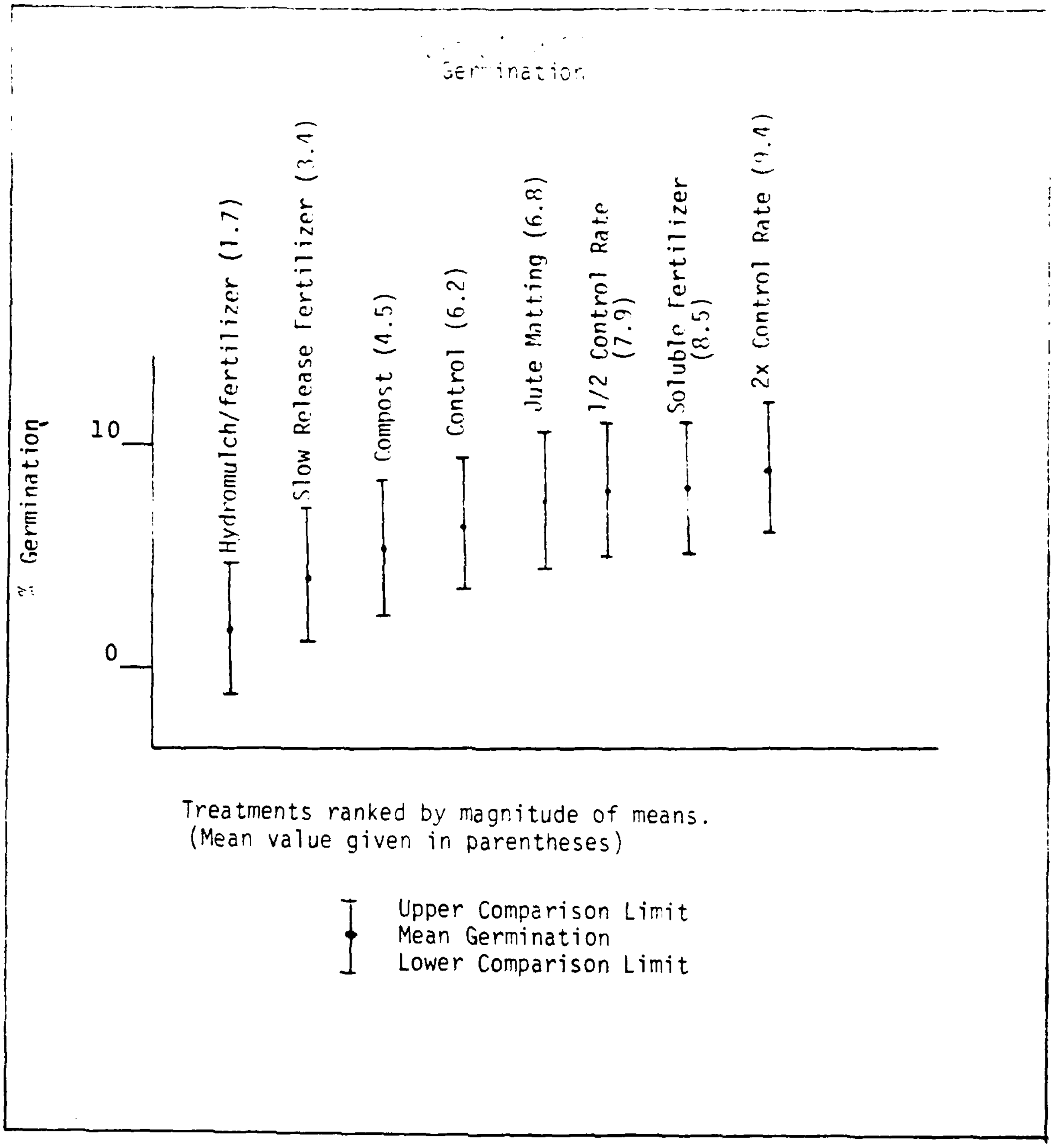


Figure 12: 95% Comparison limits for *Calystegia* Germination by Treatments. (Treatments whose intervals do not overlap are significantly different)

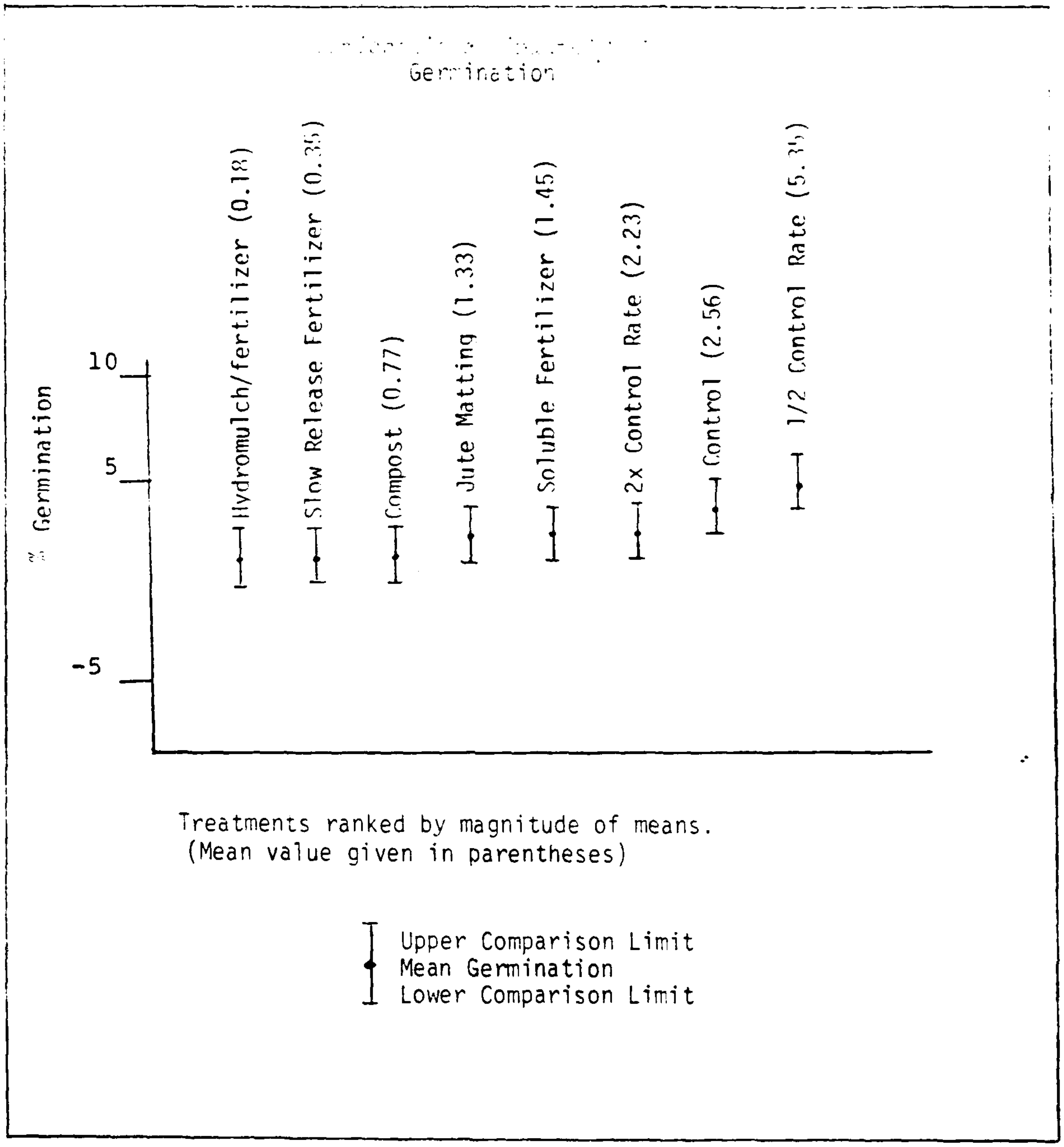


Figure 13: 95% Comparison Limits for *Camissonia* Germination by Treatments. (Treatments whose intervals do not overlap are significantly different)

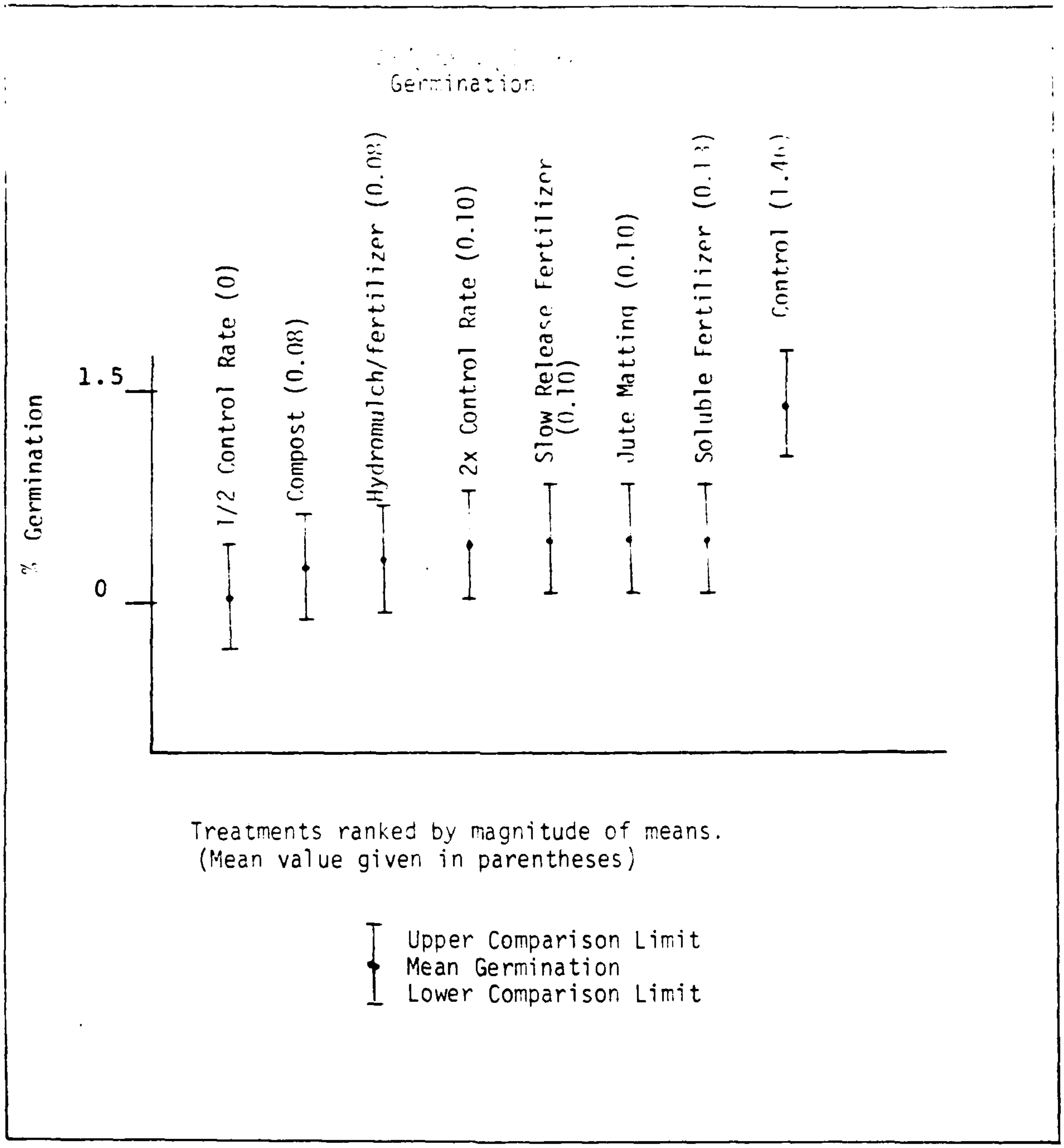


Figure 14: 95% Comparison Limits for *Erigeron* Germination by Treatment. (Treatments whose intervals do not overlap are significantly different)

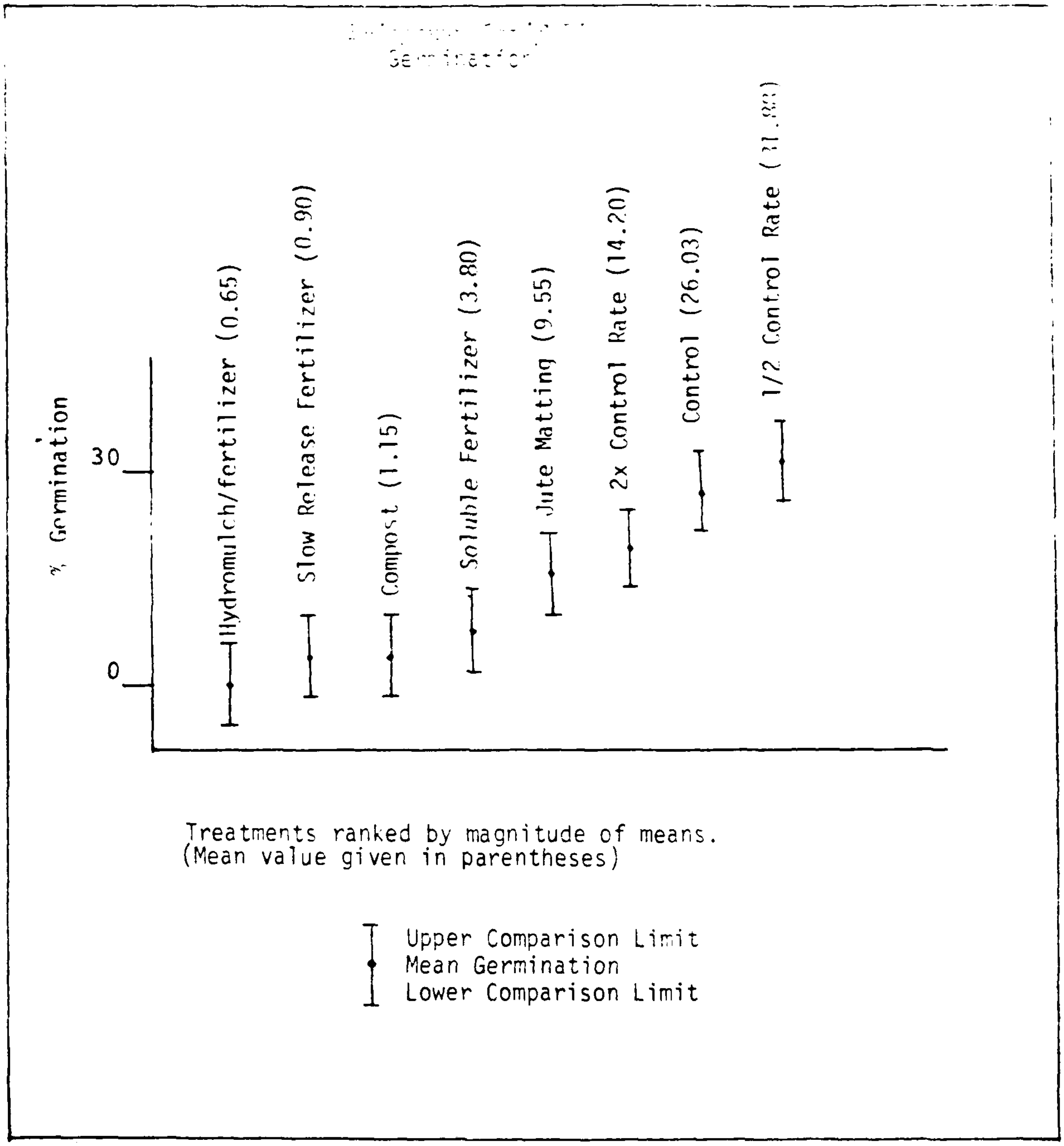


Figure 15: 95% Comparison Limits for *Eriogonum* Germination by Treatments. (Treatments whose intervals do not overlap are significantly different)

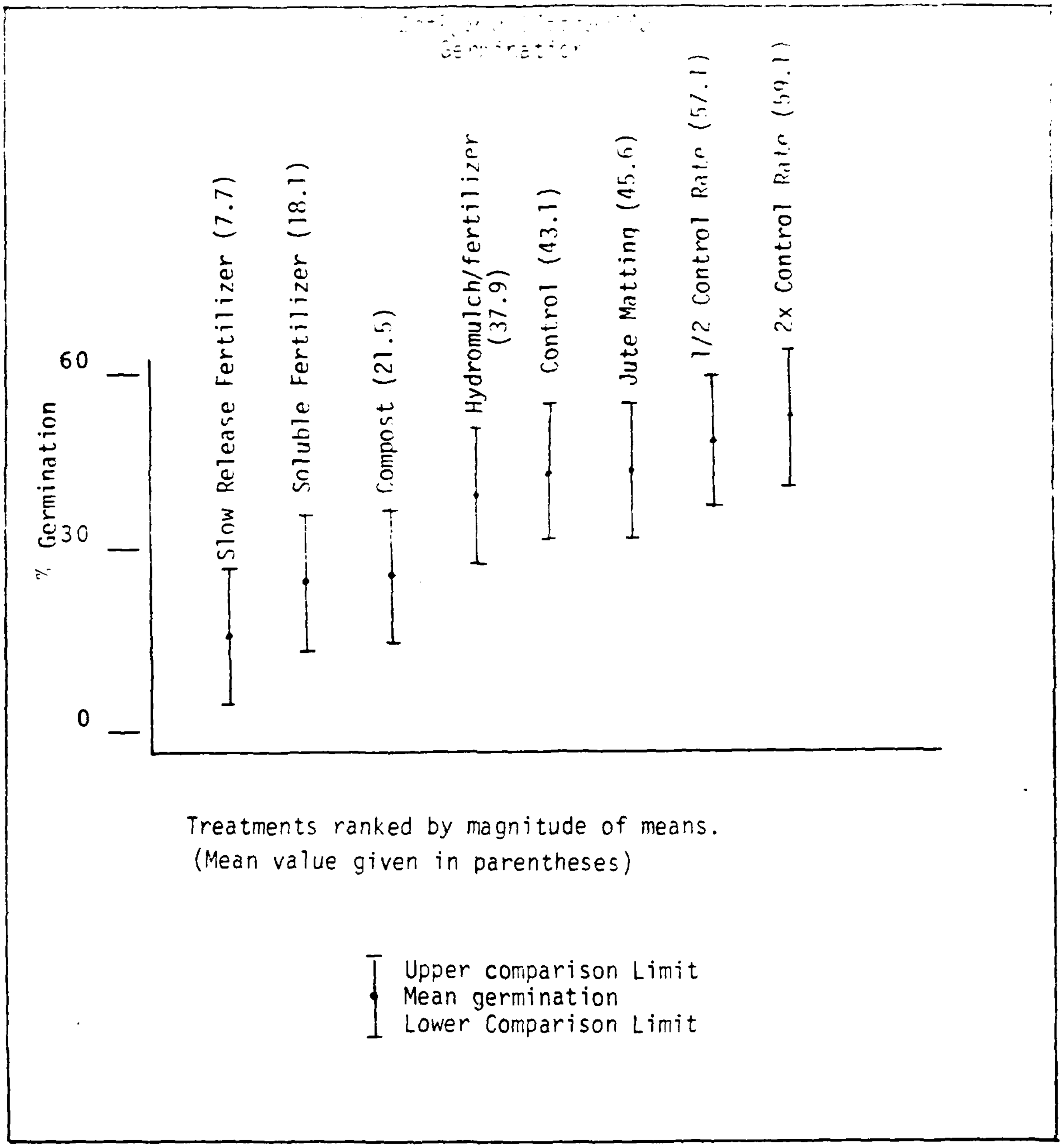


Figure 16: 95% Comparison Limits for *Lathyrus* Germination by Treatment. (Treatments whose intervals do not overlap are significantly different)

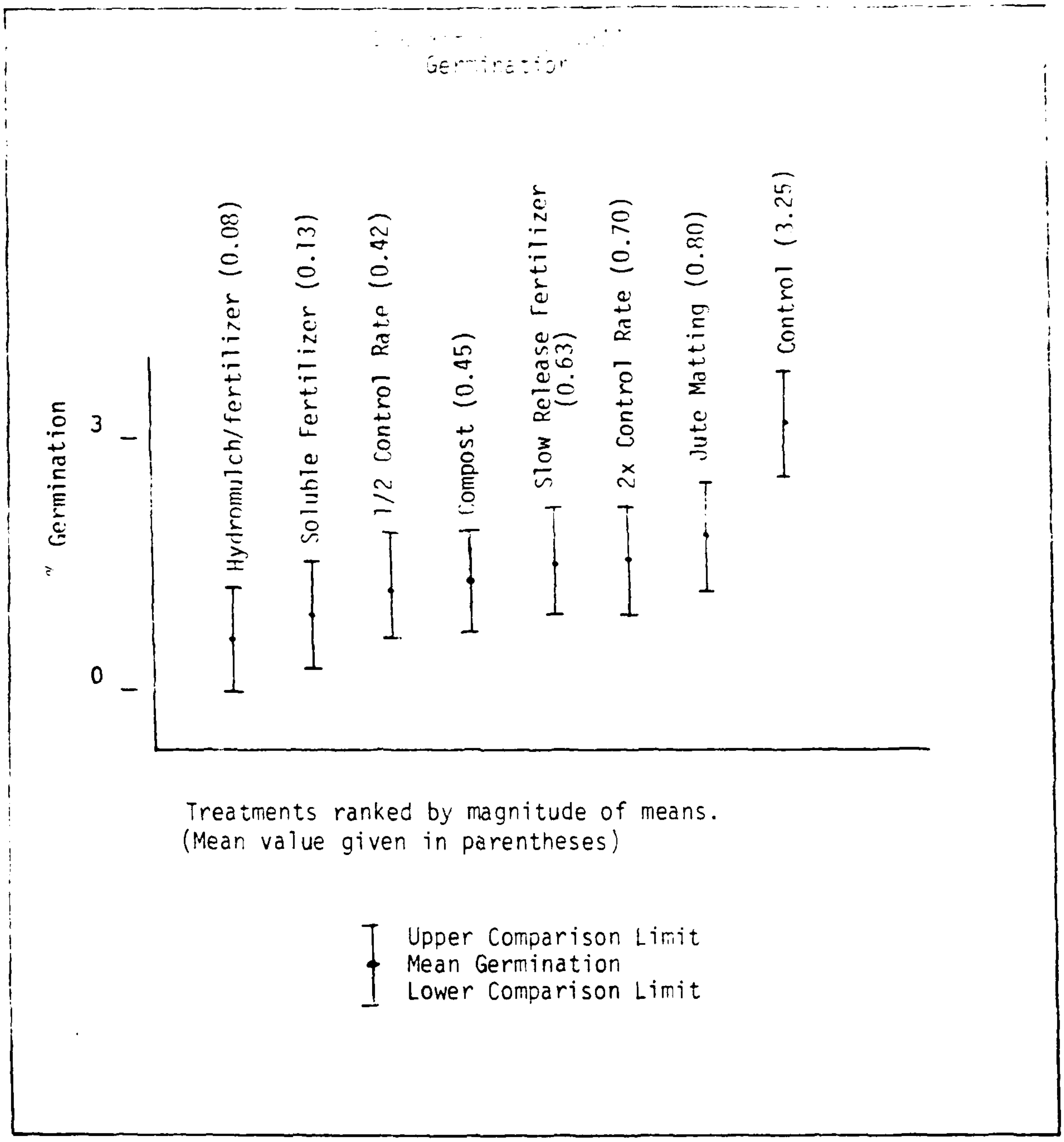


Figure 17: 95% Comparison Limits for *Tanacetum* Germination by Treatment. (Treatments whose intervals do not overlap are significantly different)

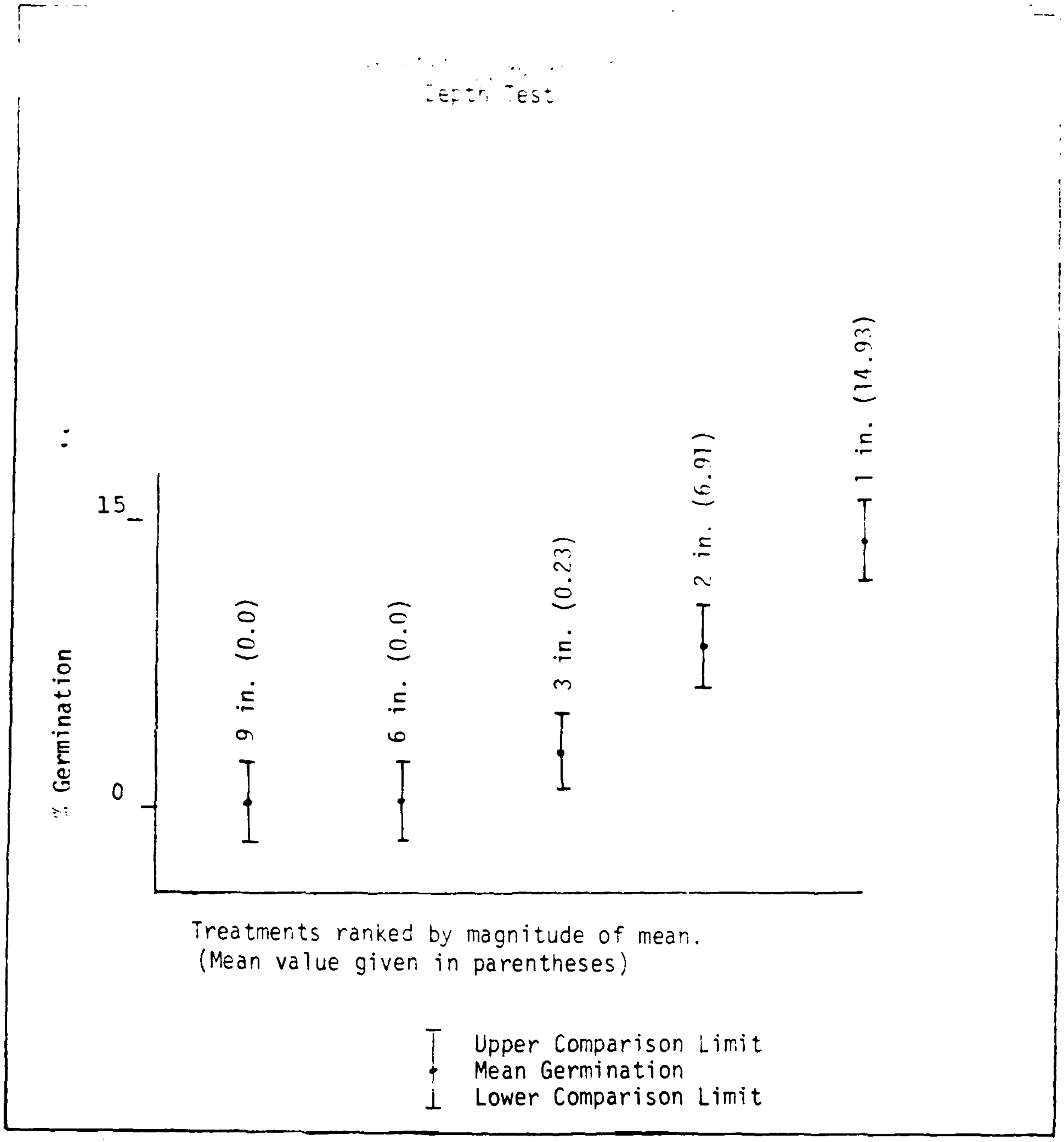


Figure 18: 95% Comparison limits for *Artemisia* germination by depth. (Treatments whose intervals do not overlap are significantly different)

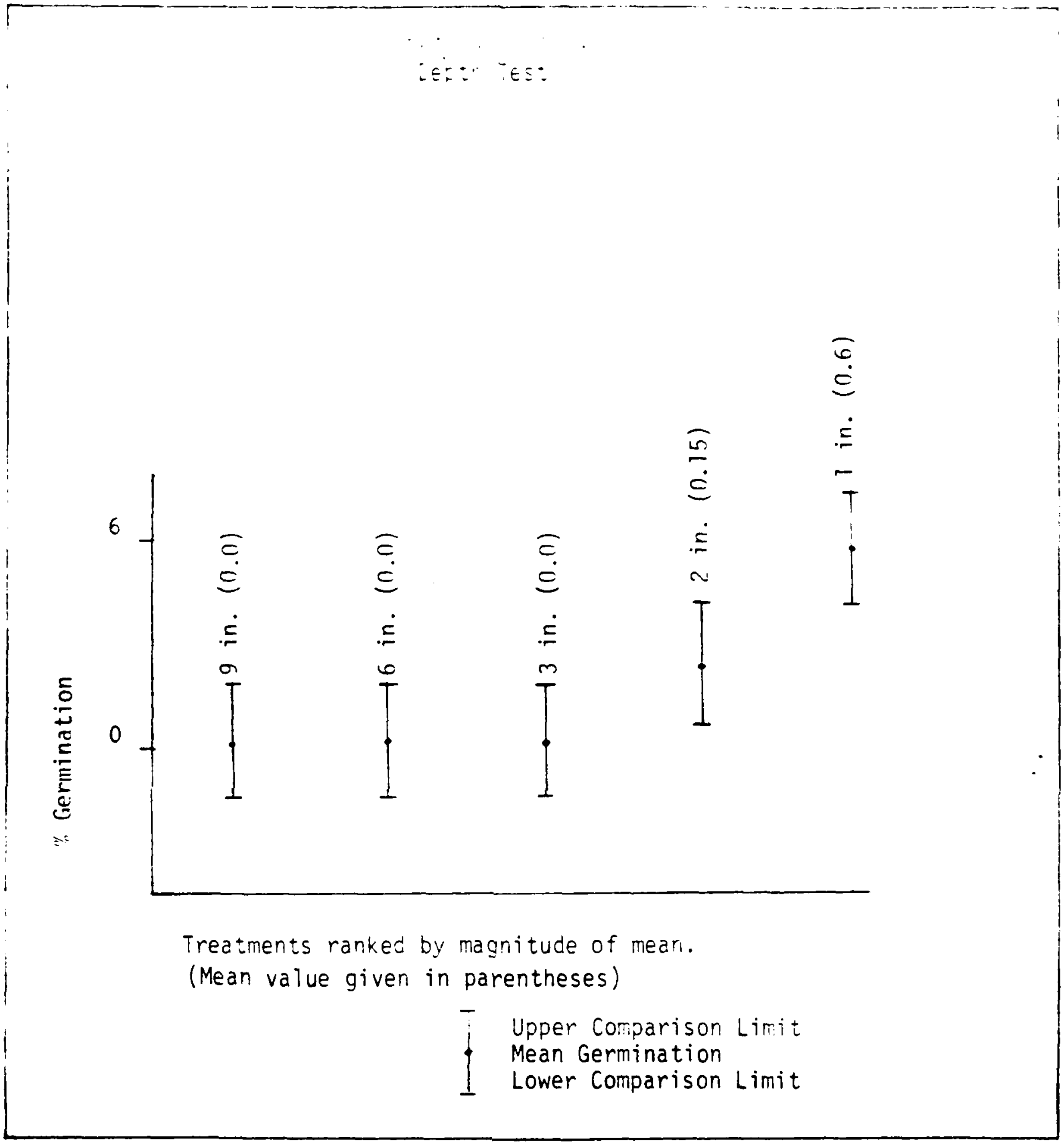


Figure 19: 95% Comparison limits for *Erigeron* germination by depth. (Treatments whose intervals do not overlap are significantly different)

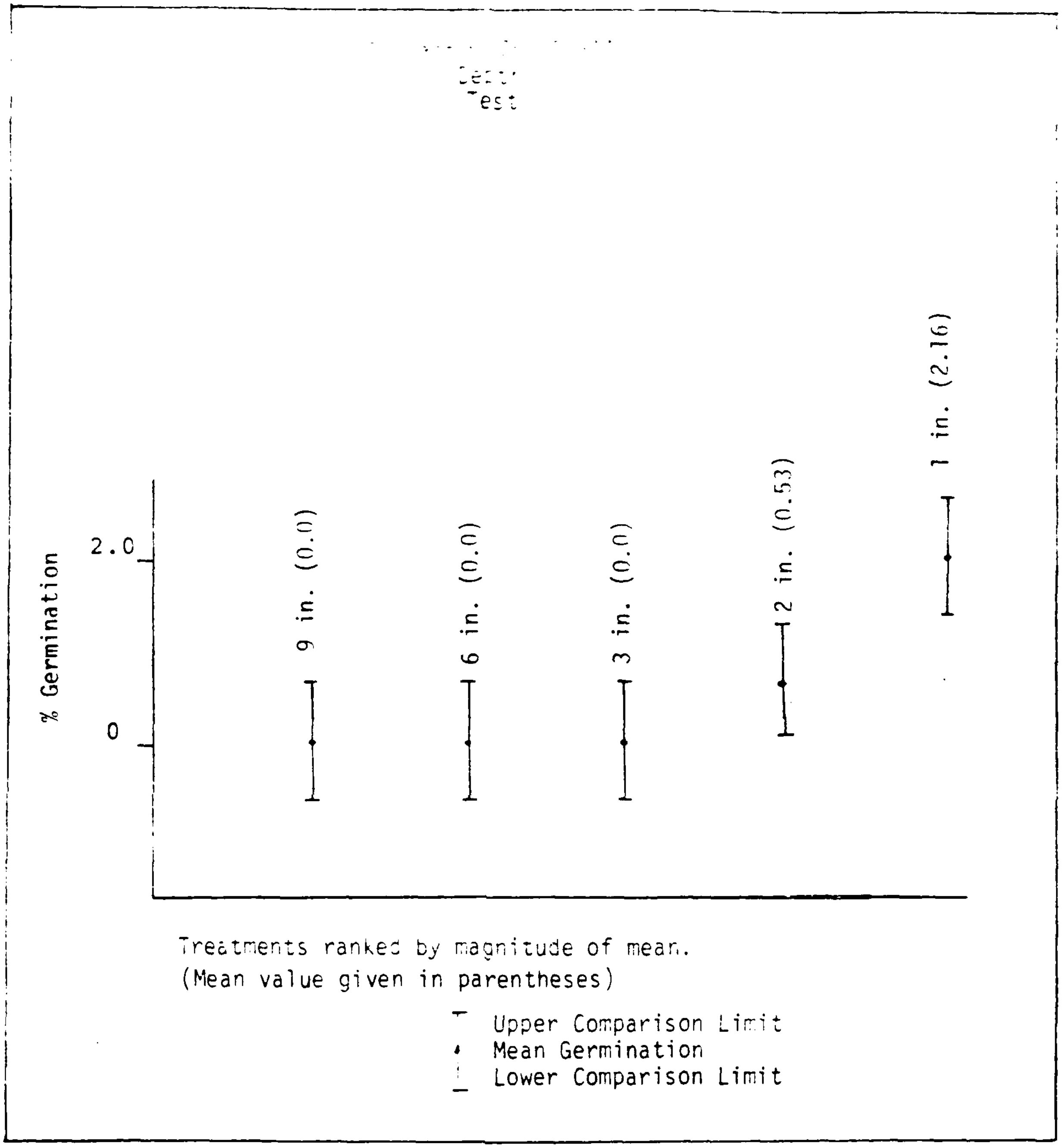


Figure 20: 95% Comparison limits for [illegible] germination by depth. (Treatments whose intervals do not overlap are significantly different)

2. Discussion

2a. Treatment Effects

The most noticeable trend for all species was inhibition of germination by non-control treatments. For all nine species, germination was highest for one of the three control application rates, most frequently the monoculture rate. Compost and hydromulch germination means fell significantly below the control means for six of the nine species. Slow release fertilizer, soluble fertilizer and jute matting means were significantly lower for four species. Of the nine species, *Calystegia* and *Lathyrus* showed the least difference among treatments.

Inhibition of germination by fertilizers when placed in close proximity to seeds is well established as the result of toxicity of certain ions and the inhibiting action of excess soluble salts of any kind. Olson and Dreier (1956) concluded that the most serious damage occurs at low moisture levels. Fertilizer in air-dry soils exhibited little or no toxicity, while maximum damage was caused by a moisture supply low enough to be stressful for germination but of significant magnitude to solubilize fertilizer. However, full germination could not be assured at any level of moisture. Nitrogen (N) materials were found to be more detrimental than Potassium (K) and damage was found to occur under critical soil moisture levels at as low as 10 lbs N/acre. Damage was less severe with pelleted rather than ground fertilizers. Straight Phosphorous (P) compounds caused no reduction in germination, although in ammonium phosphate form (16:20:0) damage was considerably greater. Roberts and Bradshaw (1985) found that toxicity was particularly severe under field conditions on sand waste due to the low ion exchange capacity, high porosity and low moisture retention. Application of a mulch somewhat reduced toxicity through enhanced moisture retention.

The severe reduction in germination observed under the soluble fertilizer, slow release fertilizer, hydromulch/fertilizer and compost plots are probably in large part the result of fertilizer induced toxicity. Although regular irrigation was provided, previous studies show that full germination is not attainable even under ideal moisture regimes. The irrigation system at the site underwent several start-up delays and seeds in the hydromulch/fertilizer, slow release fertilizer, soluble fertilizer and compost plots, planted between March 29 and April 2, were not watered until April 9. Seeds were in the soil with fertilizer from 7 to 12 days before any irrigation occurred, and initial irrigation was somewhat erratic. On April 3 soil moisture was recorded (using a moisture probe) at .5%, 1.9%, 5.5% and 7.2% at 1,2,3 and 6 inches respectively. Low moisture levels may have solubilized fertilizers without beneficial leaching effects. Olson and Dreier (1956) hypothesize that the delayed germination often observed in fertilized plantings is actually inhibition occurring until adequate rainfall or irrigation leaches fertilizers to a non-limiting level. This may account for germination delays noted for these treatments.

Roberts and Bradshaw (1985) and Sheldon and Bradshaw (1977) observed that lower toxicity levels result from slow release fertilizers than soluble fertilizers, and found that the addition of mulch had an ameliorating effect on toxicity. Treatments in Study Areas I and II show a contrary trend of decreasing germination from soluble fertilizer to slow release fertilizer to compost and hydromulch/ fertilizer.

This trend may be explained on the basis of several treatment application irregularities. In the slow-release fertilizer treatment plots Osmocote was applied at the midpoint of the range recommended by the manufacturer (10 lbs/100 sq.ft.), but only incorporated to one half of the recommended depth. This effectively doubled the rate, which is actually based on nursery container stock. The manufacturer subsequently recommended a much lower rate for use in hydromulching 1 lb/100 square feet (400 lbs./acre). Therefore, the application rate for Osmocote greatly exceeded that of soluble fertilizer (ammonium sulfate-21:0:0) applied at .7 lbs/100 square feet (300 lbs./acre and hydromulch/fertilizer (ammonium phosphate 16:20:0) applied at 1 lb/100 square feet (400 lbs./acre) in terms of N. Olson and Dreier (1956) demonstrated a proportionate increase in toxicity with increased N. Compost and hydromulch showed lowest germination, despite the reported reduction in toxicity through application of a mulch and the fact that mulches have been shown to increase germination over bare soil conditions through favorable moisture temperature interrelations (Barkley, Blaser and Schmidt 1965). The compost used, however, contained added nitrogen of approximately 1%, resulting in an N applicate rate of nearly 1000 lbs/acre, resulting in a high level of toxicity. Low hydromulch/ fertilizer germination is explained by the fact that when the hydromulch/ fertilizer was applied over the previously sown seed, the force of the hydraulically applied mulch dislodged much sand and seed in the plot. A large number of seeds subsequently germinated outside of the plot. Because of this problem, germination data for this treatment cannot be properly evaluated in the context of this study.

The inhibiting effect of jute matting was due in part to the barrier imposed by the large heavy matting to small seedlings. Jute matting exhibited an inhibiting effect only on the small to intermediate seeded species: *Artemisia, Camissonia, Eriogonum, Erigeron* and *Tanacetum*. The larger seeded species, characterized by robust seedlings (*Abronia, Calystegia* and *Lathyrus*) were not affected. The smaller seeded species exhibited reduced germination in most of the treatments (including controls) due to excessive burial (2 inches). However, the jute matting intensified this problem by (1) creating a barrier to germination, (2) reducing wind erosion and resultant exposure of seeds (as probably happened in unstabilized plots), and (3) causing additional sand deposition over the treatment plot. Before the onset of germination, ¼ to ½" of sand had accumulated over the entire treatment row, increasing the depth of seed burial.

AD-A189 037 DUNNE POINT SHORELINE EROSION DEMONSTRATION PROJECT VOLUME 1 APPENDICES A-D(U) ARMY ENGINEER DISTRICT LOS ANGELES CA AUG 87

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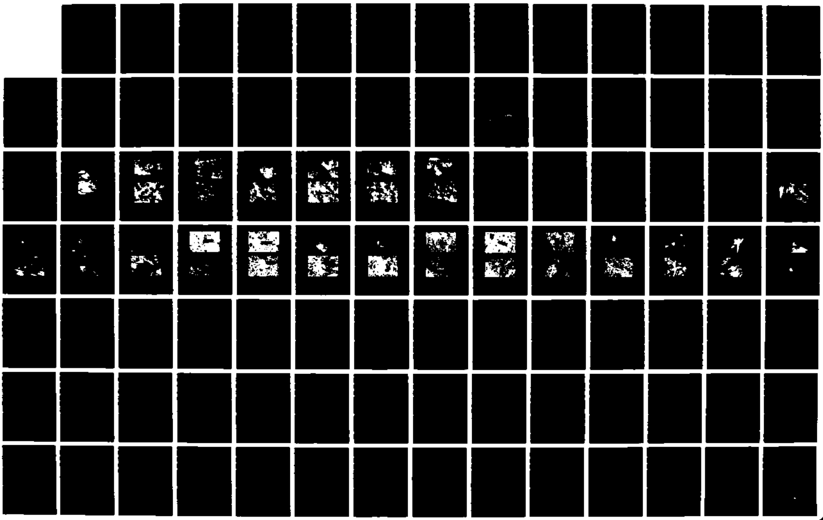
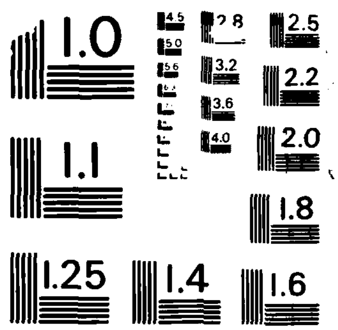




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

2c. Seed Dormancy

Germination and viability tests were conducted on samples of the seed by the State Seed Lab in Sacramento. Tetrazolium was used to test for viability in non-germinating seeds and non-viable seeds were X-rayed to check for embryo development. Table 11 shows the results of the tests compared with in situ germination of control (monoculture) treatment plots. For a number of species, field germination was very low relative to lab tests. However, for four species: *Lathyrus*, *Calystegia*, *Abronia* and *Ambrosia* (constituting all large-seeded species), field rates exceeded lab rates. Lab tests identified varying degrees of seed dormancy for these four species.

Two types of seed dormancy (involving two different mechanisms) are distinguished: embryo dormancy (where the control of dormancy lies within the embryo) and coat-imposed dormancy (dormancy is maintained by the structure enclosing the embryo). Embryo dormancy is imposed by germination inhibitors and in some cases may involve cotyledons (Bewley and Black 1982). Environmental conditions such as light, temperature, oxygen and carbon dioxide may control embryo dormancy through inhibitor response, and can be used to treat seeds for embryo dormancy. Coat-imposed dormancy may be the result of interference with water uptake and gaseous exchange. The coat may also act as a barrier to the escape of inhibitors from the embryo or it may exert a mechanical restraint on the embryo. This type of dormancy can be overcome by physical or chemical treatments such as abrasion, perforation or acid immersion.

Lab tests identified two species with seed coat dormancy: *Lathyrus* and *Calystegia*. These two species were mechanically scarified prior to planting, which probably accounts for germination rates above lab rates for unscarified seeds. However, field germination for *Calystegia* was still quite low (6.2% germinated, 84% viable), while Lathyrus germination was moderate to high (52% germinated, 76% viable). It appears likely that the scarification treatment for *Calystegia* was not as effective as for *Lathyrus*.

Some lowering of germination for these two species was probably caused by exposure of the seeds. Some seeds were observed at the surface after planting due to wind erosion of the overcovering soil. Larger seeds have been shown to be particularly susceptible to dessication at the surface due to their larger soil contact/surface area ratio (Harper and Benton, 1966).

Lab results showed 12% dormancy and 38% viability for *Ambrosia*. A 36 hour fresh water soak and 45 day stratification, or mechanical scarification and stratification have been recommended to treat this species (Trent, 1984). Seeds were scarified but not stratified before planting. Germination, at 30%, was only 4% above untreated lab germination, but was quite high relative to total viability. 49% of the total seed units were empty, while 13% were occupied but non-viable.

TABLE 11: Lab and Field Germination Test Results

Species	% Germ. Field	% Germ. Lab	% Dormant Lab	% Viable Lab	Remarks
Abronia latifolia sand verbena	21.8	0	36	36	53% empty
Ambrosia chamissonis beach bur	30.4	26	12	38	49% empty
Artemisia pycnocephala beach sagewort	9.4	88	0	88	12% empty
Calystegia soldenella beach morning glory	6.2	4	80	84	
Camissonia cheiranthifolia beach evening primrose	2.6	95	0	95	Alternated T° 15-25° at 20°C, germ=20%
Erigeron glaucus seaside daisy	1.5	97	0	97	
Eriogonum latifolium beach buckwheat	26	84	0	84	15% empty or abnormal
Lathyrus littoralis beach pea	57.1	4	72	76	
Tanacetum douglasii tansy	3.2	14	0	14	85% empty

Lab X-rays revealed that 53% of the *Abronia* anthocarps were empty. 36% of the seeds were viable but dormant. This dormancy was apparently overcome naturally to some extent (seeds were not treated) as control germination for *Abronia* averaged 22%. Germination can reportedly be increased by removing the anthocarp (Barbour, 1977), but the process is extremely labor intensive.

Field germination rates were extremely low relative to lab rates for the three small-seeded species: *Artemisa, Camissonia* and *Erigeron*. Lab rates for these three species where 88%, 95% and 97% respectively, representing 100% of viable seed. Field rates were 9.4%, 2.6% and 1.5%.

Light requirement has been shown to be an important factor in the germination of small-seeded species (Bidwell, 1979). This is an adaptation preventing germination at depth such that depletion of stored reserves occurs prior to penetration of the soil. Sand is a particularly poor transmitter of light; a 2mm layer permits less than 2% of the light to penetrate, representing only the larger wavelengths (Bidwell, 1979). Some small seeds are also intolerant of full sunlight, so the seed is prevented from germination unless it occurs at a shallow depth. Light requiring seeds are generally responsive to light only in the imbibed condition, insuring adequate moisture for germination (Bewley and Black, 1982).

It appears likely that high germination of the three small seeded species was prevented by excessive burial (2 inches). Although lab tests did not address light dependency, this phenomenon is further supported by the results of the Depth Test, which showed significantly higher germination of small seeds at 1 inch over 2 inches, and virtually none below 2 inches. Wind erosion may have brought some seeds close enough to the surface to respond to light, although complete uncovering of seeds may have resulted in loss of seeds from the plot by wind erosion, also contributing to low germination.

Observations of fruiting *Camissonia* at the end of the monitoring period suggests a likely mechanism for successful germination. Seeds fell directly below prostrate fruiting stems where, sheltered from wind by the adult plants, they germinated in high numbers. Unlike larger seeds, a smaller soil contact/surface area ratio reduces the change of dessication without burial for these seeds. In addition, soil microtopography is great relative to seed size and microsites of high atmospheric humidity occur, permitting germination at the surface (Harper, Williams and Sage, 1964).

Although *Erigeron* lab germination rates were high, the rates were achieved only through temperature alterations. At 20°C (68°F), germination was 20%. At alterations of 20-30°C (68-86°F) it increased to 36%, and at 15-25°C alterations germination reached 97%. Temperature may affect the light dependency of seeds or may independently control dormancy. Lab experiments did not address light requirements so it is uncertain whether one or both of these factors reduced germination on the site.

Lab tests showed no dormancy for the two medium sized seeds, *Tanacetum* and *Eriogonum*. *Eriogonum* was 84% viable and germinated at 84% in the lab. *Tanacetum* exhibited very low viability (14%) due to empty seed units, but all viable seed germinated in the lab. Field germination was 26% for *Eriogonum* and 3.2% for *Tanacetum*. *Tanacetum* showed greatly enhanced germination at 1 inch over 2 inches burial in the depth test. As in the case of the smaller seeds, excessive burial may account for reduced germination in these species.

B. Survival

Survival was recorded as number of individuals present over time, with cumulative adjustments made for later germination coinciding with mortality. Survival graphs were plotted for all replicate plots where germination was greater than zero, and are presented by species and treatment in Figures 21 through 29. Where germination was zero, no graphs are presented. Each species series utilizes the same vertical scale (number of individuals) to facilitate comparison of treatments, but scales differ among species. For species with a large vertical range, survival at very small percentages may appear as zero, but all replicates graphed had at least minor survival.

1. Results

To identify significant differences in survival between treatments, a one-way ANOVA ($P > .05$) was performed on each species separately, followed by Spojotvall & Stoline's T' method of multiple comparison for unequal sample sizes (survival was not calculated for replicates with zero germination resulting in unequal sample sizes). The ANOVA revealed that for three species; *Erigeron*, *Tanacetum* and *Lathyrus*, treatment had no significant effect on survival. Results of the T' method on the remaining six species are presented graphically as ranked means and comparison limits in Figures 30 to 35.

2. Discussion

In viewing overall treatment effects, no definite trend emerges. Four species exhibited a lack of significant variation among treatments. For the remaining species, only a single treatment could be shown to alter survival rate. In almost all cases the difference is attributable only indirectly to the treatment. *Abronia* showed significantly lower survival under compost and *Ambrosia* under slow release fertilizer. Both of these treatment/species plots showed extremely high cover relative to other treatments for the same species. Robust growth resulted in mortality late in the season as competition forced out smaller plants.

Another significant source of variation was jute matting, both in *Erigeron* and *Lathyrus*. This is attributable to problems with anchoring the jute matting. Wood stakes were used in place of the manufacturer-specified staples. The matting came up in a number of places, causing buckling which tore plants from the ground, or folding which buried them.

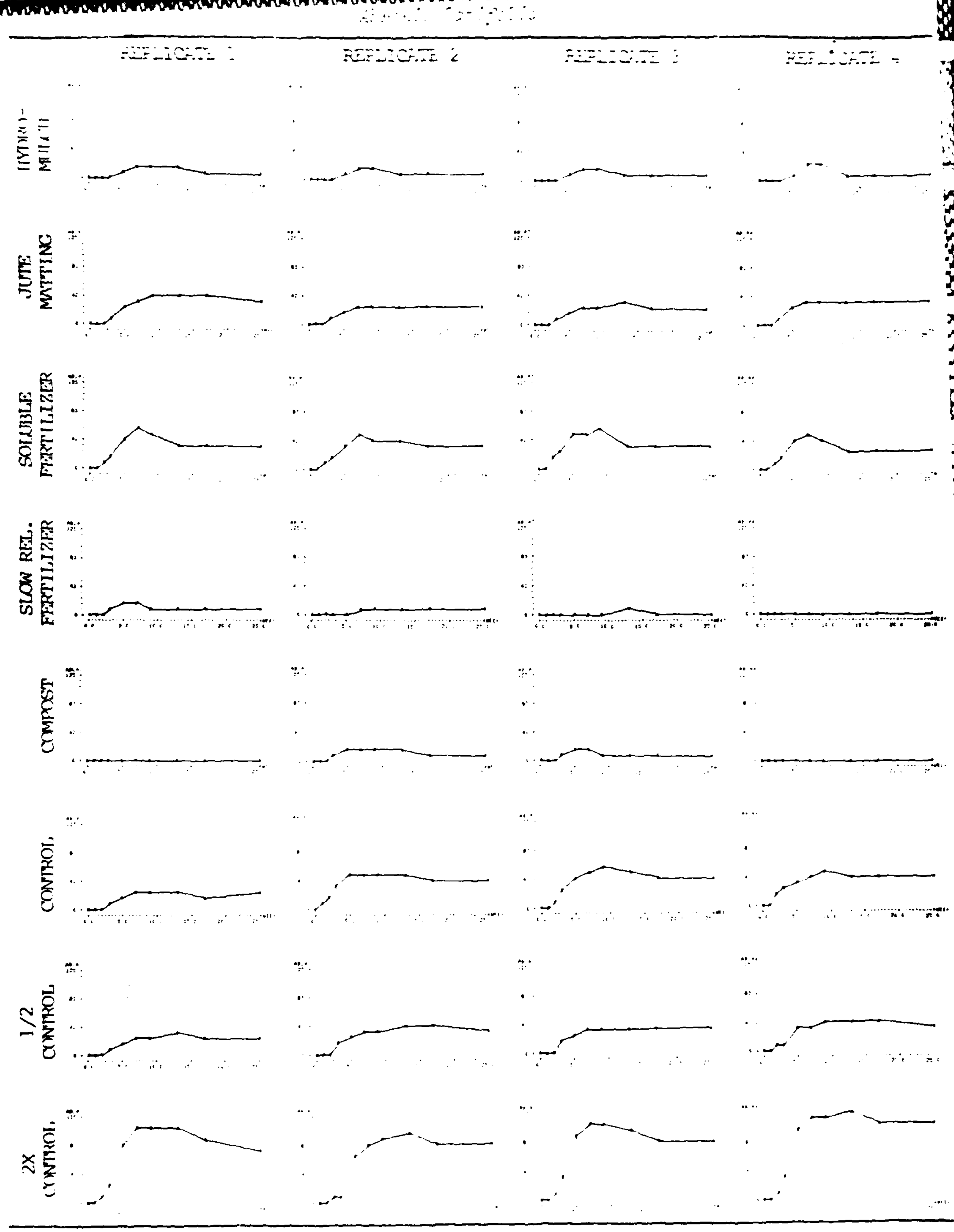


Figure 21: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week. (Missing graphs indicate zero germination)

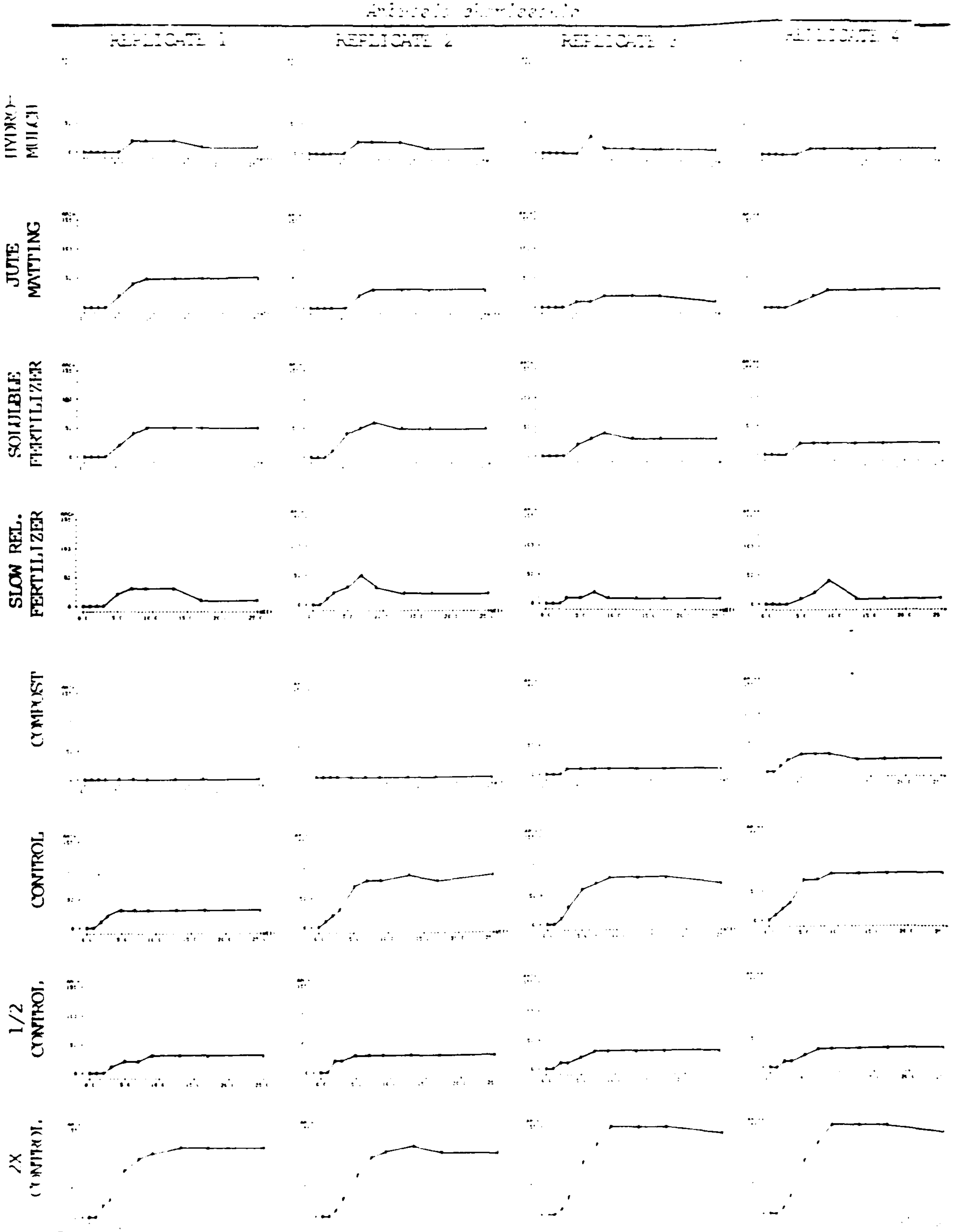


Figure 22: Survival Graphs for *Ambrosia artemisiifolia*. Number of Individuals are Plotted by Week.

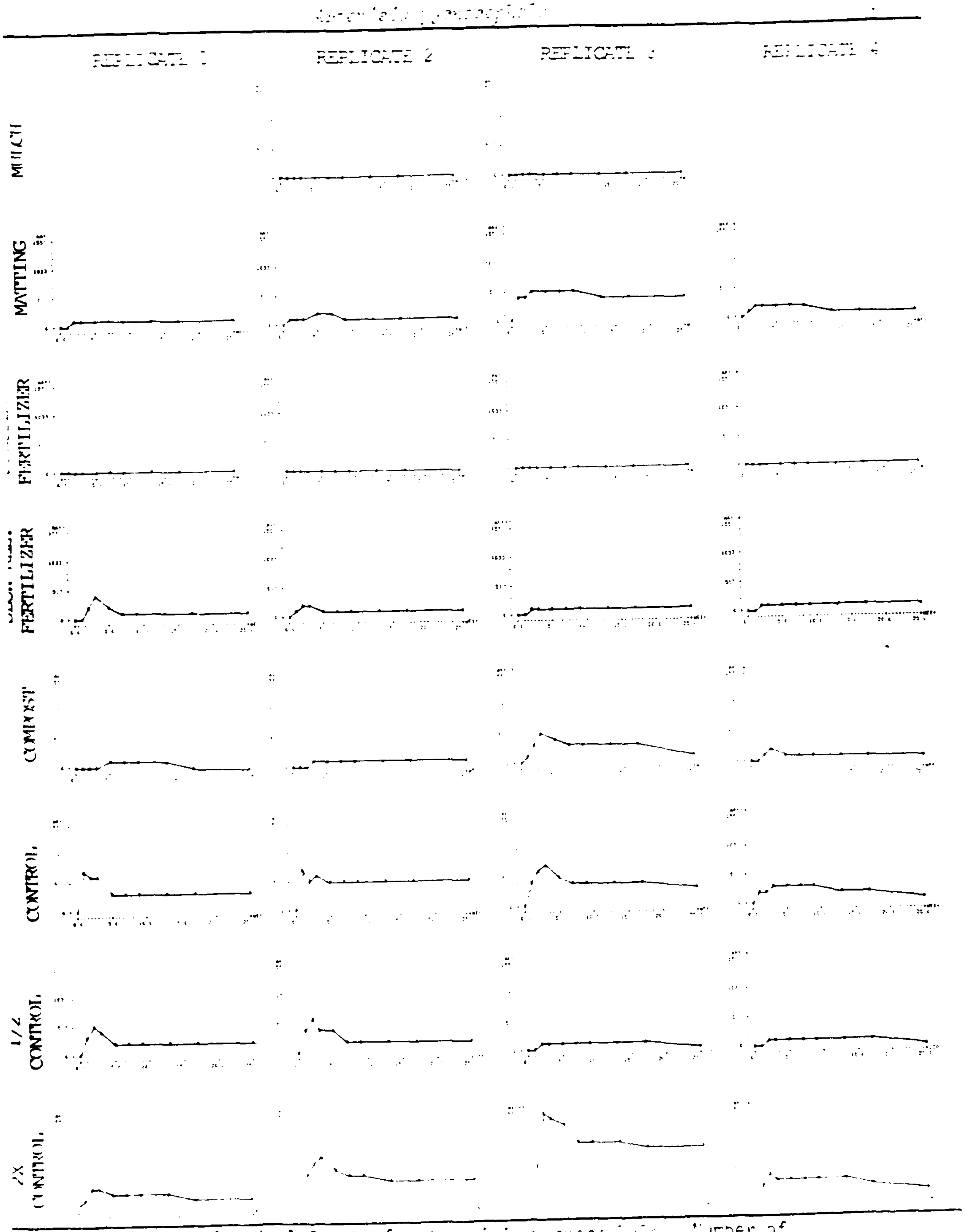


Figure 23: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week.

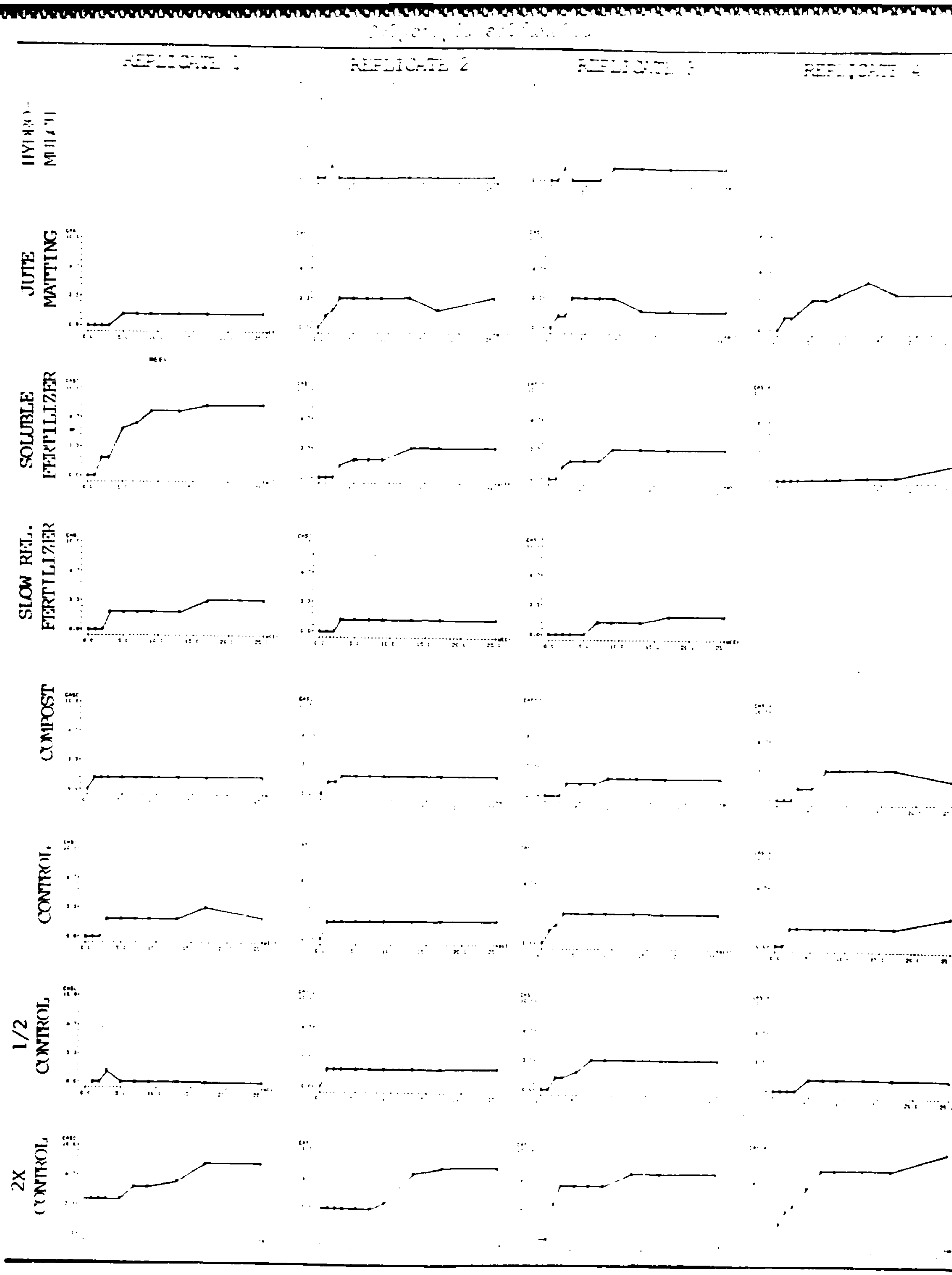


Figure 24: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week.

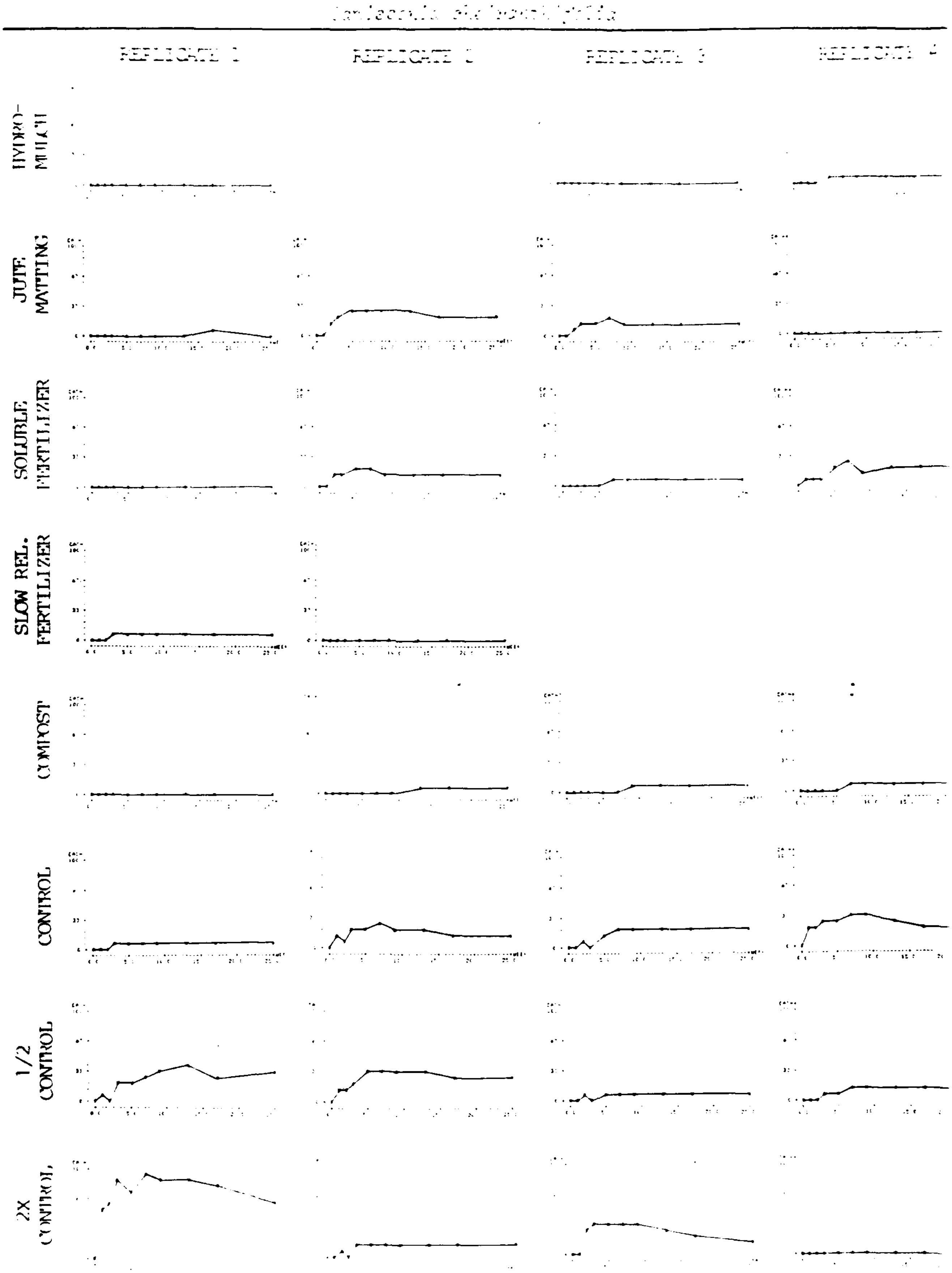


Figure 25: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week.

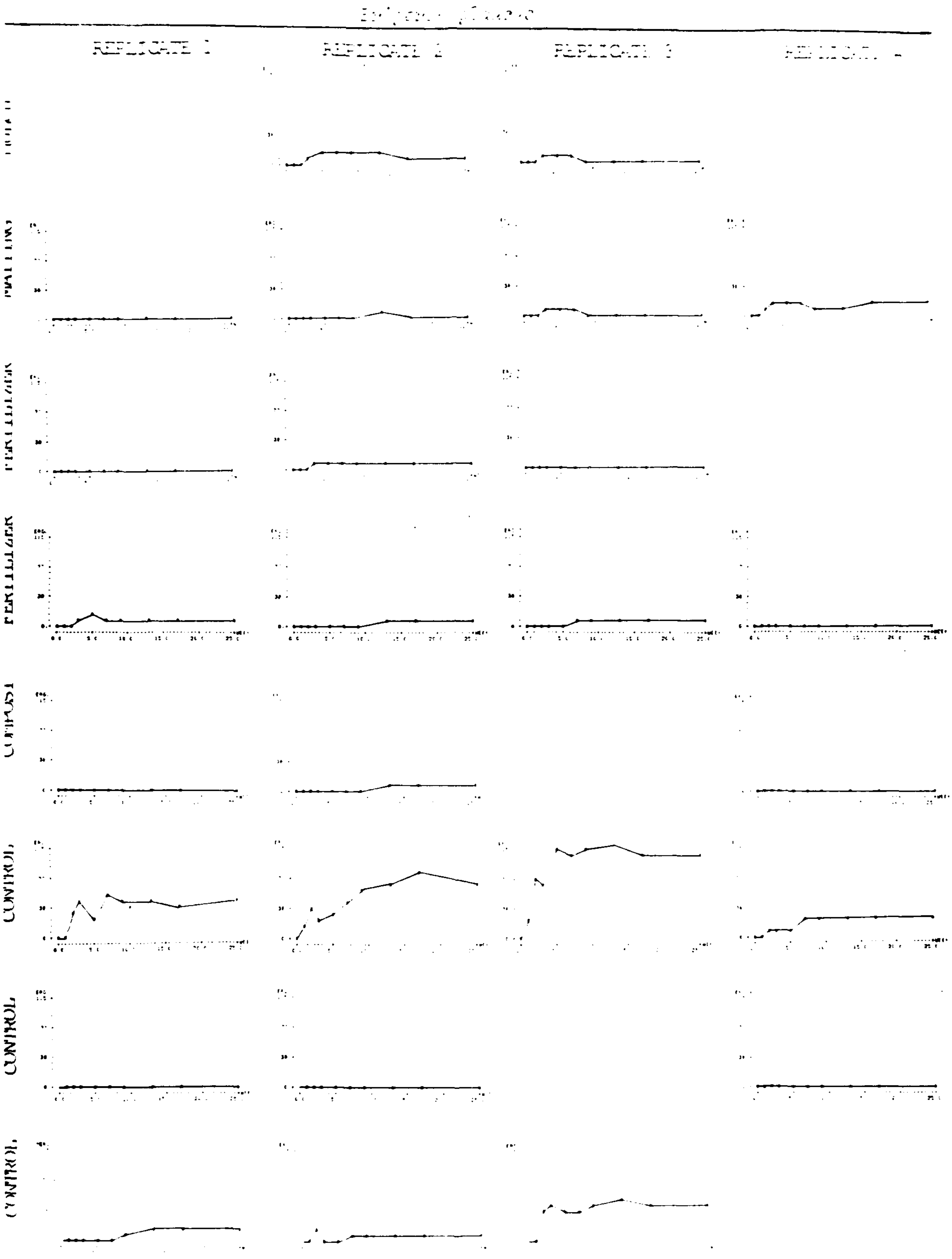


Figure 26: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week.

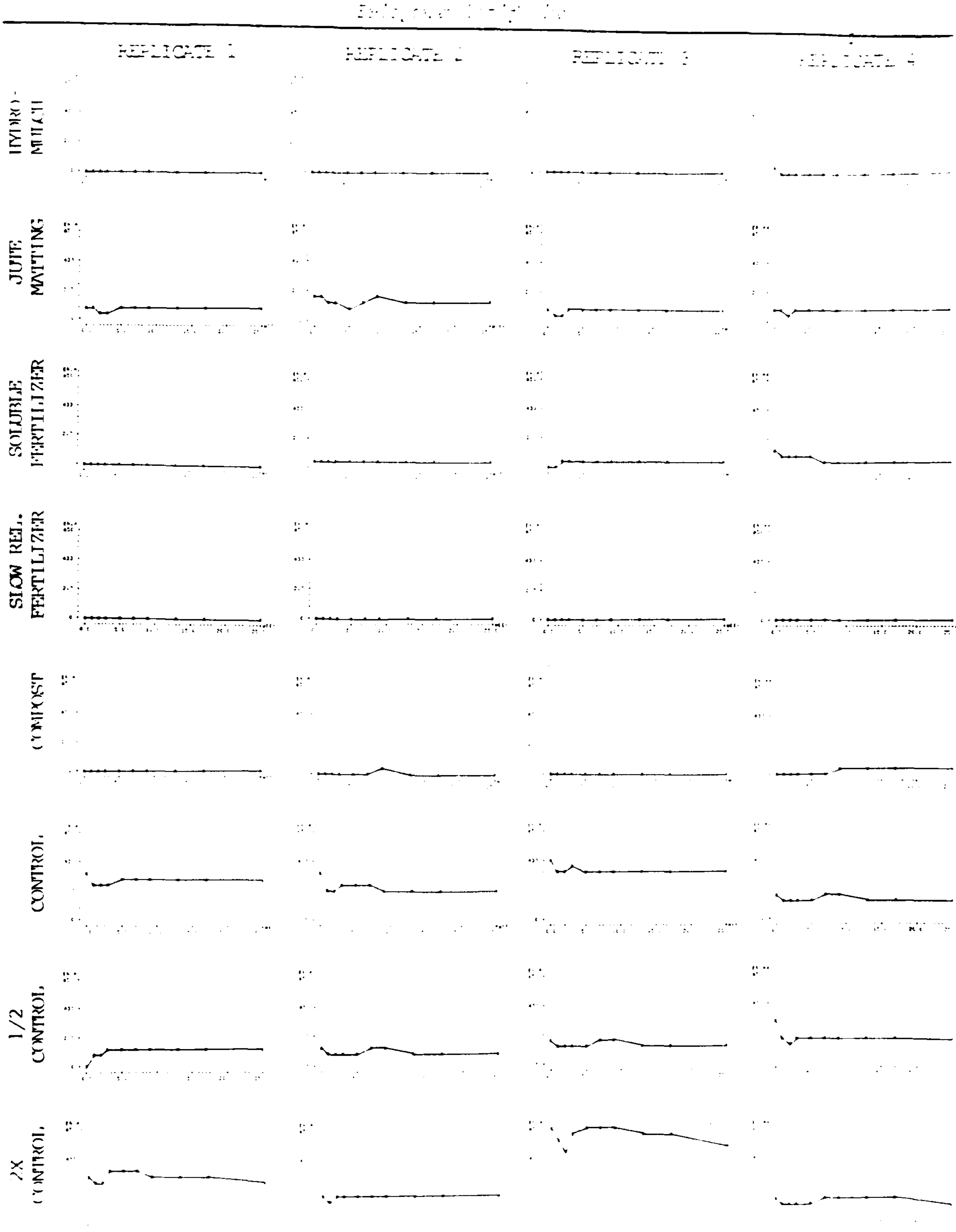


Figure 27: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week.

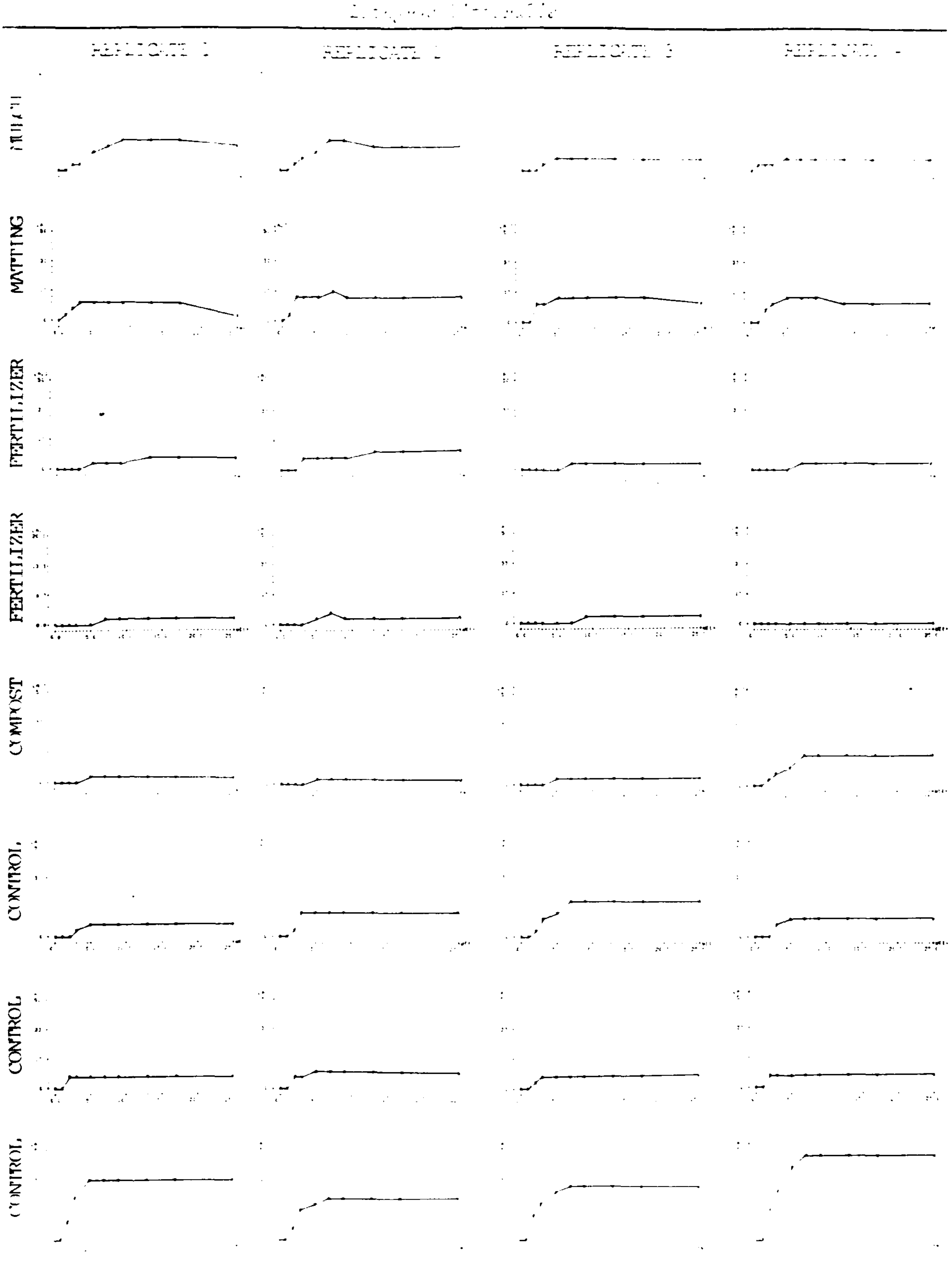


Figure 25: Survival Graphs for [illegible]. Number of Individuals are Plotted by Week.

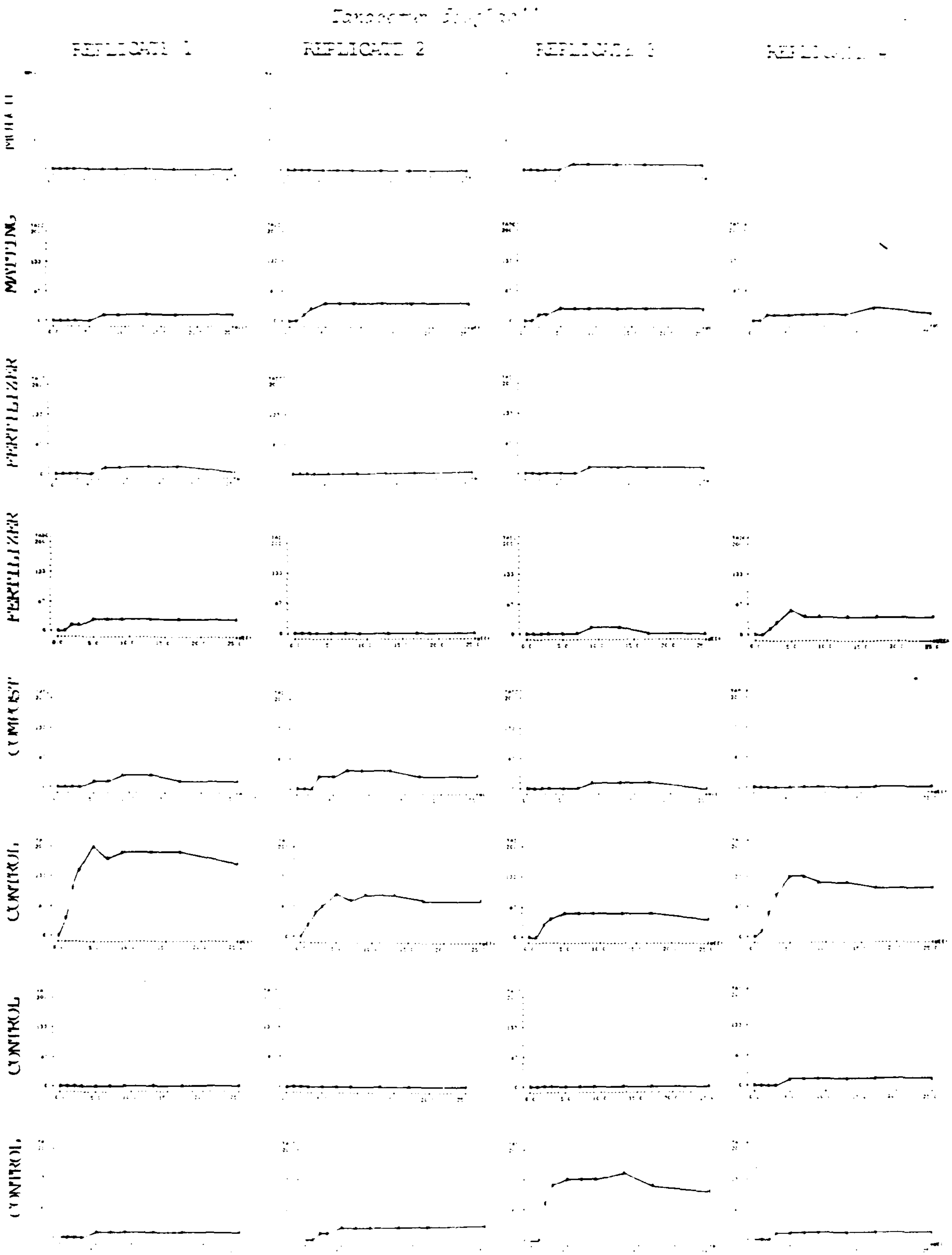


Figure 29: Survival Graphs for *Tanacetum douglasii*. Number of Individuals are Plotted by Week.

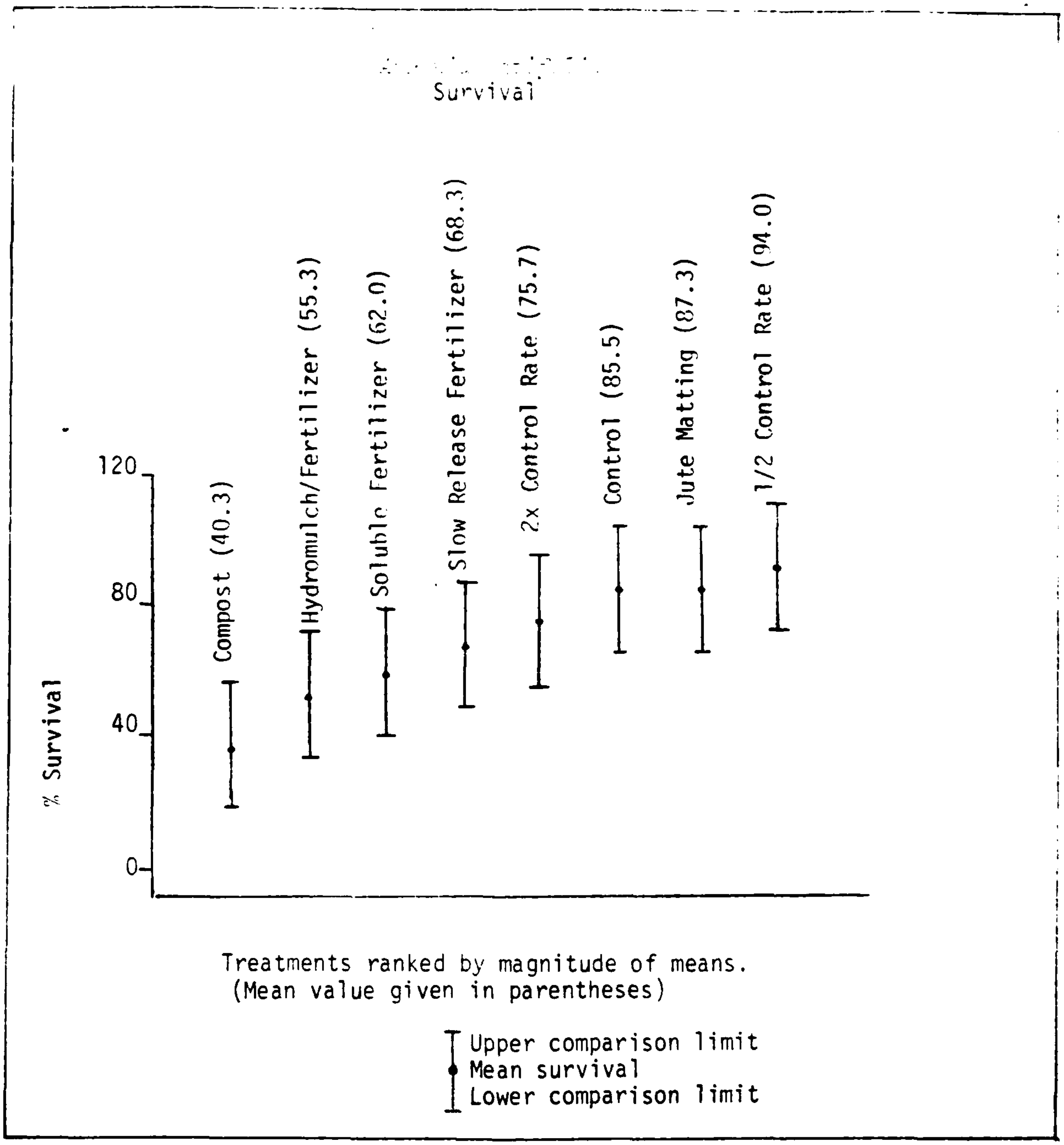


Figure 30: 95% Comparison limits for *Abronia* survival by treatment. (Treatments whose intervals do not overlap are significantly different)

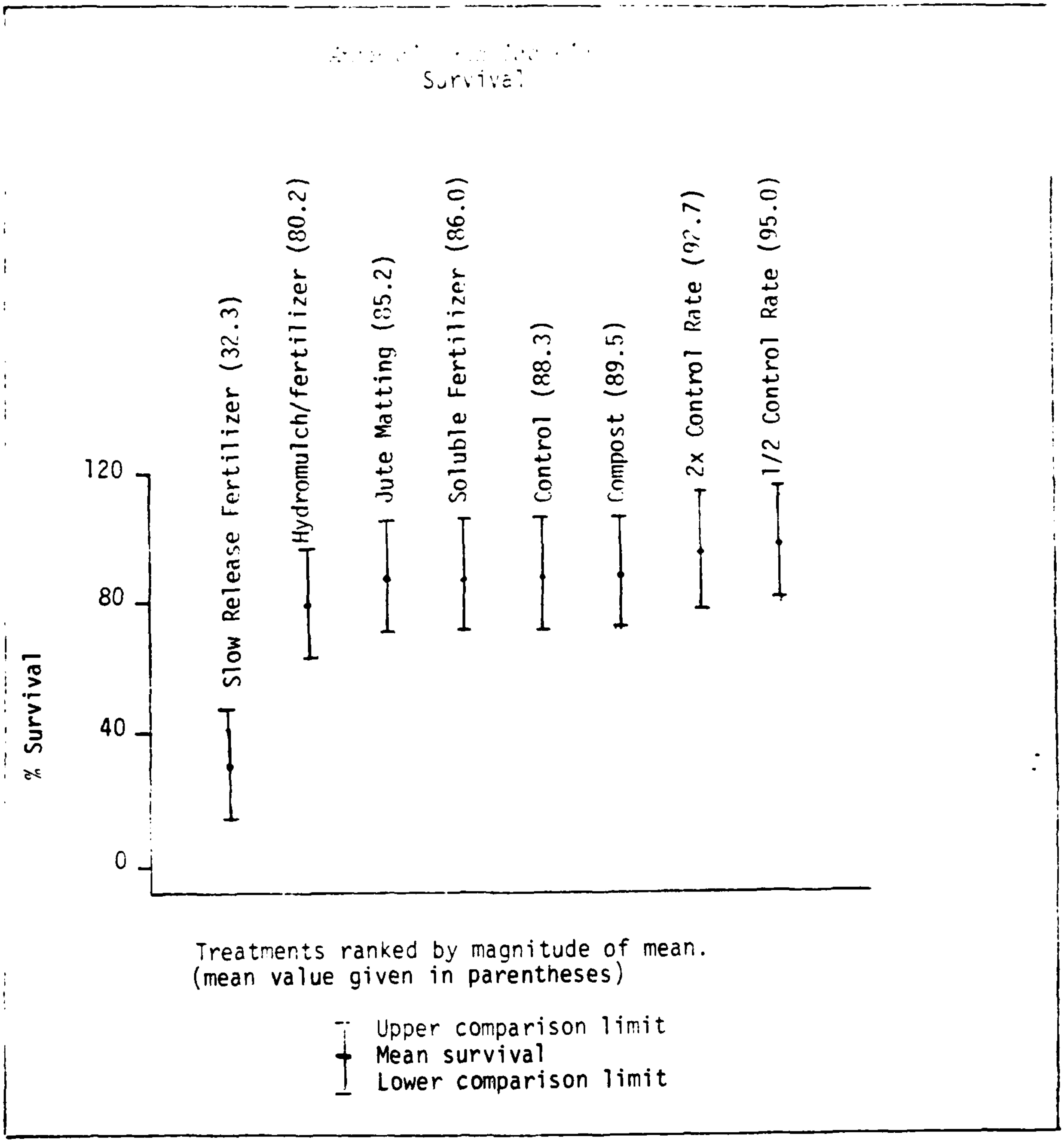


Figure 31: 95% Comparison limits for *Ambrosia* survival by treatment. (Treatments whose intervals do not overlap are significantly different)

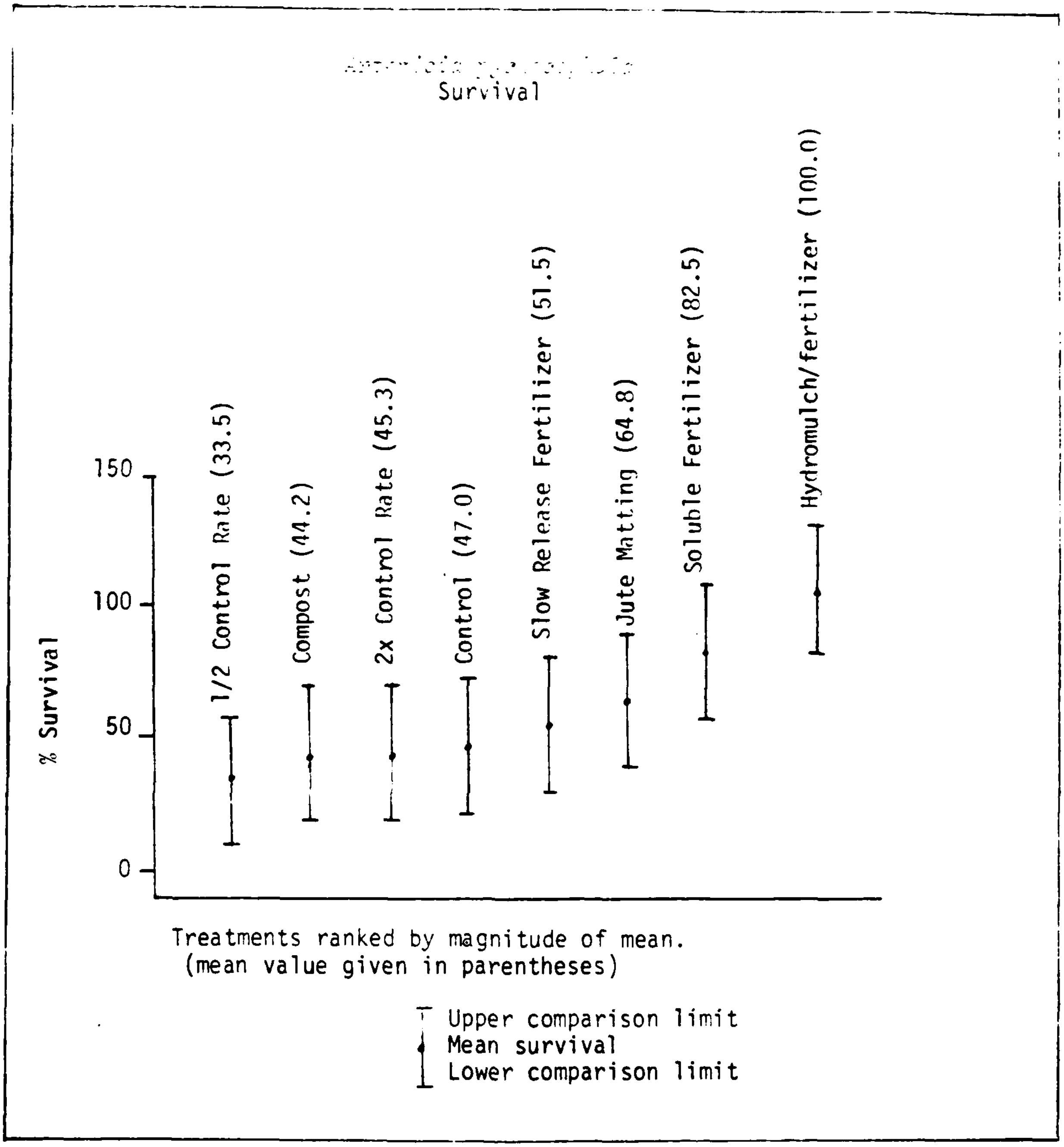


Figure 32: 95% Comparison limit for *Artemisia* survival by treatment. (Treatments whose intervals do not overlap are significantly different)

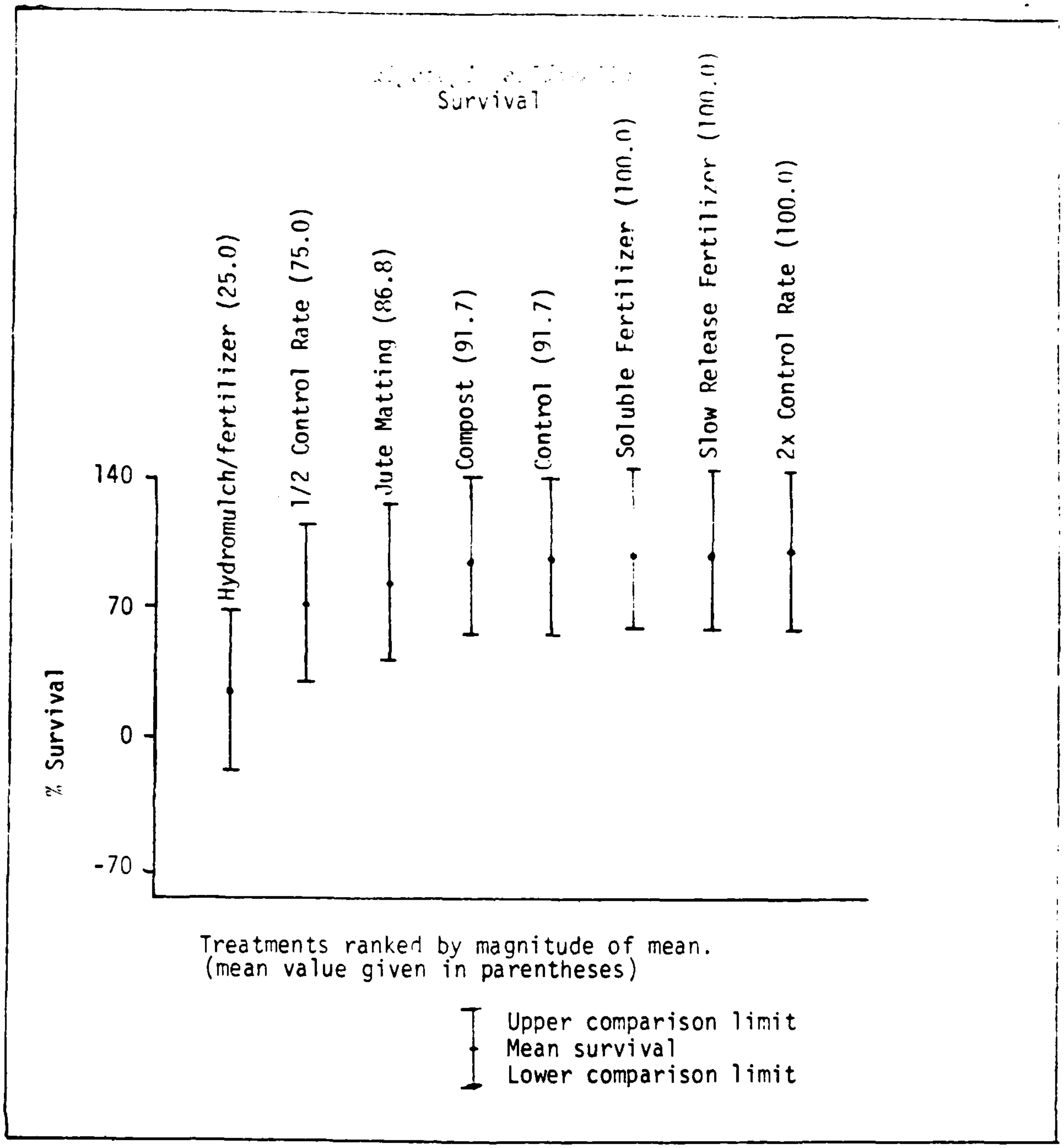


Figure 33: 95% Comparison limits for *Calystegia* survival by treatment. (Treatments whose intervals do not overlap are significantly different)

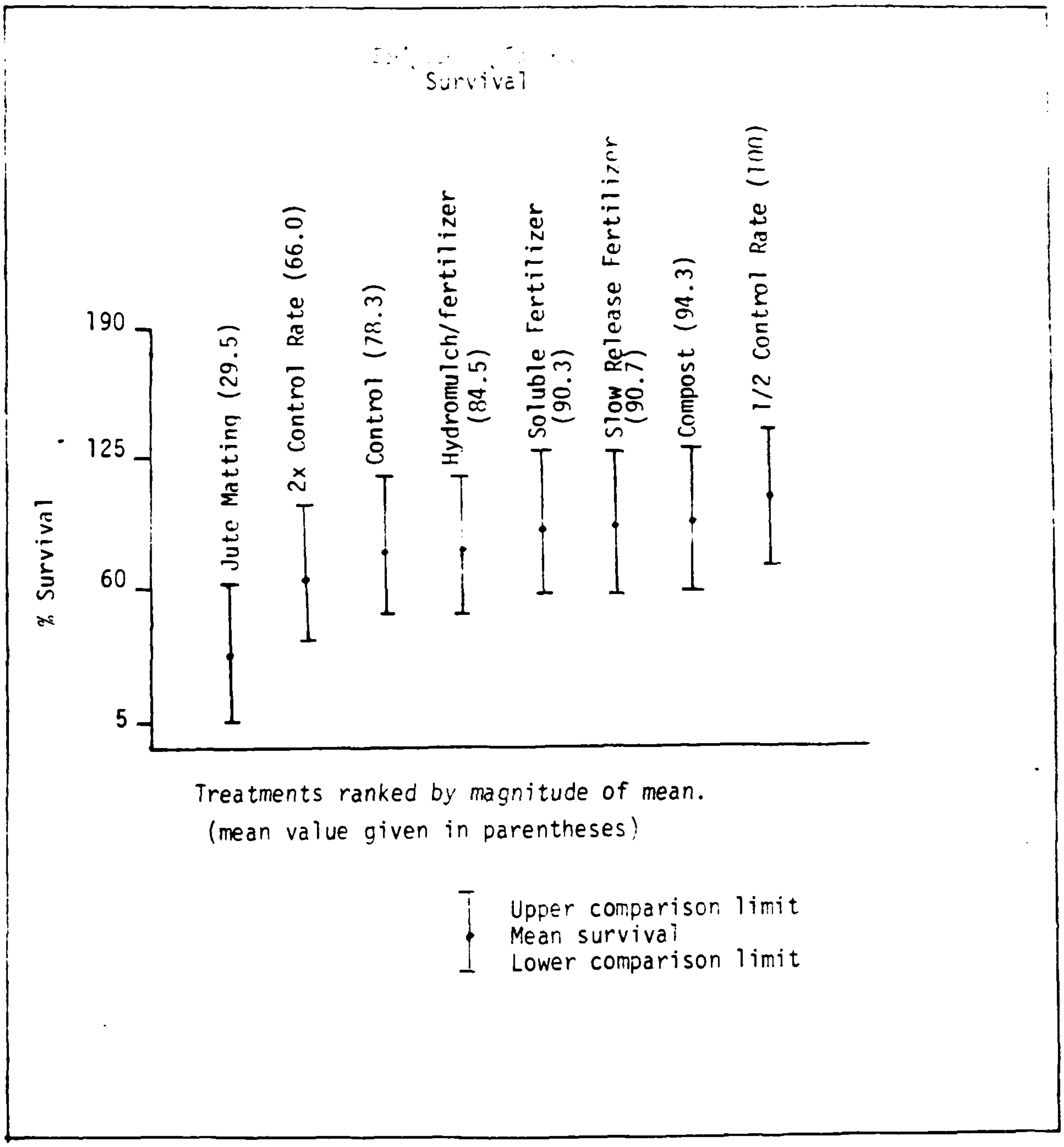


Figure 34: 95% Comparison limit for *Erigeron* survival by treatment. (Treatments whose intervals do not overlap are significantly different)

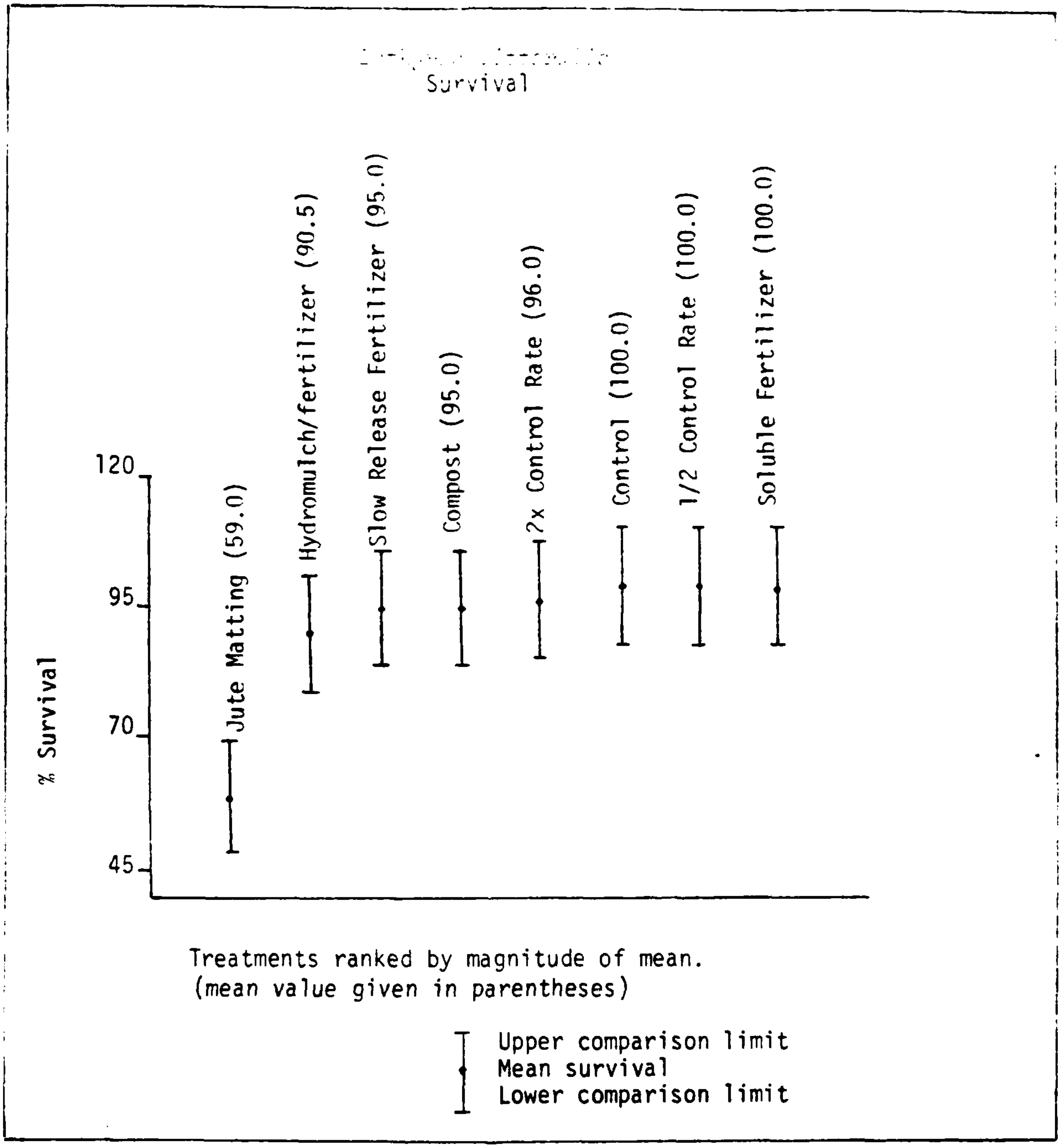


Figure 35: 95% Comparison limits for *Lathyrus* survival by treatment. (Treatments whose intervals do not overlap are significantly different)

The third source of variation was hydromulch fertilizer in the *Ammophila* plot which showed significantly higher survival. This was based on only two replicates, with a small number of individuals in each.

Overall, survival was high and showed relatively little variation by treatment. Survival was enhanced by regular irrigation and favorable weather conditions resulting in a lack of substrate mobility. Many extremely stressed individuals in control rows survived to the end of the season. Control plots for most species exhibited a pattern of smaller, stressed individuals in the center of the plot and larger more robust individuals at the edges. This was apparently an edge effect resulting from lower competition for nutrients around the edges (Figure 36). It is probable that mortality will reduce numbers significantly in the first winter due to wind erosion and sand abrasion.

C. Cover

End-of-season cover was calculated as a proportion of the original square meter plot (ie. vegetative growth outside the plot was excluded). Cover was calculated for replicates with zero germination, but was not calculated for two plots which had been severely damaged by dogs. This led to the use of a test statistic based on unequal sample sizes.

1. Results

A one-way ANOVA revealed no significant differences ($P > .05$) between treatments for four of the nine species (*Erigeron, Lathyrus, Eriogonum, Calystegia*). The remaining five species were tested using the T' method to locate differences. Results are presented graphically as ranked means and comparison limits in Figures 37 to 41.

2. Discussion

The results of the cover analysis show a strong trend toward increased cover under enhanced nutrient treatments (hydromulch/fertilizer, soluble fertilizer, slow release fertilizer, compost). This trend did not hold true for *Calystegia, Erigeron, Eriogonum* and *Lathyrus*, all of which showed no significant difference among treatments. *Lathyrus* and *Calystegia* in particular showed relatively little response to fertilizer treatments, although deficiency symptoms were commonly present in *Lathyrus* control plots. Both species grew slowly in terms of above ground biomass. However, both are rhizomatous and had begun sending up new shoots by the end of the monitoring period. It is possible that, evaluated for a second growing season, these species would show significant differences in cover under fertilized treatments resulting from enhanced rhizome growth.

Erigeron plants also did not appear to increase substantially in above ground growth, except in the hydromulch/fertilizer plots and one slow release fertilizer replicate. The high cover value afforded by the two hydromulch/fertilizer replicates was negated by two empty replicates in hydromulch/fertilizer where germination was zero.

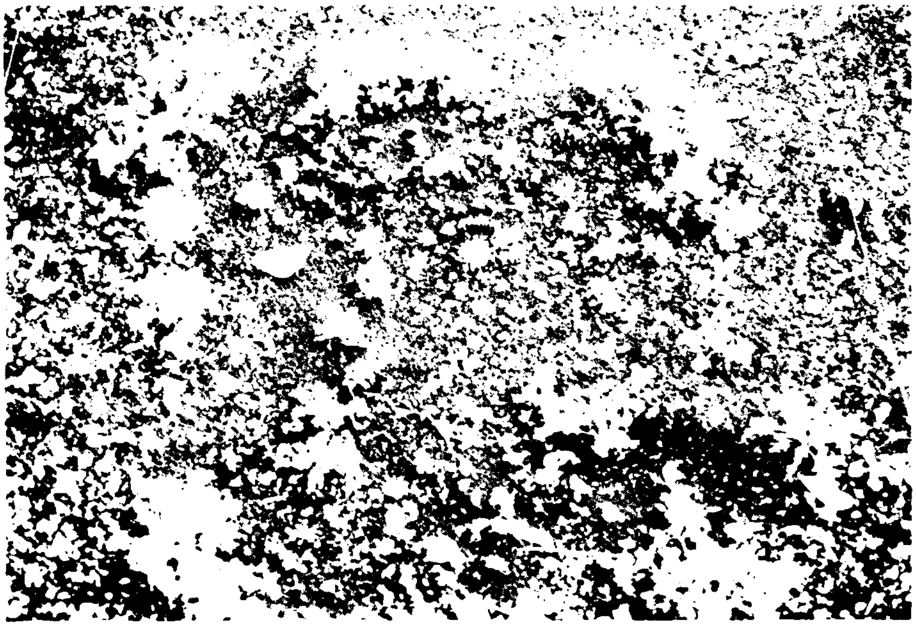


Figure 36: Edge Effect Exhibited by an *[illegible]* Control Plot.

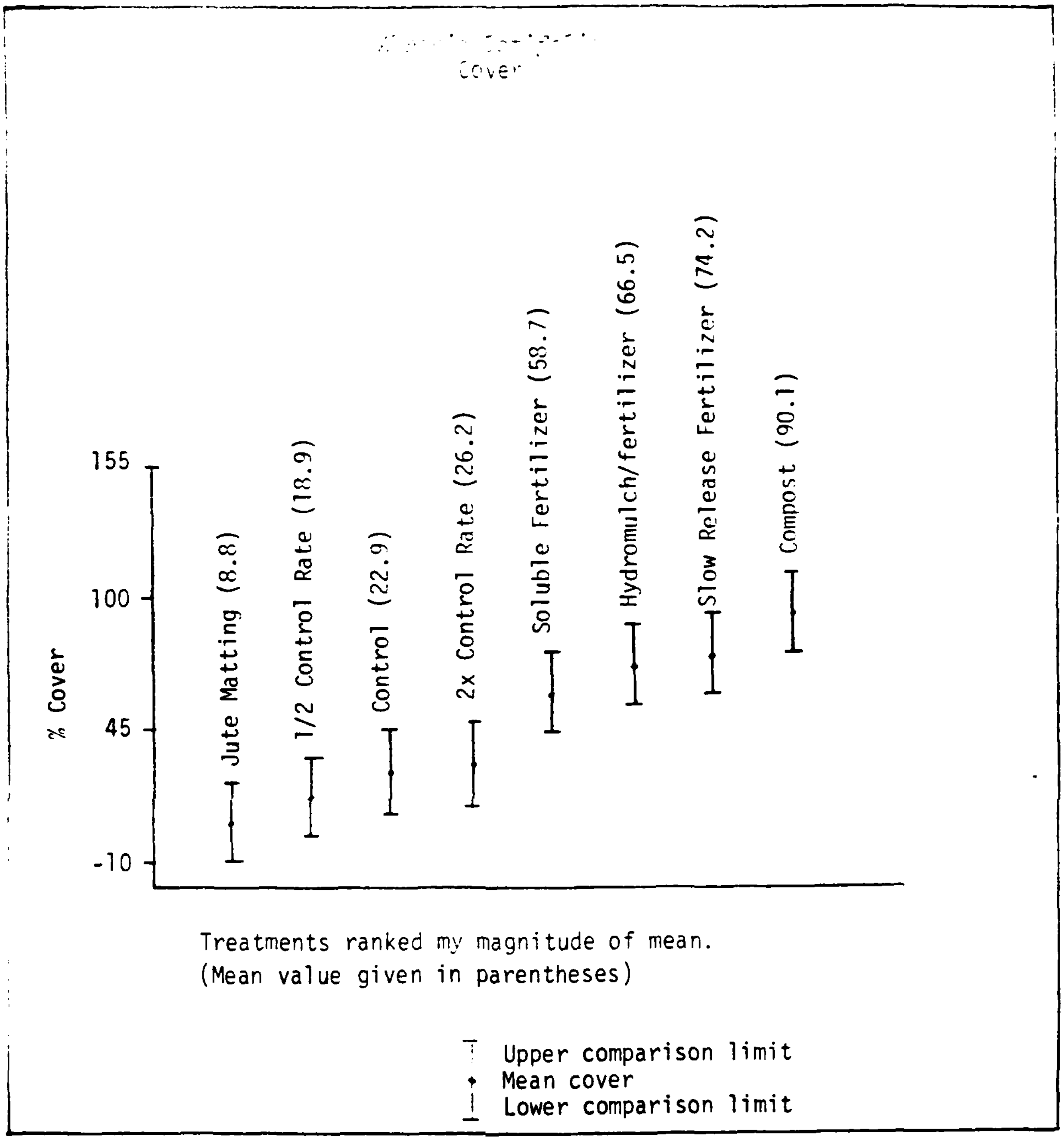


Figure 37: 95% Comparison limits for *Abronia* cover by treatment. (Treatments whose intervals do not overlap are significantly different)

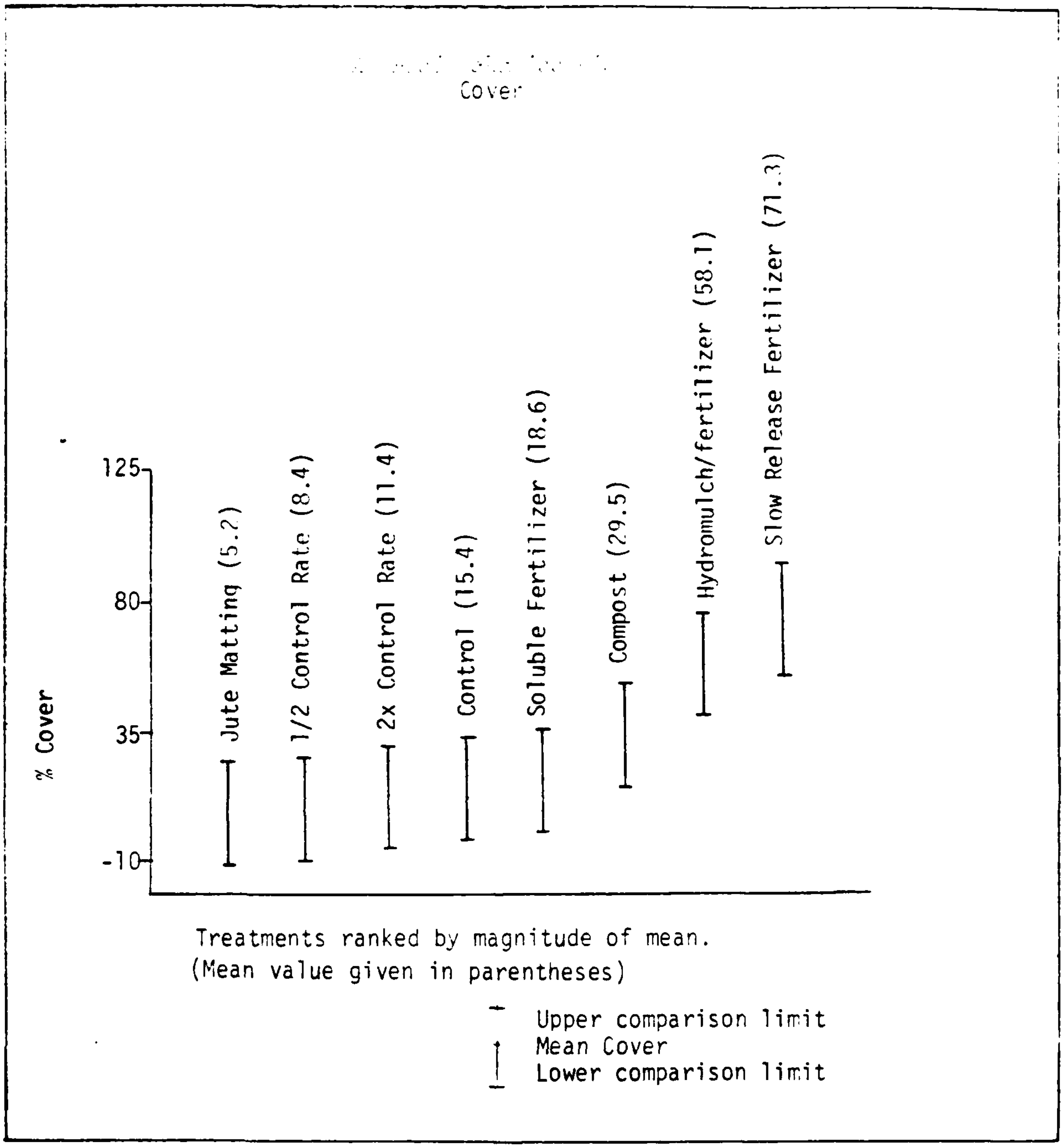


Figure 38: 95% Comparison limits for *Ambrosia* cover by treatment. (Treatments whose intervals do not overlap are significantly different)

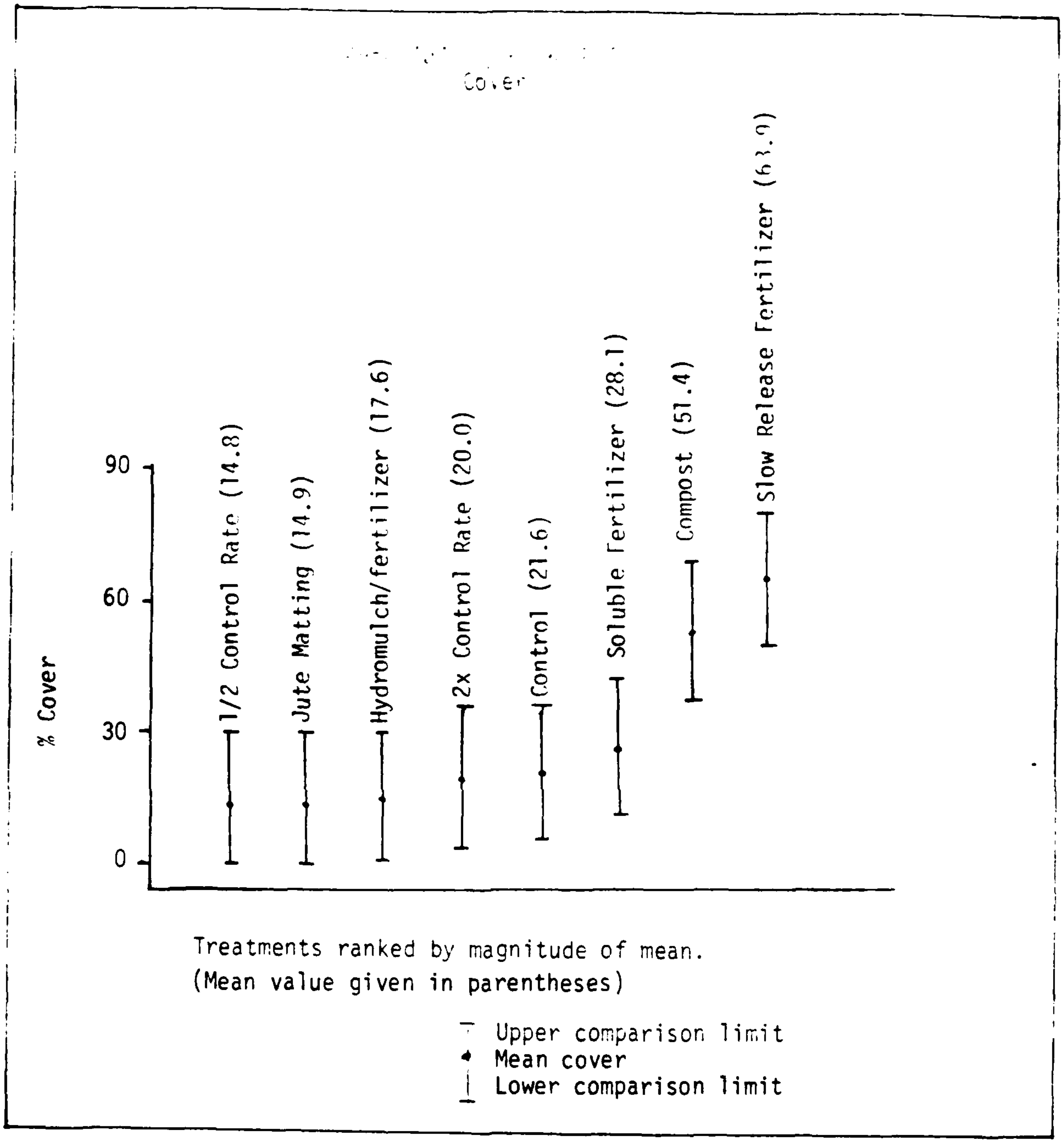


Figure 39: 95% Comparison limits for *Artemisia* cover by treatment. (Treatments whose intervals do not overlap are significantly different)

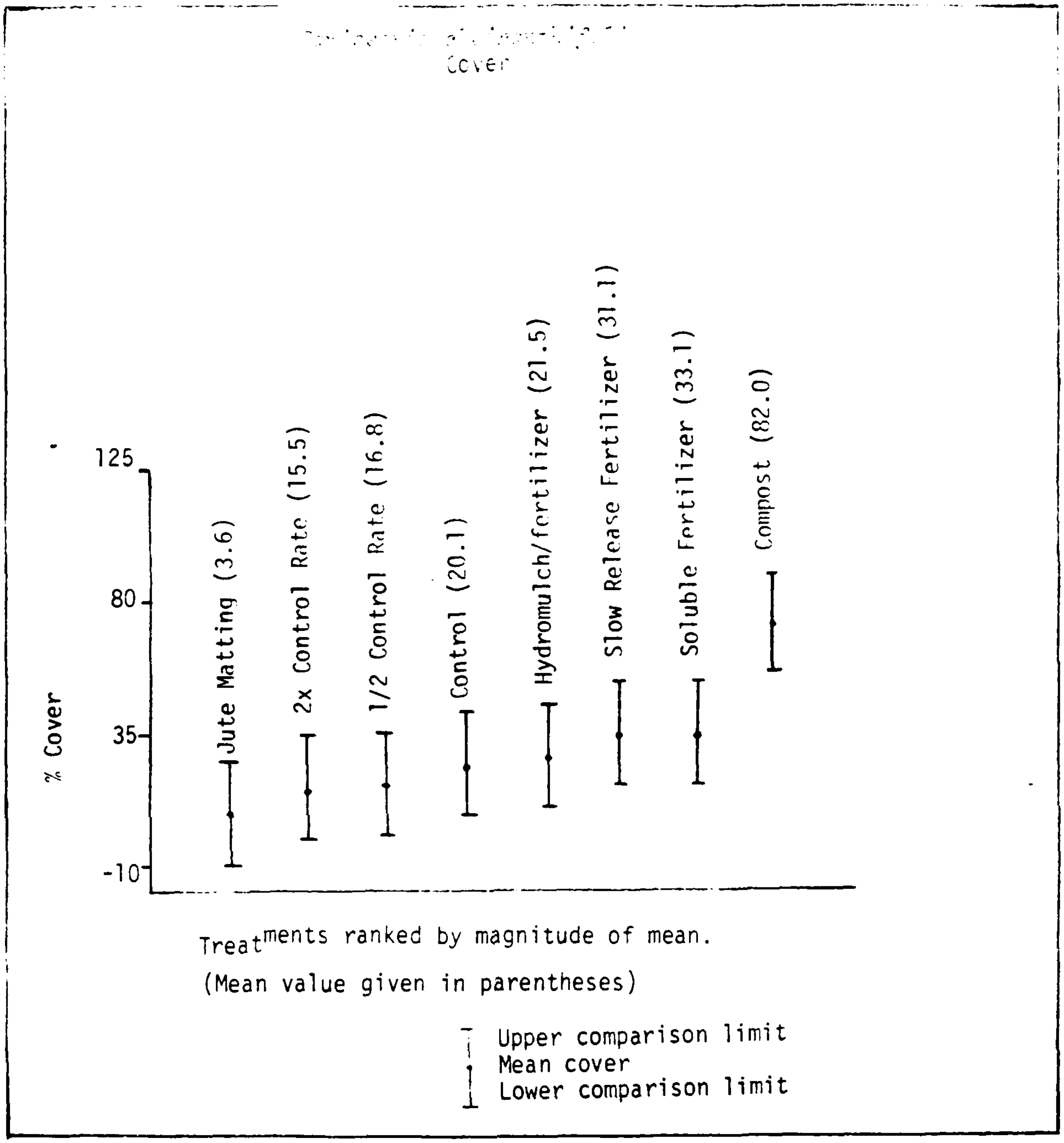


Figure 40: 95% Comparison limits for *Camissonia* cover by treatment. (Treatments whose intervals do not overlap are significantly different)

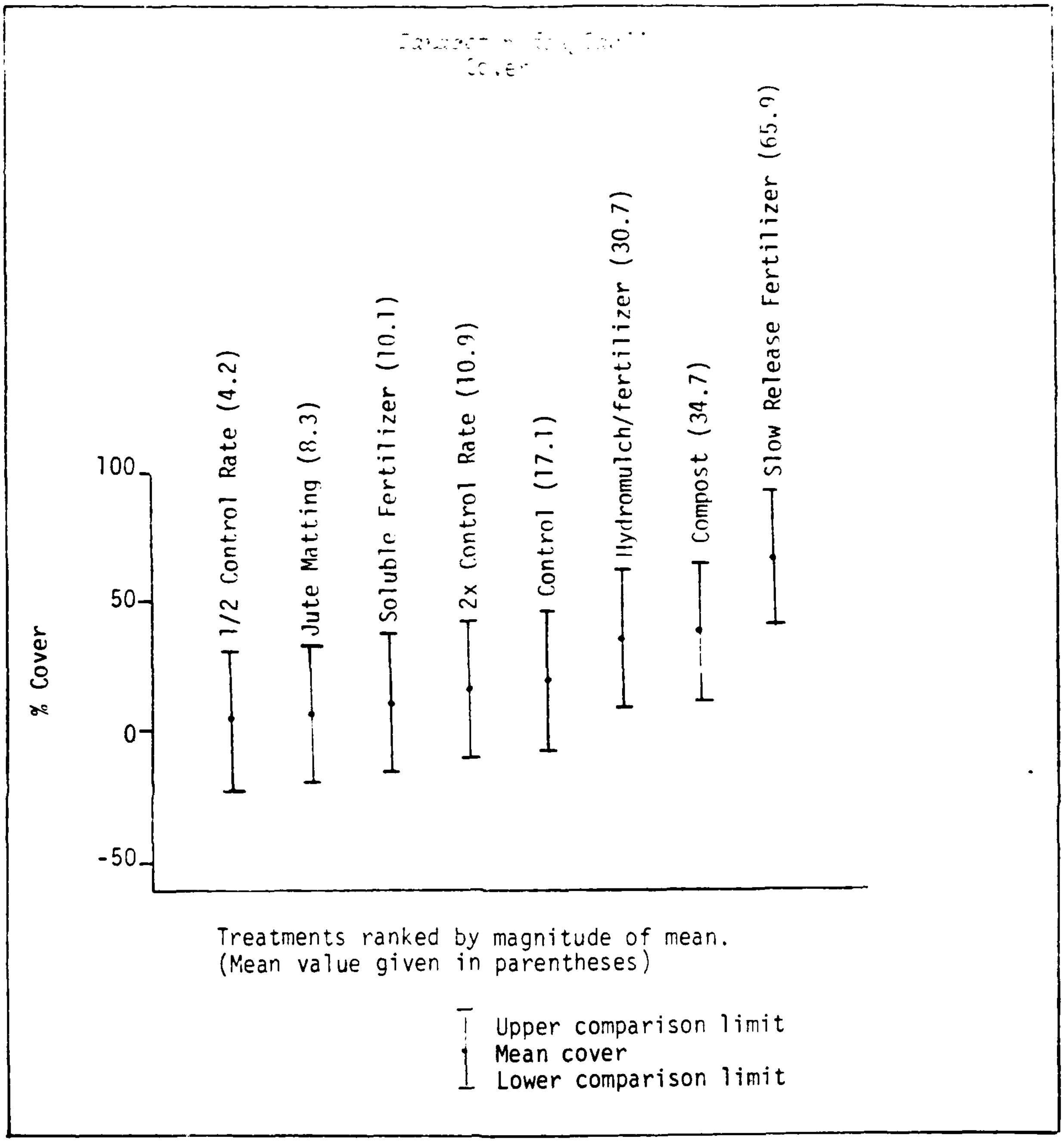


Figure 41: 95% Comparison limits for *Tanacetum* cover by treatment. (Treatments whose intervals do not overlap are significantly different)

Eriogonum individuals were noticeably larger in fertilized and compost plots than in controls. However, these plants only attained moderate stature (relative to *Artemisia*, *Ambrosia*, etc.) before flowering. As a result, a few moderate sized plants in fertilized plots (where germination was low) almost equalled the cover value of numerous small stunted plants in control plots, where germination was much higher. This explains the lack of significant difference between treatments.

All other species clearly show the superiority of the fertilized treatments in promoting cover. Of these treatments, slow release fertilizer resulted in significantly greater cover the greatest number of times (four out of five species), and soluble fertilizer the least (one out of five). This agrees with qualitative observations made at the site, with the exception that hydromulch is perhaps underrated. As discussed under the germination section, germination was artifically reduced in these plots, resulting in a number of empty replicates. The action of the hydromulch resulted in accidental germination of the wrong species in a number of these "empty" replicates, and these individuals were left to grow. By the end of the monitoring period, cover was extremely high in some of these plots (see Figure 42). It is assumed that under normal conditions, with higher germination, cover values under hydromulch/fertilizer would have approached those of slow release fertilizer.

Qualitative observations through the 85-86 winter, after the close of monitoring, indicate that over time, the treatment slow release fertilizer became even more superior to other treatments in terms of cover values. Although the formulation used was designed to release for four months, those species which do not become dormant continued to grow throughout the winter months (release is temperature-dependent and cool temperatures prolong the release time). By March, the difference between the slow release fertilizer plots and other fertilizer treatments had visibly increased. Figures 43 to 48 contain photographic examples of replicate treatment plots for two species: *Ambrosia* and *Artemisia*. Enhanced growth under fertilized treatments is apparent in viewing these photographs.

D. Species Comparisons

Because the above tests were run on each species independently, it is difficult to evaluate the relative suitability of the nine species for dune revegetation. To provide a direct comparison control values for each of the three variables (germination, survival and cover) were tested to locate differences between species. An analysis of variance was performed, followed by the T' method of multiple comparisons. Results are displayed graphically in Figures 49-51 and discussed by variable below.

1. Germination

The multiple comparison showed a number of significant differences, as illustrated in Figure 49. The species can be roughly divided into two groups of relatively lower and higher germination.

Figure 42: High cover values attained by accidental germination in empty hydromulch plots (foreground).

Figure 43: *Artemisia* and *Ambrosia*, hydromulch/fertilizer treatment (16:20:0)

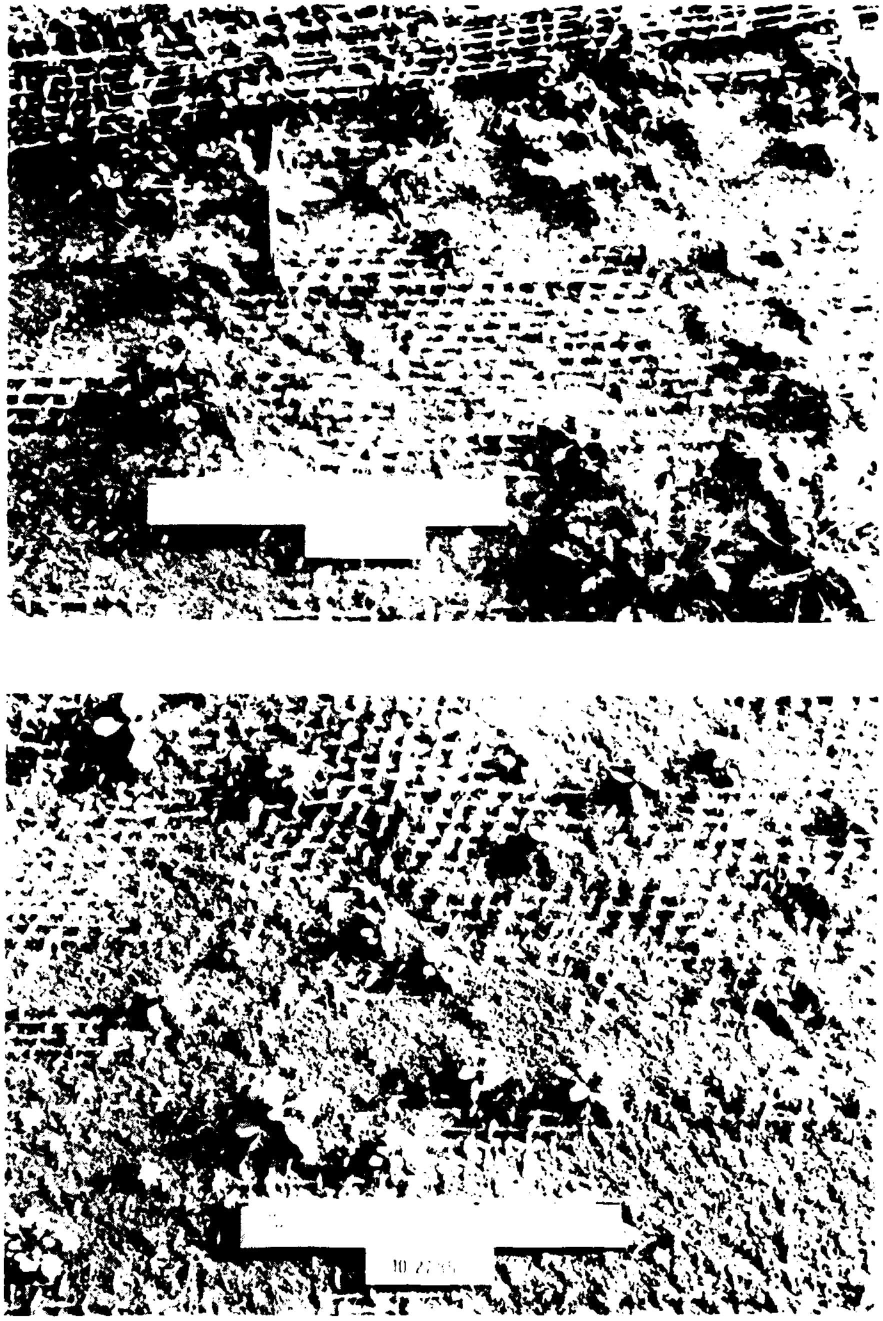


Figure 44: *Artemisia* and *Ambrosia*, jute matting treatment

Figure 45: *Artemisia* and *Ambrosia*, soluble fertilizer treatment (21:0:0)

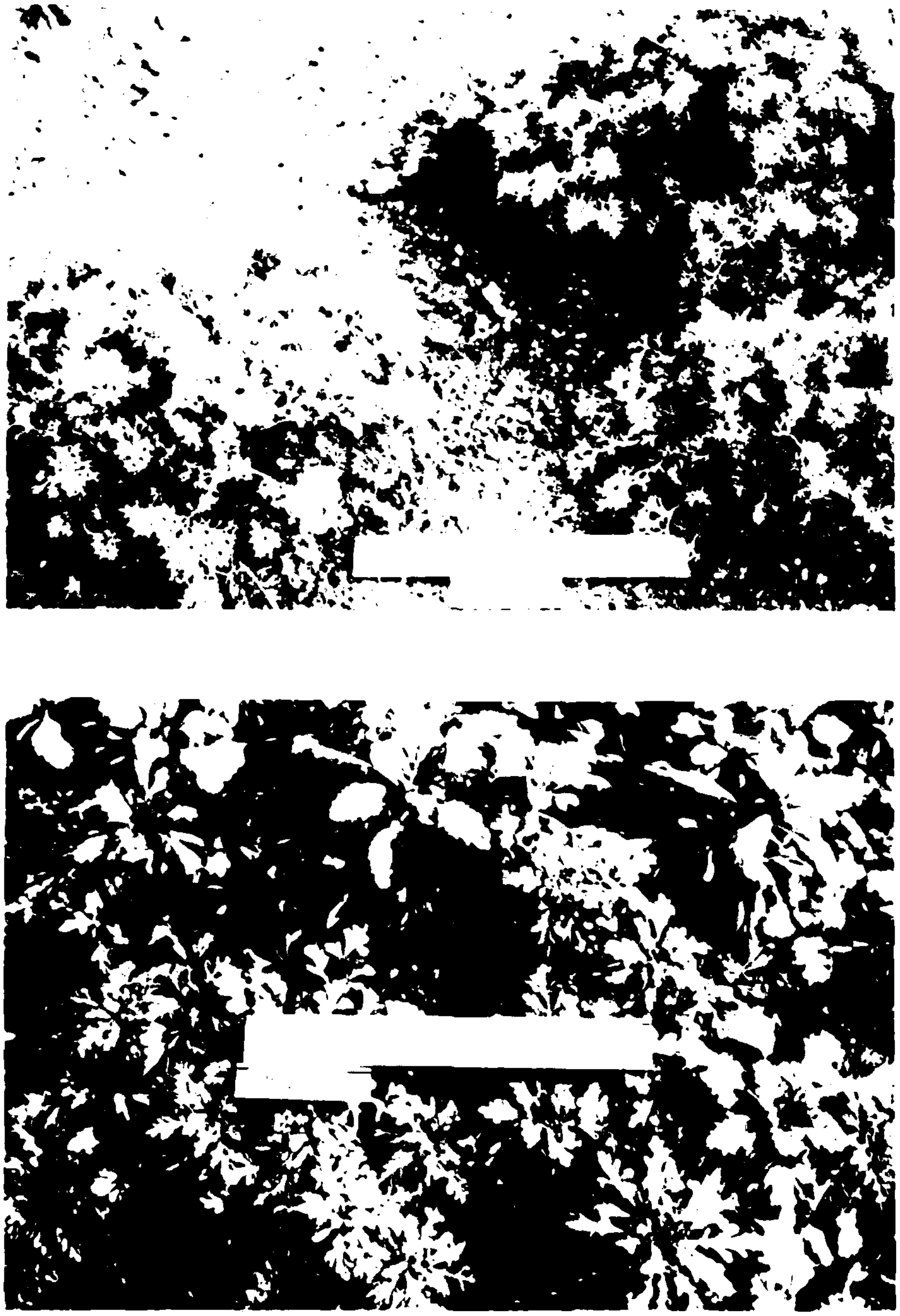


Figure 46: *Artemisia* and *Ambrosia*, Osmocote slow release fertilizer treatment (13:13:13)

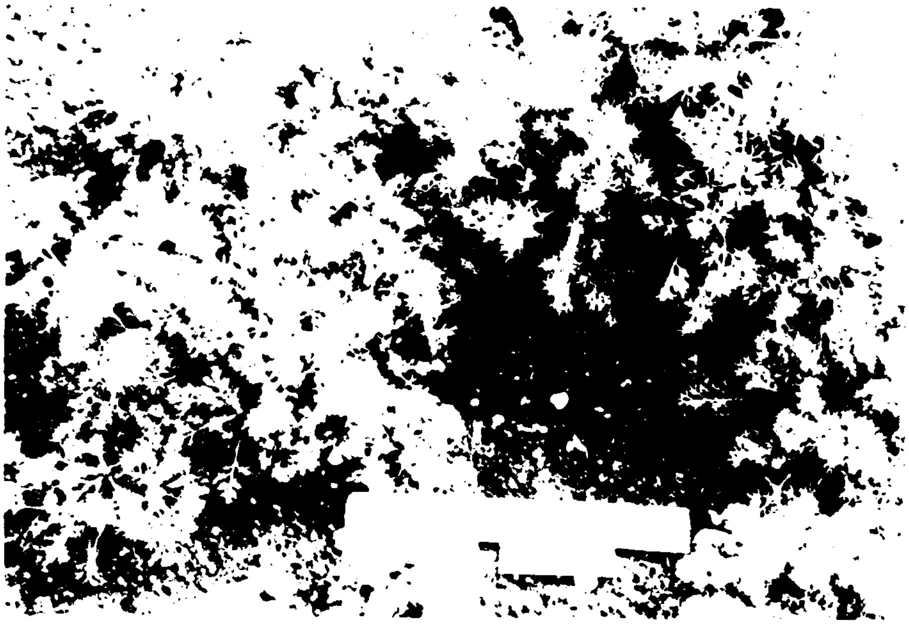


Figure 47: *Artemisia* and *Ambrosia*, compost treatment (with added nitrogen)

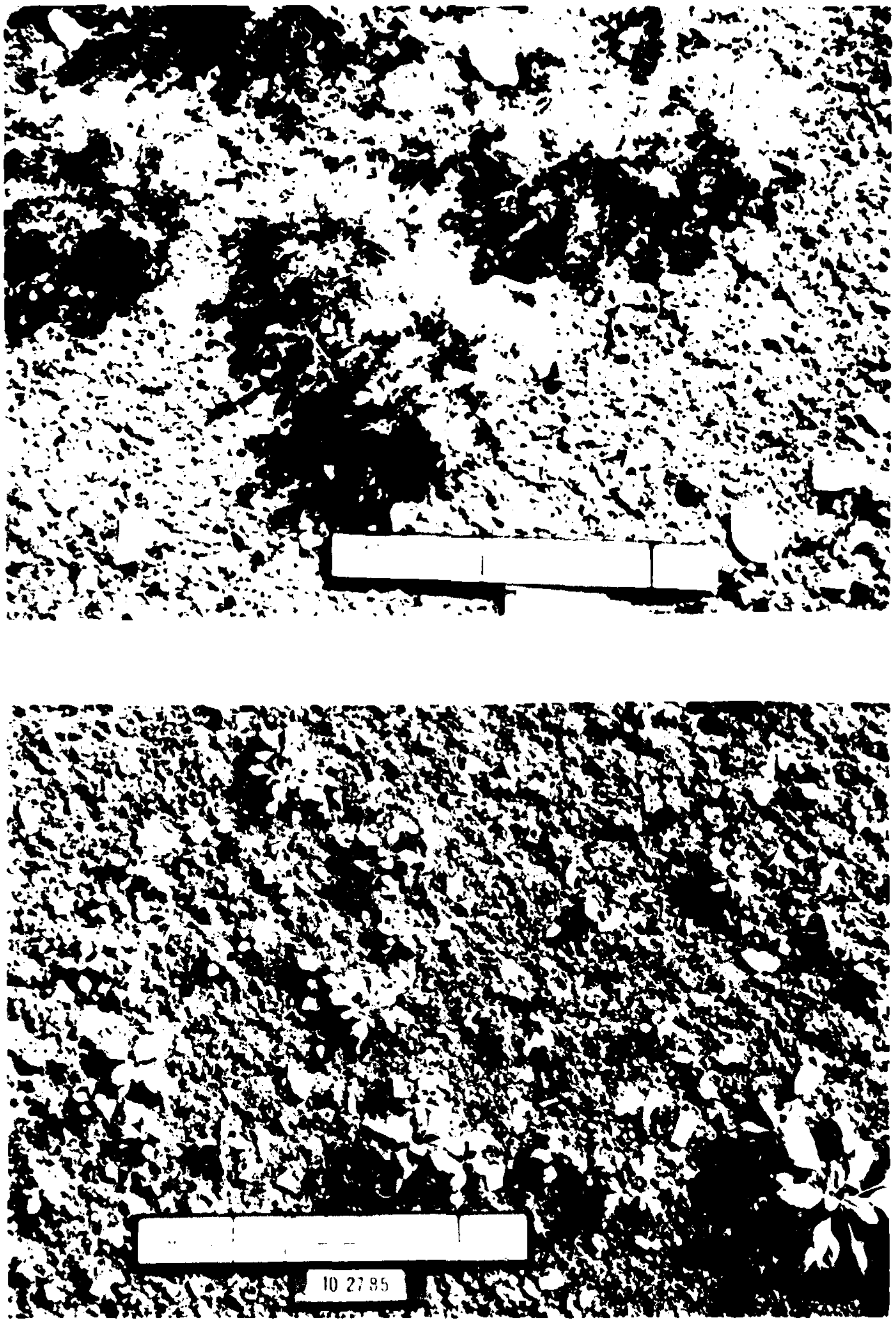


Figure 48: *Artemisia* and *Ambrosia*, control treatment

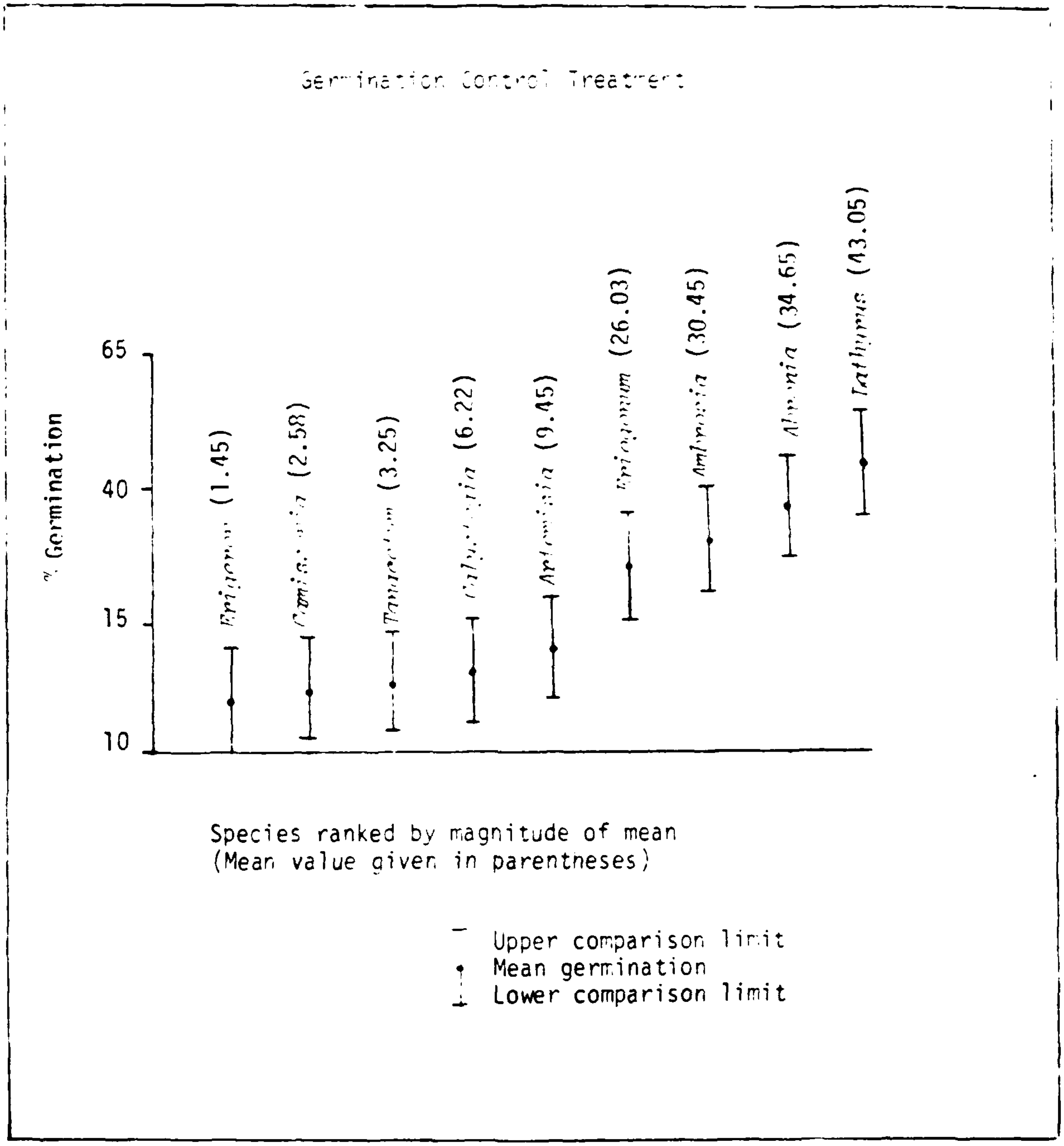


Figure 49: 95% Comparison Limits for Species Germination in the Control Treatment. (Species whose intervals do not overlap are signigicantly different)

Survival (Control Treatment)

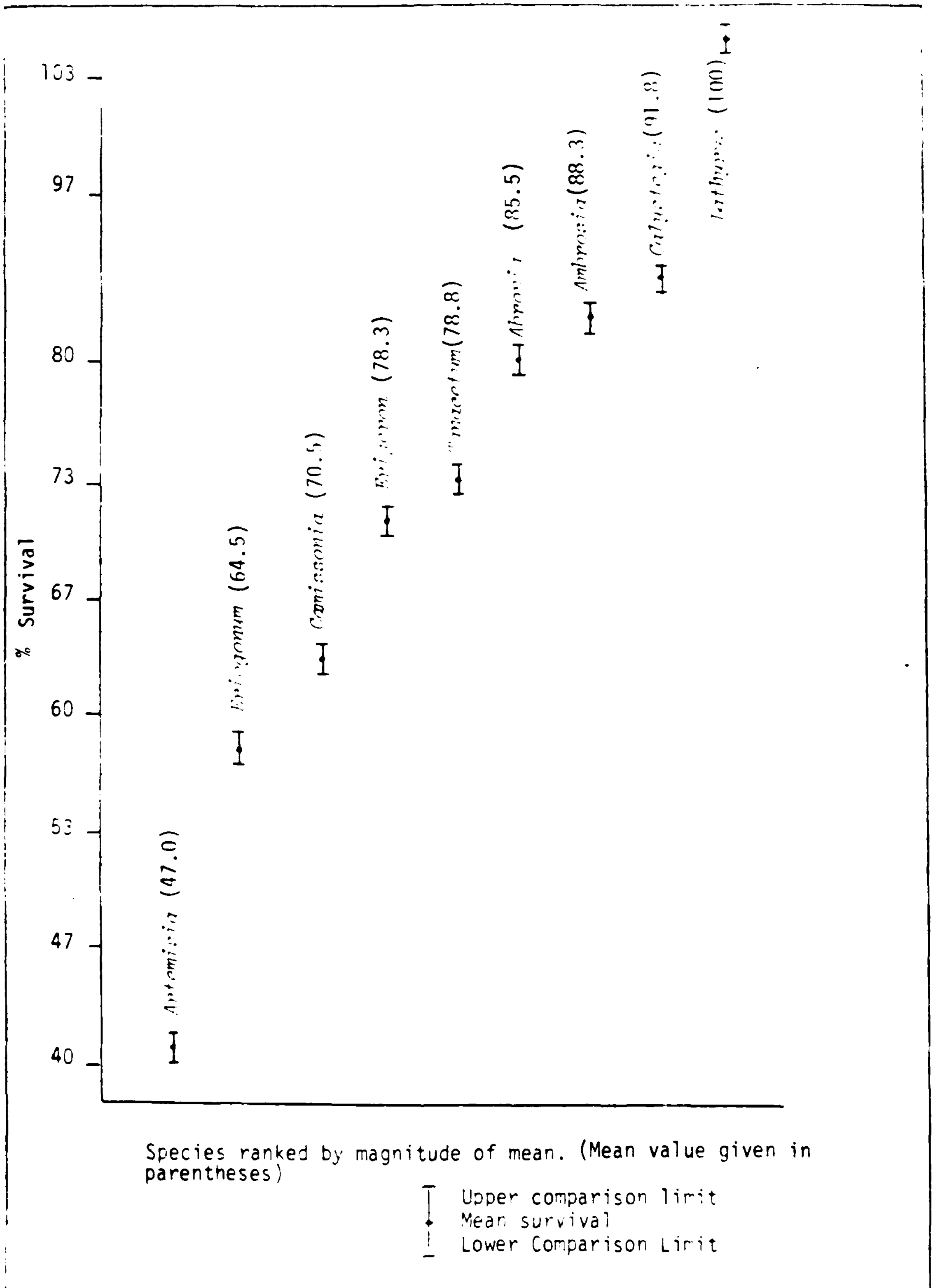


Figure 50: 95% Comparison Limits for Species Survival in the Control Treatments. (Species whose intervals do not overlap are significantly different)

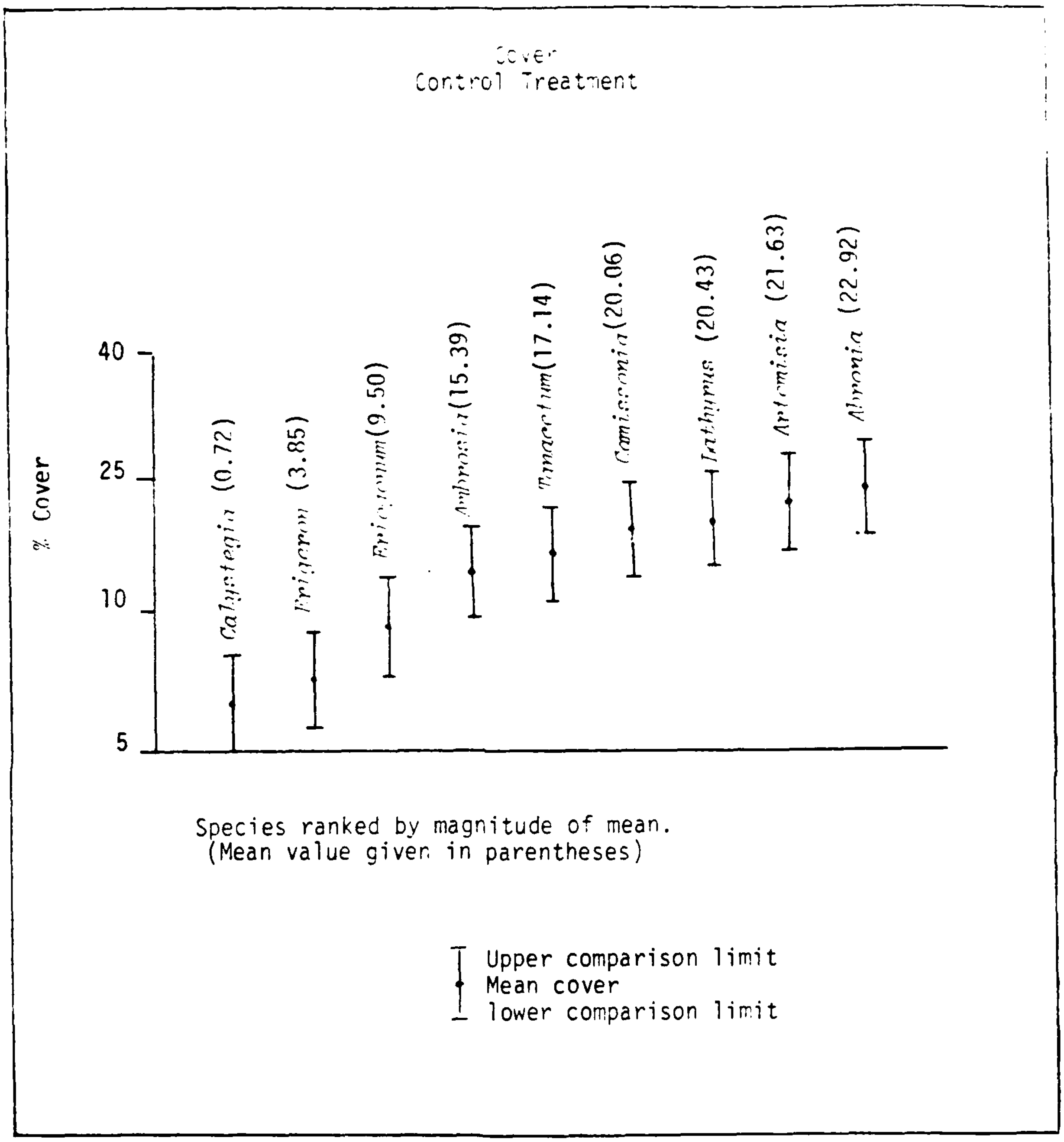


Figure 51: 95% Comparison Limit for Species Cover in the Control Treatment. (Species whose intervals do not overlap are significantly different)

[illegible] and [illegible], whose means are relatively similar, show significantly lower germination than *Lathyrus*, *Eriogonum*, *Ambrosia* and *Abronia*. *Artemisia* shows a greater affinity to the low germination group, but is not significantly different from *Eriogonum* and *Ambrosia*. These results agree with the general conclusions of the germination section. The very small seed types, *Tanacetum*, *Camissonia* and *Artemisia*, all exhibit low germination relative to the larger types, *Ambrosia*, *Abronia* and *Lathyrus*. *Calystegia*, a large seed type, was inhibited greatly by dormancy. *Eriogonum*, which has a medium sized seed and exhibits no dormancy, shows high germination. *Erigeron*, also a medium sized seed, has a high degree of dormancy.

2. Survival

Significant differences were located between the means of all species except between *Erigeron* and *Tanacetum* (Figure 49). This permits the ranking of the species tested from low to high survival as follows:

Species	Mean
Artemisia pycnocephala	0.470
Eriogonum latifolia	0.645
Camissonia cheiranthifolia	0.705
Erigeron glaucus/ Tanacetum douglasii	0.783/0.788
Abronia latifolia	0.855
Ambrosia chamissonis	0.883
Calystegia soldenella	0.918
Lathyrus littoralis	1.0

Significant differences occur partially as the result of the homogeneity of replicate samples. This caused as little as a 2.8% difference to be significant. Seven of the nine species had survival rates of over 70%, which is quite high. *Eriogonum* values (64.5%) are low in part due to the temporary failure of the irrigation system just as *Eriogonum* was germinating. The first species to germinate, it was the only one to be affected. This initial dieback is illustrated in the survival curves in Figure 26.

As discussed previously, these values are artificially high because regular watering and favorable weather permitted extremely stressed individuals to survive. Mortality is expected during the first winter. However, these values are still extremely useful as a relative measure of survival by species.

E. Cover

The T' method (Figure 30) shows a number of significant differences which suggests two groups of species. Those of relatively lower cover values are *Erigeron* and *Calystegia*. Those of relatively high cover value include all other species except *Eriogonum*, which falls between the two groups. In a control situation, cover is highly dependent on germination.

without the addition of fertilizers, individuals do not tend to increase significantly in size, so the number of individuals will control the cover rating. Low germination is essentially what differentiates *Erigeron* and *Calystegia* from the other species. However, as discussed previously, *Calystegia* does not appear to increase in above ground growth significantly with the addition of fertilizers. Therefore a poor cover rating is appropriate. Based on qualitative observations, *Artemisia, Tanacetum, Abronia, Camissonia* and *Ambrosia* distinguish themselves as having high cover potential, and respond well under fertilization. *Eriogonum* attains only moderate vegetative growth before flowering. These qualitative observations are borne out by the analysis. However, high *Lathyrus* cover means are skewed by the species' ability to achieve significant growth in an unfertilized, control situation (presumably due to the nitrogen fixing bacteria in its root nodules). However, *Lathyrus* does not respond to fertilizer (no significant differences by treatment were distinguished) so it has a lower potential for cover in a fertilized environment.

II. VEGETATIVE PROPAGULES

As discussed under Methods, vegetative propagules of seven species were collected for transplanting under control and treatment situations. Treatments consisted of a rooting compound for all species except *Poa*, which was treated with a fertilizer and monitored qualitatively. Table 8 in Methods lists species tested, propagule type, and characteristics monitored. Five randomly chosen individuals in each treatment/species group were monitored. Photographs of one individual in each species/treatment group taken at the beginning and end of the monitoring period are presented in Figures 52-66.

For each variable monitored, the net increase for the monitoring period was calculated (mortality or loss of units monitored was recorded as zero net growth). A two-tailed t-Test ($P > .05$) was performed for each variable to compare control and treatment groups for each species. For *Artemisia* and *Lathyrus*, an anova was also performed for the four treatment groups resulting from two different propagule types. End-of-season mortality was calculated for each treatment/species group rather than among sampled individuals.

A. Results

Treatment versus control means for all species are shown in Table 12. For all variables monitored, no significant differences were detected among treatment groups for all species either through the t-tests or anovas. Survival calculations are shown in Table 13. Sample size did not permit statistical comparison of control and treatment groups for survival.

B. Discussion

The rooting compound treatment had virtually no effect on growth characteristics of the species tested. Although survival was not tested statistically, it is evident from the results shown in Table 13 that treatment also had very little effect on survival.

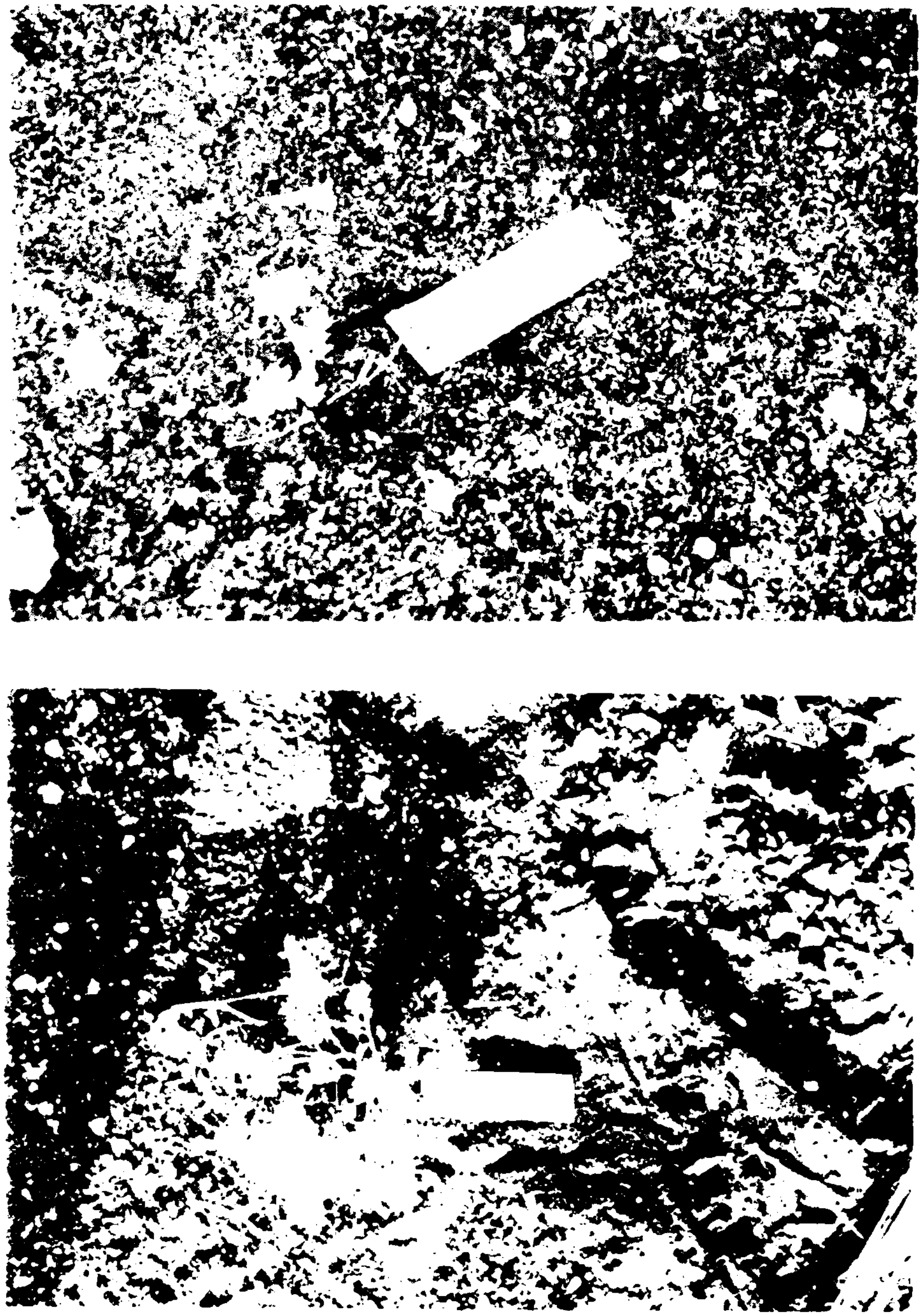
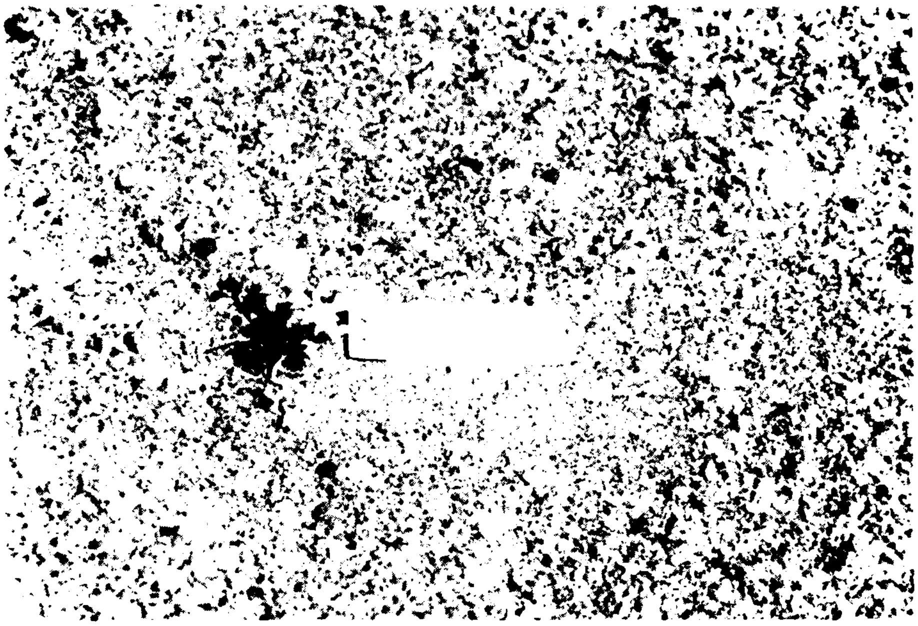


Figure 52: *Artemisia pycnocephala* division, treatment group after planting (top) and at end of monitoring period (bottom).



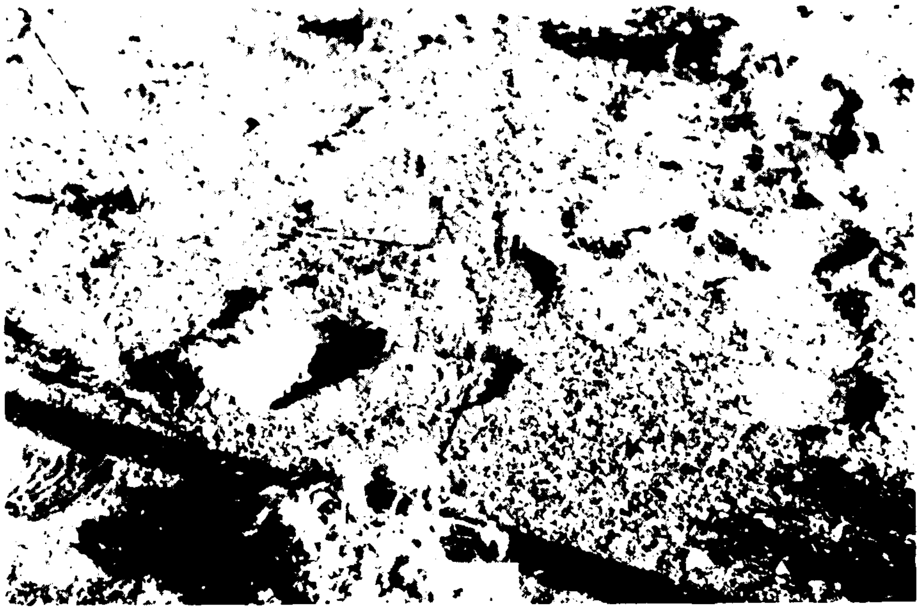
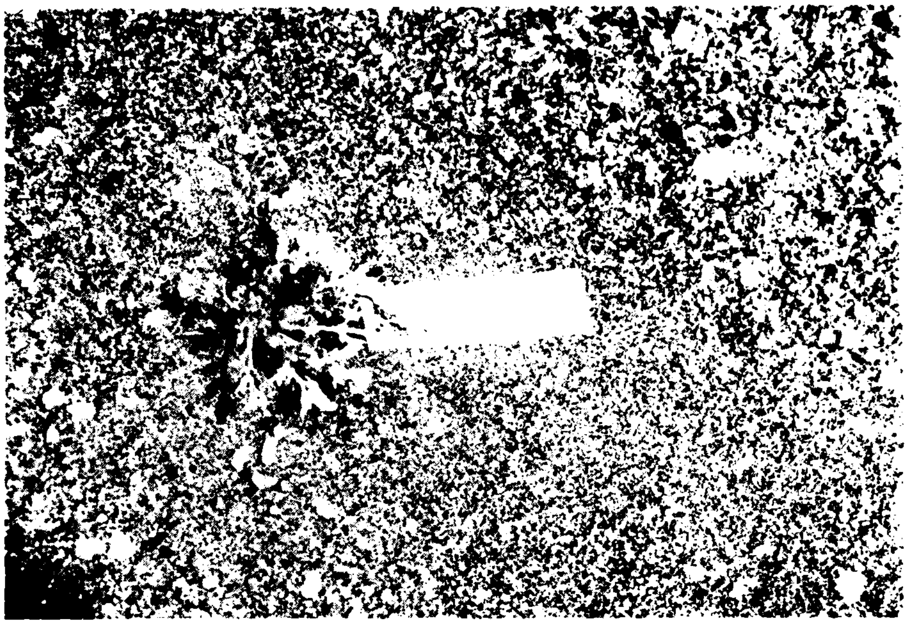


Figure 53: *Artemisia pycnocephala*, cutting, control group after planting (top) and at end of monitoring period (bottom).



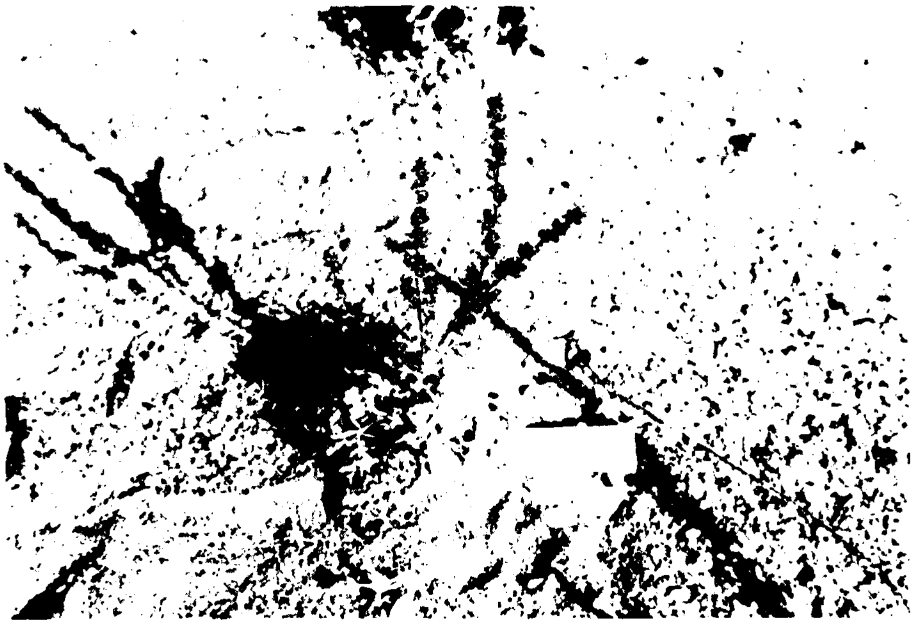
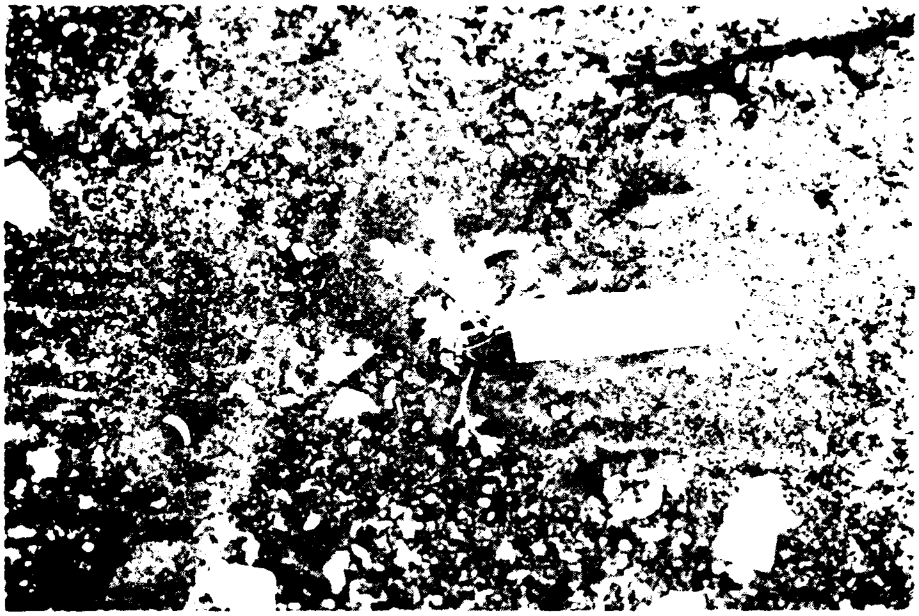


Figure 54: *Artemisia pycnocephala*, cutting, treatment group after planting (top) and at end of monitoring period (bottom).



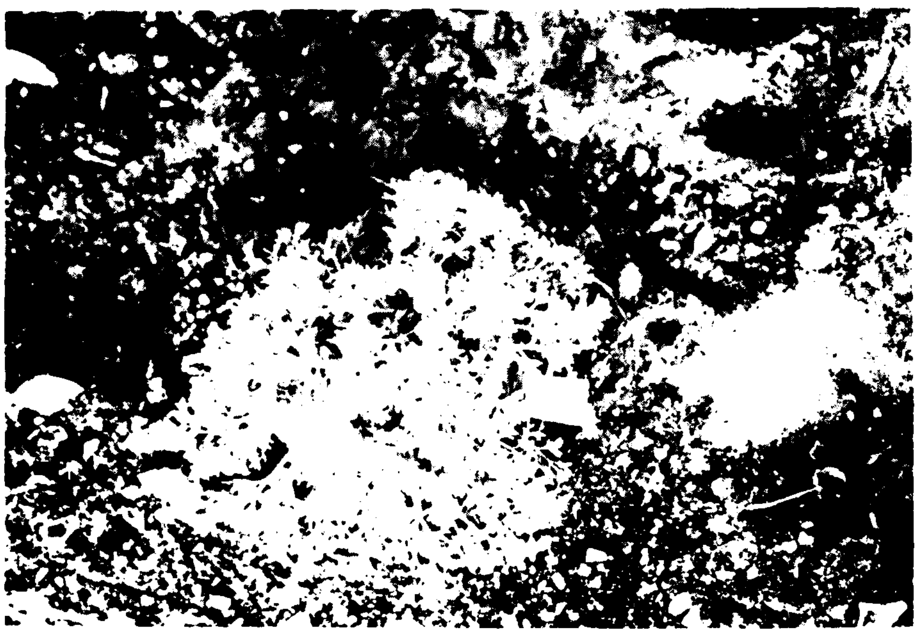


Figure 55: *Artemisia pycnocephala*, division, control group after planting (top) and at end of monitoring period (bottom).

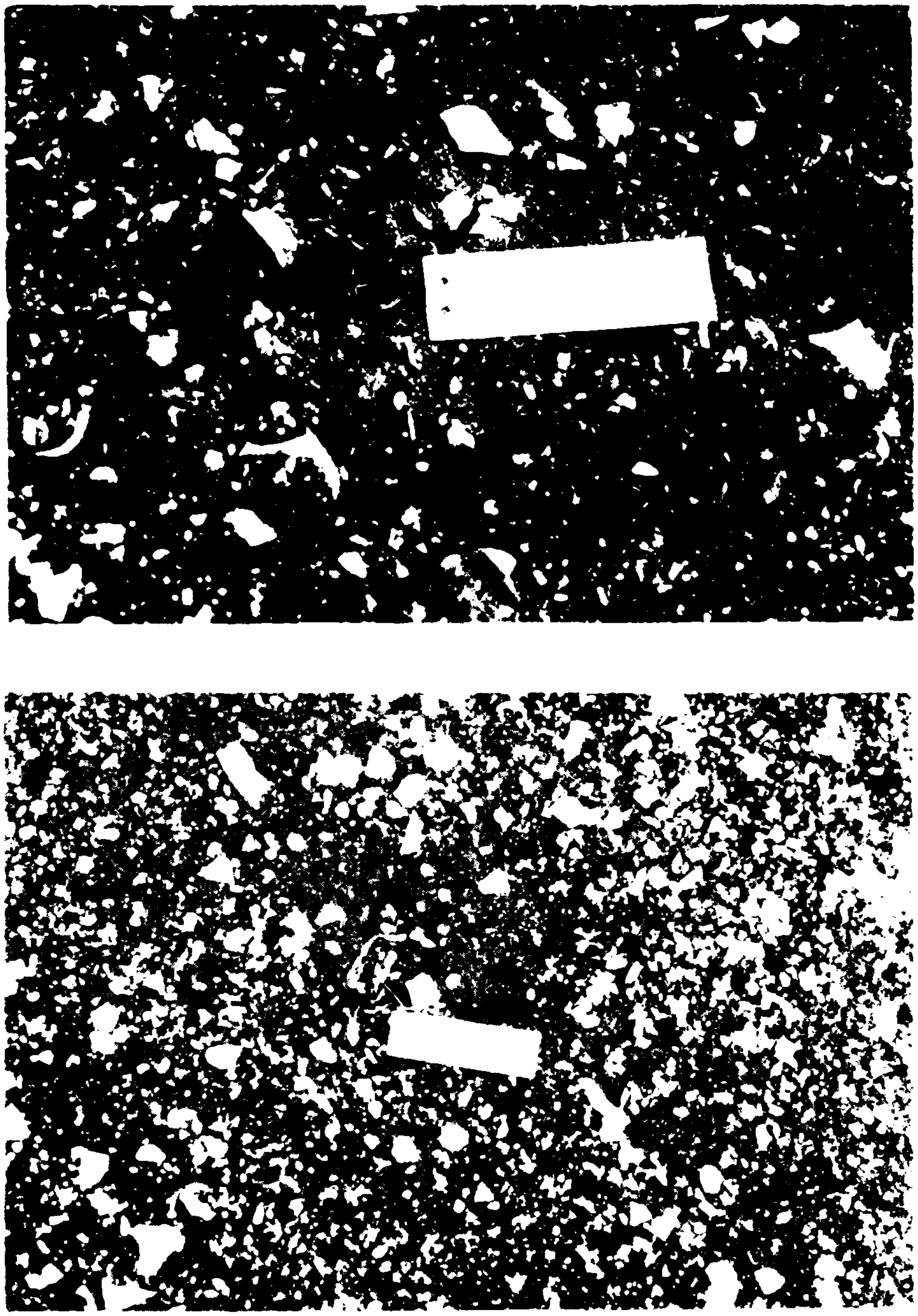


Figure 56: *Calystegia soldanella*, rhizome, control group after planting (top) and at end of monitoring period (bottom).

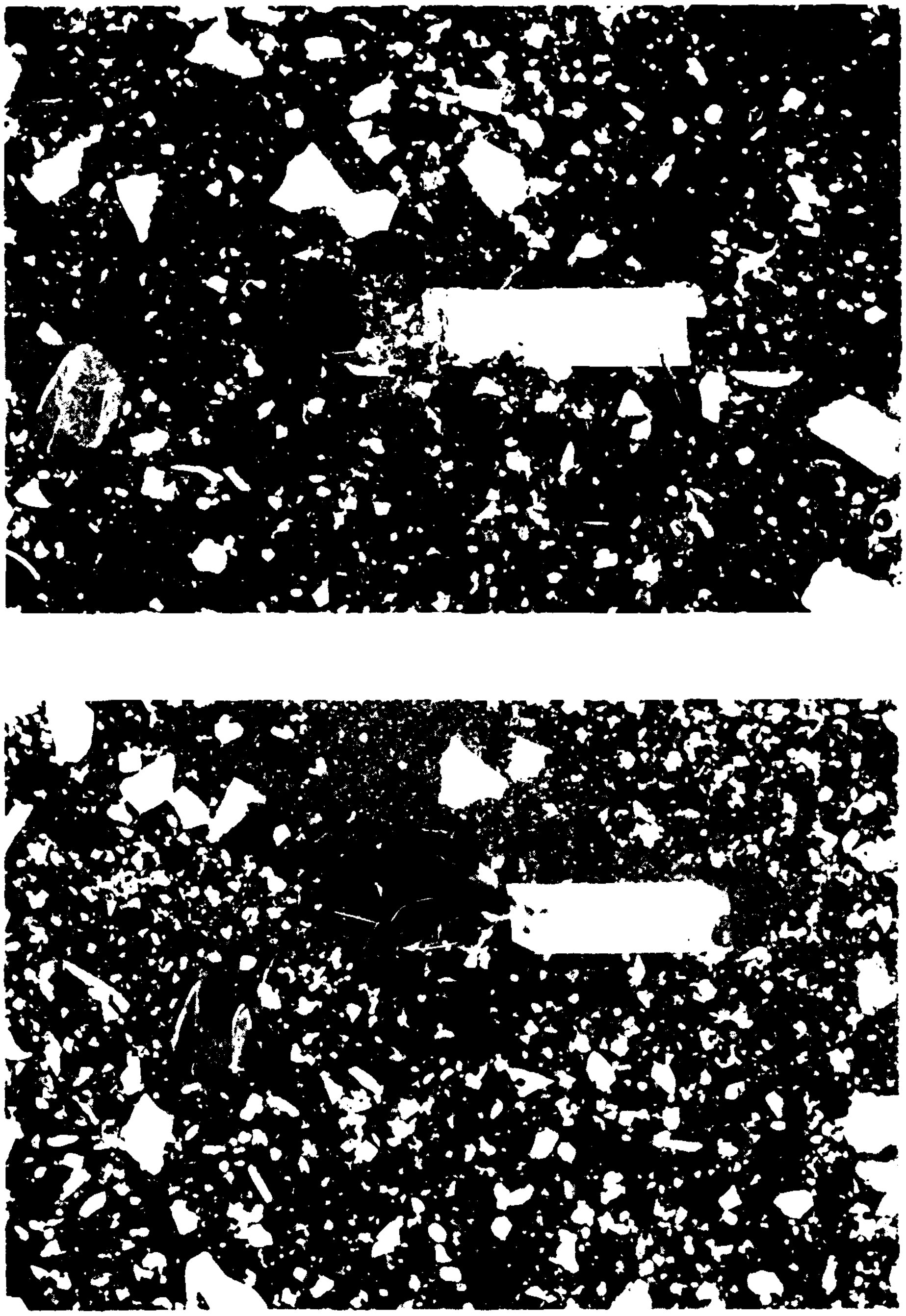
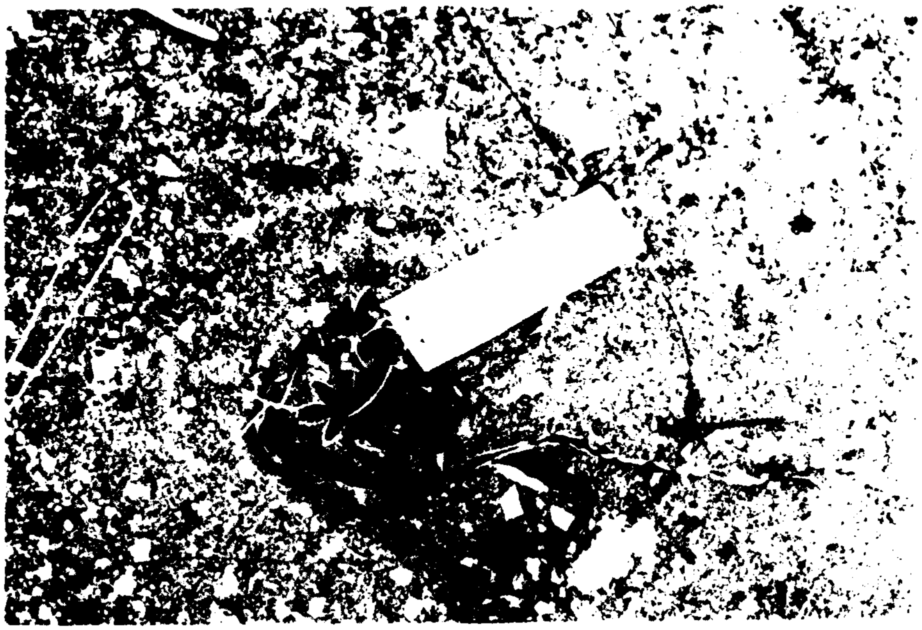


Figure 57: *Calystegia soldanella*, rhizome, control group after planting (top) and at end of monitoring period (bottom).



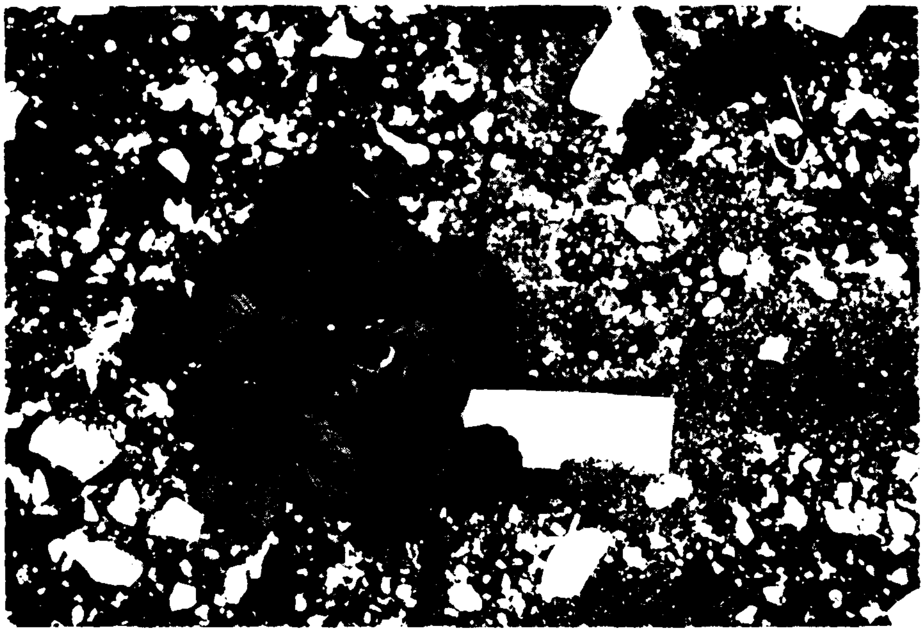
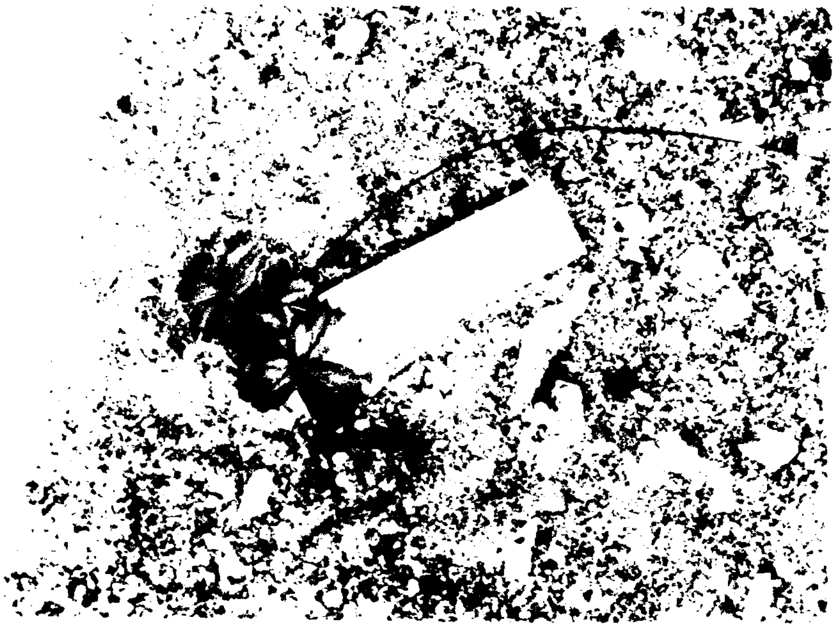


Figure 53: *Fragaria chiloensis*, division, treatment group after planting (top) and at end of monitoring period (bottom).



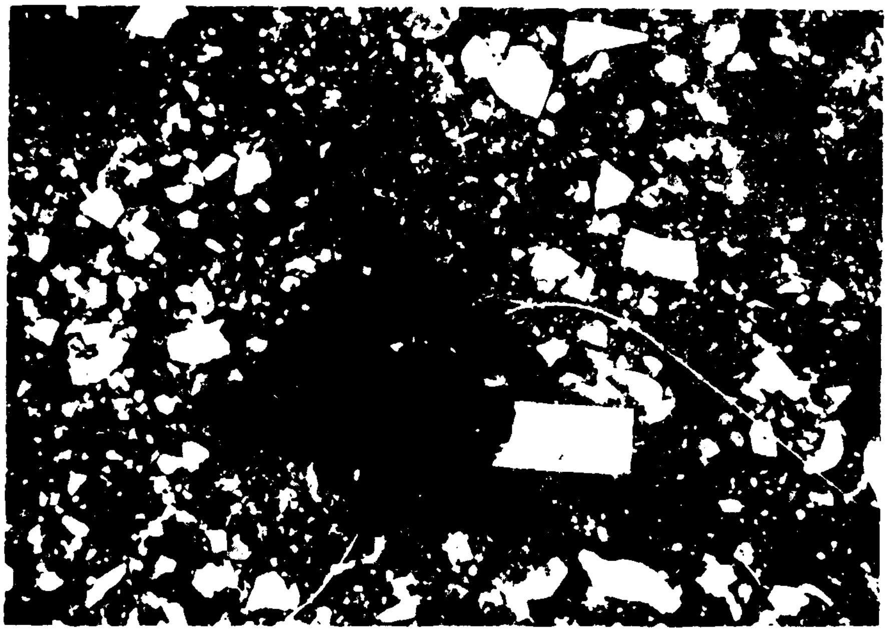
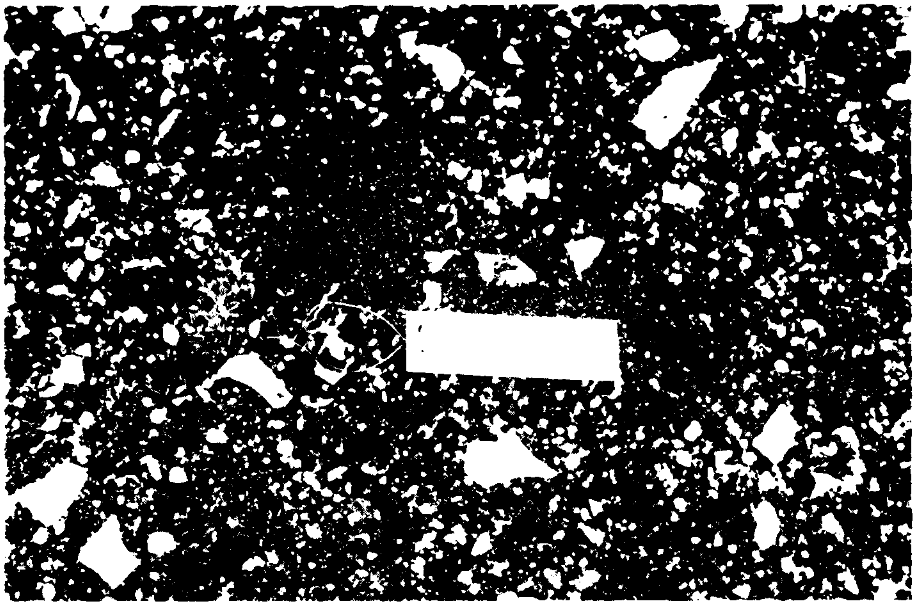


Figure 59: *Fragaria chiloensis*, division, control group after planting (top) and at end of monitoring period (bottom).



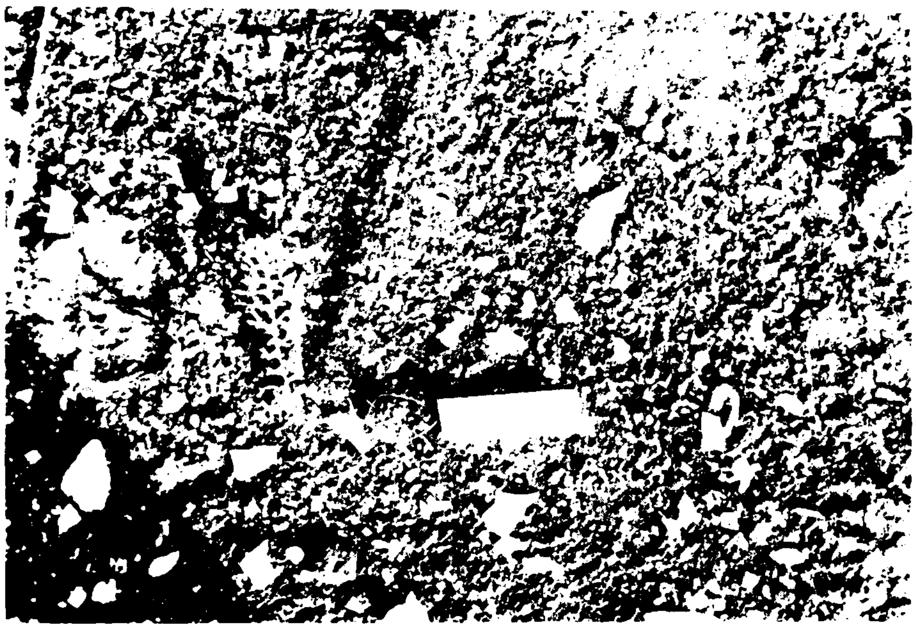


Figure 60: *Lathyrus littoralis*, division, control group
after planting (top) and at end of monitoring period (bottom).

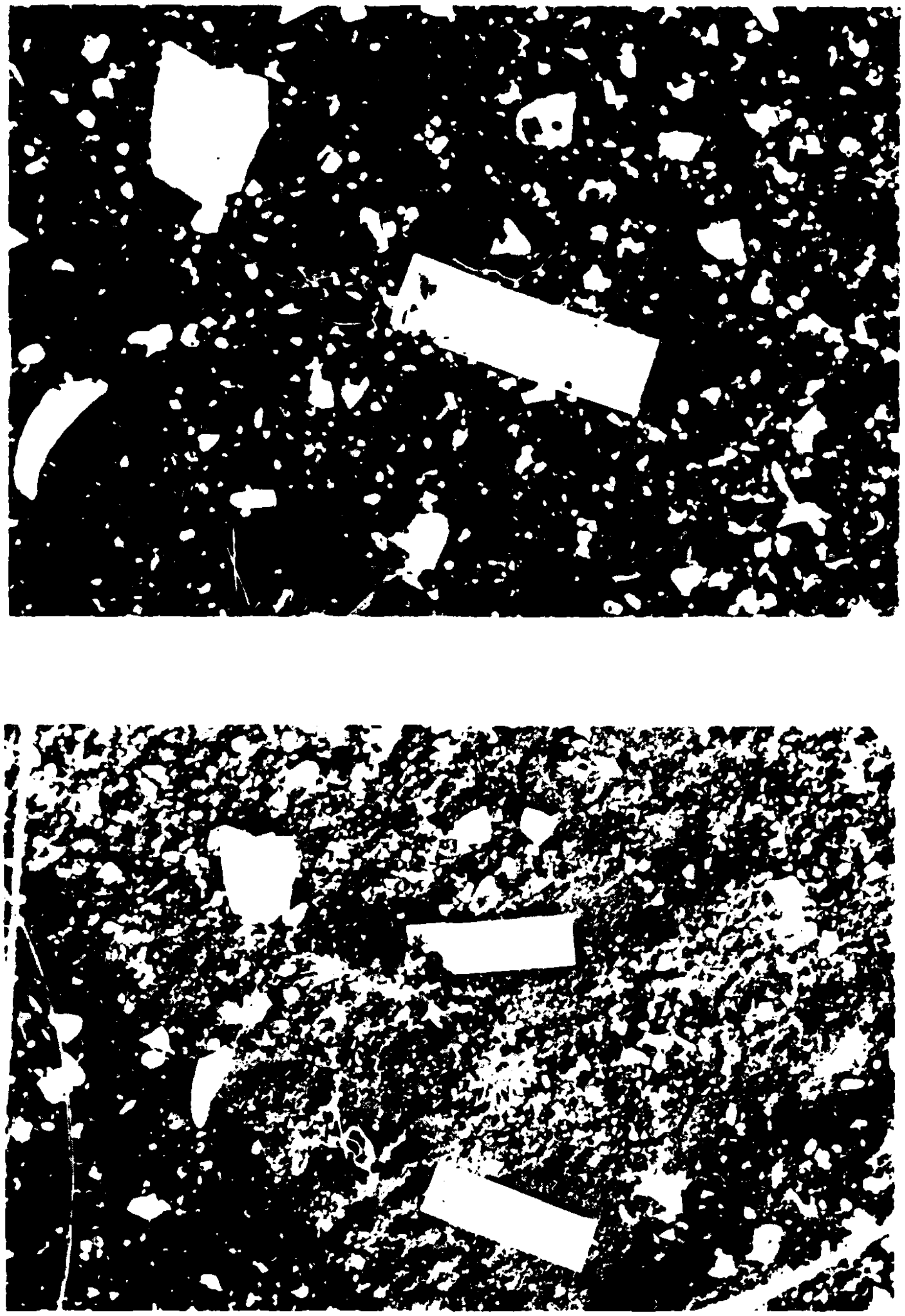


Figure 61: *Lathyrus littoralis*, division, treatment group after planting (top) and at end of monitoring period (bottom).

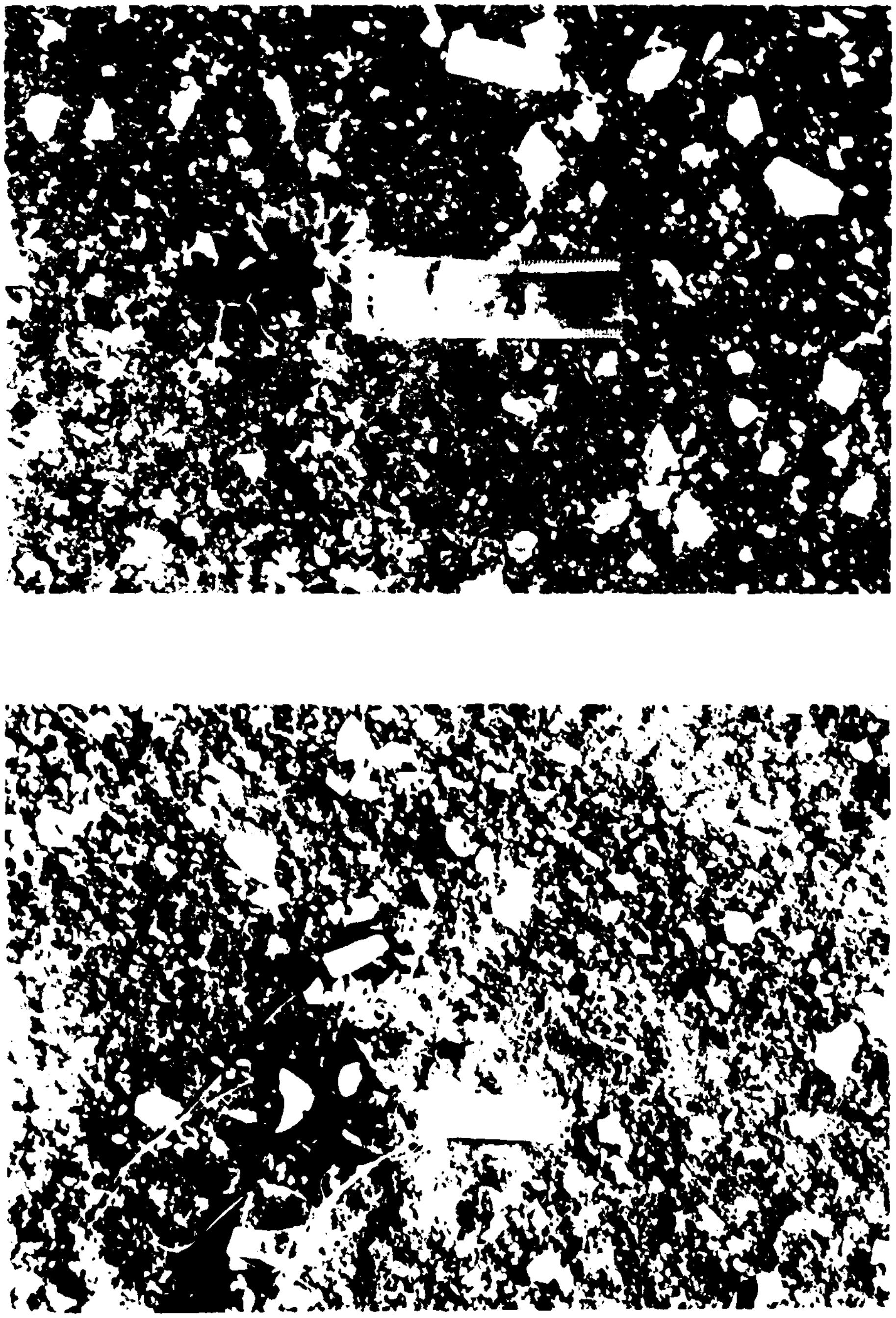


Figure 62: [illegible], cutting, treatment group after planting (top) and at end of monitoring period (bottom).

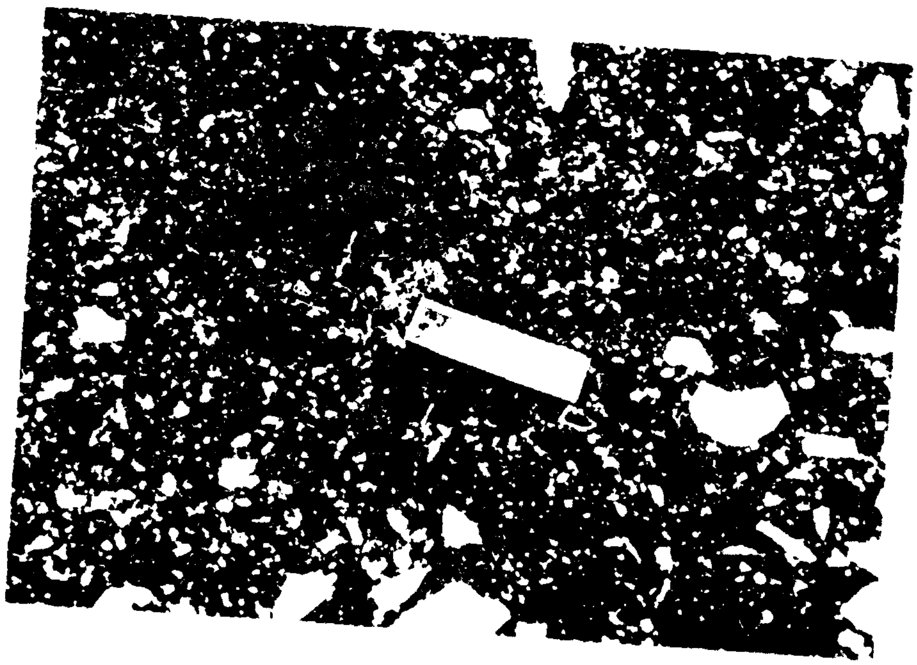


Figure 63: *[illegible] [illegible]ttoralis*, cutting, control group after planting (top) and at end of monitoring period (bottom).

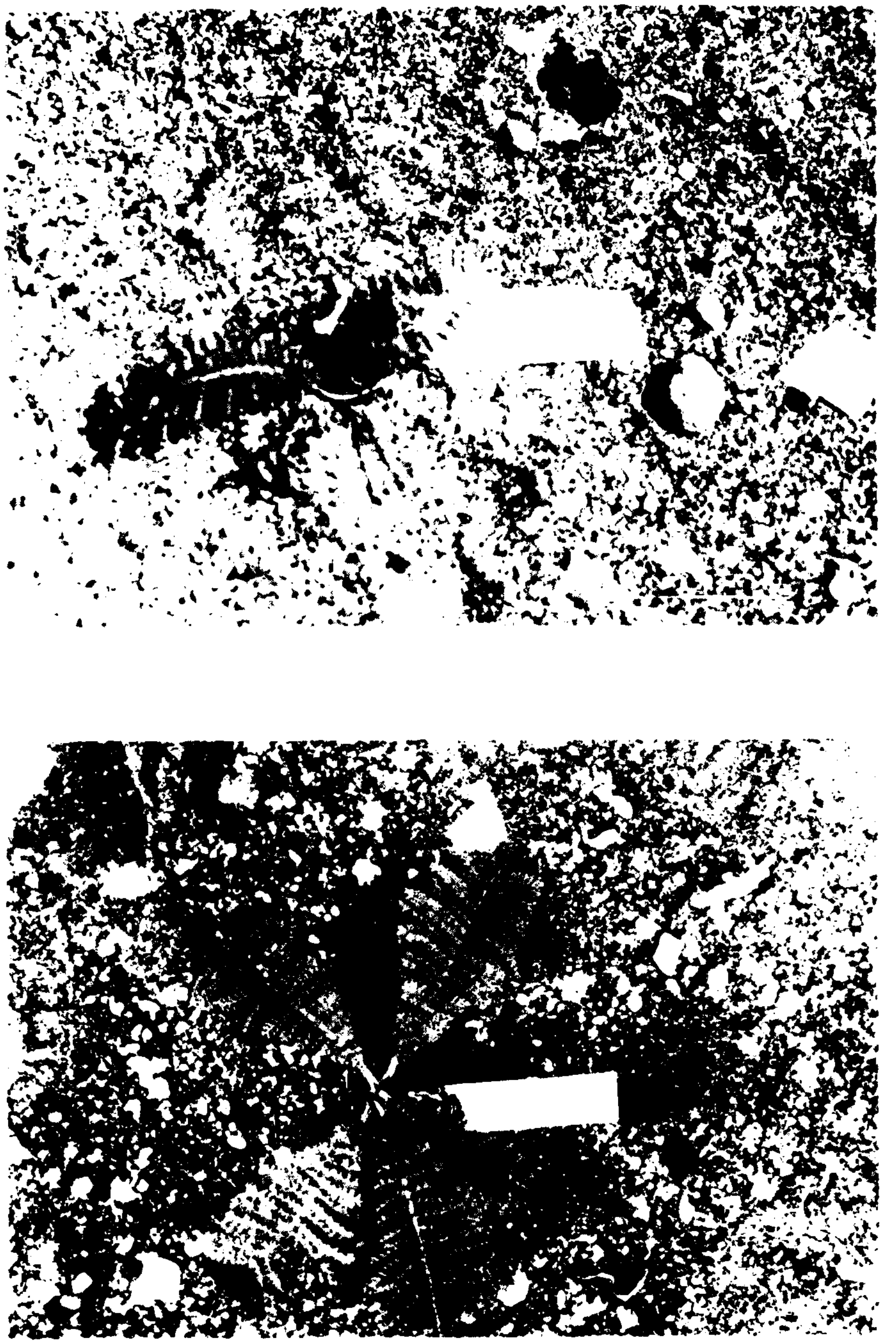


Figure 64: [illegible], division, treatment group after planting (top) and at end of monitoring period (bottom).

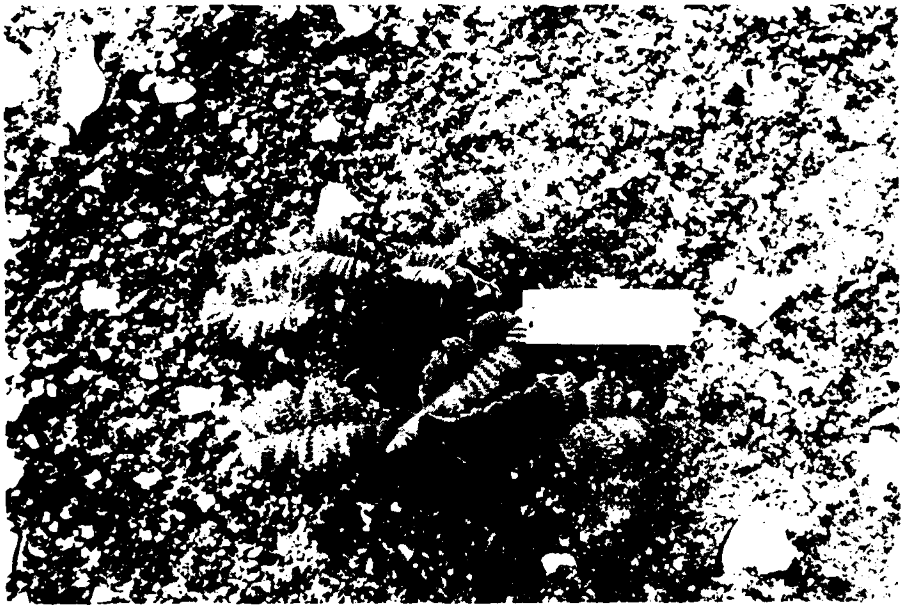


Figure 65: *Tanacetum douglasii*, division, control group
after planting (top) and at end of monitoring period (bottom).

Figure 66: [illegible], divisions, end of monitoring period, for treatment (top) and control (bottom) groups.

however, results of these tests are meaningful in evaluating relative success of different species. *Fragaria*, *Artemisia* (cuttings and rootings), and *Tanacetum* all had survival between 56 and 100%. *Tanacetum* and *Artemisia* rootings exhibited particularly high survival (92 to 100%). In contrast, *Calystegia* and *Lathyrus* survival rates were low (.2 to 12%), indicating these species are poor candidates for vegetative propagation. Results of growth characteristics monitoring point to a similar conclusion; *Fragaria, Artemisia* and *Tanacetum* show a substantial increase in biomass as measured by number of leaves, plant height, etc. while *Lathyrus* and *Calystegia* show minor growth in surviving plants. Growth of all species could presumably be increased through fertilization. *Tanacetum* and *Lathyrus* exhibited severe nutrient deficiency symptons by the end of the monitoring period. *Poa douglasii* was monitored by photographic record only, and photographs of representative individuals are shown in Figure 66. The fertilizer treatment which consisted of ammonimum sulfate (21:0:0), resulted in a substantial increase in biomass over the control group: a greater number of leaves and runners were observed, and both plants and inflorescences appeared more robust under fertilization. Survival was very high for both treatment groups. Based on observed results, *Poa* appears well suited for vegetative propagation.

Table 12: Treatment and Control Means for Growth Characteristics of Vegetative Propagules. (Values represent net increase over the monitoring period).

Species	Characteristic	Control Mean	Treatment Mean
Artemisia pycnocephala	plant height	13.5 in.	7.0 in.
beach sagewort	no. leaves	53.8	50.6
Divisions			
Artemisia pycnocephala	plant height	19.8 in.	10.4 in.
beach sagewort	no. leaves	50.3	46.4
Cuttings			
Calystegia soldanella	no. leaves	1.0	0.2
beach morning glory			
Fragaria chiloensis	rosette diameter	14.7 in.	20.0in.
beach strawberry	no. leaves	25.2	38.3
	no. runners	1.6	2.3
Lathyrus littoralis	no. branches	0.2	0.4
beach pea			
Divisions			
Lathyrus littoralis	no. branches	0.4	3.2
beach pea			
Cuttings			
Tanacetum douglasii	plant height	10.7 in.	9.4 in.
tansy			

Table 13: Survival of Vegetative Propagules by Treatment

Species	% Survival Control	% Survival Treatment
Artemisia pycnocephala beach sagewort Divisions	92	94
Artemisia pycnocephala beach sagewort Cuttings	56	70
Calystegia soldanella beach morning glory	8	18
Fragaria chiloensis beach strawberry	56	56
Lathyrus littoralis beach pea Divisions	4	2
Lathyrus littoralis beach pea Cuttings	12	8
Tanacetum douglasii tansy	100	100

The Buhne Point experimental planting provides a great deal of useful information that can be applied (to varying degrees) to other dune revegetation projects on the West Coast. However, the choice of species and planting techniques for any project will depend on a number of considerations such as cost, seasonal limitations, characteristics of the site and goals of restoration. Therefore, conclusions and recommendations provided below are specific to the Buhne Point project, and were drawn upon in designing the Phase 2 planting.

I. SPECIFIC RECOMMENDATIONS

A. Species Selection and Seed Prescriptions

The suitability of a species for stabilization depends on other criteria in addition to the growth characteristics evaluated in this study. The cost of the seed (which relies to some extent on availability if seed is collected locally) may determine whether or not the species is selected for use. Collection of seeds from the local region is highly recommended over the purchase of commercial seeds in order to protect local genetic strains and prevent accidental introductions.

Collection costs for all species utilized in this experimental planting are documented in Phase 2 Seed Collection (Newton, 1986). The per-pound cost does not, however, provide a relative basis for comparison or evaluation of species. The actual cost is dependent upon the proportion of seed called for in the mix, which is based upon the monoculture application rate. A revised seed prescription is provided in Table 14. Monoculture rates were adjusted from those specified in Phase 1 planting based on the lab and field germination tests. The rates can be used to create a mix of any combination of species, using the ratio of the monoculture rate for a single species to the total of monoculture rates of all species in the mix. This will provide a proportion for that species.

Per pound cost is shown in Table 15, as well as per acre cost, i.e. the per pound cost times the monoculture application rate. The resulting per acre costs can be compared between species to evaluate relative cost.

The only species omitted from the revised seed prescription was *Calystegia*. This was due to extremely low germination and cover values. If a successful dormancy treatment is found, this species would be a beneficial addition.

Two species, *Erigeron* and *Tanacetum*, showed extremely low field germination rates. These species are considered desirable as stabilizers in part because they provide winter cover, whereas many of the other species tested lose above-ground growth in winter. Both species continued to grow throughout the winter in fertilized plots. Because of their low germination and high monoculture rates, it is recommended that if these two species are used, the overall application rate of the planting be increased.

		[illegible]	Per Acre Cost
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	$1375
[illegible]	[illegible]	[illegible]	$1220
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Three species were included in the mix plots but not investigated independently: [illegible] and [illegible] *purpurascens* var. *latifolius*. None of the three germinated in the mix plots (nor were they observed in the Phase 1 qualitative mix plantings). Lab tests indicate high germination and viability potential for *Solidago* (91% germination, 91% viability) and *Orthocarpus* (76% germination, 76% viability), while *Polygonum* exhibited high viability (76%) and low germination (32%) due to dormancy. *Orthocarpus* is an annual and populations are potentially more susceptible to impact through large scale collections. For this reason it is not recommended for future planting. *Polygonum* would be a beneficial addition if a dormancy treatment were identified. *Solidago*, planted in the Phase 2 planting in November, germinated well, indicating that seasonality or age of seed may have affected germination. This species is an important component of the local dune mat community and a good source of winter cover. Because field germination rates are undocumented for this species, the monoculture rate is unsubstantiated and it is recommended that the overall application rate be increased if this species is added.

Species diversity is recognized as a goal of the revegetation planting in recognition of ecological values and because the native community, which the planting was designed after, is of a highly diverse nature. For this reason it is recommended that the maximum number of species be utilized. In many plantings it may be desirable to vary seed prescription by geographical location, according to site characteristics. The Phase 1 qualitative planting indicated that site variation did not restrict establishment of any species planted, although *Elymus* plantings were located in areas considered least suitable for the mix.

B. Planting Methods

The recommended planting method for this site is hydromulch applied with 25 pounds per acre of seed (see mix prescription in Table 14), 2000 pounds per acre mulch and 300 pounds per acre Osmocote 13:13:3. Although application of the fertilizer simultaneously with seed will cause toxicity, regular irrigation and the use of slow release fertilizer and a mulch will reduce inhibition. A second alternative is application of the fertilizer after plants emerge, however this will preclude incorporation of the fertilizer in the mulch so the fertilizer application rate should be reduced. Hydromulch is recommended because of its beneficial moisture-retaining properties and cost effectiveness. Seeds are suspended throughout the mulch and are closer to the surface than if incorporated into the soil. This should increase germination of small seeds. Hydromulch also acts as a stabilizer, a benefit which proved unnecessary in this project. A potential problem with the hydromulch method is the accidental introduction of grasses through contamination of the slurry by residues of previous applications. The mulch tank must be thoroughly washed before applying native seed. A nutrient study of the Buhne Point Spit was conducted in the winter of 1986-86 by Ken Clarke (1986). the study demonstrated the superiority of Osmocote over all other treatments in maintaining soil nitrogen levels over a prolonged period. The study concluded that the application rate used in the Phase II planting was too high (400 lbs./acre), and recommends further testing to determine an optimum rate at which native species would flourish while weedy species should be discouraged.

Per acre costs for all treatments investigated are shown in Table 15. Costs for hydromulch include the cost of applying seeds, and application labor costs are supplied for other treatments in order to permit comparison. Labor costs are for manual application and are based on $8.00 per hour labor (Bioflora Research, Inc., 1986). Alternative methods of application (such as hydroseeding and harrow) are possible for fertilizer treatments, but were not analyzed in the Phase I experimental plots.

Table 15: Approximate Per Acre Treatment Costs (excluding cost of [illegible]

Treatment	Materials (includes equip.)	Labor ($8 per hour)	Total Per Acre Cost
Hydromulch, Soluble Fertilizer	$1600	-	$1600
Jute Matting	$5700	$400*	$6100
Soluble Fertilizer (300 lbs/acre)	$ 40	$400*	$ 440
Slow Release** Fertilizer (300 lbs/acre)	$ 300	$400*	$ 700
Redwood compost	$6080	$400*	$6480
Control	-	$400*	$ 400
Hydromulch Slow Release Fertilizer, 300 lbs/acre (recommended)	$1900	-	$1900

*based on manual seed application using a broadcast spreader and raking seeds beneath surface

**based on recommended rate, not tested rate

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SECTION 4

A REVIEW OF CALIFORNIA COASTAL DUNE RESTORATION/REVEGETATION PROJECTS

A REVIEW OF CALIFORNIA COASTAL DUNE RESTORATION/REVEGETATION PROJECTS

August 1985

Prepared by:

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Natural Resources Division
Humboldt County
Public Works Department

Submitted to:

U.S. Army Corps of Engineers
San Francisco District
Contract No: DACW07-85-M-0521

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INTRODUCTION

Under a contract to the San Francisco District Corps of Engineers, Humboldt County Public Works Department is currently implementing a dune revegetation project for the Bunne Point Shoreline Erosion Control Demonstration Project at King Salmon on Humboldt Bay. The revegetation project is being designed cooperatively by the County and the Los Angeles District Corps of Engineers. To facilitate an effective and economical design, a review of recent California dune restoration projects was compiled. This survey includes a review of revegetation techniques and important project parameters. Past, current and proposed projects are included. Several small projects, or projects for which no documentation was available have been omitted. A contact person is provided for each project as a source of more detailed information and references are provided. Figure 1 shows the location of sites included in this report, and project parameters are summarized in Table 1.

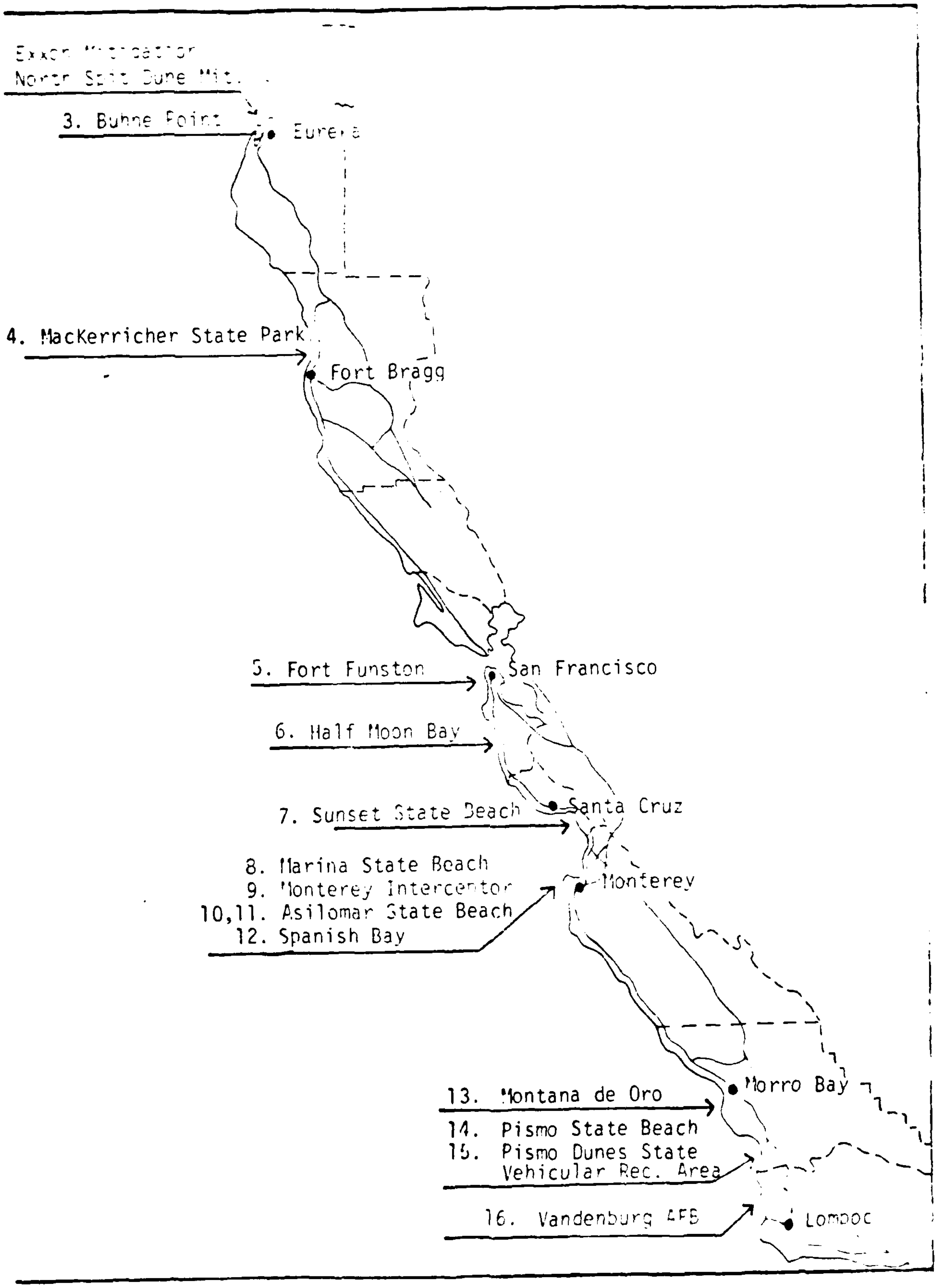


Figure 1: Location of Restoration Revegetation Areas.

TABLE 1
Summary of Restoration/Revegetation Projects

PROJECT	LOCATION	SPONSOR	PROPERTY OWNER	CONTRACTOR(S)	CONTACT	SIZE	COST	IMPLEMENTATION DATE
Exxon Wallflower Mitigation	North Spit Humboldt Bay Humboldt Co., CA	Exxon Co USA	Bureau of Land Management	Woodward-Clyde Consultants	Ted Winfield Woodward-Clyde 619-224-2911	20 acres	-	-
North Spit Dune Mitigation Bank	North Spit Humboldt Bay Humboldt Co., CA	Humboldt County Public Works State Coastal Conservancy	City of Eureka	Humboldt County Public Works	Andrea Pickart Humboldt County Public Works Dept. 707-445-7741 Liza Riddle, Coastal Conservancy 415-464-4166	53 acres	$325,000	Fall 1986
Buhne Point Shoreline Erosion Control Demonstration Project	King Salmon Humboldt Bay Humboldt Co., CA	U.S. Army Corps of Engineers	Humboldt Bay Harbor, Rec. & Conservation District	Humboldt County Public Works Dept. Gail Newton	Jack Farless Corps of Engineers 415-974-0387 Andrea Pickart Humboldt County Public Works Dept. 707-445-7741	15 acres	$100,000	November 1985
MacKerricher State Park	Ten Mile Dunes Ft. Bragg Mendocino Co., CA	Calif. Dept. Parks & Recreation	Calif. Dept. Parks & Rec.	Calif. Conservation Corps	Jim Barry Calif. Dept. Parks & Rec. 916-322-8562	20 acres	$130,000	December 1986
Fort Funston Launch Area	Fort Funston San Francisco, CA	National Park Service			Bill Van Peters LA Dist. U.S. Army Corps of Engineers 213-894-0236	2 acres		Winter 1979
Half Moon State Beach	Dunes Beach San Mateo Co., CA	Calif. Dept. Parks & Recreation	Calif. Dept. Parks & Rec.		Jim Barry Calif. Dept. Parks & Rec. 916-322-8562	8.5 acres	$90,000	Winter 1981
Sunset State Beach	Monterey Co., CA	Calif. Dept. Parks & Recreation			Ken Gray Calif. Dept. Parks & Rec. 916-322-8562	17 acres	$78,000	1986
Marina State Beach	Marina, Monterey Co., CA	Calif. Dept. Parks & Recreation			Ken Gray Calif. Dept. Parks & Rec. 916-322-8562	50 acres	$296,000	Fall 1985 & 198

PROJECT	LOCATION	SPONSOR	PROPERTY OWNER	CONTRACTOR(S)	CONTACT	SIZE	COST	IMPLEMENTATION DATE
Monterey Interceptor	Monterey, CA	Monterey Regional Water Pollution Control Agency		Richard Murray & Assoc.	Richard Murray 408-624-5700	9.1 acres	$89,000	Summer 1983
Asilomar State Conference Grounds	Asilomar State Beach, Monterey Co., CA	Asilomar Corp.		Bruce Cowan	Jim Barry Calif. Dept. Parks & Rec. 916-322-8562	3.5 acres	-	1972
Asilomar State Conference Grounds	Asilomar State Beach, Monterey Co., CA	Calif. Dept. Parks & Recreation	Calif. Dept. Parks & Rec.		Tom Moss Asilomar State Conference Grounds 408-372-0181	12 acres	-	Fall 1985
Spanish Bay Dune Restoration	Spanish Bay Monterey Co., CA	Pebble Beach Co.	Pebble Beach Co.	Larry Seeman Assoc.	Larry Stromberg Larry Seeman Assoc. 415-841-6840	60 acres	$500,000	Summer 1985
Montana de Oro State Park	Morro Bay, San Luis Obispo	Calif. Dept. Parks & Recreation	Calif. Dept. Parks & Rec.		Jim Barry Calif. Dept. Parks & Rec. 916-322-8562	15 acres	$140,000	December 1986
Pismo State Beach	Nipomo Dunes San Luis Obispo Co., CA	Calif. Dept. Parks & Recreation	Calif. Dept. Parks & Rec.		Jim Barry Calif. Dept. Parks & Rec. 916-322-8562	4 acres	$36,000	Unknown
Pismo Dunes State Vehicular Recreation Area	Nipomo Dunes San Luis Obispo Co., CA	Calif. Dept. Parks & Recreation Off Highway Vehicle Division	Calif. Dept. Parks & Rec.	Cal Polytech State University, San Luis Obispo	Jim Barry Calif. Dept. Parks & Rec. 916-322-8562	70 acres	$1.2 million	1985/86
Vandenburg Air Force Base MX Road Cuts	Vandenburg Air Force Base, Santa Barbara, CA	U.S. Air Force	U.S. Air Force		Bill Van Peters LA Dist. U.S. Army Corps of Engineers 213-894-0236	10 acres	-	Summer 1981

PROJECT: Exxon Wallflower Mitigation Project

LOCATION: North Spit Humboldt Bay, Humboldt County, CA

SPONSOR: Exxon Co, USA

PROPERTY OWNER: Bureau of Land Management

CONTACT: Ted Winfield, Woodward-Clyde Consultants, 415-945-3000

SIZE: 20 Acres

COST: --

SCHEDULE: Project cancelled, implementation uncertain

Summary

To mitigate impacts of a proposed offshore oil rig jacket assembly plant, 20 acres of Menzies wallflower (*Erysimum menziesii*) habitat would be created by restoring 20 acres of degraded dune habitat within two sites. A 40 acre site currently supports wallflowers and contains native dune scrub but is being encroached upon by exotic species (primarily bush lupine (*Lupinus arboreus*)) and disturbed by ORV traffic. Exotic species will be eradicated over 15 acres of this site and revegetation with native species will be designed to provide habitat for the introduction of *Erysimum*. On a second 10 acre site nearby, five acres of *Ammophila arenaria* will be manually eradicated so that restoration can occur. Both sites will be fenced to prevent vehicle trespass and will be monitored for three years.

The following techniques are proposed in the Draft Mitigation Plan and are subject to modification:

Revegetation will utilize hydromulching with fertilizer (slow release, 10 lbs/100 sq.ft), wood fiber mulch (2000 lbs/acre) and a tacking agent (30 gals/acre). Native seeds including *Erysimum* will be included in the slurry. Hydromulching will occur in November or March depending on the project schedule. *Erysimum* seeds will also be propagated in a greenhouse and transplanted. Irrigation will be utilized as necessary.

Native seed mix will include:

Abronia latifolia
Ambrosia chamissonis
Artemisia pycnocephala
Camissonia cheiranthifolia
Erigeron glaucus
Eriogonum latifolium

Ambrosia and *Abronia* will be propagated in a greenhouse and outplanted on windward slopes of dunes. A total of 1200 *Ambrosia* plants will be placed in the 16 acre site and 2400 in the five acre site. 4,000 *Abronias* will be planted, 2000 per site.

References

Winfield, 1994. Menzies Wallflower Mitigation Plan for the Proposed North Spit Offshore Jacket Assembly Project, Humboldt Bay, CA. Woodward Clyde Consultants.

PROJECT: North Spit Dune Mitigation Bank

LOCATION: North Spit Humboldt Bay, Humboldt County, CA

SPONSOR: State Coastal Conservancy

CONTRACTOR: Humboldt County Public Works Department

PROPERTY OWNER: City of Eureka

CONTACT: Liza Riddle, Coastal Conservancy, 415-464-4166
Andrea Pickart, Humboldt County Public Works Department, 707-445-7741

SIZE: 58 Acres

COST: $325,000 (estimated)

SCHEDULE: Design Phase: June, 1985
Implementation: Fall, 1986

Summary

Under a grant from the State Coastal Conservancy, an 80-acre degraded dune area on the North Spit will be enhanced through removal of exotic species and native revegetation. The objective is to create habitat for and increase the population of the State-listed endangered Menzies wallflower (*Erysimum menziesii*) which now occurs on the site, and to restore several dune hollows. Design phase will consist of baseline habitat and population inventories, sampling for habitat composition and structure and experimental plots to examine exotic eradication, revegetation and *Erysimum* introduction techniques.

Full scale restoration will involve removal of exotics over 37 acres, (primarily bush lupine (*Lupinus arboreus*) and weedy, invasive exotics and natives), revegetation of 53 acres, creation of five acres of dune hollows, fencing of the entire 80-acre site and monitoring.

References

The Enhancement Plan due out in May 1986 will contain project specifications. Documentaion of experimental data will be available as it is produced. Contact Humboldt County Public Works Department or Coastal Conservancy.

PROJECT: Buhne Point Shoreline Erosion Control Demonstration Revegetation Project

LOCATION: King Salmon, Humboldt County, CA

SPONSOR: U.S. Army Corps of Engineers, San Francisco District

PROPERTY OWNER: Humboldt Bay Harbor, Recreation and Conservation District

CONTRACTORS: Humboldt County Public Works Department, Natural Resources Division

Gail Newton, Botanical Consultant, Eureka

CONTACT: Jack Farless, San Francisco District Corps of Engineers, 415-974-0387
Andrea Pickart, Humboldt County Public Works Department 707-445-7741

SIZE: 15 Acres

COST: $100,000 (estimated)

SCHEDULE: Phase 1 Seed Collection - August-October 1984
Phase 1 *Elymus* Planting - March 1985
Experimental Planting/Monitoring - March-November 1985
Phase 2 Seed Collection -August-October 1985
Phase 2 Planting - November 1985

Summary

An artificially created sand dune system totaling 23 acres was constructed to replace an eroded sand spit. Phase 1 seed collecting consisted of collection of 75 lbs. of the following species from around the Humboldt Bay region:

Abronia latifolia
Ambrosia chamissonis
Armeria maritima
Artemisia pycnocephala
Cakile maritima
Calystegia soldanella
Erigeron glaucus
Eriogonum latifolium
Lathyrus littoralis
Orthocarpus purpurascens
Plantago hookeriana
Poa douglasii
Polygonum paronychia
Solidago spathulata
Tanacetum douglasii

All species were subjected to germination and viability testing by the State Seed Lab in Sacramento.

Seeds were processed and cleaned when necessary, dried, treated with fungicide and insecticide and stored until March. In Phase 1 two acres of *Elymus* were planted on graded dune crests and windward slopes. was purchased from Wilbur Ternyik, Wave Beachgrass Nursery, Florence, Oregon. Subsequently, it was determined that one third of the stock purchased was *Ammophila*, which was replaced by the supplier. A total of 80,000 culms costing $4600 were planted two per hill on 24" centers using CCC labor. Plants were fertilized at the time of planting using 21:0:0 at 400 lbs/acre. A seed mix of the above collected species was planted in two meter wide strips separated by two meters located between dunes, totalling approximately one acre. The application rate was 20 lbs/acre. Seeds of *Calystegia, Lathyrus, Ambrosia* and *Polygonum* were scarified before planting. Seeds were raked to a depth of 2" using CCC labor. Fertilizer (21:0:0) was added to half the seeded area 8 weeks after planting. All areas were irrigated with a permanent rainbird sprinkler system.

Two study areas were established which examined the following treatments:

Hydromulch
Jute Matting
21:0:0 Fertilizer
Osmocote slow release fertilizer (14-14-14, 3 to 4 months formulation)
Compost
Control (application rates derived from known germination rates and seed counts of these or similar species)
1/2 Application Rate of Control
2x Application Rate of Control
Depth Test (sown to depths of 1,2,3,6,9")

A total of nine species and a mix were subjected to the above treatments.

In addition, the following species were transplanted as cuttings, rootings or divisions:

Artemisia pycnocephala
Solidago spathulata
Poa douglasii
Calystegia soldanella
Fragaria chiloensis
Lathyrus littoralis
Tanacetum douglassi

The propagules were collected from local stock and planted by the CCC. Propagules were divided into a control group and an experimental group subjected to treatments of rooting compound or fertilizer.

Phase 2 seed collection will entail collecting and processing of 300 pounds to be planted over 15 acres in November 1986, using the following techniques:

1) Hand raking (2" depth) and hydromulch (1500 lbs/acre fiber) and fertilizer (13:13:13 Osmocote at 500 lbs/acre)

2) Hand raking (2" depth) with soluble fertilizer applied when above ground growth is established.

3) Hydroseed and hydromulch (1500 lbs/acre fiber and 500 lbs acre 13:13:13 Osmocote).

4) Tractor harrow, with soluble fertilizer applied when above-ground growth is established.

References

Newton, Gail, 1985. Seed Collection, Buhne Point Shoreline Erosion Demonstration Project. Submitted to Humboldt County Public Works Department under contract to U.S. Army Corps of Engineers.

Newton, Gail, 1985. Phase One Planting, Buhne Point Shoreline Erosion Demonstration Project. Submitted to Humboldt County Public Works Department under contract to U.S. Army Corps of Engineers.

Future reports will be available documenting results of the Monitoring Program, Phase 2 Seed Collection and Phase 2 Planting.

PROJECT: MacKerricher State Park

LOCATION: Ten Mile Dunes, Fort Bragg, Mendocino County, CA

SPONSOR: California Department of Parks & Recreation

CONTACT: Jim Barry, Senior State Park Plant Ecologist, California Department of Parks & Recreation, 916-322-8562

SIZE: 20 Acres

COST: $130,000 (Projected)

SCHEDULE: Trials - March 85, June 85
1st Planting - December 86

Summary

Experimental trials in March 85 consisted of different fertilizers on naturally regenerating areas. One meter-square plots were established examining the following fertilizers (incorporated to 3 cm):

Treatment	Rate (gm/m2)
Ammonium sulfate 21-0-0-13	100
Super phosphate 0-20-0-10	100
Plant-a-gel	10/20 gm/plant
Potassium chloride 0-0-60	36
Control	0
Micro Mix	100
Ammonium phosphate 16-20-0-13	100
Potassium nitrate 16-0-64	100
Copper sulfate	4.5
Sodium borate	4.9
Zinc sulfate	4.9
16-20-16-13 + Micromix	150
16-20-0-13 + Potassium chloride + Micromix	100

In addition, pot tests were performed to estimate fertilizer requirements.

In June 1985 stabilization trials were begun. Seeds will be collected by CCC's in Summer 1985 and will be propagated at Yahtville Nursery (CCC). Phase I planting in December 1986 will utilize 163,400 plants (see species list below) grown in plastic plug containers ("super cells" or equivalent) 1.5 inches in diameter, 8 inches deep, with 10 cubic inches volume. Plants will be grown in vermiculite-peatmoss mix (9:1) with micronutrient, slow release fertilizer (3 to 5 month), double-superphosphate and dolomite lime to bring mix near neutral pH (2 lbs dolomite per cubic yard soil mix). A moisture retention polymer will be added. Sand stabilization will occur for at least two years. Prior to stabilization, a mixture of 20 pounds Zorro fescue ([illegible]) and 30 pounds Blando brome ([illegible]) seed per acre shall be broadcast in alternate strips with fertilizer (16-20-0-5) applied over seeded and non-seeded areas at 400 lbs/acre. Mechanical stabilization will consist of the following.

1) Crimped straw mulch (4,000 lbs/acre) - (possibly with tackifier).

2) Plastic netting over straw mulch (anchored with 12 inch staples).

3) Soil binding resin (E-10 or equivalent) applied at a rate of 435 to 870 gal/acre after vegetation planting (following last spring rains). This method is still being tested at Pismo Dunes.

Sand fences will be installed along two major dune crests. A portable sprinkling system will be installed. Planting will occur when sand below one inch depth is at field capacity. Plantings will be placed 24 inches on center in a random manner.

Plant Community Prescription

	Foredune	Crest	Hind-dune
Abronia latifolia	1,500	500	
Ambrosia chamissonis	9,500	500	
Artemisia pycnocephala	25,000	500	20,000
Artriplex leucophylla	1,900	100	
Camissonia cheiranthifolia	1,000	500	
Elymus mollis	10,000	1,000	3,000
Eriogonum latifolium		1,000	500
Lupinus albifrons		400	17,000
Lupinus chamissonis	500	14,500	15,000
Poa douglasii spp *macrantha*	15,000	15,000	5,000
Total	64,400	34,000	60,500

Rare plant reestablishment will occur for the following species:

Chorizanthe howellii
Erysimum menziesii

The Department of Parks and Recreation will study niche disturbance, distribution, autecology and propagation of these species. Ecological monitoring will be performed to assess the effectiveness of the stabilization project. European beachgrass eradication will also occur on the site.

References

Barry, W. James 1985. MacKerricher State Park Ten Mile Dune Restoration Plan, Resources Agency, Department of Parks and Recreation, Resource Protection Division.

PROJECT: Fort Funston Launch Area

LOCATION: Fort Funston, San Francisco, CA

SPONSOR: National Park Service

CONTACT: Bill Van Peters, Los Angeles District, U.S. Army Corps of Engineers, 213-894-0236

SIZE: Approximately 2 Acres

COST: --

SCHEDULE: Winter 1979

Summary

Project consisted of revegetating a disturbed area where pipe was installed. Seeds were collected locally and also purchased from Clyde Robbins. Species included:

Achillea millefolium
Artemisia pycnocephala
Lupinus arboreus
L. chamissonis
Calystegia soldanella
Eriogonum latifolium
Eschscholzia californica

Seeds were hydromulched at approximately 30 lbs. per acre with fertilizer and tacant. No irrigation was utilized. Rodent predation of seeds was a problem. Although initial germination was high, subsequent mortality occurred. *Mesembryanthemum* from adjacent areas eventually colonized and replaced natives.

PROJECT: Half Moon Bay State Beach

LOCATION: Dunes Beach, San Mateo County, CA

SPONSOR: California Department of Parks & Recreation

CONTACT: Jim Barry, Senior State Park Plant Ecologist, California Department of Parks and Recreation, 916-322-3562

SIZE: 8.5 Acres

COST: $90,000 (Includes regrading parking lot)

SCHEDULE: Winter 1981

Summary

An 8.5 acre area between the south parking lot and the beach was recontoured. A two-inch layer of compost mulch was mixed into artificial dunes to enhance moisture-holding capacity. (No irrigation was available). The area was hydromulched with 2500 lbs/acre wood fiber, 400 lbs/acre 20:20:20 fertilizer and a seed mix of 30 lbs *Lolium* sp., 30 lbs. *Lotus* sp., 5 lbs. *Eschscholzia californica* and a small amount of *Lupinus arboreus*. Plastic netting was placed on windward sides. Seeds were collected in summer and fall 1981, propagated in 1.5" and 8.5" tube containers and plug planted in Fall 1982. By spring 1982 a dense stand of ripgut covered site (apparently introduced with compost), and is still present. Subsequently, various ruderal species have invaded. Natives were plug planted in hydromulched areas and bare sand to north and south. Survival was 95% in bare sand and 50% in hydromulched areas due to rodent predation. Severe winter storms physically removed the plants in bare sand, while stabilized dunes remained intact.

References

Barry, James. 1984. Ecosystem Restoration in the California State Park System. California Department of Parks & Recreation.

PROJECT: Sunset State Beach

LOCATION: Monterey County, CA

SPONSOR: California Department of Parks and Recreation

CONTACT: Ken Gray, California Department of Parks and Recreation, 916-322-8562

SIZE: 17 Acres

COST: $78,000

SCHEDULE: 1986

Summary

A six acre blowout will be stabilized and revegetated in addition to nine acres over which exotic species (primarily sea fig) will be removed. Techniques for planting are as stated under Marina State Beach project.

PROJECT: Monterey Interceptor Project

LOCATION: Monterey Sewage Treatment Facility to Seaside Sewage Treatment
Facility, Monterey County, CA

SPONSOR: Monterey Regional Water Pollution Control Agency

CONTRACTOR: Richard Murray Associates, Carmel, CA

CONTACT: Richard G. Murray, 408-624-5700

SIZE: 9.1 Acres

COST: $89,000

SCHEDULE: Summer 1983
Hydromulch - Fall 1983

Summary

13 acres of a 20-acre area disturbed by construction of an interceptor was regraded to form dunes. Three general planting areas included: 1) *Ammophila arenaria* on windward slopes and crests of dunes; 2) "Indigenous" planting pockets of nursery grown stock including *Calocephalus brownii*, *Cupressus macrocarpa*, *Lupinus arboreus;* 3) Hydromulched seed mix of *Abronia latifolia, Dudleya caespitosa, Eriogonum latifolium, Haplopappus ericoides, Lupinus arboreus, Camissonia cheiranthifolia* and *Poa douglasii*, purchased from S&S Seeds. Snow fencing and jute matting were used in exposed areas (8% of area jute matted). Snow fencing was used along the crests of critical dunes. 45% of the site was irrigated; hydromulched areas were planted in fall and were not irrigated. Irrigation consisted of Rainbird impact sprinklers with overlapping spray patterns and automatic controller. The schedule for irrigation was weekly between April and October. Sprinklers were programmed to water 30 min/day (.44 in/hr) one day/week = .22 in/week.

References

Richard Murray & Associates, 1981. Preliminary Dune Restoration Plan, Draft Basis of Design Report. Monterey Regional Water Poluttion Control Agency, Monterey County, CA.

PROJECT: Asilomar State Conference Grounds

LOCATION: Asilomar State Beach, Monterey County, CA

SPONSOR: Asilomar Corporation

CONTRACTOR: Bruce Cowan, Consultant, Pacific Grove

CONTACT: Jim Barry, Senior State Park Plant Ecologist, California Department of Parks & Recreation, 916-322-8562
Tom Moss, Resource Ecologist, Asilomar State Beach, 408-372-0481
Bruce Cowan, 408-372-7650

SIZE: 3.5 Acres

COST: --

SCHEDULE: 1972

Summary

A dune encroaching on park structures was bulldozed back and recontoured. A two-phased approach was utilized. Phase 1 consisted of hydromulching with a mixture of annual and perennial rye grass at 2 lbs/1000 sq.ft. with a binder, Osmocote and native seeds collected off Asilomar Dunes. A temporary impact sprinkler system was installed prior to seeding. Sea fig *(Carpobrotus aequilaterus)* cuttings were plugged. Wire cages were placed over *Lupinus arboreus* seedlings to protect from grazing. Other natives included *Artemisia pycnocephala, Abronia latifolia, A. umbellata* and *Haplopappus ericoides*. Irrigation was subsequently eliminated and grasses died off, leaving a mulch. *Artemisia*, both plugged and seeded, was the most successful species, whereas *Lupinus arboreus* showed poor success. *Haplopappus* and *Lupinus chamissonis* were moderately successful. The site was subsequently subjected to excessive disturbance by foot traffic.

References

Cowan, Bruce. 1975. Protecting and Restoring Native Dune Plants. Fremontia Vol 3 No. 2.

Barry, James. 1984. Ecosystem Restoration in the California State Park System. California Department of Parks & Recreation.

PROJECT: Asilomar State Conference Grounds

LOCATION: Asilomar State Beach, Monterey County, CA

SPONSOR: California Department of Parks & Recreation

CONTACT: Tom Moss, Resource Ecologist, Asilomar State Beach, 408-372-0481

SIZE: 12 Acres (two phases, six acres each)

COST: --

SCHEDULE: Trial planting: December 1984
Phase 1: Fall 1985
Phase 2: Fall 1987 (estimated)

Summary

A trial planting consisted of revegetation of a disturbed 35' x 70' area. The area was hydromulched with five species of native seeds (untreated), at approximately 20 lbs/acre and a mix of *Bromus mollis* and Italian rye as a nurse crop. The mulch contained osmocote and no irrigation was utilized. Seeding was done in December 1984, and grasses came up quickly. By April 1985 some *Artemesia pycnocephala* seedlings had appeared.

The full scale project will involve two phases, each covering six acres. The site is presently dominated by ice plant which will be removed prior to planting. A greenhouse will be constructed in summer 1985 to propagate native seeds of 10 species collected from the State Beach. Dunes will be recontoured and fenced to control use. Hydromulching will include native seeds at 15 pounds/acre. A nurse crop of *Bromus mollis* or Italian rye will be used. Propagated natives will be plugged. A temporary above-ground irrigation system will be installed and used for 2-3 years, then transferred to the Phase 2 site.

PROJECT: Spanish Bay Dune Restoration

LOCATION: Spanish Bay, Monterey County, CA

SPONSOR: Pebble Beach Co.

CONTRACTOR: Larry Seeman Associates, Inc.

CONTACT: Larry Stromberg, Larry Seeman Associates, 415-841-6840

SIZE: 60 Acres

COST: \$500,000 (estimated)

SCHEDULE: Experimental Dune: February 1984
Restoration: Summer 1985

<u>Summary</u>

A 150'x200' (x25' high) experimental dune was created by removing 21,000 cy of sand from a proposed hotel site. The top foot of sand was retained and spread over the surface of the artificial dune but subsequently eroded and was deposited on the lee side. The dune was hydroseeded with natives as well as a nurse crop of barley and rye. Seed application rates (for nurse crops) were varied over half the dune while fertilizer rates were varied over the other half. Both halves were subjected to the following treatments:

1) wood chips
2) jute netting
3) excelsior blanket
4) straw and plastic netting
5) hydromulch (2000 lbs/acre with soil seal)

Irrigation was utilized until June. Seeds were purchased from S&S Seed Company and consisted of the following:

Cakile maritima
Eriogonum latifolium
Erigeron glaucus
Camissonia cheiranthifolia
Artemisia pycnocephala
Abronia latifolia
A. maritima
Lupinus arboreus
Grindelia stricta ssp. *venulusa*

Irrigation was utilized until June. This mix apparently included the wrong species or subspecies of *Grindelia*.

The large scale restoration will occur on 60 acres surrounding a golf course and other planned structures. 500,000 cy of sand will be imported from a site one mile away. 150 lbs of seeds representing 18 dune species were collected in summer/fall 1984 and an additional amount (up to 1500 lbs) will be collected in summer/fall 1985. *Lupinus arboreus* will be omitted from the seed prescription due to its aggressive nature. The following variations will be used in hydromulched areas:

1) 24:8:8 slow release fertilizer with 3% soluble at 200 lbs and 150 lbs/acre (8 to 9 month formulation).

2) Fiber at 1,000, 1,500 and 2,000 lbs/acre.

3) Three different application rates for nurse crop.

4) Two different native seed prescriptions.

In addition, plots with known seeding density will be tested for the effects of different fertilizers.

Approximately 20 species will be propagated from seed and cuttings in a greenhouse and outplanted. Approximately 600,000 planting units of *Carex pansa* will be grown on land owned by Leonard Coates Nursery from propagules salvaged off the site, and transplanted onto completed dunes in transitional areas between golf course landscaping and native areas. An irrigation system will be utilized. Planting is expected to take 18 months. Ice plant eradication will also occur on the site.

References

Larry Seeman Associates, 1985. Spanish Bay Dune Restoration Resource Management Plan. Submitted to California Coastal Commission.

PROJECT: Montana de Oro State Park

LOCATION: Morro Bay, San Luis Obispo

SPONSOR: California Department of Parks & Recreation

CONTACT: Ken Gray, California Department of Parks and Recreation, 916-322-8562

SIZE: 15 Acres

COST: $140,000

SCHEDULE: September 1985 - snow fencing installed mechanical stabilization planting initiated.
November 1986 - Major planting completed.

Summary

Seeds will be collected by CCC's in summer 1985 and will be propagated by Yahtville Nursery (CCC). Planting will utilize containerized natives on two foot centers (163,000 total). No irrigation will be utilized (water source lacking). The following stabilization treatments will be used:

1) Chopped straw and plastic netting
2) Blown and crimped straw
3) Soil seal or E-10

Planting labor will be supplied by the CCC's.

The following species will be utilized:

Abronia latifolia
A. maritima
Ambrosia chamissonis
Atriplex leucophylla
Baccharis pilularis var *consanguinea*
Calystegia soldanella
Camissonia cheiranthifolia
Croton californica
Elymus pacifica
E. mollis
Eriogonum parvifolium
Eriophyllum staechadifolium
Haplopappus ericoides
Lotus scoparius
Lupinus arboreus
L. chamissonis

PROJECT: Pismo State Beach

LOCATION: Nipomo Dunes, San Luis Obispo, CA

SPONSOR: California Department of Parks & Recreation

CONTACT: Jim Barry, Senior State Park Plant Ecologist, California Department of Parks and Recreation, 916-322-8562

SIZE: 4 Acres

COST: $36,000

SCHEDULE: Uncertain

Summary

Project consists of revegetation of four acres of primary dunes near a parking facility at the Grand Avenue entrance. Plants propagated by the CCC at Yahtville Nursery will be plugged and stabilized using crimped straw mulch. A fertilizer-injected impact sprinkler system will be installed. Plant community prescriptions will be developed for dune crest, hind dune and dune slack communities.

References

Barry, James, 1984. Ecosystem Restoration in the California State Park System, California Department of Parks & Recreation.

PROJECT: Pismo Dunes State Vehicular Recreation Area

LOCATION: Nipomo Dunes, San Luis Obispo County, CA

SPONSOR: California Department of Parks & Recreation, Off Highway Vehicle Division

CONTRACTOR: California Polytechnic State University, San Luis Obispo (in part)

CONTACT: Jim Barry, California Department of Parks & Recreation, 916-322-8562

SIZE: 70 Acres

COST: (projected): $1.2 million

SCHEDULE:
1) Sampling program - 1982
2) Laboratory experiments - 1982-84
3) Trial planting #1 - 1983
4) Trial planting #2 - Feb. 1985
5) Full scale planting - undetermined

Summary

A preliminary sampling program sampled undisturbed dune communities for floristic, vegetational and soil characteristics, with special emphasis on 11 threatened, endangered and endemic species. Soil was analyzed for physical and chemical parameters including bulk density, available water, conductivity, pH and texture (Harris & Lambert, 1982).

Lab studies examined propagation techniques including seed treatments, germination/rooting media and various growing conditions. Trent (1984) investigated seed treatments for 36 species. Treatments recommended were as follows:

Ambrosia chamissonis: 1) mechanical/hand scarification + 45 day stratification.

2) 36-hour freshwater soak + 45 day stratification.

Calystegia soldanella: mechanical scarification

Lupinus arboreus: scarification (causes accelerated germination)

This study also examined eight different germination media composed of various proportions of vermiculite or perlite, dune sand (or sand) and peat. None proved superior.

Yates (1982) documented seed counts for 37 species collected off Ocean dunes. Number of seeds per ounce is provided for unprocessed and in some cases processed (removed from anthocarp) seed.

Frey (1983) also investigated seed treatments and germination media, as well as container types. Seeds were sown in combinations of sand, perlite and peatmoss. The most satisfactory media was determined to be beach sand with a small amount of peatmoss. Seed treatments included hot water, acid, scarification, stratification, water soak and fire. All composites with pappus on the achene responded best without treatments. All lupines responded equally with or without treatments of heat or scarification. Special emphasis was placed on *Ambrosia chamissonis* and *Abronia latifolia*. *Ambrosia* showed highest germination (60% germinated within 90 days) under 36 hour freshwater soak and 45 day stratification. *Abronia* required no treatment, and was planted as cleaned from anthocarp or with anthocarp intact. The major problem with *Abronia* was empty anthocarps. In all trials fresh seed showed lower and slower germination than older seeds. The report recommends planting seeds directly into tubes and super-cells, thereby eliminating the need for transplanting.

Planting techniques were examined by Doherty (1982). Phase 1 tested seven species under various growing conditions: *Abronia umbellata*, *A. maritima*, *Croton californicus*, *Haplopappus ericoides*, *Isocoma venusta* and *Lupinus chamissonis*. Cuttings were subjected to different hormonal concentrations (Hormex #1, .1%; Hormex #8, .8%, Liquid 1.0%), 2 rooting media (equal parts peat/perlite and coarse sand) and 2 sets of environmental conditions (overhead suspended mist system with heating cable and control (hand watering/no heat).

Losses ranged from 75-100%. Losses were higher on the hand watering bench. Sand proved more effective than perlite for hand watering due to superior drainage capacity.

Phase 2 examined only *Croton californicus* (with 75% loss in Phase 1), and utilized mist and heat with peat/perlite. Losses were reduced to 18%.

Trial planting #1 investigated the use of direct planting of containerized stock into active dunes (Sellery et al, 1983). 2,000 plants (35 species) were planted at 4 locations west of Oso Flaco Lake. Locations consisted of fore dune, primary crest dune, deflation plain and secondary dune. 36 plants per 3x3m plots were planted on 18" centers in a checkerboard fashion. Only five species survived: *Ambrosia chamissonis*, *Atriplex leucophylla*, *Elymus multinodus*, *E. pacificus* and *Juncus leseureii*. Two major problems were observed: 1) roots were unable to integrate into moving sand; and 2) severe windburn of foliage occurred. The study concluded that appropriate plants for this method of planting should have the following properties: 1) growth habit prostrate, fine foliage (to protect from dessication); 2) growth rate rapid to permit burial; 3) extensive root system for stability and water derivation.

The trial planting of February 1985 examines mechanical stabilization of techniques at Oso Flaco Lake. 60,000 plants were provided under contract by Cal Poly, San Luis Obispo and were planted by the CCC. The following species were used: *Calystegia soldanella*, *Erigeron glaucus*, *Achillea millefolium*, *Lupinus chamissonis*, *Eriophyllum staechadifolium*, *Erysimum suffrutescens* and *Haplopappus ericoides*. Techniques included: 1) straw covered with plastic netting (3,000 lbs/acre) in strips 20' wide separated by 20' unstabilized strips and 20' E-10 polymer. Initial results indicate that straw and plastic netting is able to withstand the extreme wind onsite, as well as E-10 polymer. Severe wind stress on plants is a major problem in these conditions.

The full scale planting is intended to stabilize massive moving dunes which are now encroaching on Oso Flaco Lake, using methods determined effective through experimentation at this and other State Park sites.

References

Frey, Woodey 1983. Pismo Dunes Floral Propagation Report. California Polytechnic State University, San Luis Obispo, Ornamental Horticulture Department.

Harris, J. and Royce Lambert 1982. Pismo Dunes Stabilization Study. Agreement 4-823-1026. Submitted to California Department of Parks & Recreation.

Sellery, S. Trent & T. Gurdinier 1983. The Revegetation Potential of the Nipomo Dunes Using Container Grown Native Plants. Cal Poly Tech State University, San Luis Obispo, Ornamental Horticulture Department.

Trent, Susan 1984. Pismo Revegetation Propagation Report. California Polytechnic State University, San Luis Obispo. Ornamental Horticulture Department.

Yates, Annie 1982. Ocean Dunes Vegetation Seed Count for Plant Species. Cal Ploy Tech, San Luis Obispo.

PROJECT: Vandenberg Air Force Base MX Road Cuts

LOCATION: Vandenberg Air Force Base, Santa Barbara, CA

SPONSOR: U.S. Air Force

CONTACT: Bill Van Peters, Los Angeles District, U.S. Army Corps of Engineers, 213-894-0236

SIZE: Approximately 10 Acres

COST: --

SCHEDULE: Summer 1981

Summary

Disturbances along road cuts were revegetated in May 1981 using native seeds from a commercial supplier. Areas were irrigated. Plantings failed and in August the area was replanted by hydromulching rye grass. Irrigation was supplied by water trucks. Second planting also yielded low success.

APPENDIX C

SECTION 1	PHASE II SEED COLLECTION: METHODS AND COST ANALYSIS
SECTION 2	PHASE II PLANTING: METHODS AND COSTS
SECTION 3	QUALITATIVE EVALUATION OF PHASE II PLANTING
SECTION 4	PHASE II MONITORING REPORT

SECTION 1

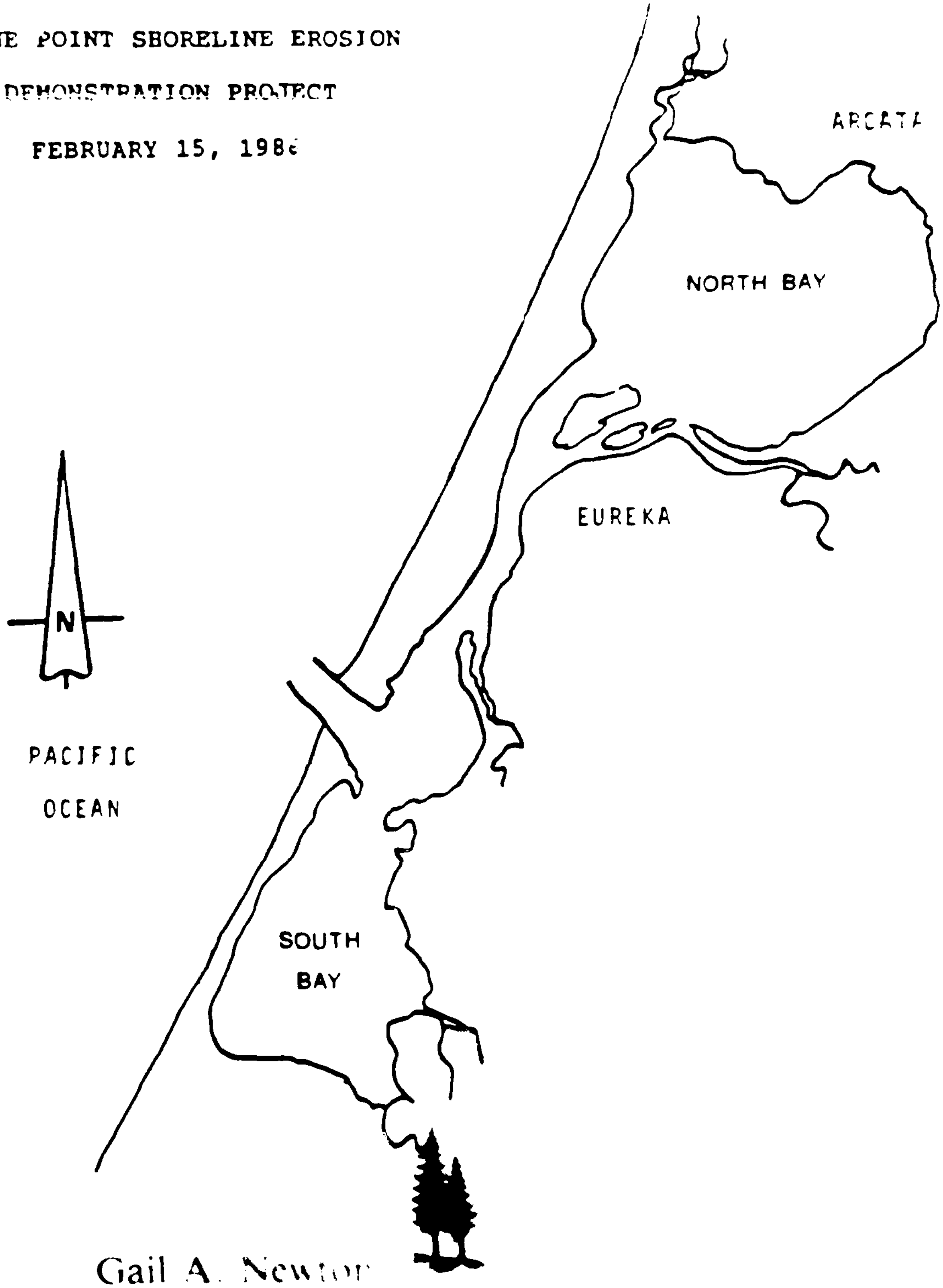
PHASE II SEED COLLECTION: METHODS AND COST ANALYSIS

PHASE TWO SEED COLLECTION: METHODS AND COST ANALYSIS

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

FEBRUARY 15, 1986



Gail A. Newton

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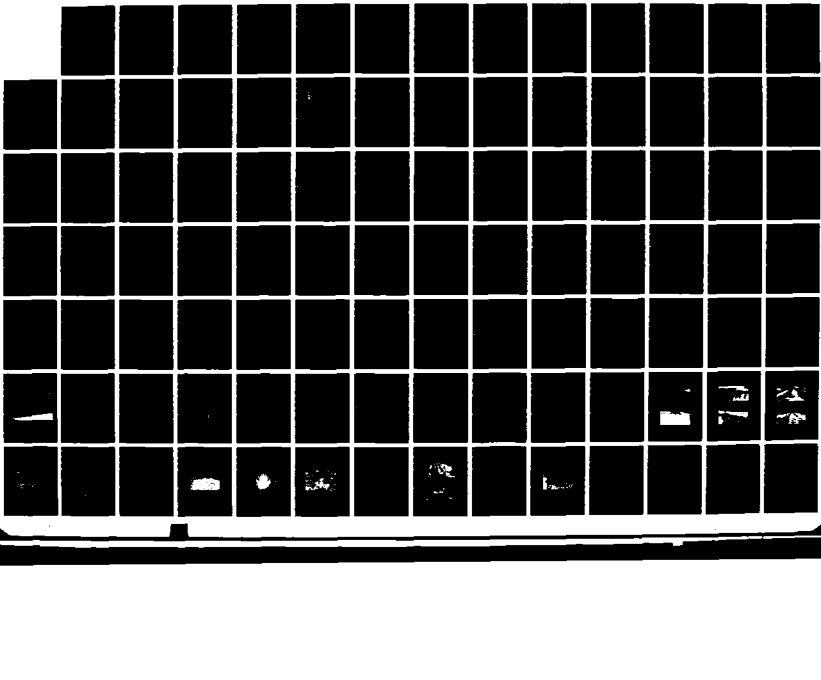

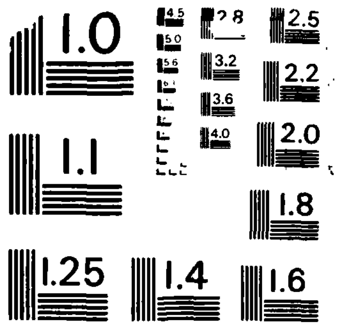

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

PHASE TWO SEED COLLECTION: METHODS AND COST ANALYSIS

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

LOCATION:	HUMBOLDT BAY, HUMBOLDT COUNTY, CALIFORNIA
SUBMITTED TO:	COUNTY OF HUMBOLDT DEPARTMENT OF PUBLIC WORKS NATURAL RESOURCES DIVISION 1106 SECOND STREET EUREKA, CALIFORNIA 95501
DATE:	FEBRUARY 15, 1985
SUBMITTED BY:	GAIL A. NEWTON BOTANICAL CONSULTANT P.O. BOX 234 ARCATA, CALIFORNIA 95521

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INTRODUCTION

An artificial dune system was created from dredge spoils at Buhne Point to protect an area known as King Salmon from tidal erosion. The dune system was planted with native species in 1984 and 1985 in hopes that a stable and self-propagating dune system will emerge.

The revegetation of the Buhne Point Shoreline Demonstration Project began in the Summer of 1984 with the design and implementation of the pilot project. The pilot project was cooperatively designed by the Humboldt County Department of Public Works and the Los Angeles District Army Corps of Engineers. The pilot project included the collecting and processing of propagules from native dune species and the subsequent planting of the propagules. The data on methods and costs derived from the pilot project (Newton 1985a and Newton 1985b) were used to predict costs for the full-scale project. This report contains the data for seed collection for the full-scale project. The seeds were planted in fall 1985 under a separate contract.

There are two main reasons for collecting seed stock from local dune areas. First, most of the species used for the revegetation plan (see Table 1) are not available from commercial seed suppliers. Second, a species commonly comprises genetically distinct races that are closely attuned to local environmental conditions and; therefore, these races have a higher probability of survival under the local conditions (Turesson 1922, Clausen 1939, 1940, 1951, and Gregor 1942, 1946).

The use of native species for dune revegetation in California is relatively new, and little is known of the costs associated with the various aspects of dune revegetation. The purpose of this report is to document the cost, man-hours, and procedures necessary for the collecting, processing, and storing of seeds from the local native dune plants listed in Table 1.

The areas that were visited to assess the quantity of seed stock are mapped and described in the section on Site Analysis. The materials and equipment necessary for the project are outlined in the section after the site analysis. The costs involved in various aspects of the contract are analyzed by species in the Cost section. Detailed information on methods involved in collecting and processing the propagules of each species listed in Table 1 is given in the Species section.

The collecting and processing of propagules were carried out by Humboldt County Department of Public Works under contract to the San Francisco District, Army Corps of Engineers. The County subcontracted with botanical consultant Gail A. Newton for supervision and other tasks documented in this report.

TABLE 1: SPECIES LIST

SCIENTIFIC NAME	CODE	PLANT FAMILY	COMMON NAME
Abronia latifolia	ABLA	Nyctaginaceae	yellow sand verbena
Ambrosia chamissonis	AMCH	Compositae	beach bur
Artemisia pycnocephala	ARPY	Compositae	beach sagewort
Camissonia cheiranthifolia	CACH	Onagraceae	beach evening primrose
Eriogonum latifolium	ERLA	Polygonaceae	seaside buckwheat
Lathyrus littoralis	LALI	Leguminosae	beach pea
Solidago spathulata	SOSP	Compositae	goldenrod
Tanacetum douglasii	TADO	Compositae	dune tansy

COLLECTION SITES

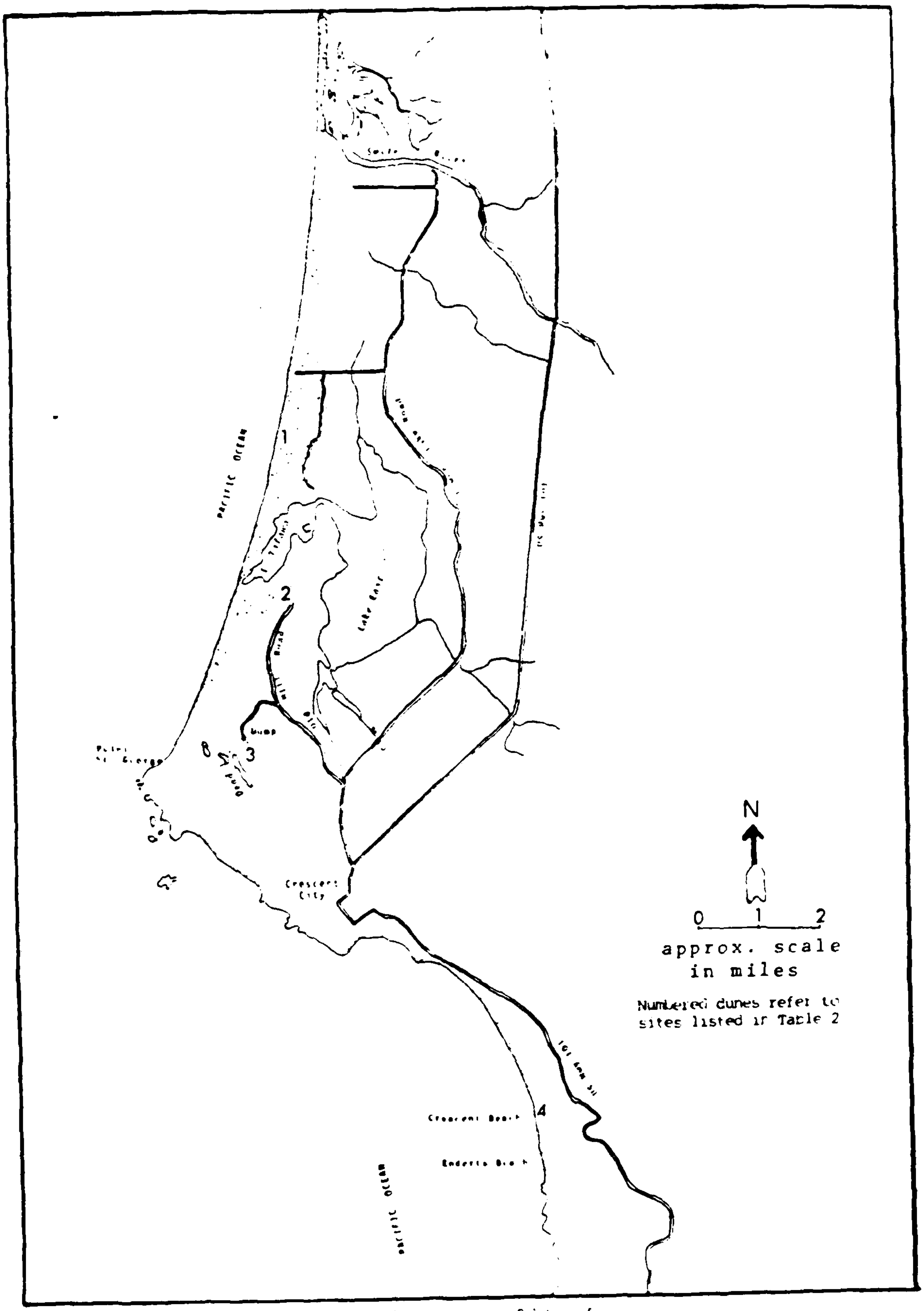
Due to the large amount of seed needed for the Buhne Point Demonstration Project, sand dune habitats from the Crescent City area to the Mouth of the Mattole River were visited to ascertain the quantities of fruits available for the various species at each site.

The sites that were surveyed are, from north to south, Lake Earl State Park, the end of Old Mill Road (Crescent City), City Dump (Crescent City), Crescent Beach-Enherts Beach, False Klamath Cove, the mouth of the Klamath River, Gold Bluffs (Redwood National Park--RNP), Redwood Creek Beach (RNP), Lookout Point Beach (RNP), Freshwater Lagoon Spit (RNP), Stone Lagoon State Park, Dry Lagoon State Park, Big Lagoon (both county and state parklands), Clam Beach County Park, Mad River Beach, The Lanphere-Christensen Dune Preserve (property of The Nature Conservancy), Samoa Peninsula, Elk River Wildlife Area, Elk River Spit, South Spit, mouth of the Eel River, Zanone Ranch--Mussel Rock Beach, and the mouth of the Mattole River. (See Maps 1-7.)

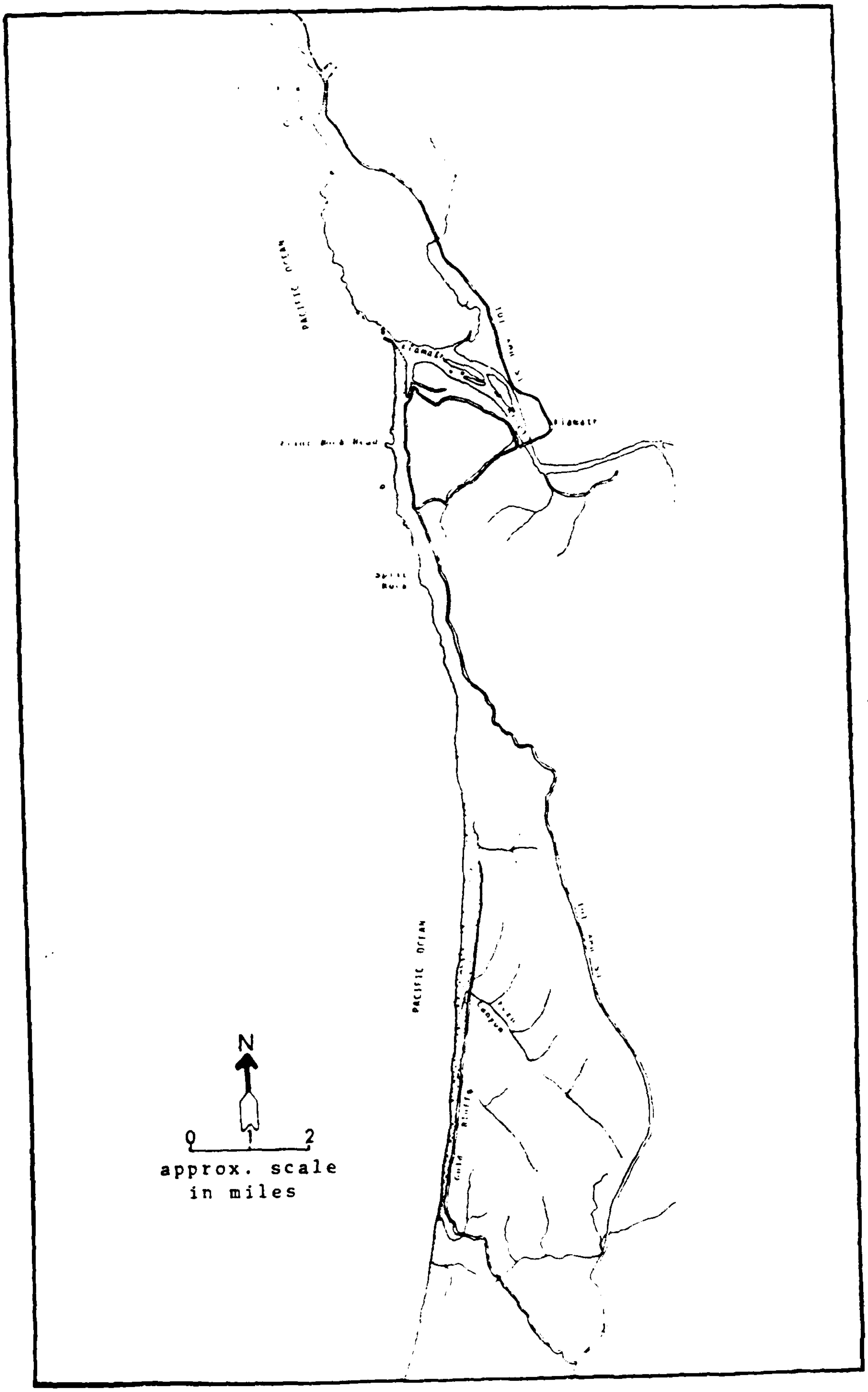
From the abundance indices presented in Table 2, the relative importance of a site is evident. Sites that did not contain enough seed source to warrant collection are not included in the table. Since both the Samoa Spit and the South Spit are several miles long and contain important seed collection sites, they are further divided for better identification of the collection sites. Sites on the Samoa Peninsula are, from north to south: Lupine Avenue, west of LP (Louisiana Pacific Plant), west of the Samoa Boat Ramp, west of the Coast Guard Station, and south of the Coast Guard Station. The South Spit sites are identified as the third opening in the European beachgrass (Ammophila arenaria) stand, the second opening in the European beachgrass stand, South Spit at the base of Table Bluff, and from the base of the bluff, south along the Eel River Spit.

The sites cover approximately 125 miles from the Oregon boarder to the mouth of the Mattole River. From Eureka to Crescent City is 83 miles, and from Eureka to the Mattole River is about 42 miles. (Buhne Point is located approximately five miles south of Eureka on Humboldt Bay.) The climate of this coastal region is marine. There is no weather station at Petrolia or any nearby, representative area; however, there are many years of weather data for Crescent City and Eureka. Eureka has a mean annual rainfall of 40 inches with a mean annual temperature of 52 degrees. Crescent City has a mean annual rainfall of 73 inches and a mean annual temperature of 53 degrees (data from the U.S. Weather Service).

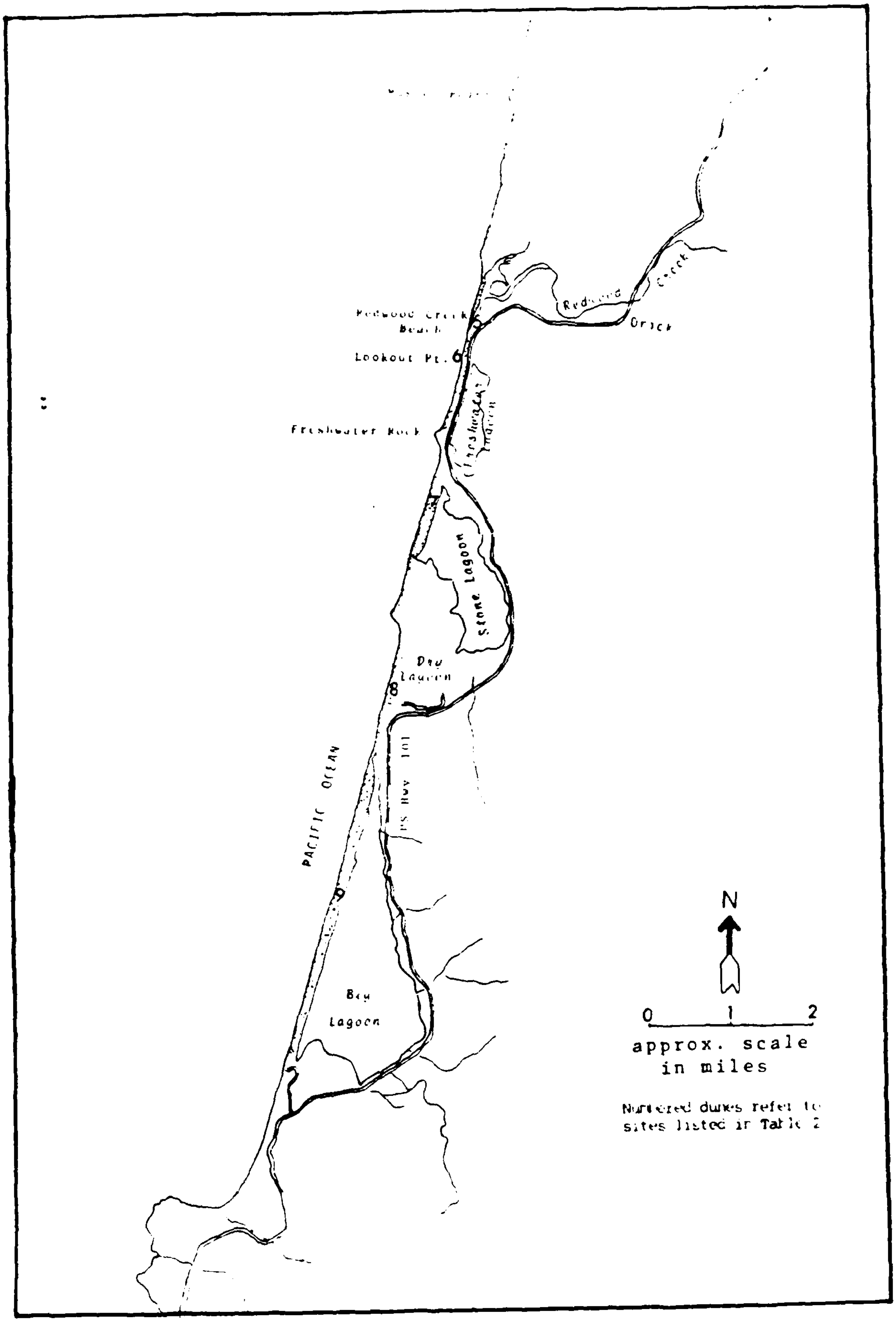
Perhaps better data for comparing climatic differences between the two cities are the mean summer rainfalls. Crescent City has a mean summer rainfall of 2.40 inches while Eureka's mean summer rainfall is 1.09 inches (data from the U.S. Weather Service). In general, summer rainfalls decrease as one moves southward.



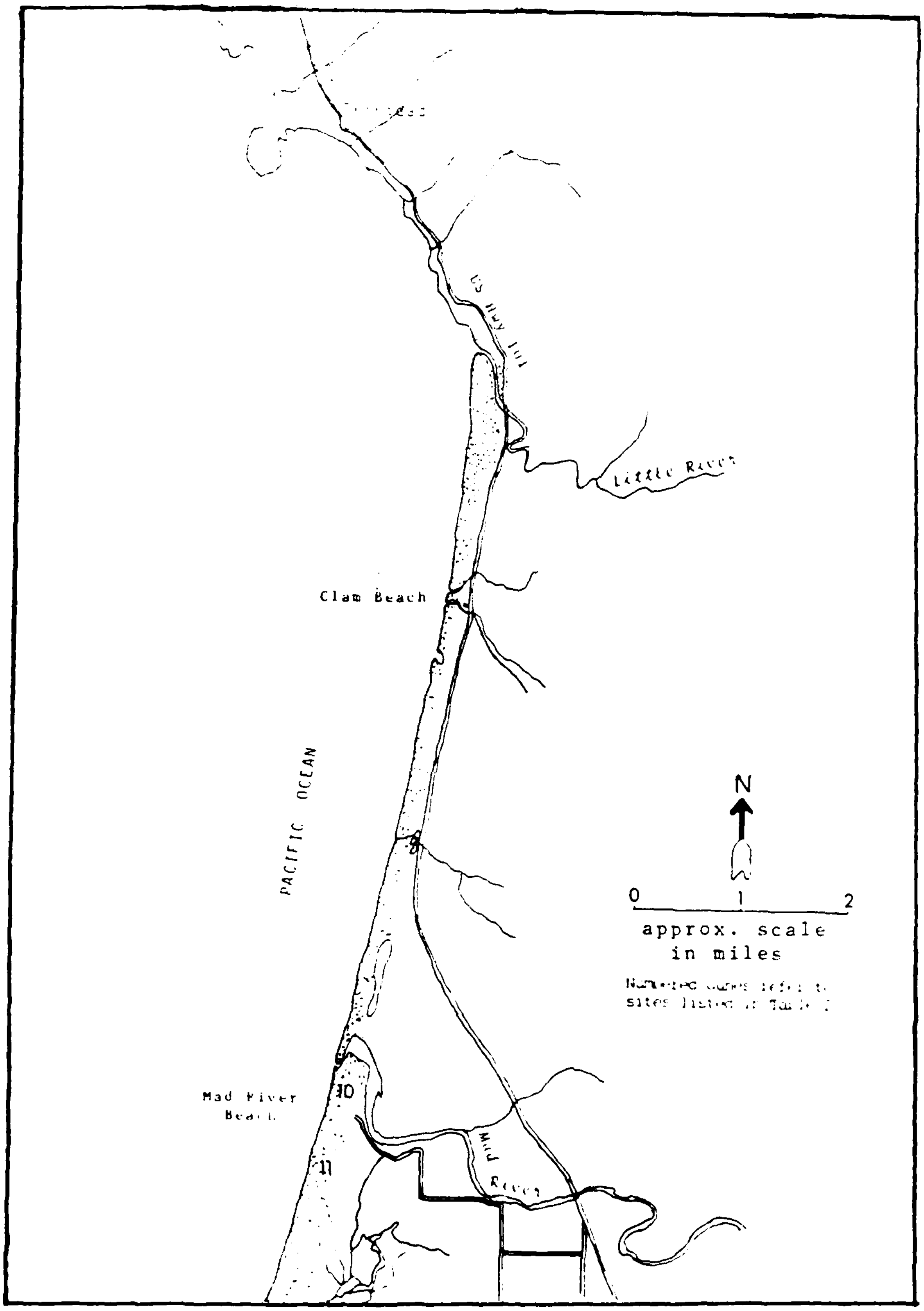
Map 1: Collection Sites, Crescent City Area.



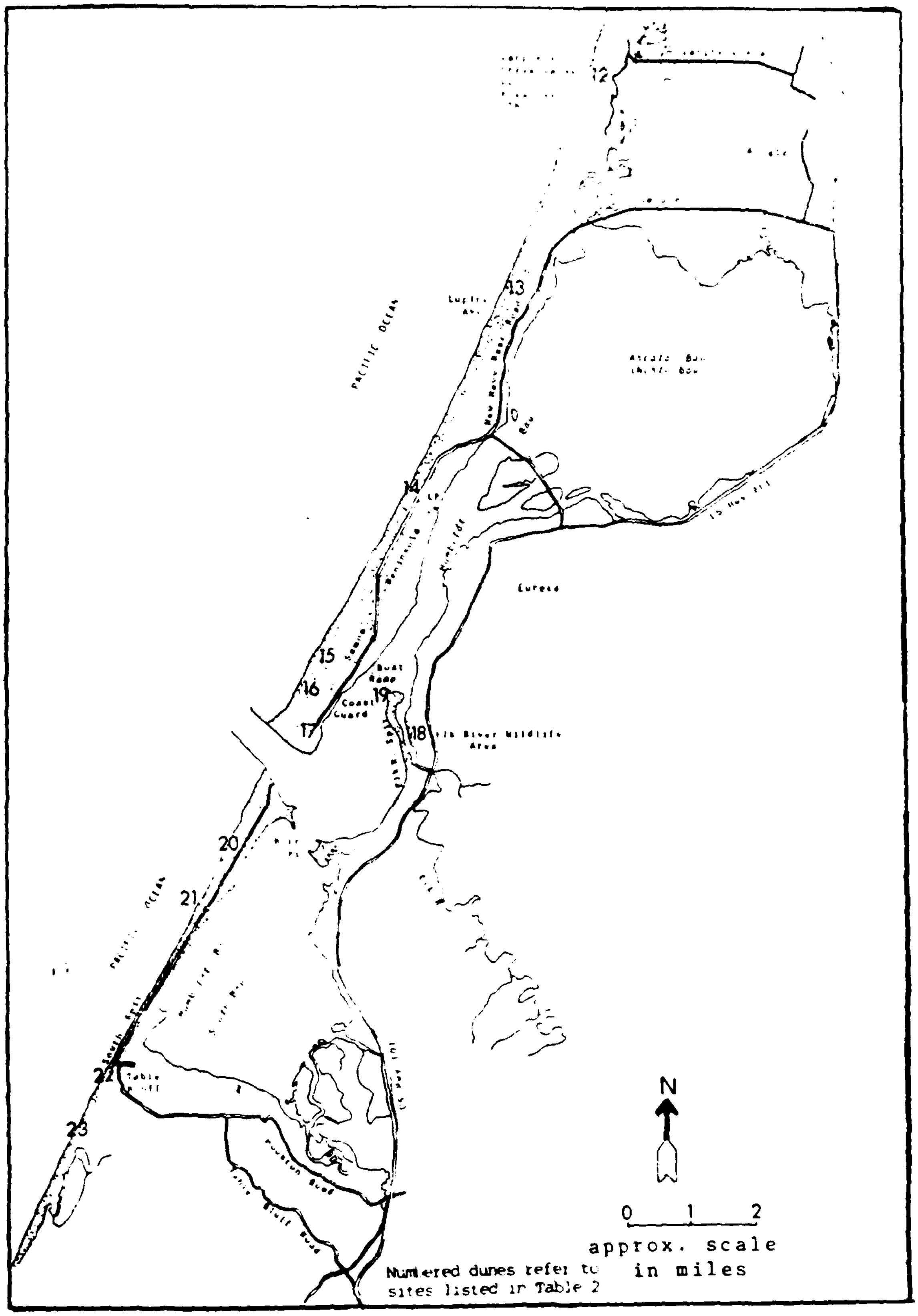
Map 2: Collection Sites, Klamath Area.



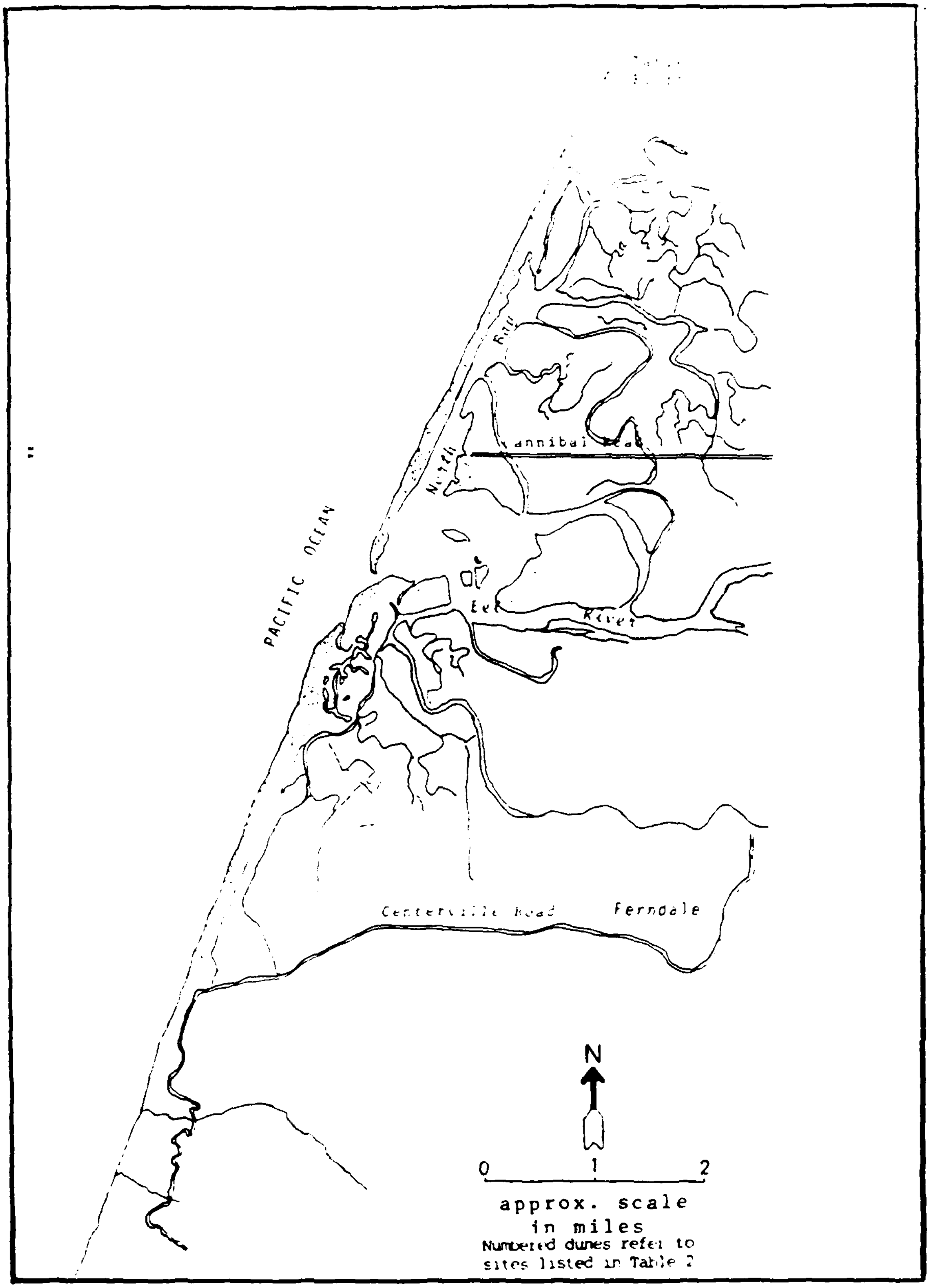
Map 3: Collection Sites, Orick Area.



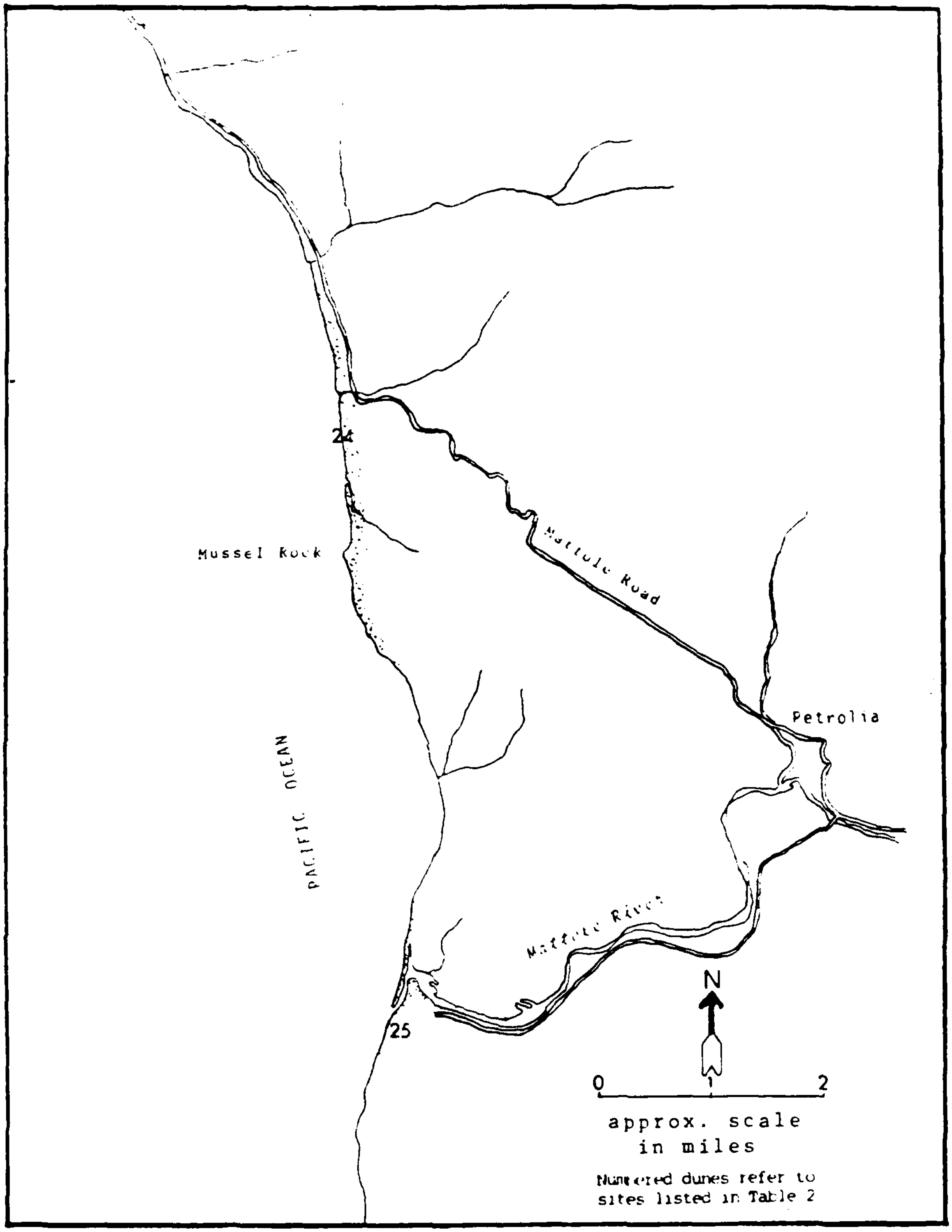
Map 4: Collection Sites, Trinidad to Arcata Area.



Map 5: Collection Sites, Arcata-Eureka Area (Humboldt Bay).



Map 6: Collection Sites, Ferndale Area.



Map 7: Collection Sites, Petrolia Area.

TABLE 2: SPECIES ABUNDANCE BY SITE

SITES: NORTH TO SOUTH	ABLA	AMCH	ARPY	CACH	ERLA	LALI	SOSP	TADO
1. LAKE EARL		-	A	-	-			
2. OLD MILL RD.					A			
3. CC DUMP			A					
4. CRESCENT BEACH	-	+						A
5. REDWOOD CK. BEACH	+	-		A		+		
6. LOOKOUT PT. BEACH				A		+		
7. STONE LAGOON								-
8. DRY LAGOON	+	-				+		+
9. BIG LAGOON		+						-
10. MAD RIVER - NO.		+		-	+	+		
11. MAD RIVER - SO.	-	+		-	+	+		
12. TNC	A	-	+	A	A	A	A	
13. LUPINE AVE.	+	-		-	+	A	A	+
14. LP	+	-	A	-	+		+	
15. BOAT RAMP	A		A		+		-	A
16. CG - WEST			A		-		+	+
17. SOUTH OF CG		-	+					A
18. ERWA							+	+
19. ELK R. SPIT		-	A	-	-		+	-
20. SO. SPIT - 3RD O.	+	A			+		A	
21. SO. SPIT - 2ND O.	+	A						+
22. SO. SPIT - BASE		A		-	-	-		
23. TABLE BLUFF - SO.	+	A		+	-		-	+
24. ZANONE-MUSSEL	A	A						
25. MOUTH OF MATTOLE	+	+		+		+		

A= very abundant, best site for collection of the species.
+= abundant, good site for collection of the species.
-= common, species may be collected at the site, optimal areas elsewhere.

A key to the species codes used in the above table can be found in Table 1.
The numbers of each site in the above table corresponds to the numbers on the Maps 1-7.

Within the 125 miles of California coastline, there are variations that affect the vegetation differently in each area, and on each site within an area. One of the largest differences between the sites is the development of dune systems. Sites 5, 6, 7, 8, 9, 21, 22, 23, 24, and 25 are all small littoral zones or narrow sand spits across lagoons and bays that lack dune system development. The substrates of these areas are generally very coarse sand which has a lower nutrient holding ability than a fine sand substrate. These areas are also very exposed to wind, salt spray, and extreme winter storms.

Sites 1, 2, 3, 10, 11, 12, and 13 all have a well-developed dune system. However, the microclimate of a particular area within a dune system depends on factors such as the distance of the site from the high tide line, the aspect of the site, the parent material, the particle grain size of the substrate, and the plant species growing on the site. For example, within the Manila Dunes (locations 11, 12, 13) and the Crescent City Dunes (locations 1, 2, 3,), the pH and the nutrient level of the soil vary with distance from the ocean and with position or aspect on the dunes. Johnson (1963) found that the pH of sand soils from Arcata decreased from: 8.2 at the beach site to 7.1 at the foredune site to 6.5 on a stable ridge to 5.6 within a dune forest. Johnson also found that, overall, the available nutrients of the soils increased with distance from the beach. Wiedemann (1966) found that the windward slope of the foredune had a higher pH and a lower percent organic matter than the lee slope of the foredune. Johnson (1963) and Wiedemann (1966) also found alterations in soil nutrients with amount and type of plant cover.

Given the large acreage of sand dunes on the coast from Oregon to Freshwater Lagoon, the native populations cover a fairly small area. The only areas of large (in acreage and height) dune development are the Lake Earl Sate Parklands (Crescent City Dunes). However, the Lake Earl State Parklands are dominated by European beach grass which has out-competed most of the native species. From Freshwater Lagoon to Mad River, large dune areas, and therefore large populations of native dune species, are rare. The coast from Mad River to the mouth of the Eel River does contain areas of large dune systems, and many of these dune systems are dominated by native dune mat vegetation. Therefore this area is the greatest resource on the entire stretch of coast for native dune species seed collection. South of the Eel River, dune development is sparse and so are native plant populations.

Since the best seed sources are located around the Humboldt Bay area, seed collection for the Buhne Point Project was concentrated at sites 5, 10, 11, 13, 14, 15, 16, 20, 21, 22, and 23. All these sites are located around Humboldt Bay with the exception of the Redwood Creek site (approximately 45 miles north of the project site), where a majority of the beach evening primrose was collected.

MATERIALS AND EQUIPMENT

The costs for materials and equipment needed for all aspects of seed collecting and processing are listed in Table 3. Materials used solely for collecting cost $153.63, those used solely for processing cost $902.17; and those used for both collecting and processing cost $237.50. The major equipment purchases were associated with the processing of the seeds. Two dryers were purchased from a local supplier and a seed cleaner was purchased from Ohio. A field scale was also purchased. The cost of these pieces of equipment was $1717.00. For details on exact materials and costs see Table 3.

Most of the materials used for collecting and processing are expendable (e.g. sandpaper, dust masks, and sanding blocks). The bags used for collecting are rarely without holes following only one use. The leather gloves used for collecting and processing were mostly worn through by the end of the contract. The only materials that are reuseable are some of the trash cans, the plastic buckets, and the respirator masks. These items have a present value of about $250.00.

The dryers and the seed cleaner are still in good working order. The only major expense that should be calculated for future use is the replacement of the screens in the dryers. Large mesh screens were installed in the dryers by the supplier. The smaller species collected (beach sagewort, seaside buckwheat, and beach evening primrose) fall through these screens. The screens had to be covered with a fine mesh cloth, a cumbersome procedure that decreased air circulation. To alleviate these problems the proper size screens should be installed prior to future use.

The screens in the dryers had to be changed three times per day. The actual time needed to change the screens varied from 15 minutes to 30 minutes per dryer, depending on the species. Travel time from Eureka to McKinleyville (the location of the processing and storage room) is 25 minutes, from Arcata to McKinleyville is 10 minutes; the staff would have to be reimbursed for this travel time. Therefore, it was cost effective to store the dryers at the attendants' homes to eliminate travel time and mileage costs. The attendants were reimbursed for dryer operating time at a rate of $0.06/hour/dryer. This reimbursement schedule is the source of the $344.64 electricity cost.

A general outline of the operation of the seed cleaner and grader follows. (See Figure 1 for a drawing of the machine.) The plant material is first fed into the hopper (the top bin). The material feeds slowly from the hopper onto the top screen. Material that is too large to fall through the top screen moves across the screen and falls into the top-screen bucket (outlet 1). The rest of the material falls from the top screen to the bottom screen. During its fall, the lighter material is sucked off by the blower and expelled into the exhaust trash can. The

TABLE 3: LIST OF MATERIALS

MATERIALS FOR COLLECTING ONLY	
data cards printing	$ 26.18
trash bags:	$ 98.46
30-gallon trash bags	
12-gallon trash bags	
8-gallon trash bags	
4-gallon trash bags	
1-gallon ziplock bags	
4 strainers	$ 9.88
3 pruning shears	$ 19.11

SUBTOTAL	$153.63
MATERIALS FOR BOTH COLLECTING AND PROCESSING	
20 leather gloves	$200.00
computer consultant	$ 20.00
time cards	$ 17.50

SUBTOTAL	$237.50
MATERIALS FOR PROCESSING ONLY	
22 plastic garbage cans	$134.82
20 5-gallon plastic buckets	$ 71.66
2 respirator masks	$ 51.98
4 sets of respirator cartridges	$ 37.96
processing materials: (dust masks, sandpaper, sanding screens, sanding sponges, goggles, etc.	$216.69
1 whisk broom	$ 3.39
1 dozen letter pads	$ 10.65
1 post-it pad	$ 1.03
2 insect foggers	$ 13.96
dust pan and broom	$ 10.18
industrial vacuum rental	$ 25.44
cleaning materials	$ 15.77
electricity (for dryers)	$344.64

SUBTOTAL	$902.17
EQUIPMENT FOR PROCESSING	
Vac-A-Way Seed Cleaner	$495.00
shipping	$145.00
2 Seed Dryers	$700.00
shipping	$ 20.00
Field Scale (incl. shipping)	$357.00

SUBTOTAL	$1717.00
MATERIALS AND EQUIPMENT GRAND TOTAL	$3046.30

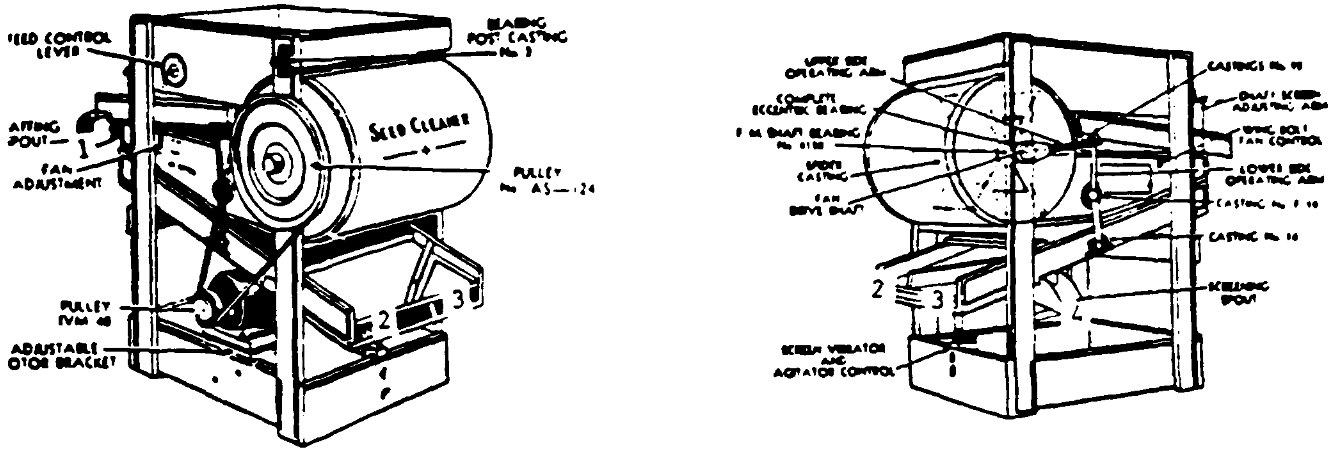


FIGURE 1: Lateral Views of the VAC-A-WAY Seed and Grain Cleaner and Grader.

Available From: Hance Corporation
235 E. Broadway
Westerville, Ohio 43081
(614) 882-7400

Numbers on above figure refer to the outlets for various end products.

1= Outlet for large material unable to pass through top screen
2= Outlet for medium material unable to pass through upper portion of bottom screen
3= Outlet for smaller material unable to pass through lower portion of bottom screen
4= Outlet for smallest material that has passed through all screens.

heavier material then moves across the bottom screen. The two layers of the bottom screen sort the material into three buckets. The smallest material falls through both layers of the bottom screen and ends up in the side bucket (outlet 4). The middle-sized material falls through the top layer but not the lower layer and ends up in one of the back buckets (outlet 3). The largest material falls through neither of the layers and comes out in the other back bucket (outlet 2). The species being .pn17 processed and the screens being used determines which outlet contains the desired end product. Specific information on processing each species can be found in the section on species under each species.

COST ANALYSIS

The pilot project of 1984 attempted to predict the costs associated with collecting and processing native seeds as a source for dune revegetation. The final costs from the 1984 pilot project were used to predict the costs for collecting and processing seeds for this full-scale project. This section presents the results of the costs incurred during the 1985 full-scale seed collection program combined with the Humboldt County dune mitigation data. The 1985 results from the combined project are also compared to the 1984 results to check for predictability and variability in costs.

Table 4 outlines the summary data from the 1985 seed collection contracts. (For more detailed data refer to the Summary Chart in Appendix 1.) Table 4 gives the total pounds of final product of each species collected and the costs (or hours) involved. Estimates of dollars per pound are given based on our actual costs. The total costs for each project should be increased by a given percentage to cover administration, overhead, profit, and materials and equipment costs. For example, our expendable materials and equipment costs were 6% above the price for collecting and processing the seeds (total equipment and materials costs including dryers and seed cleaner were 13% above). The administration cost was approximately 15% above the price for collecting and processing seeds; no cost for overhead or profit was charged. (Costs involved in preparing this report including the collection of data are not included in any of the cost analyses.)

Different methods in 1985, as compared to 1984, were used to process the plant material (1984 material was hand processed, 1985 material was largely machine processed). Therefore, the only data that can be used to evaluate the variablity in costs between years are the hourly data involved strictly in collection of a species. The hours involved in collecting are compared for all the species using the original collection data of 1984 versus 1985. The data used for comparison is the total number of hours involved in collection of the species as a ratio to the total number of pounds of end product. Therefore, a difference in this ratio can be due to collection problems or due to differences in the end product.

The results of these comparisons can be misleading, but still yield insights. For yellow sand verbena, it took 68% more hours to collect a given poundage of end product in 1985 than in 1984. There are two reasons for the increase in the cost of collecting this species: 1) the best site for collecting yellow sand verbena was built on in 1985; the new sites for collection were further from the road and contained more contamination (plant debris from various species, rabbit pellets, and seeds from weedy species); therefore, 2) the collection material in 1985 had to be processed to rid the end product of weedy species and debris. The processing decreased the total poundage of end product. (Processing causes some good seeds to be discarded.)

TABLE 4: COSTS PER POUND FOR EACH OF THE EIGHT SPECIES (These costs per pound should be increased by administration, overhead, profit, and materials and equipment costs, see text.)

	ABLA	AMCH	ARPY	CACH	ERLA	LALI	SOSP	TADO
TOTAL POUNDS	86.929	102.951	45.499	6.152	48.580	17.503	60.844	4.402
TOTAL HOURS[d]	208.94	379.89	843.13	224.82	677.22	382.81	212.88	8.05
:HRS/LB	2.40	3.69	18.53	36.54	13.94	21.87	3.50	1.83
TOTAL MILES	681.17	1669.69	3280.24	867.44	2050.02	828.12	717.39	60.01
:MI/LB	7.84	16.22	72.10	141.00	42.29	47.31	11.79	13.63
1985-$/LB @ $6.25/HOUR & $0.25/MILE	16.98	27.12	139.34	263.65	97.68	148.52	24.82	14.16
1985-$/LB @ $8.00/HOUR & $0.25/MILE	**21.19*[a]**	**33.57*[b]**	**166.27**	**327.60**	**122.07**	**186.80[ab]**	**30.94**	**18.04[c]**
1984-$/LB @ $8.00/HOUR & $0.25/MILE	11.78	19.52	1043.48	888.89	271.50	133.79	43.48	53.34

* - processing added in 1985
a- difference in sites used for collection
b= 1985 data includes scarification
c= small sample size in 1985, 1984 costs are probably more accurate
d Non-specific costs (e.g. organizational meetings) from Appendix 1 are added into the Total Hours.

The 1985 results for dollars/pound using $6.25/hour is an approximation of the cost for the combined contracts. The 1984 results were presented previously using $8.00/hour; therefore, an extra line is added to the above chart to estimate the 1985 costs at $8.00/hour. This extra calculation allows one to compare results from 1984 and 1985.

Beach bur took 15% more hours to collect in 1985. This is not a substantial increase in the collecting time; the percent increase is due to the fact that this species was processed and scarified in 1985 thereby reducing the total poundage of end product. Beach sagewort cost 60% less to collect in 1985, attributable to the better processing methods which released more of the seeds. Beach evening primrose cost 7% less to collect in 1985, not a significant decrease.

Seaside buckwheat cost 48% less in 1985. This decrease is probably due to better processing methods which released more seed and to better collection sites. Beach pea cost 26% more to collect in 1985. This increase is due to the collection sites: the 1985 beach pea collection sites did not yield as many pounds per hour as the 1984 Lanphere-Christensen Dune Perserve sites. The Nature Conservancy did not allow collection on their property in 1985; the best populations of beach pea are on the preserve. Goldenrod cost 33% less in 1985, probably due to collection sites. Dune tansy cost 50% more in 1985. The 1985 total poundage for dune tansy was small, as compared to the 1984 poundage. The 1984 estimates are probably more accurate. Another source of variation in the cost of collecting species was the efficiency of the individual collectors. For example, the number of collecting hours per pound of beach pea seed varied from 9.78 hours/pound to 18.60 hours/pound (data from the same collection site, the same time period, but different collectors).

Given the above results it should be obvious that a large amount of variation is expected in predicting the costs of collecting and processing native seeds. The costs depend on the sites available for collecting, the collector, the weather, the processing methods, and the abundances of species within a given growing season. These numerous sources of variation need to be kept in mind when using the estimated figures (dollars per pound) presented in Table 4.

SPECIES

A list of the dune species collected for seed can be found in Table 1. Detailed information on the collecting and processing of the seven species used in the full-scale revegetation plan follows. The information is arranged in alphabetical order by scientific name.

Abronia latifolia (yellow sand verbena)

End product: fruit--an achene
Best site: Samoa Peninsula--west of the Boat Ramp
Total pounds: 86.929 of end product

Biology and Ecology

Yellow sand verbena is in the Nyctaginaceae--the four-o'clock family. This species is a perennial herb with prostrate stems and clustered yellow flowers. The fruit of this species is an achene, a one-seeded, indehiscent fruit. This fruit is oblong, 8-15mm long with five wing-like lobes. The seed located in this fruit is medium brown, 4-5mm long, and can be collected from August to the end of September. This species forms mats on tops of stable mounds located in areas of active sand movement.

Collecting

Since the plant forms large mats usually distant from other species, it was easiest to collect quantities of yellow sand verbena by straining the fruits from the sand around the mounds. The strainers used for this contract were common large mesh kitchen strainers. Time was needed to locate large mature populations of this species. It is common in the dunes of this area, but not always in stands large enough to allow for cost-effective collecting.

Processing

The collection sites visited during this season (Summer 1985) contained more seeds from the highly invasive, yellow bush lupine (Lupinus arboreus) and other contaminates (plant debris and rabbit pellets) than the site used for collection last year (Summer 1984--Simpson Plant Site). The Simpson Plant site was developed for industrial uses. The collection method of straining sand for fruits introduces large amounts of contamination into the seed collection; therefore, cleaning of the fruits is necessary. Rabbit pellets are also commonly included in the collections, most were picked out.

Yellow sand verbena was processed in two steps ("runs"). The material collected was put through the Vac-A-Way seed cleaner in batches with the 13/64 screen on the top and the 6/22 X 6/24 screen on bottom. The sand verbena fruits varied considerably in size and 1/4 to 1/3 of the fruits were too large to pass through even the largest-sized top screen. Therefore, the procedure for the first run was for one person to feed the plant material onto the top screen and pick out and discard the large twigs and leaves as the material moved across the top screen. The material reaching the top screen bucket (outlet 1; see Figure 1) consisted of large seeds plus a few large twigs and leaves.

The remaining plant material passed through the top screen and was sorted by the machine into three buckets: outlet 2) large sand verbena fruits (plus some plant debris); outlet 3) small sand verbena fruits; and outlet 4) sand, dirt, and other small debris. At the end of run 1, the material in the top-screen bucket was retained for weighing and the other two buckets of sand verbena fruits were used for run 2.

The primary purpose of run 2 was to remove yellow bush lupine seeds that were inadvertently collected along with the sand verbena. The screens used for this run were 18/64 for the top and 7/64 X 5/64 for the bottom. One person fed the material into the hopper while the other swept the twigs and leaves off into the top-screen bucket (outlet 1).

The three end products of run 2 were large sand verbena fruits, small fruits plus debris and sometimes yellow bush lupine seeds, and sand and dirt. If the bucket containing the small fruits contained a few yellow bush lupine seeds, these were picked out by hand. If the bucket was heavily contaminated by bush lupine, the whole bucket was discarded. The purified sand verbena fruits from the two runs were combined, weighed, and labeled.

Notes and Recommendations

This species was the easiest to collect; however, collections were often highly contaminated. Processing of the fruits into pure seed would be extremely time consuming, and unless germination studies show that the germination increases significantly using pure seed versus fruits, there is no reason to process this species to that extreme.

Approximately 40% of the fruits collected in the pilot study of 1984 were found to be empty. A large quantity of yellow sand verbena fruits should be collected to compensate for this species low rate of germination and high percentage of empty fruit.

Different techniques were tried to attempt to separate the empty fruits from the ones containing seeds. There was no consistent size or shape to indicate which fruits were empty. The sizes of the fruits vary enough that it would also be difficult to separate the fruits based on weight. No one site was found to contain a higher percentage of seeds in the fruits; more variation was found within sites than between sites.

Ambrosia chamissonis (beach bur)

End product: fruit--a one seeded bur.
Best site: South Spit.
Total pounds: 102.951

Biology and Ecology

Beach bur is a perennial herb with horizontal branching stems that form loose mats. The flowers of this species are unisexual. The male flowers are located on the top of the spike with the female flower below, rather different from the usual inflorescences of the composite family (daisy family). The burs are one seeded, 8-10mm long. The larger populations of this species were found in areas of moving sand. This species can be collected from mid-October to mid-November.

Collecting

The burs were stripped off the plants while wearing heavy leather gloves (gloves are necessary!). As a result of the method of collection, a considerable amount of leaves, twigs, and sand were collected along with the burs.

Processing

Drying of the burs was difficult due to handling problems. The burs stuck to the drying screens, and once again, heavy leather gloves had to be worn.

Processing of the material collected was necessary for two reasons: 1) to remove sand, dirt, and plant debris from the seeds, and 2) to scarify the burs (scarification is necessary to achieve an adequate germination rate). Collections of this species contained a large percentage of sand and plant debris. Approximately one-half of the beginning volume and weight were sand and debris.

Small batches of beach bur were abraded between two heavy-mesh sanding screens or between a sanding screen and a sanding sponge. Scarification was considered to be adequate when one or more tips of the bur were broken. After scarification, the batches were run through the Vac-A-Way seed cleaner.

A total of two runs were used for cleaning this species. The top screen was 13/64 and the bottom screen was 6/22 X 6/24 for the first run. The blower was used to remove the fine dust. The material was fed through the hopper slowly. One person attended the top screen, sweeping the twigs into the top-screen bucket. The resulting fruits and fine debris was sorted by the machine into three buckets containing: outlet 2) large beach burs; outlet 3) small burs plus fine plant debris; and outlet 4) sand and dirt.

After changing the lower screen to 7/64 X 5/64, the material in the bucket containing the small fruits plus debris was run again. The second run separated most of the remaining fine debris from the fruits. Following the second run, the purified burs from both runs were combined, weighed, and labeled.

An additional step was added in some cases. The collections for this species were so dusty and irritating to the nose and throat that an additional step was added to cut down the dust during machine processing. Prior to scarification 3-5 gallon batches of the burs were placed in a 30 gallon garbage can and stomped on for several minutes. The crushed material was then placed on screens from the dryers and the fine dirt was shaken through the screens. The seed material on the screen was then scarified and processed as previously described. The stomping and screening was done outside which significantly reduced the amount of dust stirred up during the operation of the machine. In addition, many spine tips were broken off during stopping; thereby reducing the amount of time necessary for scarification. However, this additional step did add time to the overall processing.

<u>Notes and Recommendations</u>

It is fairly easy to collect large quantities of this species as long as hand protection is used. Most sites have enough of this species to warrant collection; however large stands were found only on the South Spit. Dust and hairs become airborne during processing; therefore, processing should be done in a well-ventilated room and processors should always wear dust masks and goggles.

<u>Artemisia pycnocephala</u> (beach sagewort)

End product: fruit--an achene
Best site: Samoa Peninsula--west of Boat Ramp
Total pounds: 45.499 of end product

<u>Biology and Ecology</u>

Beach sagewort is in the asteraceae family--the sunflower family. The flowers and seeds of this species are very small. The inflorescence is a narrow, erect cluster of flowers rising about 1/3 meter above the rest of the plant. The flower heads are small. (Flowers of the asteraceae family are grouped into heads.) The fruit is an achene 1.5mm in size, tightly enclosing the small seed. This species can be collected from mid August to the end of September. The best populations are located on stable sand dunes.

<u>Collecting</u>

Collection of beach sagewort was best accomplished by stripping heads off ripe inflorescences or by collecting the whole inflorescence. The hairs present on the leaves and stems of this species were extremely irritating to the nose and eyes of the collectors; therefore, dust masks are recommended.

Processing

While drying, the inflorescences of this species produced an odor that caused headaches in the people attending the dryers. The airborne pubescence required the use of goggles and dust mask while handing. The seeds were smaller than the dryer screens; therefore, the screens were lined with material.

Inhalation of airborne particles given off by this species caused a mild to severe reaction in the processors' respiratory systems. Therefore, respirator masks with replaceable cartridges were purchased. These masks and goggles had to be worn at all times while drying, processing, or storing this species.

Once dried, the first process was to release the seeds from the large amount of material collected (94% of the initial weight was chaff and debris). The plant material was put into a 30 gallon trash can and crushed by stomping up and down. The length of stomping required to adequately crush the material depends on the amount of sticks and other large debris included in the collected material (highly variable among collectors). Then small batches of the material were rubbed between gloved hands or between sanding screens to liberate the remaining seeds. Once the hopper was full, the material was slowly fed through the seed cleaner.

One person fed the material through the hopper while the other person insured that the larger material progressed across the 1/15 top screen and into the top-screen bucket (outlet 1). The air was adjusted such that light debris was blown off. The remaining debris sorted from the seeds into the back buckets (outlets 2 and 3). Some sand and the seeds fell through both of the bottom screens and ended in outlet 4. To decrease the amount of small chaff coming off with the seeds in the end product, the end product was run again with the blower at a higher setting. The remaining sand was separated from the seeds using a slant board.

Notes and Recommendations

It was easy to collect large amounts of inflorescences from this species. However, processing of the species was time consuming and yielded few fruits for our labor. Given the bulk of the inflorescences processed, few fruits were yielded. Inhalation of airborne particles given off by this species irritates processors' respiratory systems.

Camissonia cheiranthifolia (beach evening primrose)

End product: seed
Best site: Redwood Creek Beach
Total pounds: 6.152 of pure seed

Biology and Ecology

Beach evening primrose, in the Convolvulaceae (evening primrose family), is a perennial herb with several prostrate stems. The flower of this species are bright yellow, aging red, and long blooming. The fruit is a capsule that becomes coiled when mature. The capsule is about 12-22 mm long and contains many dark brown 1 mm long seeds. This species was most abundant in areas of moving sand. The fruits are ripe for collecting from August until late September.

Collecting

Collection of this species was easy once quantities were located. Whole inflorescences were clipped off the plants with pruning shears and placed into large plastic bags.

Processing

The inflorescences were dried. Drying was a problem because the extremely small seeds would fall through the screens in the dryer; a fine mesh material was added to the dryer screens to alleviate this problem.

Once dried, the first process was to release the seeds from the tangled inflorescences (90% of the initial weight of plant material was chaff and debris). Approximately 30 gallons of raw material was placed into a trash can and stomped and crushed. Next, the inflorescences were twisted and torn over the hopper. When the hopper was full, the batch was run.

Running this species through the seed cleaner required two people to attend the machine. One person worked material in the hopper through the opening at a slow rate. This species tended to clog the hopper. The second person pressed the material against the 1/15 top screen facilitating the release of the seeds. The first run was done with the air at a low setting and the 20X21 bottom screen.

The end product of seed, sand, and some chaff was found in outlet 4. To get the best result, the lower screen is changed to the 6X34 screen for two or more runs until the desired purity is attained. With the air at the appropriate setting, the end product consisted of only seed and some sand. The end product was re-ran until no more sand came off in the blower. The remaining sand mixed in with the seed was removed by hand, using a gravity board.

Notes and Recommendations

The seeds of this species are extremely small, but collection of the inflorescences is quick and easy. Plants of this species tend to grow distant from each other. Processing of the inflorescences is not hard, but because of the seed size, yields very little poundage. Beetle infestation is a problem requiring immediate fumigation of the collections.

Eriogonum latifolium (seaside buckwheat)

End product: seed
Best site: Samoa Peninsula--Lupine Avenue (TNC if available)
Total pounds: 48.580 of pure seed

Biology and Ecology

Seaside buckwheat is in the Polygonaceae--the buckwheat family. This species is a perennial, somewhat woody, herb to shrub. The flowers of this species are pink, ripening brown. The fruit of this species is a brown achene, about 4 mm long, enclosed by the calyx. The fruit and calyx fall together or separately when the fruits are ripe. This species grows in areas of newer sand dune ridges. This species has a staggered ripening time between plants and within inflorescences and can be collected during August and September.

Collecting

Collection of this species was easily accomplished by rubbing the ripe inflorescences over a bag or bucket. The ripe fruits and their calyces dropped into the bag, the immature fruits remained on the plant. The collection of this species was limited by seasonality. Most of the inflorescences, aided by the strong winds and rains of the late fall, had completely dispensed their achenes by the end of September. The fruit should be collected during August and September.

Processing

Seaside buckwheat yielded an average of 0.136 pounds of seed per gallon of raw material. This figure was equivalent to an average of 0.224 pounds of seed per every pound of raw material collected. The chaff and debris weight composed 77.57% of the original weight of the raw material. Seaside buckwheat obviously required a large amount of processing.

The process used to separate the seeds from the debris and chaff follows. Using the Vac-Away Seed Cleaner, up to five runs are required per batch. The top screen was always 13/64. Prior to the first run, the raw material was slowly worked between a sanding block and a sanding net. This step separated most of the seeds from the calyces. The first batch was run with the air on low and the 8/64-7/64 screen on the bottom.

The sanding was repeated one to two times (depending on the end product) and run one to two times with a 7/64-5 (4 bottom) screen. The final step of the process required one or two runs with the 6/22-6/24 screen on the bottom. The best product was attained with fine adjustments in air flow. Too much air caused a high loss of good seed; too little air left aborted seed and chaff in with the good seed. A cautionary note: good seed may be caught in the blower opening. Check the opening between runs.

Notes and Recommendations

Crews that were experienced with the numerous fine adjustments possible on the seed cleaner yielded the purest end product with the least amount of processing time (i.e. fewer runs). Face masks and goggles had to be worn at all times while processing this species due to the large amount of dust produced.

Lathyrus littoralis (beach pea)

End product: seed
Best site: Samoa Peninsula--Lupine Avenue (TNC if available)
Total pounds: 17.503

Biology and Ecology

Beach pea is in the Fabaceae--the pea family. This species is a perennial herb with pink colored, typical legume flowers. Beach pea blooms very early and therefore the fruits are also ready quite early. The fruits of this species are like a dry and leathery pea pod. The pod contains 1 to 5 seeds; rarely 3 or more seeds per pod were found in these populations. Seeds of this species are 5 mm in diameter. The best populations of this species are located near active sand such as on the edge of hollows and deflation plains. This species blooms early and the fruits are ready for collection in August and early September.

Collecting and Processing

Collection of the seeds from this species was very time consuming. A good deal of the time was spent walking from patch to patch, search for good populations.

Of the pods that were not obviously empty (flat pods were obviously empty) only 10% of the remaining pods contained viable seeds. The low viability of the seeds was due in part to abortion but mainly to insect damage. The infecting insect bores a hole into the pod and lays its eggs. The offspring hatch out, ingest the seeds, and eat their way out of the pod.

Due to the large amount of insect damage, it proved to be cost-effective to process in the field. Processing involved shucking the peas by hand. The infection did tend to be localized within a patch; therefore, the collector could move a few feet away and begin collecting again if the previous spit was too badly infected.

Notes and Recommendations

Usually only one seed per pod was untouched by the insects. Seeds that had already been shed onto the sand were also collected. Pods both on the plant and on the ground were checked. There was no difference in the amount of insect damage between the pods still held by the plant and those already on the sand. This species is the first one ready for collecting.

Solidago spathulata (goldenrod)

End product: fruit--an achene plus pappus
Best site: South Spit
Total pounds: 60.844

Biology and Ecology

Goldenrod is a member of the asteraceae family--the sunflower family. The stems of this perennial herb arise from a caudex or woody rhizome. The leaves of this species are bright green and mostly basal. The yellow flowers of goldenrod are arranged in heads along compound, spike-like inflorescences. The dispersal unit of this species is a short achene with attached pappus. Goldenrod is found on established ridges and protected flats. The fruits can be collected during the months of September and October.

Collecting

One method of collecting this species was to strip the whole inflorescence. Using this method, the involucre was collected along with the achenes. The involucre was difficult to separate from the achenes while off the plant. To get a cleaner product, the achenes were pulled off the involucre head by head.

Processing

An attempt was made to clean the collections of goldenrod that included the involucre and pieces of the stem. It was found that such cleaning was extremely difficult and later collections included only the achenes and attached pappus. No processing of the achenes was attempted.

Notes and Recommendations

This species has an extremely staggered ripening time. Though some insect damage was found, it was not a problem with this species.

Tanacetum douglasii (dune tansy)

End product: fruit--an achene
Best site: Samoa Peninsula--near the Coast Guard Station
Total pounds: 4.402

Biology and Ecology

Dune tansy is in the asteraceae family--the sunflower family. This species is an aromatic perennial herb that is highly rhizomatous. The leaves of dune tansy are highly divided. Flowers and fruit of this species are very small, typical of the sunflower family. The achenes are about 3-4 mm long. Dune tansy is found in areas of stabilized dunes and flats that are usually well vegetated. Collection of the fruits from this species is best between mid-September to mid-November.

Collecting

Occurrence of this species is highly localized; therefore, a large amount of ripe inflorescences are available at one time at a site. Collection of the whole inflorescence caused problems with processing. The best way to collect this species was to break off the inflorescence just below the involucre, then lightly rub the decaying flowers off the top of the achenes. The achenes were later separated from the involucre. Most of the heads had some amount of insect damage; lightly damaged heads were collected.

Processing

When dried in closed quarters, the odor of this species causes headaches in some people. After drying, the achenes were pulled off the involucre by hand. This was actually very easy to do and not very time consuming. Successively smaller screens were used to separate any included debris from the ripe achenes.

Notes

Dune tansy tends to dominate the areas where it grows. This species is also found at the upper edges of dune areas, near upland grasslands.

DISCUSSION

The site surveys illustrated that the Humboldt Bay area has, by far, the best seed sources for most of the species used in the revegetation plan. In general, the dunes from the Oregon border to Freshwater Lagoon are dominated by European beachgrass, whose effect is to "crowd out, through rapid growth and dense cover, the native hummock builders" (Wiedemann 1984). European beachgrass outcompetes the native dune species, resulting in almost monotypic stands. "In many places where they once occurred commonly, such species as American dunegrass, sandverbena (sic), silver bursage, beach morning glory, and dune tansy occur sparingly or are not seen at all" (Wiedemann 1984).

Wiedemann (1984) also recognized the unique resources of Humboldt Bay.

> "European beachgrass has spread along the west coast of North America from 34° to 55° latitude. In only a very few locations has it not taken over entirely in the foredune zone just above the beach. These areas, most notably parts of the north and south spits of Humboldt Bay, give a clue to the appearance of the vegetation of the foredune zone prior to the takeover by European beachgrass.

Therefore, significant impacts to the Humboldt Bay dune systems are significant impacts to the native dune plant populations of the Pacific Northwest Coast.

The impact that seed collecting has on native dune plant populations is unknown. Our methods of collecting do not completely strip a plant of seeds. I would estimate that we collect no more than 50% of the available seeds from a given plant. Seedling survival of dune plants is generally believed to be low under field conditions. Therefore, the potential impact of depleting the seed sources of the native populations is probably very low, for the two years of collecting included in this report. However, there is no information to assess the cumulative impact on the seed bank of collecting over time at the same sites.

I believe the largest impact that collecting has on the native population is the effect of trampling the vegetation. Dune species are sensitive to trampling. The collectors were trained to stay off the vegetation as much as possible.

The impact of the collectors is probably negligible compared to the impact of the other users on the dunes. Almost all of the Humboldt Bay dune areas used for collection are also open to unrestricted foot traffic and off-road vehicles. These dunes are widely known by off-road vehicles advocates as one of the few coastal areas left for riding. The adverse effects of the vehicular use is evident in the large, denuded, moving dunes near the Lupine Avenue site.

The close proximity of the best collecting areas in the Pacific Northwest helps to keep costs of collecting from the wild down. To further reduce the costs of processing, there should be further mechanization of the seed cleaning processes. Most of the threshing needed to release the seeds from the raw plant material was done by hand. This costly step could be done by a machine either adapted to fit above the hopper of the Vac-A-Way seed cleaner, or built separately.

The costs outlined in the Cost Analysis section are as accurate as the data from one season can allow. The difference between years due to fluctuations in plant populations and seed set cannot be quantified with our data. Given differences between collection years as a source of variation, along with the sources outlined previously (between collectors, between collection sites, and between methods), fixing exact costs to a species can be misleading. Planners using these figures for fixing contract costs must obviously remain somewhat flexible.

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APPENDIX 1: SUMMARY CHART FOR 1985

TASKS	ABRONIA	AMBROSIA	ARTEMISIA	CAMISSONIA	ERIOGONUM	LATHYRUS	SOLIDAGO	TANACETUM	NOT SPECIFIC[a]	TOTALS
COLLECT	111.10	148.39	405.40	87.55	283.16	214.68	129.45	10.59	37.35	1426.67
WALK	18.08	14.98	45.62	10.10	33.94	14.82	15.82	.00	.00	153.36
TRAVEL	23.45	30.42	70.69	19.10	50.38	28.27	24.42	1.66	4.91	253.30
PREP	.64	.62	2.49	1.32	2.24	2.80	1.74	.00	70.02	81.87
BREAKS	2.72	5.32	11.20	2.93	8.43	3.86	4.79	.00	.93	40.18
PROCESS	23.97	108.49	189.31	63.22	216.23	87.50	5.16	3.62	72.34	769.84
DRYING	12.74	29.08	45.86	22.06	24.34	5.50	17.65	1.58	7.45	166.26
PROC TRAV.	2.93	18.39	18.85	4.22	15.36	1.00	.29	.00	1.00	62.04
TOTAL HRS	195.63	355.69	789.42	210.50	634.08	358.43	199.32	17.45	194.00	2954.52
MILES										
COLLECT MILEAGE	508.80	862.60	2243.88	495.43	1184.67	711.25	623.10	54.00	327.00	
PROCESS MILEAGE	104.20	640.00	708.10	285.20	660.20	34.00	22.50	.00	530.50	
TOTAL MILEAGE	613.00	1502.60	2951.98	780.63	1844.87	745.25	645.60	54.00	857.50	9995.43
OTHER STATS										
RAW VOLUME[b]	177.75	272.50	810.50	351.00	358.65	5.0	180.75	5.3		
RAW POUNDS	127.742	202.905	732.317	62.351	216.612	N/A	N/A	N/A		
% CHAFF WT.	31.95%	49.26%	93.79%	90.13%	77.57%	N/A	N/A	N/A		
FINAL WT.	86.929	102.951	45.499	6.152	48.580	17.503	60.844	4.402		372.86

a= Not Specific Category includes aquisition of materials and equipment, organizational meetings, and other costs not assignable to a species.
b= Raw Volume given in gallons.

Administration Costs (including mileage) are 15% above cost of collecting and processing.
Equipment and Materials costs are 13% above cost of collecting and processing.

SECTION 2

PHASE II PLANTING: METHODS AND COSTS

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

HUMBOLDT BAY, HUMBOLDT COUNTY, CALIFORNIA

PHASE TWO PLANTING:

METHODS AND COSTS

County of Humboldt
Department of Public Works
Natural Resources Division
1106 Second Street
Eureka, California 95501

March 19, 1986

Bio-Flora Research, Inc.
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Ferndale, California 95536

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LIST OF DIAGRAMS

INTRODUCTION

The Buhne Point Shoreline Erosion Demonstration Project was developed to protect the area known as King Salmon, a community on the shoreline of Humboldt Bay, Humboldt County, California, from tidal erosion. A beach and dune area of approximately 23 acres was created from bay-dredged sandy fill, and protected by a rock breakwater embankment. The dune area was the site for an experimental pilot revegetation project using only native species, which was conducted in the Spring of 1985. The purpose of that project was "to determine the cost, man-hours, procedures, and equipment necessary" to establish a permanent native plant cover sufficient to stabilize the dune system. The results of that project are described in the report "Phase One Planting: Methods and Cost Analysis, Buhne Point Shoreline Erosion Demonstration Project"(1).

Based on the results of the pilot project, the Humboldt County Department of Public Works developed a Phase Two Planting Plan to vegetate the remaining portions of the dune and backdune areas. The County retained the services of the firm of Bio-Flora Research, Inc. to provide supervision and coordination of the planting.

In addition to establishing a plant cover, a primary purpose of this project is to refine planting techniques and provide an accurate cost analysis for each technique. This report describes the planting techniques used and provides per-acre time and costs for each method, as well as a cost summary for this phase of the project. This information is intended to be of use to planners in developing larger-scale dune planting and re-vegetation projects.

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(1) County of Humboldt, Department of Public Works, Natural Resources Division, 1106 Second Street, Eureka, California, 955[illegible]. May 30, 1985. Gail Newton, Botanical Consultant, Eureka, California.

PLANTING PLAN OVERVIEW

The Buhne Spit Revegetation Plan is shown on the map at the end of this report. The five dunes rise approximately three feet above the surrounding sand. The Phase One planting project established native dune grass (Elymus mollis) on the windward sides and tops of Dunes II, III, IV and part of Dune V. Certain areas behind these dunes were planted with seeds and with vegetative propagules of selected native plants. Those areas are shown on the maps as study areas, planting corridors and experimental sprig blocks.

In the Plase Two Planting, portions of the unplanted areas behind the dunes were seeded with native dune mat species, using several different techniques described in detail below. These areas are shown on the map as "Hand rake (A)"; "Hand rake-Hydromulch (B)"; "Hydroseed-Hydromulch (C)"; and "Harrow (D)". The rest of the unplanted area behind the dune system was hydroseeded with a turf grass species. This area is indicated on the map as "Red Fescue (E)".

Some of the dune grass provided by the supplier for the Phase One Planting turned out to be American beach grass, (Ammophila breviligulata), a highly undesirable, invasive, non-native grass species. Subsequently, the larger areas containing American beach grass were sprayed with the herbicide Roundup and later hand-dug. Smaller areas were hand-dug but not sprayed. During the Phase Two planting, the resulting bare areas of previously planted dunes were replanted with native dune grass. In addition, the unplanted area between Dunes IV and V and the fence, and the rest of Dune V were planted with native dune grass. These areas are shown on the map as "Dune grass (E)".

The original planting plan as prepared by the County was modified slightly during the course of this project for easier movement of the hydromulching equipment and the tractor. These modifications are reflected in the Planting Plan Map included with this report. Modifications to the planting specifications are described in the appropriate sections.

DUNE GRASS PLANTING

Collection techniques

Culms of the native dune grass (Elymus mollis) were collected both from the established on-site plantings and from a native off-site location (see Appendix 1: Sources of dune grass).

Culms were severed from the underground rhizomes using a tile spade. The spade was inserted into the sand approximately three inches (3") from the base of the dune grass clump, angled slightly toward the clump and pushed abruptly into the sand using foot pressure. The underground rhizomes were usually severed cleanly and the culms could easily be lifted free of the sand. Ideally a small portion of the rhizome remained attached to the aerial portion. Long rhizome remnants were removed from the culms during processing. Placement of the spade too close to the base of the clump or using too great an angle of insertion resulted in severing the culms above the location of the adventitious buds at the base of the culm. These "orphaned" culms must be discarded as they will not grow.

It was most efficient and productive using the spade technique to harvest the entire aerial portion of the clump. This method disrupts the base of the clump and the underground rhizomes. Harvesting all the culms in the clump ensures that no disturbed culms will be left behind to possibly die. However, it is assumed that the rhizomes will be able to withstand the disturbance and produce more culms at that location in the next growing season.

An alternative method of harvesting dune grass culms does not require the use of a spade. The collector uses the fingers to dig slightly into the sand at the base of the culm and, using a twisting motion, snaps the culm sideways while at the same time pulling sharply upward. Culms harvested in this way seldom had long segments of rhizome attached at the base. In addition, using this technique allowed for the selective removal of culms from a clump without extensive disturbance to the rest of the culms or the underlying rhizomes. This may be an advantage or even a necessity in areas sparsely populated by dune grass but from which it is desirable to collect. Alternatively, this method may allow for harvesting of dune grass from sparsely populated areas which otherwise could not support harvesting. The disadvantages to this technique compared to the spade technique are that fewer culms are harvested per man-hour(2) and that the collector must bend over further to pull the culm, thus becoming more tired and therefore probably even slower.

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(2) As this technique was used by only one person for part of one day, an accurate time comparison was not possible. However, it was the project supervisor's observation that this method was slower.

Processing

Dune grass culms were processed for planting by removing excessive rhizome remnants and cutting the tops so that the culm was about 20 inches long. The rhizome remnants were removed by snapping them off, but a sharp knife could also be used. Initially, some of the dead leaf material was stripped from the culms, but this was discontinued on the basis of the statement in the report on the Phase One planting (page 32) that the adventitious buds at the base of the culm are sufficiently vigorous to penetrate the sheath of outer leaves, and that the leaves may protect the buds from mechanical damage during planting.

Processed culms collected on-site were planted immediately. Culms collected off-site were counted and bagged in large garbage bags in groups of 500. If these culms were not to be planted immediately, they were heeled-in at the site(3).

Planting

Dune grass planting took place on November 18-20, 22, 25, 27 and December 9, 1985. Weather conditions on those days are shown in Appendix 5: Weather. The highest daily temperature reported by the National Weather Service Bureau in Eureka was 53 degrees Fahrenheit on one day; on most other days the high was 50 degrees Fahrenheit (10.00 to 11.67 degrees Celsius). Although some of the days were sunny, the wind was usually cold. Weather conditions were generally not severe and did not influence planting activities.

The dune grass was planted in hills on 24 inch centers at two culms per hill by a California Conservation Corps crew. Planters worked in pairs. The first worker inserted a tile spade into the sand to a depth of approximately 8" and rocked it back and forth to make a v-shaped hole. The second worker, following behind, placed two culms into the hole and closed the hole with his foot, placing the foot near the hole, not on top of it and pressing at an angle in order to prevent the formation of air pockets in the sand.

Planting occurred at several different times as the dune grass became available. The first plantings were made using the marked string spacing method described in the Phase One planting report (cited above). A back-line was set up on the top of the dune using stakes and string with markings every 24 inches. Each team of two workers used a guide-line with markings every 24 inches set up at right angles to the back-

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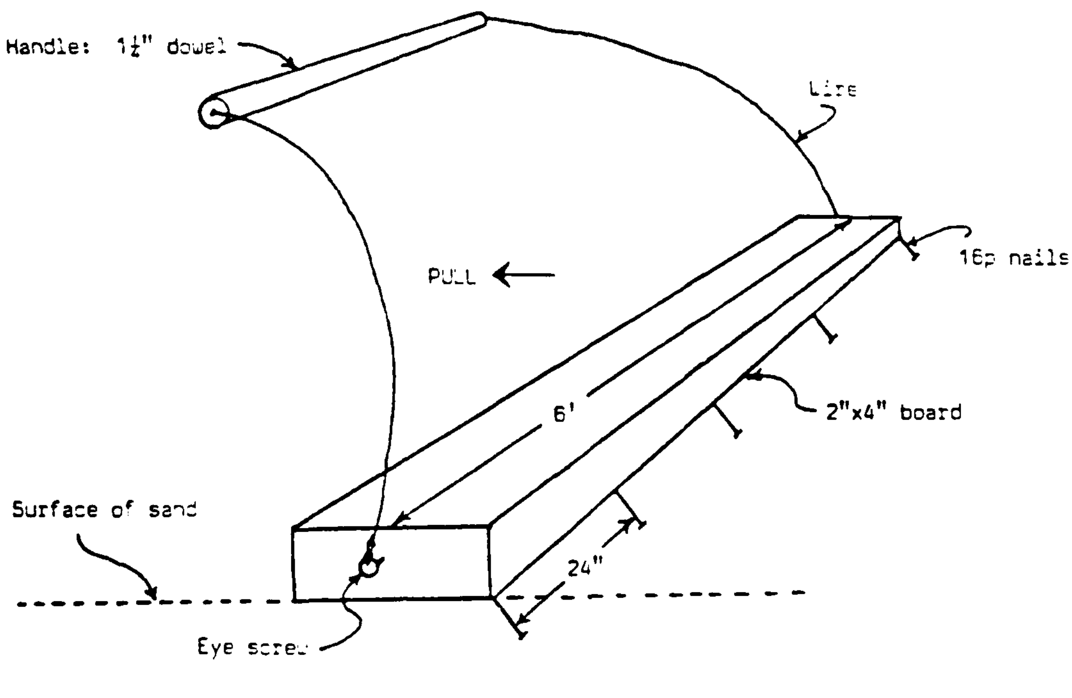
(3) Commercially supplied culms were bundled in lots of approximately 500 and tied with twine, not bagged in plastic. They were stored prior to shipment in refrigerated coolers at 34 degrees Fahrenheit.

line to establish the rows. This method proved to be cumbersome and slow (see Table 2).

A different method was used for the rest of the dune grass planting which substantially improved time efficiency. A row marking tool was constructed from a 2" by 4" by 6' board. Large nails were spaced every 24" along the length, and a handle was made of wire and 1" dowel (see Diagram 1). The board was dragged over the sand, allowing the nails to score markings in the surface 24" apart. The planting teams accurately measured 24" using some convenient device such as their pace, toe-to-heel footsteps, or a mark on the handle of their spade to use for their 24 inch "scale" for planting along the rows scored in the sand. The accuracy of the spacing was periodically checked using a tape measure. This method worked well for this late Fall planting when the sand was wet. Dry sand should still hold the scored row markings unless the wind is strong.

Diagram 1: Row marking tool



SEEDING

Seed mixing

Seeds of eight native dune plant species were supplied by the County. The seeds were mixed according to a precise formula specified by the County (see Appendix 2: Seed mix formula), and packaged in one-acre lots in 30-gallon plastic garbage cans. Seed lots of less than one acre were packaged in separate garbage cans.

Seeds were weighed on a balance scale capable of accuracy to 0.001 pound. Mixing was done by hand, adding each species to the can one at a time, stirring the seeds with a shovel and pouring the mixture back and forth between cans. The bulky, large and light-weight seeds were mixed first. Two species used in the mix have seeds which are small and dense(4). To prevent those seeds from settling to the bottom of the can during transportation and storage, they were mixed and packaged separately, in this case in a large zip-lock bag, and placed on the top of the rest of the seeds in the garbage can. These seeds were mixed in by hand on-site just prior to application. Most of the time needed for preparing the seed formula mix was spent weighing the seed lots.

Seed treatments

Certain of the seeds in the mix were treated to allow breaking of dormancy. The beach pea (*Lathyrus littoralis*) seeds were scarified by rubbing the seed between sheets of coarse sandpaper. The seeds of beach bur (*Ambrosia chamissonis*) were given a 36-hour soak. See the Phase One report previously cited for a discussion of seed dormancy in native dune species.

Seed application

The seeds were applied using a wheeled whirlybird garden seeder with a useful hopper capacity of approximately 10 quarts (total hopper capacity 18 quarts). A sliding shutter controlled the size of the opening through which the seed dropped into the whirlybird apparatus.

The rate of seed application was specified by the County to be 25.28 pounds per acre. The sizes of the different treatment areas to be

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(4) *Artemisia pycnocephala* and *Camissonia cheiranthifolia*.

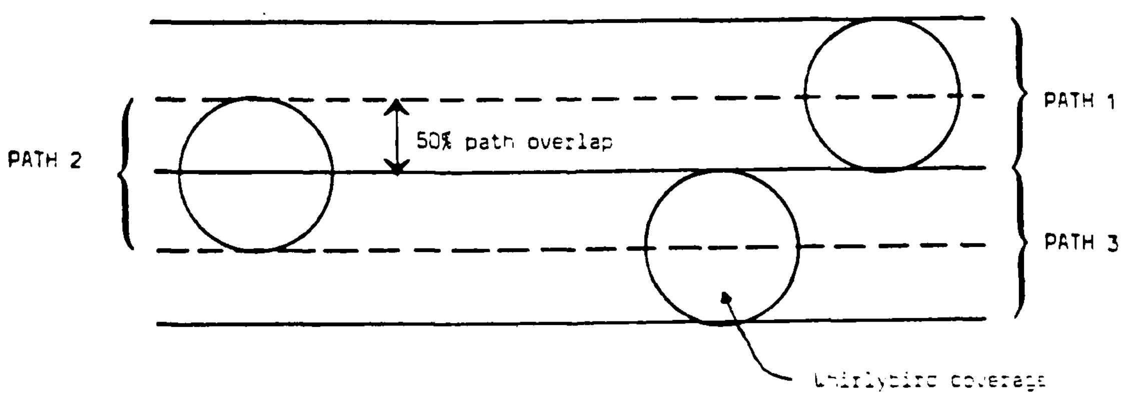
seeded were estimated by the County, and the seeds were prepared in acreage lots according to the area estimate.

The rate of application was computed for a small test area by weighing the amount of the seed mix needed for that area based on the per acre rate and adjusting the control of the spreader to use up the weighed seed entirely within the measured area.

The contract specifications called for seed application using a 1:1 mixture of seed and sand, first screening the sand to exclude shell fragments, or to use "an equivalent technique to insure uniform dispersal". A small test area was first seeded uniformly with the lightweight, bulky seed mix and then seeded with the heavier, fine seed mix. The hopper opening control lever tended to jiggle out of position, and the smallest possible hopper opening still allowed the fine seed to be spread too thickly (the measured allotment of seed ran out before covering the test area), making it virtually impossible to achieve uniform dispersal of the fine seed using this double-seeding method.

Another test area was seeded with the fine seed already mixed with the bulky seed. The project supervisor tested the application uniformity by placing large (24" x 26") pieces of white paper on the ground in the path of the spreader and observing the seed coverage at several distances from the center of the spreader path. It was found that the smaller heavier seeds were flung further out from the spreader than the larger, lighter and bulkier seeds. On a single pass, the center of the path had too high a concentration of light bulky seeds and the sides had too high a concentration of small heavy seeds. By overlapping the seeder coverage paths, and again observing the seed dispersal on white paper, the project supervisor was able to achieve fairly uniform distribution with a 50% overlap of the paths (see Diagram 2).

Diagram 2: Seeder path overlap



The overall rate in pounds per acre was controlled by the size of the hopper opening setting, and was initially set at 12 on a numbered scale with 1 the smallest and 15 the largest settings. At settings of less than ten on the scale, the bulky seed mixture was unable to drop down into the whirlybird at all. The mixture also tended to settle and become compacted, again preventing the seed from dropping and making it necessary for the operator to frequently loosen up the mixture.

No application test was made using seed mixed with sand because screening the sand first to remove shell fragments would be more time-consuming than the simple overlap method described above. Since adequate seed dispersal was achieved with the overlap method, that method was selected at the project supervisor's discretion for the large scale planting.

After seeding about one-third acre of area "B", it was clear that the seed was not being used up at a proportional rate; in other words, there was too much seed left in the can. The seed application rate was adjusted by using a bigger hopper opening setting, so that the seed was used up proportionally. The area first seeded at the lower rate was re-seeded with sufficient seed to equal the new rate. One reason that the application rate was in error was because the seed mixture in the cans actually weighed more than the assumed 25.28 pounds for one acre, due to the unknown amount of water weight in the soaked beach bur seeds(5). One can of seed was later weighed using a suspension spring scale which indicated that the mix in that can weighed approximately 33 pounds.

Ultimately, the seed was applied with the seed hopper control set at the maximum opening, in order to keep the spreader coverage path overlap at 50% for uniform seed dispersal. Thus, the application rate was controlled entirely by the amount of row overlap.

The same application rate was achieved for areas "A", "B" and "D". There was about 0.4 acre worth of seed left after seeding area "B". The seed provided for area "A" ran out before all the area was covered, so the remaining seed from area "B" was used, ending with only about eight quarts of seed left after seeding both areas (enough for approximately 0.09 acre). After seeding area "D" at the same rate as areas "A" and "B", an additional two quarts of seed remained. It was apparent that the acreage estimates for the different treatment areas were in error (see Appendix 3: Acreage estimates). Although the seed was applied at a uniform rate throughout areas "A", "B" and "D", it is important to know as closely as possible just what that rate was in order to make meaningful comparisons between the treatments. Accordingly, this contractor measured and re-mapped the portion of the project area receiving treatments "A", "B", "C" and "D".

The estimates of the rate of seed application for areas "A", "B", "C" and "D" are presented in Table 1. The map included with this report does not show the sizes of the dunes to scale and was not used to

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(5) The seed mixture was prepared using dry weights, and the beach bur seeds were soaked separately after weighing out the seed lots.

compute the revised acreages. Although the seed application rate is different for the hydroseeded area "C", this information may still enable a comparison between the treatment methods.

Table 1: Native Seed application rates

Area	Rate (lb./acre)	Total seed (lb.)	Acres
A	40.16	65.86	1.64
B	40.16	50.60	1.26
C	33.09	63.20	1.91
D	40.16	12.05	0.30
Total		191.71	5.11

Planting techniques

Four different techniques were used to sow the native plant seeds. A time-and-cost analysis for the techniques is presented in a later section. In general, the planner will select the most cost-effective method. However, different techniques may be needed for situations where the most efficient method is impracticable or impossible. The four techniques are described below.

Hand-rake: Area "A" - 1.64 acres

Seeds were raked into the sand according to contract specifications "to a depth of two inches", using bow rakes. Raking acutally mixed the seeds with the top 2" of sand, but did not bury the seeds under 2" of sand. In order to cover the seeds with 2" of sand, the sand must be raked aside, the seeds distributed, and the sand raked back over the area. This method would be time-consuming and awkward to use over a large area. "Raking the seed in" succeeds in covering the vast majority of the seeds, but does leave some exposed. One person spreading the seed with one person supplying seed to the spreader could stay ahead of 9 or 10 people raking. The acreage of area "A" was originally estimated to be 2.2 acres.

Hand-rake/hydromulch: Area "B" - 1.26 acres

Seeds were sown as in area "A" by handraking with bow rakes "to a depth of two inches", and subsequently hydromulched with Spra-mulch at 1500 pounds per acre. The hydromulcher completed coverage of the designated area and had Spra-mulch left over. Consequently, six days later, he applied the remaining Spray-mulch over area "B", resulting in a coverage which he estimated to be 2500 pounds per acre. The second application occurred after some seeds had begun germinating, and the force of the slurry buffeted the previously mulched surface of the sand in some areas. Osmocote 13-13-13, a slow-release fertilizer included in the slurry, was originally specified at 500 pounds per acre. The heavier coverage resulted in the fertilizer being applied at approximately 833 pounds per acre. The acreage of area "B" was originally estimated to be 2.45 acres.

Hydroseed/hydromulch: Area "C" - 1.91 acres

The specifications for area "C" called for native seed to be applied in a slurry with 500 pounds per acre of Spra-mulch and 500 pounds per acre of Osmocote 13-13-13, with a second application of Spra-mulch alone at 1000 pounds per acre. The actual amount of seed mix supplied to the hydromulcher was based on an application rate of 25.28 pounds per acre for 2.5 acres. Approximately two-thirds of area "C" was covered in two applications as described above. The county representative approved a change for the remaining one-third of Area "C" to be seeded in a slurry with the fertilizer and 1500 pounds per acre of Spra-mulch, applied all at once. The area which received this treatment is the 30-foot-wide strip behind Dune V.

Because of the original overestimate of acreage, the coverage exceeded the specified 1500 pounds per acre of Spra-mulch. The hydromulcher estimated the actual coverage to be approximately 2000 pounds per acre. The heavier coverage resulted in the fertilizer being applied at 665 pounds per acre. The acreage of area "C" was originally estimated at 2.34 acres.

Tractor harrow: Area "D" - 0.30 acre

Seed was applied at the same rate and by the same method as in areas "A" and "B" above, and the seed was sown "to a depth of two inches" using a tractor drawn harrow. The tractor used was a 30 draw bar horse power farm tractor. The harrow was of the type known as a spike harrow. The tractor operator encountered difficulties turning in confined areas, which left tire ruts in a few places. It got stuck once and dug a small hole with the drive tires before pulling free. However, it traversed the larger areas without much difficulty, providing coverage for the vast majority of the seeds. The acreage of area "D" was originally estimated at 0.59 acres.

Notes

One of the species of native dune plant seed was subjected to a pre-soak to facilitate breaking dormancy. This resulted in wetting the entire seed mixture and caused, or could cause, several problems. First, if the seed is not to be sown immediately, germination could occur within the storage container and damage to the seedlings would likely result. Even if the seed is expected to be sown within a few days, factors beyond the control of the planner may result in delays.

such as equipment failure, bad weather or staff time conflicts. It may be possible to dispense with the presoak when the seed is to be sown in the late fall when rains are expected to continue for an extended time, or when an irrigation system has been installed on the project area. Secondly, the unknown water weight in the seed mix made it impossible, under the circumstances, to apply the seed at the specified rate. Prorating the seed to the area may work, but in this case resulted in a rate higher than that specified because the area estimates were incorrect. Lastly, the damp seed compacted more easily, making application with the spreader more difficult.

The area sown by the tractor and harrow method was completely flat and the sand wet and compacted. The tractor used would encounter difficulties pulling the spike harrow over dunes, on soft sand and over irregular terrain such as would be found in native conditions. The type of harrow known as a "Swiss harrow" would encounter less resistence dragging over the sand, and might be used successfully on irregular terrain. We recommend the use of a four-wheel-drive tractor which will substantially reduce the possibility of down-time from getting stuck in the sand.

PLANTING TIME AND COSTS

This section summarizes costs of the different planting methods in completing the Phase Two Planting. Costs which are specific to this project but not directly related to planting, such as site preparation, seed mixing and _Ammophila_ eradication are presented in a later section.

A detailed presentation of time and costs for dune grass collection and planting are covered in detail in a later section. The costs for dune grass planting are included in Table 2: Project cost summary, and discussed briefly below, for comparison with seeding technique costs.

Labor

The California Conservation Corps crew provided labor at no cost to the County. For this discussion, projected costs are based on $8.00 per hour for laborers and $17 per hour for supervisors. These figures are assumed to cover only wages and labor-related expenses including employer's taxes, workers' compensation insurance and administration of payroll. They do not include a component for contractor's overhead and profit, nor other insurance needs such as employees' non-owned auto or general liability.

The man-hours and costs per acre for the different planting treatments are given in Table 2. The hydroseeded areas, C and E had no laborer costs, and the labor cost for area D was for surface application of the seed. For these areas, the primary cost of the planting technique was due to equipment and materials.

Seed planting activities consisted of seed application with a garden seeder and raking the seed into the sand for areas A and B. These tasks required 25.50 to 25.55 man-hours per acre and would cost an average of $204.20 per acre. Planting activities for area D consisted of surface application of the seed with the garden seeder. It would require 2.50 man-hours per acre and would cost $20.00 per acre. Planting labor for dune grass averaged 110.53 man-hours per acre for the project and ranged from 86.74 to 157.68 man-hours per acre depending on the planting technique.

The seed planting labor in the Phase One planting project was 183.45 man-hours per acre, but included tasks not included here. The Phase One labor for seeding alone (the activity closest to "seed planting" here) was 81.75 hours for 0.74 acres, or 110.47 man-hours per acre. The more than 400% reduction in labor on a per-acre basis for the Phase Two planting may be accounted for by the different techniques used in planting, crew management, the seeding of small patches and narrow strips in Phase One versus larger areas in Phase Two, and simple economies of scale for the larger planting.

The average dune grass planting labor in the Phase One project was 38 to 64 hills per man-hour compared to 69.1 hills per man-hour in Phase Two using comparable technique. A rate of 125.6 hills per man-hour was achieved in the Phase Two planting using the faster technique. The area planted in Phase Two was about the same size as in Phase One, so the faster rates cannot be attributed to economies of scale, but may be attributed to greater crew efficiency.

Other planting-related activities such as orientation, tool and equipment organization and walking to and from the planting area are included in "other" labor. These costs were about 10% of the planting labor costs, and are project-specific. Since the seeding and raking took 74.03 man-hours for 2.9 acres, which is one good day's work for a crew of 10, economies of scale would apply here to larger projects. This is evident in the dune grass planting, where the "other" labor costs were less than 5% of the planting labor cost.

Supervisor's time includes all activities related to the planting including planning, travel, organization of labor, supervision of workers' activities and materials acquisition. The supervisor's time to calculate the seed application rate and to coordinate the hydromulcher is pro-rated to each technique, although the time spent on these activities would have been nearly the same regardless of the acreages involved. Again, economies of scale would apply to larger projects. Supervisor's activities for seeding took 43.00 hours and cost $[illegible].

Supervisor's activities for dune grass planting took 11.21 hours and cost $207.57.

Equipment and supplies

The cost of the fertilizer is based on using Osmocote 13-13-13, costing $1 per pound. The specified application rate, 500 pounds per acre, would cost $500 per acre but the heavier coverage resulted in a greater cost per acre for this project.

The cost of hydromulching equipment, operators and hydromulch was quoted at $1,000.00 per acre; however, the contractor performed the hydroseeding, hydromulching and harrowing for a set contract price of $6,500, based on the original acreage estimates of 6.79 acres for hydroseeding/hydromulching and 0.59 acres to harrow. In Table 2, the actual contract cost was pro-rated to each area based on revised acreages, which were approximately 4.67 acres for hydroseeding/hydromulching and 0.30 acres to harrow. Therefore, the actual per-acre cost exceeded $1,000/acre for this project, and was approximately $1,385/acre. The tractor and harrow equipment cost given for area "D" is based on a separate source quote of $35 per hour(6).

The garden seeder was rented for $6.10 per day. All the areas to be seeded with the seeder could have been finished in 2 days, but because of equipment scheduling and staff time conflicts, the seeder was rented for a longer period.

Planting costs

The actual cost of all planting was $10,896.93 and would have cost $13,414.93 without using California Conservation Corps labor. Equipment and materials cost $9,958.36. Supervision cost $938.57.

Planting costs per acre

The average cost per acre was $1,498.89 using California Conservation Corps labor, and would have cost $1,845.24 with $8-per-hour labor.

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(6) Tractor, harrow and operator costs quoted are $35 per hour, stand-by at one-half rate, and a minimum drop charge of $35 for one hour with additional travel time added at the per-hour rate.

The hydromulching methods cost the most per acre, averaging about $2,066 per acre for hydroseeding and hydromulching to $1,77[illegible] per acre for handraking and hydromulching. The actual cost for the handraking and hydromulching was $2,545.19 per acre using California Conservation Corps labor.

The handraking and tractor harrow methods cost the least per acre, $399.08 and $466.37 respectively. The handraking actually cost $265.13 per acre, and the harrow method cost $139.91, using California Conservation Corps labor.

The dune grass planting was $107.50 per acre and would have cost $1,032.03 with $8-per-hour labor.

TABLE 2: PLANTING TIME AND COST SUMMARY

	Planting technique (does not include cost of propagules)						
	F DUNE GRASS	A HANDRAKE	B HANDRAKE-HYDROMULCH	C HYDROSEED-HYDROMULCH	D HARROW	E TURF HYDROSEED	TOTALS
Area (acres)	2.01	1.64	1.26	1.91	0.30	1.50	7.27
Planting labor, man-hours/acre	110.53(a)	25.55	25.50	0.00	2.50	0.00	
1. Planting labor @ $8 per hour	$1,777.36	$335.20	$ 257.04	0.00	$ 7.12	0.00	$2,376.72
2. Other labor @ $8 per hour(b)	80.96	34.16	26.16	0.00	0.00	0.00	141.28
3. Supervisor @ $17 per hour	207.57	257.04	224.23	187.34	57.63	4.76	938.57
4. Equip. & mtls.(c)	8.50	28.09	2,982.71	3,799.87	75.16	3,064.03	9,958.36
Projected cost w/o CCC's (1+2+3+4)	$2,074.39	$654.49	$3,490.14	$3,987.21	$139.91	$3,068.79	$13,414.93
Actual cost w/ CCC's (3+4)	$216.07	$285.13	$3,206.94	$3,987.21	$132.79	$3,068.79	$10,896.93
Planting labor, cost/acre @ $8 per hour	$884.24	$204.40	$204.00	$0.00	$20.00	$0.00	
Project cost/acre w/o CCC' (1+2+3+4)	$1,032.03	$399.08	$2,769.95	$2,087.54	$466.37	$2,045.86	$ 1,845.24
Project cost/acre w/ CCC's (3+4)	$107.50	$173.86	$2,545.19	$2,087.54	$442.63	$2,045.86	$ 1,498.89

(a) This figure would have been 86.70 using the row-marking tool only; 10,890 hills/acre.
(b) Project-variable tasks: orientation, tool & equipment organization, walking to & from vehicle access.
(c) These figures are actual costs pro-rated for areas B, C & E, and would have been lower if original specified application rates & costs were used for hydromulcher and fertilizer (see text p. 13).

DUNE GRASS TIME AND COSTS

This section presents a brief discussion of the time and costs involved in collecting and planting the dune grass, and defines the activities included in each task. Labor costs are presented at $8 per hour for laborer time and $17 per hour for supervisor's time. Supervisor's time includes all activities related to the collection and planting of the dune grass such as planning, travel, organization of labor, supervision of workers' activities and materials acquisition. The dune grass planting costs are compared to the costs of the seeding techniques in Table 2. Complete cost analyses for dune grass collection and planting are presented in Tables 3 and 4.

Collection

The activities included in dune grass collection are digging and processing of the dune grass culms, as described on pages 3 and 4. Included under "other" are the workers' travel time to and from the collection site, and activities such as organizing tools and equipment and site cleanup, as the time required for these will vary depending on the condition, location and accessibility of the collection sites and are thus project-specific.

Table 3 presents the time and costs for dune grass collection and contrasts collection on-site versus off-site. The faster collection rate in culms per hour and the resulting lower cost per culm for the off-site collection probably reflects the fact that the workers were more experienced, and their training period took place while collecting on-site. The average cost per culm for both on- and off-site collection is 5.6 cents for collection labor only, and 8.5 cents for all labor costs. The higher total cost per culm for off-site collection reflects the time to travel to the site. The lower cost per culm for the supervisor's time on-site is because other activities were taking place concurrently, and time was pro-rated to all activities.

It must be stressed that the amount of dune grass collected was a small sample compared to the amounts available from commercial sources. The current commercial price quoted for dune grass is 7.5 cents per culm.

TABLE 3: DUNE GRASS COLLECTION TIME AND COSTS

Labor costs given below are based on $8 per hour for laborer and $17 per hour for supervisor.

	On-site	Off-site	Total
Number of culms	12,700*	10,065	22,765
Rate, culms/man-hour	136.19	151.70	142.64
Man-hours			
Collection	93.25	66.35	159.60
Other	3.30	25.04	13.75
Supervision	10.99	13.75	24.74
Labor Cost			
Collection	$746.00	$530.80	$1,276.80
Other	26.40	200.32	226.72
Supervision	186.83	233.75	420.58
Total	959.23	964.87	1,924.10
Labor Cost, cents/culm			
Collection	5.9	5.3	5.6
Other	0.2	2.0	1.0
Supervision	1.5	2.3	1.9
Total	7.6	9.6	8.5
Equipment rental cost	$0.00	$53.90	$53.90

* This figure is an estimate based partly on counting planted hills.

Planting

The activities included in dune grass planting are marking rows, planting at 2 culms per hill on 24" centers, and quality control. Not included are the workers' travel time to and from the planting site, or any other related activities such as organizing tools and equipment and site cleanup, as the time required for these activities will vary depending on the location and accessibility of the planting site. Although it was not easy to keep separate the time carrying tools from the van to the planting area, this time was isolated as much as possible, since the distance from vehicle access to the planting site will vary for other projects. In other words, a serious attempt was made to separate the time and costs for planting alone.

Dune grass planted using the marked-twine spacing method was planted at the rate of 69.1 hills per man-hour; that planted with the row-marking tool was at the rate of 125.6 hills per man-hour. At a labor cost of $8.00 per hour, the planting labor would cost $1,260.80 per acre with the twine method, and $693.60 per acre with the row tool.

The planting which took place the first 2.3 days of work on the project was with dune grass harvested on-site, using the marked-twine spacing method. Crew members were transferred from digging to processing to planting depending on the amount of culms ready to plant or in need of processing. The number of culms harvested on-site were not counted before planting, but the number was estimated after planting by counting rows of hills. It was difficult to make estimates in areas of remedial planting where the culms were planted where needed and not in whole rows. Therefore, the number of hills planted using the twine method is a figure derived in part from estimated counts, and in part from actual counts. The number of hills planted using the board marking tool is based on the counted culms supplied from off-site sources.

Equipment and supplies

Most of the equipment used to collect dune grass culms is the same as that used to plant them. The County had purchased tile spades, stakes, twine and other supplies during the Phase One Planting. These were made available for the Phase Two Planting and no new supplies were purchased specifically for the dune grass collection or planting.

A boat was rented at the cost of $44.74 for one day to transport the culms collected on Elk River Spit from the collection site to a nearby access road. This enabled the workers to collect more culms in one day than they would have been able to carry out to the access point.

TABLE 4: DUNE GRASS PLANTING TIME AND COST

Labor costs given below are based on $8 per hour for laborer and $17 per hour for supervisor.

	Twine method	Board method	Total
No. hills @ 2 culms/hill	7,350*	14,533	21,883
Rate, hills/man-hour	69.1	125.6	98.5
Man-hours			
Planting	6.42	115.75	222.17
Other	4.86	5.26	10.12
Supervision	5.86	6.35	12.21
Labor Cost			
Planting	$851.36	$926.00	$1,777.36
Other	38.88	42.08	80.96
Supervision	99.62	107.95	207.57
Total	989.86	1,076.03	2,065.89

* This figure is an estimate based partly on counting planted hills.

OTHER PROJECT COSTS

This section describes certain costs of this project which may be substantially different from other projects and are not therefore included in the time and cost analysis presented above.

Seed mixing

The time required for mixing the seed was 32.39 hours. At $17.00 per hour, the actual cost was $550.63. This task included computing the seed weights for each species in the formula mixture, weighing the seed to a high level of accuracy, pre-treating seeds of certain species in order to facilitate breaking dormancy, mixing the seeds together and packaging the seed in useful-sized lots. Two formula mixtures were prepared, one for the areas seeded by the techniques described in this report, and a separate batch which was hydroseeded and then hydromulched on an adjacent area, not included in this report. <u>The time spent mixing the two batches was not separated.</u>

Planning and organization, materials acquisition, cleanup of the seed storage and mixing location and travel time totaled 14.13 hours and cost $240.21. Total labor cost for all aspects of seed mixing was $790.84.

The County provided the location for storage and mixing of the seed, and the use of a balance scale. The seed was provided under a separate contract and was supplied packaged in various containers, including several 30-gallon garbage cans which were reused for packaging of the mixed seed. The supplies purchased specifically to complete packaging of the mixed seed were tape, and additional garbage cans, at a total cost of $50.07.

Site preparation

Tasks included here are staking and flagging on-site, eradication of <u>Ammophila</u>, acquisition of supplies used in site preparation, cleanup, and placement of perimeter signs. The total cost of labor would be $459.49 based on 13.89 hours at $17 and 27.92 hours at $8. Since the $8-per-hour labor was provided by the California Conservation Corps, the actual cost of labor was $236.13 for the project supervisor's time.

The treatment area and buffer zone boundaries were delineated before work began using stakes and string. These were usually knocked over within a day or two by local area dogs, which are allowed to roam freely. For long-term boundary demarcation, lines of stakes with color-coded flagging and no string were more functional. The minimum staking actually needed was to delineate seed treatment areas. During planting, area boundaries including buffer zones could be marked on the sand just prior to application of the treatment.

The supplies purchased for site preparation include stakes, string, flagging and U-bolts, and cost $80.76.

Transportation of propagules

The cost of transporting a shipment of 16,500 dune grass culms from Crescent City to the site was $195.

Trailor rent to transport seed totaled $45; to transport dune grass collected locally, $30.

Other

An attempt was made to harvest dune grass at a site which proved to be unsatisfactory. This resulted in a loss of 7.50 man-hours of laborer time and 1.50 hours of supervisor's time. On one day, vicious dogs attacked the workers on the site, resulting in the loss of one tile spade, 6.75 man-hours of laborer time and 1.00 hour of supervisor's time.

The cost of measuring and remapping part of the project area to prepare the revised acreage estimates was $265.80.

Mileage charges for use of private vehicles totaled $310.26

APPENDIX 1: SOURCES OF DUNE GRASS

The native dune grass, Elymus mollis, used in the project's Phase Two planting came from three sources.

Approximately 12,000 culms were collected on-site from the hills planted the previous spring. Some hills yielded 7 to 10 culms after the one growing season, although the average yield per hill was about 4 culms. The thinning was first done according to a fairly strict formula of "dig one hill, pass by the next four hills and dig the next one, but do not dig that next selected hill if it is adjacent to bare areas". This formula, which was intended to result in the harvest of 15 to 20% of the hills, did not yield a harvest of 15 to 20% of the available harvestable culms. Large harvestable clumps were left because they were not selected by the counting method, while adjacent small clumps were dug up. Accordingly, harvesting became a more subjective task, requiring attention on the part of the workers to concentrate harvesting in the thick areas and to leave the thin areas alone.

During processing, it was observed that a few of the culms from on-site harvest contained an insect grub which appeared to be feeding on the interior of the culm. The damage was usually sufficient to sever the culms, and they were discarded.

The second source of dune grass was on nearby Elk River Spit, where a relatively pure stand of Elymus mollis occurs (see the Phase One Planting Report for a map of the location of this population). On November 22 and 25, the California Conservation Corps crew collected 10,065 culms. This stand had been thinned the previous spring for the Phase One Planting project, and the dune grass had recovered sufficiently to allow this additional harvest.

The third source of dune grass was from a commercial supplier: Wave Beachgrass Nursery, Wilbur Ternyik, proprietor, Florence, Oregon. The first batch of 4,500 culms was delivered on November 27 and the second batch of 16,500 culms was delivered on December 8, 1985. The supplier mentioned to this contractor's representative that a few of the culms may contain an insect grub which feeds on the culms, and that the grub is found on dune grass throughout its range in California, Oregon and Washington. These plants were collected on the Oregon and southern Washington coasts. The shipments were inspected by the Humboldt County Agricultural Inspector and released at the site.

APPENDIX E: SEED MIX FORMULA

The county's representative specified the seed mix formula based on the total poundage of seeds supplied under a separate contract. The following table gives the pounds per acre of each of the eight species in the mix, and the ratio of each species in the mix based on weight.

SPECIES	POUNDS PER ACRE	RATIO (%)
Abronia latifolia yellow sand verbena	7.033	27.9
Ambrosia chamissonis beach bur	6.199	24.5
Artemisia pycnocephala beach sagewort	3.416	13.5
Camissonia cheiranthifolia beach evening primrose	0.354	1.4
Eriogonum latifolium seaside buckwheat	2.657	10.5
Lathyrus littoralis beach pea	1.695	6.7
Solidago spathulata goldenrod	2.707	10.7
Tanacetum douglasii dune tansy	1.214	4.8
TOTAL	25.28	100.0

APPENDIX G: ACREAGE ESTIMATES

Areas were measured by pacing distances. Each large irregular area was divided into smaller areas consisting of rectangles and triangles. Area computations were made on these small areas and totals were summed. Total acreage estimates were obtained for each treatment area (A, B, C and D) by the following formula: Sum of smaller areas measured in sq. ft. divided by 43,560 (number of sq. ft per acre).

The following table compares the original area estimates with the revised estimates, and also with a figure based on the hydromulcher's estimate of final mulch coverage.

ESTIMATE OF ACREAGES

Area	Original	Revised	Hydromulcher
A	2.20	1.64	
B	2.45	1.26	1.47
C	2.34	1.91	1.76
D	0.59	0.30	
E	2.00		1.50

APPENDIX 4: ACTIVITY LOG

The different activities performed during the course of this planting are shown by dates in the table below.

DATES OF ACTIVITY

Date	Activity
11-18	Dig *Elymus* on-site, process, plant *Elymus* with marked twine
11-19	Dig *Elymus* on-site, process, plant *Elymus* with marked twine
11-20	Aborted off-site *Elymus* collection; dig, process & plant on-site with marked twine; calculate seed application rate in area "F"; seed and handrake area "F"
11-21	Seed and handrake area "A"
11-22	Dig and process *Elymus* off-site (collected 6,900 culms); plant 2,000 culms with marked twine, heel in remainder
11-25	Dig and process *Elymus* off-site (collected 3,165 culms); plant 8,065 culms with row-marking tool
11-27	Plant 4,500 culms from Oregon supplier with row-marking tool
11-29	Hydromulch area "B" (first time)
12-05	Hydromulch area "B" (second time); hydroseed and hydromulch part of area "C"
12-09	Plant 16,500 culms from Oregon supplier with row-marking tool; hydroseed and hydromulch rest of area "C"; hydroseed area "E"
12-10	Surface application of seed and harrow area "D"

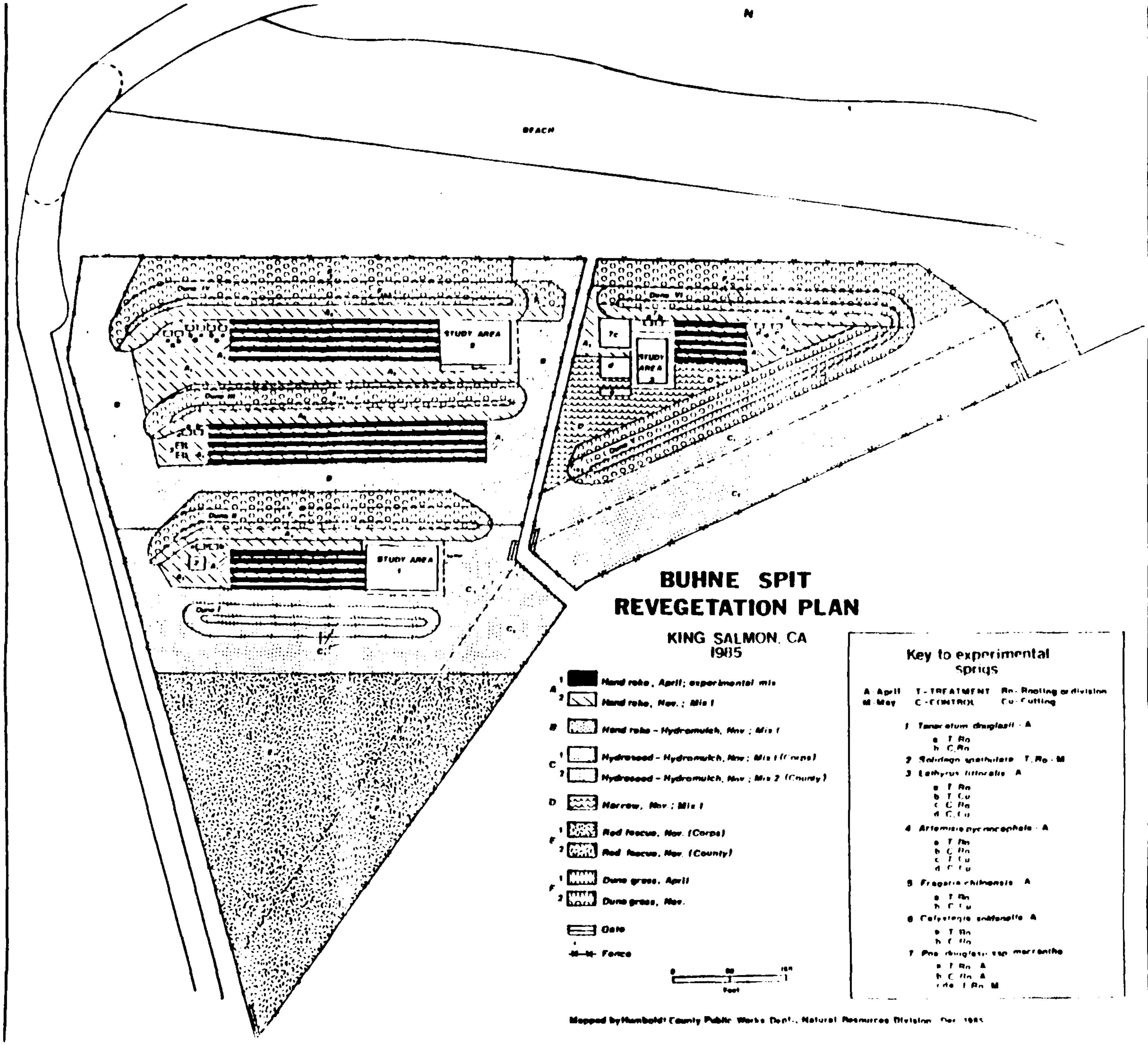
APPENDIX F: WEATHER

The contract specifications did not call for keeping weather records during the planting. However, it was later requested that some notation of weather on activity days be included in this report, since weather conditions at the time of planting of the Elymus are an important factor to consider in its later performance.

Weather records were obtained from the U. S. Weather Service Bureau office in Eureka, California. The weather station is located on the roof of a 5-story building in downtown Eureka at Fifth and H Streets, five city blocks from Humboldt Bay and about five miles from the project site. This information was combined with the planting supervisor's recollections of weather conditions to produce the table below.

WEATHER CONDITIONS AT TIME OF PLANTING

Date	Temp. (F) High	Temp. (F) Low	24 hour Precip.	Ave. Wind Speed (mph)	General Conditions
11-18	50	37	none	3.1	Sunny, cold, light wind
11-19	50	36	none	3.3	Cloudy, cold, light wind
11-20	51	39	0.07"	4.3	Cloudy, showers, light wind
11-21	48	37	none	4.3	Cloudy, cold, light wind
11-22	50	42	0.04"	5.4	Cloudy, cold, moderate wind
11-25	50	38	none	8.5	Cloudy, cold, moderate wind
11-27	53	42	0.52"	7.7	Cloudy, showers, moderate wind
11-29	49	44	0.11"	13.8	Overcast, cold, windy
12-05	59	51	0.03"	5.1	Scatt. clouds, haze, lt. wind
12-09	52	36	none	6.3	Sunny, cold, moderate wind
12-10	54	33	none	4.5	Sunny, cold, light wind


N
BEACH
STUDY AREA 3
STUDY AREA 2
STUDY AREA 1
Dune I
Dune II
Dune III
Dune IV
Dune VI
BUHNE SPIT
REVEGETATION PLAN
KING SALMON, CA
1985
A 1 Hand rake, April; experimental mix
A 2 Hand rake, Nov.; Mix I
B Hand rake - Hydromulch, Nov; Mix I
C 1 Hydroseed - Hydromulch, Nov; Mix I (Corps)
C 2 Hydroseed - Hydromulch, Nov; Mix 2 (County)
D Harrow, Nov; Mix I
E 1 Red fescue, Nov. (Corps)
E 2 Red fescue, Nov. (County)
F 1 Dune grass, April
F 2 Dune grass, Nov.
Gate
Fence
0
50
100
Feet
Key to experimental sprigs
A - April
M - May
T - TREATMENT
C - CONTROL
Rn - Rooting or division
Cu - Cutting
1 Tanacetum douglasii - A
a T Rn
b C Rn
2 Solidago spathulata T Rn - M
3 Lathyrus littoralis A
a T Rn
b T Cu
c C Rn
d C Cu
4 Artemisia pycnocephala - A
a T Rn
b C Rn
c T Cu
d C Cu
5 Fragaria chiloensis A
a T Rn
b C Cu
6 Calystegia soldanella A
a T Rn
b C Rn
7 Poa douglasii ssp. macrantha
a T Rn A
b C Rn A
c,d,e T Rn M
Mapped by Humboldt County Public Works Dept., Natural Resources Division Dec. 1985

SECTION 3

QUALITATIVE EVALUATION OF PHASE II PLANTING

QUALITATIVE EVALUATION OF
PHASE TWO PLANTING

BUHNE POINT SHORELINE EROSION
DEMONSTRATION PROJECT

Prepared by: Andrea Pickart
October 26, 1986

Submitted to:

Humboldt County Public Works Dept.
Natural Resources Division
1106 Second Street
Eureka, CA 95501

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Cover photo: Air photo of project site taken soon after Phase 2 planting.

INTRODUCTION

In 1984 An eroded 22 acre sand spit was restored through jetty construction and fill (using dredge spoils) by the Corps of Engineers at King Salmon on Humboldt Bay, California. An experimental planting was developed by the Public Works Department of Humboldt County to test revegetation methods using native plants. This first phase of revegetation consisted of both qualitative and quantitative experiments. Phase 1 planting occurred in March 1985 and was monitored over a two year period. Reports were prepared documenting the methods of Phase 1 qualititative experimental plantings (Newton 1985) and Phase 1 quantitative experimental methods and results (Pickart 1986a, 1986b). The second phase of planting, which was intended to complete revegetation of the site, was initiated in November 1985. Because Phase 1 Monitoring was not yet complete, planting methods relied upon incomplete and qualitative observations. The resultant planting design is documented in the Phase 2 Planting Report (Bio-flora Research 1986), and pertinent parts will be reiterated here. The purpose of this document is to evaluate the results of this second phase approximately one year after planting. Although no quantitative monitoring occurred, qualititative observations were made throughout the year, and documented with photographs. These observations allow some general conclusions which should guide planting efforts in the small Phase 3 area that has been set aside to test the prescriptions developed as a result of Phase 2 Monitoring.

The following discussion has been divided into three sections, covering three generalized propagule types (seed mix, dune grass divisions and red fescue seed . Further divisions of methods exist withing the seed mix area. The location of each planting method is shown on Figure 1, which should be referred to throughout the discussion.

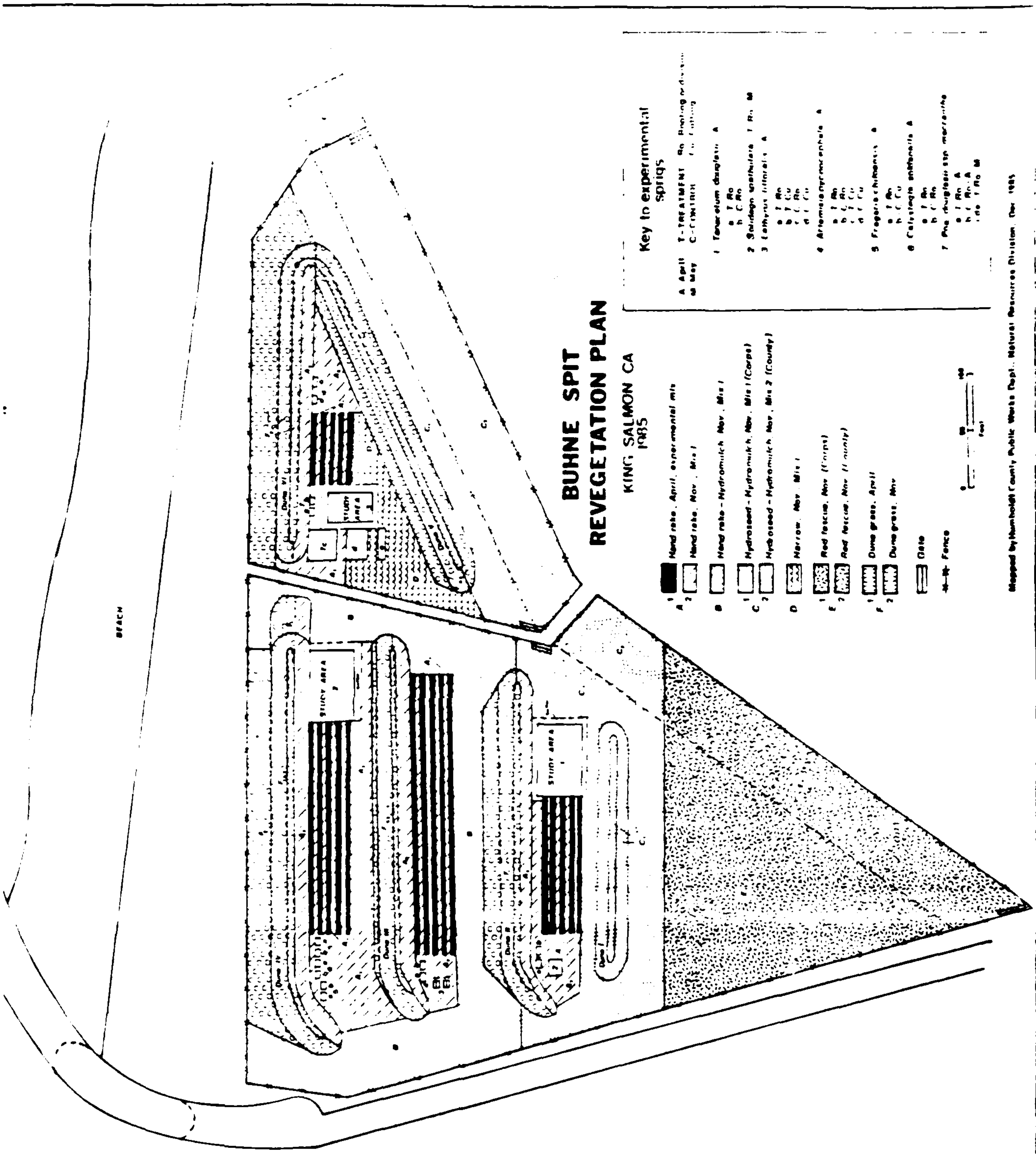


Figure 1. Map of the project site showing location of planting methods. Methods A2, B, C1, D, E1 and F2 constitute the Phase 2 plantings (see legend).

1. SEED MIX

Seeds of eight native dune plants (see Table 1) were collected and processed in the summer of 1985 (Newton 1986) and planted using four techniques: Hand-raked, Hand-raked/hydromulched, Hydroseeded/hydromulched and Hand-sown/harrowed. See Bio-flora Research (1986) for a more complete discussion of these methods. The seed mix followed a prescription which had been revised from the Phase 1 planting based on qualitative observations and was influenced by the availability of seed. It was later recognized, as the result of quantitative monitoring of Phase 1 plots, that this revised mix was inappropriate for many of the species. Table 2 shows the original Phase 1 seed prescription contrasted with that of Phase 2 planting and the final recommendation developed by Pickart (1986a). Due to a large difference in seed sizes of some species, the same proportion of a pound for two different species may represent extremely disparate numbers of seed. In order that such differences can be appreciated, the number of seeds represented by the given proportion of one pound is also shown. This number multiplied by the number of pounds applied per acre yields the actual number of seeds applied per acre on the site. It is evident that several species were overrepresented in the mix, particularly Artemesia. To a lesser degree, Camissonia and Eriogonum were also overrepresented, while Lathyrus and Tanacetum were underrepresented (primarily due to lack of availability).

These seed application rates begin to explain the resultant vegetation patterns. Differences resulting from planting method were subordinated to an overall pattern of predominance of certain species over others. Artemisia, Camissonia and Eriogonum were inordinately dominant after one year. As mentioned above, these three species were all overrepresented in the mix, particularly Artemisia, which is now the dominant species on the site. But the predominance of these species (and the paucity of others) can be further explained by the differential rate of emergence of the various species under conditions of high competition for resources.

Overall, the Phase 2 planting can be characterized by an overapplication of seed. Seed application rates were specified at 25 pounds per acre, but due to difficulties encountered by the contractor, actual seed application rates ranged from 33 to 40 pounds per acre, depending on planting method (see Table 3). So a mix already concentrated in seed number (due to higher than desirable proportions of several species) was further increased by overapplication. The result was an extremely dense population of individuals, characterized by a high degree of competition for resources. The resources which these individuals were in competition for included space, moisture and nutrients. In the hydromulched areas, fertilizer was mixed in with the slurry and was therefore also overapplied and was presumably non-limiting (see Table 3). But in the hand-raked and harrow areas, fertilization was delayed until July, and then applied at much lower rates ranging from 25-225 pounds per acre (compared with the original specified rate of 500 pounds per acre). This was done as an experiment to examine fertilizer application rates, which had been questioned by Clark (1986). Fertilizer treatments are detailed in the project Management Recommendations (Pickart 1986c) and shown in Figure 2. By examining growth in these areas compared with hydromulched areas, it is evident that the increased fertilizer and the beneficial water retaining effects of the mulch (Pickart 1986a) permitted greater plant growth in hydromulched areas. An observed gradient of growth from the lowest (25 pounds per acre) to the highest (225 pounds per acre) fertilized hand-raked areas indicates that fertilizer was a limiting factor in this area (Figure 3). But probably more limiting overall was the availability of water. This is supported by the fact that when winter

Table 1. Native dune species planted in Phase 2 areas.

Abronia latifolia	sand verbena
Ambrosia chamissonis	beach bur
Artemisia pycnocephala	beach sagewort
Camissonia cheiranthifolia	beach evening primrose
Eriogonum latifolium	beach buckwheat
Lathyrus littoralis	beach pea
Solidago spathulata	goldenrod
Tanacetum douglasii	tansy

Table 2. Seed prescriptions for Phase 1 and Phase 2 Planting contrasted with final recommendations based on Phase 1 Monitoring.

Prescription is expressed as the proportion of a given species in each pound of seed applied, followed in parantheses by the approximate number of seeds in that proportion of a pound. To compare absolute values of numbers of seed applied, the seed number should be multiplied by the pounds applied per acre (20 pounds per acre for Phase 1 and recommended, 33 or 40 pounds per acre for Phase 2, depending on planting area).

Species	Phase 1	Phase 2	Recommended
Abronia latifolia	.199 (4049)	.278 (5657)	.265 (5392)
Ambrosia chamissonis	.149 (5107)	.245 (8397)	.199 (6820)
Artemisia pycnocephala	0*	.135 (247,072)	.033 (60,395)
Calystegia soldanella	.100 (891)	0	0
Camissonia cheiranthifolia	.005 (18,650)	.014 (52,220)	.009 (33,570)
Erigeron glaucus	.075 (111,510)	0	0
Eriogonum latifolium	.075 (28,817)	.105 (40,344)	.066 (25,359)
Lathyrus littoralis	.100 (586)	.067*(393)	.132 (774)
Orthocarpus purpurascens	.025 **	0	**
Polygonum paronychia	.100 **	0	**
Solidago spathulata	.075 **	.107 **	**
Tanacetum douglasii	.100 (74,851)	.048*(35,928)	.165 (123,503)

*Proportion determined largely by seed availability
**This species was not monitored quantitatively in Phase 1, therefore prescribed rate is approximated, and seed counts are not known.

Table 1. Specified vs. actual seed and fertilizer application rates.

Planting method	Intended seed applic. rate	Actual seed applic. rate	Intended fertilizer	Actual fertilizer
Hand-raked	25 lbs./acre	40 lbs./acre	500 lbs./ac	25-225 lbs ac
Hand-raked/ hydromulched	25 lbs./acre	40 lbs./acre	500 lbs./ac	800 lbs./acre
Hydroseeded/ hydromulched	25 lbs./acre	33 lbs./acre	500 lbs./ac	600 lbs./acre
Hand-sown/ harrowed	25 lbs./acre	40 lbs./acre	500 lbs./ac	25 lbs./acre

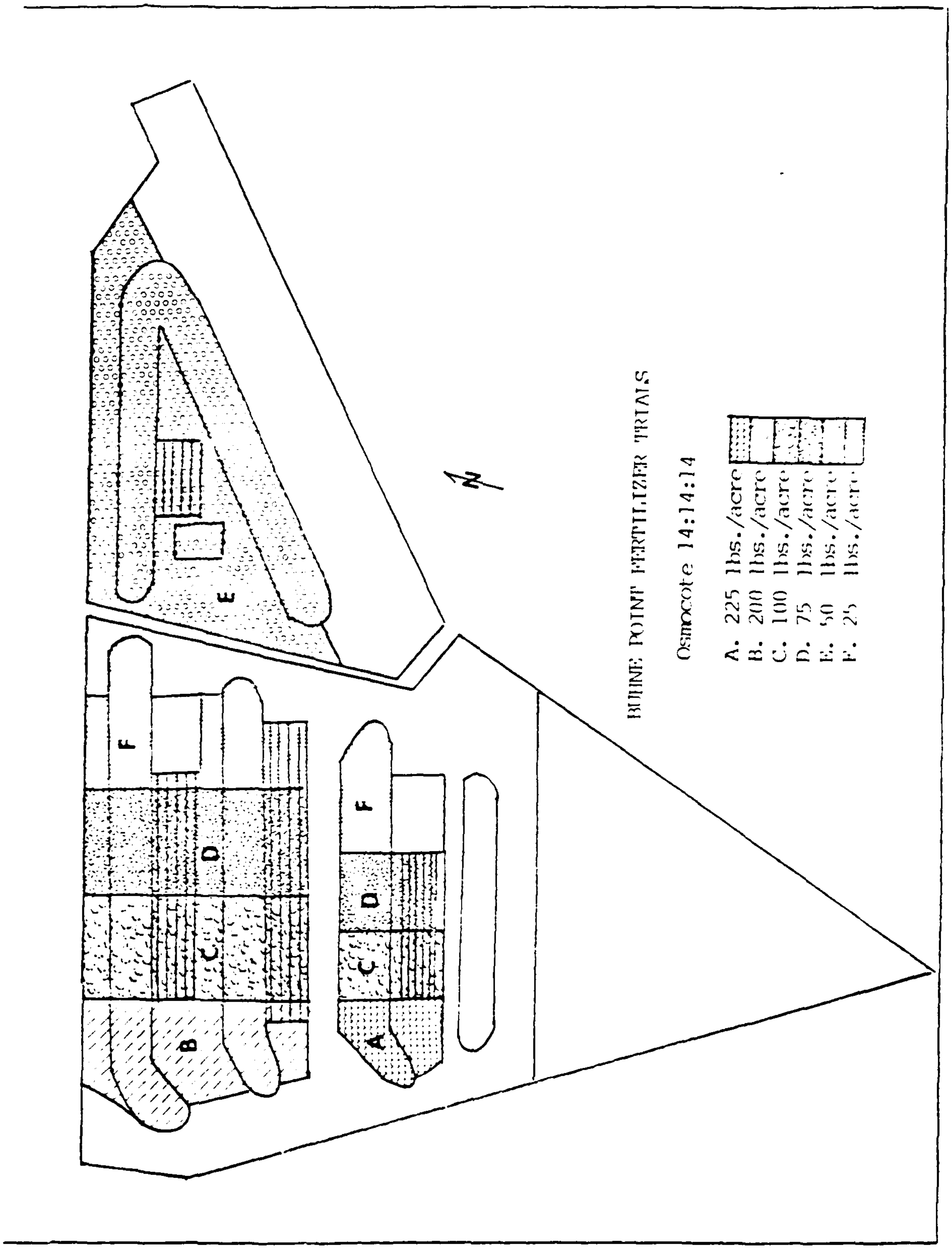
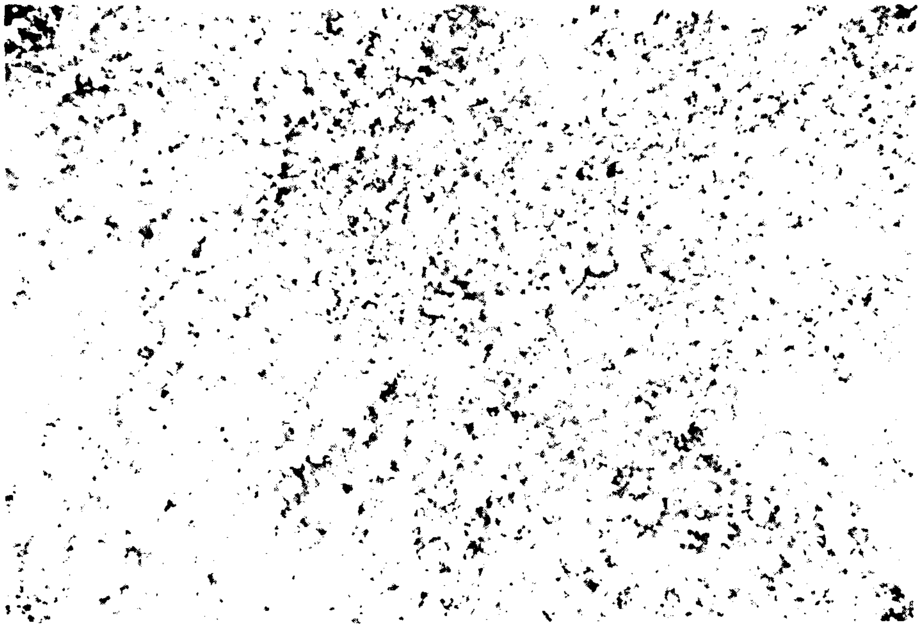


Figure 2. Map of the project site showing location of different fertilizer application rates in hand-raked, handsown harrowed and dune grass areas.



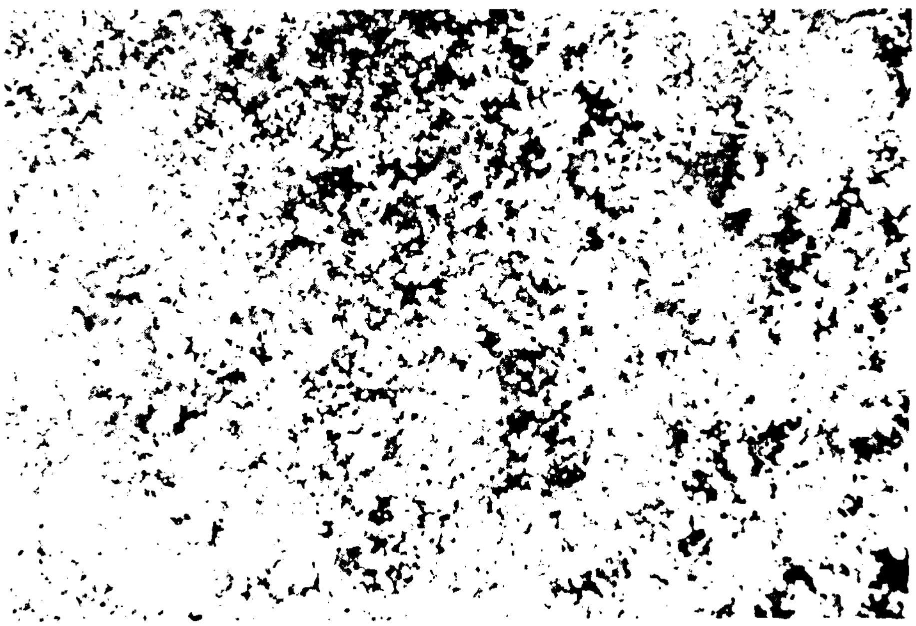


Figure 3: Fertilizer trials in hand-raked area; identical seed prescriptions were fertilized with slow release 14:14:14 at 25 pounds per acre (top) and 200 pounds per acre (bottom).

rains began in September (before the end of the growing season) growth was vigorously accelerated in all planting areas (Figure 4). The limiting effect of water was also evidenced by the patterns of mortality and growth that could be observed as the result of irrigation patterns (and presence or absence of water-retaining mulch) throughout the summer (Figure 5). All observed signs of stress and causes of mortality were drought-related. Wilting was prevalent throughout the site, and heaviest in non-mulched areas. Irrigation rates were identical to those used on Phase I planting, for which they were adequate. However, phase 2 planting densities were far greater than Phase 1 and the irrigation rate should have been increased.

The high level of competition for resources compounded the effects of application rates in causing a prevelance of three species. The three species overapplied were, by coincidence, the fastest germinating of the species. Artemisia, Camissonia and Eriogonum are each characterized by a lack of dormancy mechanisms, associated with the fact that they typically germinate in early fall with the onset of winter rains (Barbour et al 1985). Ambrosia, Lathyrus and Abronia typically germinate in late spring. Although Lathyrus and Ambrosia were treated for dormancy, slower germination rates are still to be expected, as they are for Tanacetum, based on Phase 1 monitoring results (Pickart 1986a). In a mixed population undergoing competition for resources, the phenomenon of "space capture" or pre-emption of resources by early germinating species is well documented (Harper 1977). Growth and development (flowering, fruiting, rhizome development) have been shown to be reduced by the presence of competing inter- or intraspecific individuals (Clatworthy 1960). In the case of Phase 2 planting, excessive seed application caused the dominance of early germinating species; while subsequent water deprivation (after the rainy season ceased) suppressed the growth and development of individuals present. After 10 months, growth for all species present was greatly inferior to growth acheived after 7 months in Phase 1 areas (Figure 6). While flowering was common for three species (Eriogonum, Camissonia and Abronia) by the end of the first growing season in Phase 1, only one species (Camissonia) flowered by the end of the growing season in Phase 2. A clue to the competetive nature of the planting site is provided by observing the growth of accidentally dispersed seeds on open sites where dune grass was planted but did not survive. These areas were fertilized late (July) and at relatively low rates, but the amount of nutrients and water (via irrigation) available to the plants was apparently adequate for the density at which they occurred. It is only in these areas where Phase 2 growth and development approached that of Phase 1 (see Figure 7).

It must be remembered that disproportionate seed application was also a factor in reducing the occurrence of Lathyrus and Tanacetum. In addition to this, several other limiting factors are possible. Lathyrus scarification for Phase 1 was done thoroughly and individually, and Phase 2 scarification may have been less thorough due to the volume of seeds involved. Ambrosia seeds in Phase 1 were subjected only to manual scarification, while Phase 2 seeds were also treated with a 36-hour cold water soak (as recommended by Frey (1983)). In a small subsample of seeds which were soaked and then held over due to delays, mold had developed after 24 hours. Both Abronia and Ambrosia germinated in control plots planted at the same time as the Phase 2 planting (Figure 8). The Ambrosia in control plots were not soaked. It is recommended that this treatment not be used, as germination of Ambrosia without the treatment is very high when viability rates are considered (Pickart 1986a).

Another possible factor limiting the germination of Lathyrus (and or other species) is the presence of germination inhibitors produced by other established species. Artemsia and Lathyrus are rarely found together in the

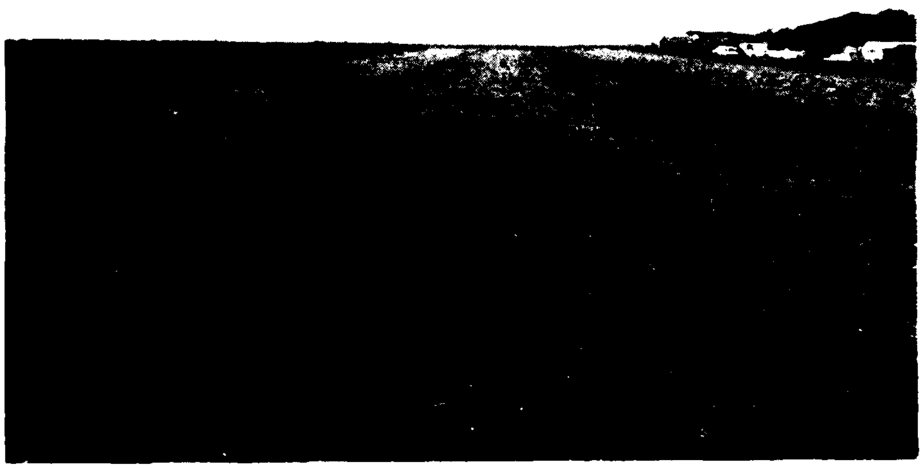
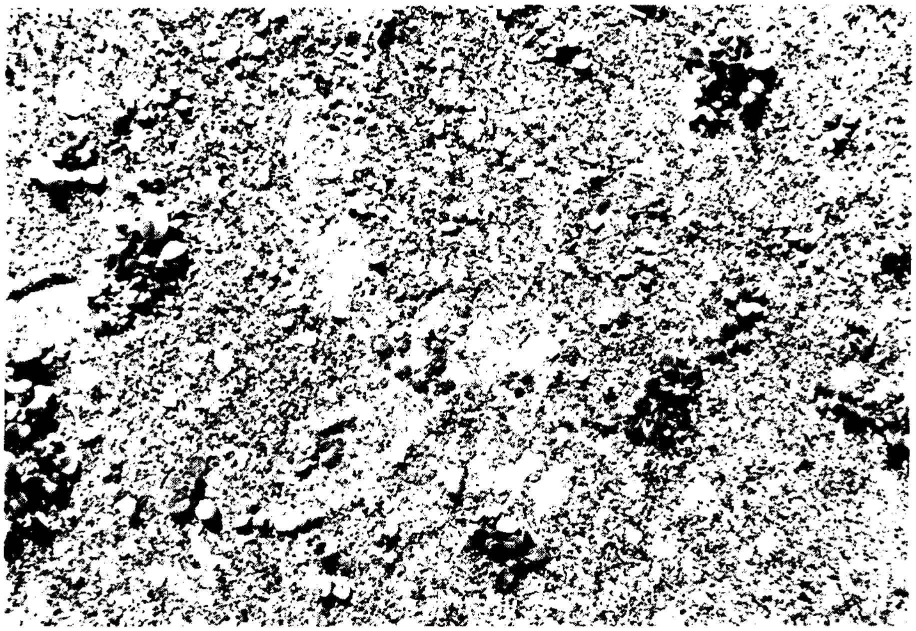


Figure 4: Hydroseeded/hydromulched areas in early September (top, prior to onset of rains) and late October (bottom, following rainy period). Note irrigation patterns in top photo (greatest growth along central irrigation line). This pattern is no longer evident after post-rain greening up of area.

Figure 5: Staked boundary is shown between hand-raked area (left) and hand-raked/hydromulched area (right). Top photo, taken in early September, shows greatest growth in irrigated, mulched area (right foreground). By late October (after rains), irrigation patterns are no longer detectable.

Figure 6: Phase 1 hand-raked areas in October 1985 (top), contrasted with Phase 2 hand raked areas in October 1986 (located between Phase 1 strips in bottom photo).

Figure 7: Accidental growth in fertilized, irrigated areas of Phase 2 where *Elymus* did not survive. Note size of plants and flowering of *Eriogonum* and *Camissonia*.



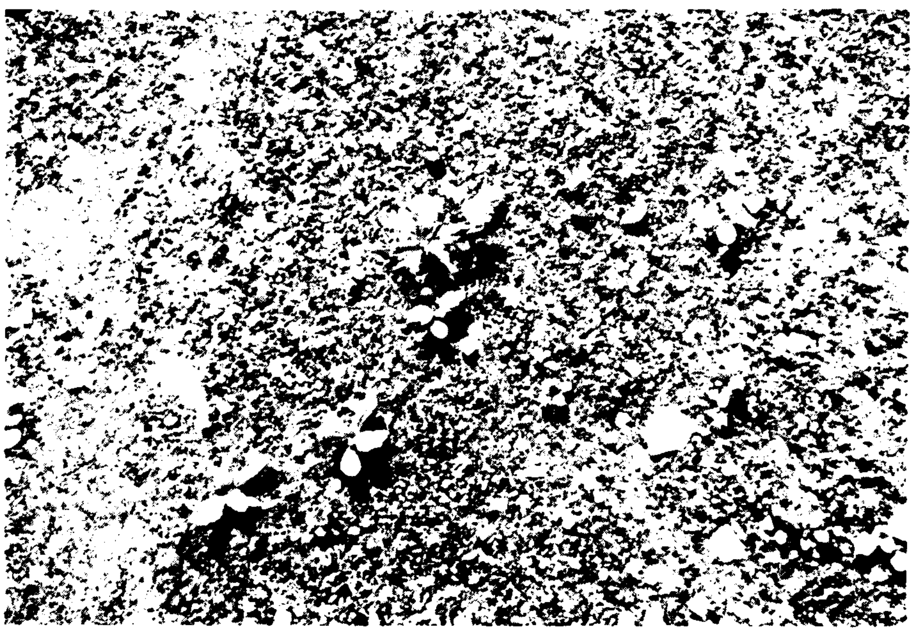


Figure 8: Abronia (top) and Ambrosia (bottom) growing in Phase 2 control plots.

dune mat vegetation of Humboldt County. Instead, one or the other is frequently dominant (pers. obsv.). The species Artemisia absinthium is known to produce inhibitors that prevent the germination of a number of species, including Lathyrus clymena (Mayer and Poljakoff-Mayber 1982). Because Artemisia is the earlier germinator of the two, it is possible that it could cause suppression of Lathyrus germination in this way (although alleopathy exhibited by Artemisia would fail to account for the absence of Artemisia in Lathyrus-dominated stands of the natural dune mat community).

Although apparently suppressed, Lathyrus was observed to germinate in low numbers in late Spring, as was Abronia, however, they are virtually absent now. It is concluded that mortality of these species was very high due to the phenomenon of space capture described above. Tanacetum can be found as a subdominant in Phase 2 areas, but is far more prevalent in hydromulched areas, and is actually dominant in a small depressed area caused by tire tracks from the hydroseeder (Figure 9). Tanacetum is known to be weedy in character and is common in moist areas or areas of greater organic accumulation. This species is presumably a better competitor than the earlier germinating species under conditions of high fertility and adequate moisture. Differential "aggressiveness" can cause deviation from the expected patterns generated by space capture (Clatworthy 1960).

Solidago was observed to germinate in control plots fairly early, yet is uncommon or absent in Phase 2 areas. In control plots this species was quickly decimated by drought, due to its extremely small seed reserves. Its presence would be expected in Phase 2 mulched areas on this basis, and its absense cannot be explained except as underapplication of seed. Control plots received an extremeley high application rate. The appropriate application rate for this species is uncertain as it was not examined in Phase 1 quantitative experiments.

In the Phase 1 planting, seeds of Orthocarpus purpurascens and Polygonum paronychia were included in the seed prescription but did not germinate until the following spring, following Phase 2 planting (Figures 10 and 11). Orthocarpus is a hemiparasite which does not require a host plant for germination, but members of the genera are known to require stratification (Kuijt 1969). Polygonum was shown to exhibit seed coat dormancy, which was overcome in the lab using sulfuric acid (Newton unpubl. data). Germination rates or times are not known for this species from Phase 1. Both species can be utilized without dormancy treatments provided they are planted in the fall and subjected to overwintering.

In summary, the low species diversity and stunted growth of plants observed throughout all planting method areas of Phase 2 is the result the overapplication of seed. As a result of high densities, irrigation became a limiting factor in growth and development. In non-mulched areas inadequate fertilization was also a problem and drought conditions were even more severe due to the absense of mulch. Differences in planting method expresseed as species diversity or cover are difficult to assess without quantitative sampling. Observations indicate, however, that cover and diversity are highest in mulched areas. Cover was lowest in the hand-raked and harrowed areas characterized by low fertilizer rates. One exception to this is the lee sides of dunes. These areas were in places subject to erosion and/or burial and had extremely low cover regardless of fertilizer application rate.

Figure 9: Depression caused by tire tracks in Hydroseeded/hydromulched area (center of photo) in which Tanacetum is dominant.

Figure 10: <u>Orthocarpus purpurascens</u> in Phase 2 planting area.

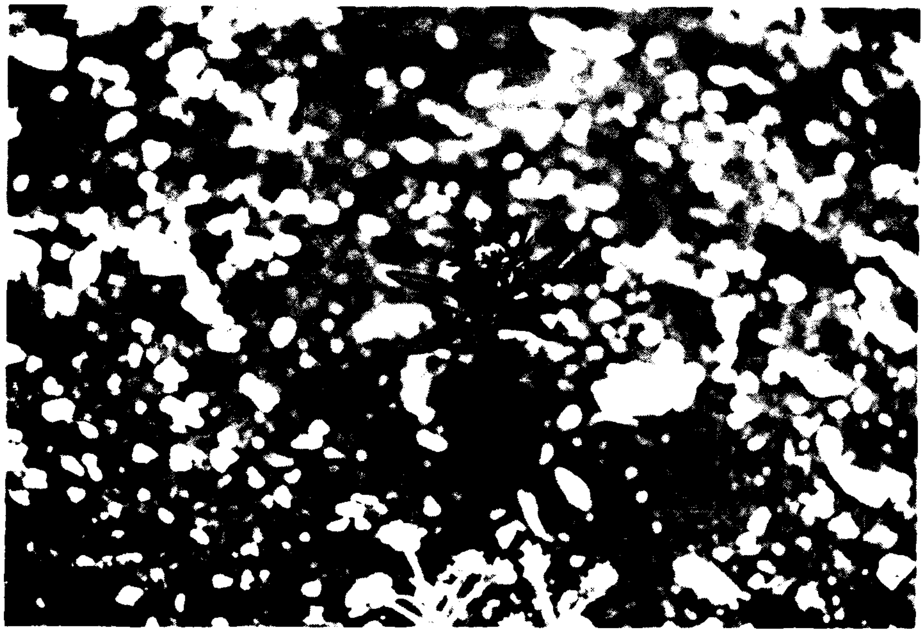


Figure 11: Polygonum paronychia in Phase 2 planting area.

2. DUNE GRASS

Dune grass (<u>Elymus</u> <u>mollis</u>) was planted on the windward sides and crests of "dunes" in March 1985 as a part of Phase 1 planting (Figure 1). In December 1986 the <u>Elymus</u> plantings were expanded, and remedial plantings were done to compensate for mortality in Phase 1 areas (including those areas in which American beachgrass (<u>Ammophila</u> <u>breviligulata</u>) had been accidentally planted and later eradicated). Phase 1 propagules were imported from Oregon, while for Phase 2 a mixture of imported, on-site harvested and off-site (Elk River Spit) harvested divisions were used. Refer to Bio-flora Research (1986) and Newton (1985) for details concerning planting techniques. First year mortality of <u>Elymus</u> varied by dune due to different sources and irrigation peculiarities. Per hill mortality ranged from 12.9 to 47.1%, with an overall mortality rate of 39.2% (Newton 1985). Mortality rates were not determined for Phase 2 plantings. However, qualitative observations indicate that plantings were fairly successful. Of significance is the high survival rate relative to Phase 1 for non-irrigated areas. This is presumably due to the time of planting, which allowed for a more extended period of growth while water was available from late winter rains after plants emerged from dormancy. <u>Elymus</u> plantings from both Phase 1 and 2 were subjected to variable fertilizer rates applied in June 1986 (Figure 2). Rates ranged from 25-225 pounds per acre of slow release fertilizer (14:14:14), in contrast with first year rates of 400 pounds per acre of soluble fertilizer (21:0:0). Although differences between second year rates are difficult to detect, there is an obvious difference in vigour between the condition of the plants at the end of the first year and the second year (Figure 12). Nitrogen deficiency is indicated by the color of the plants in the second year.

Because of the apparent nutrient deficiency, it is recommended that fertilizer application rates be increased beginning in spring 1987. With adequate fertilizer the <u>Elymus</u> plantings, which were quite successful, should continue to multiply. Given the endangerment of the <u>Elymus</u> foredune community on the west coast (Van Hook 1983), the project site represents an important propagule source for future revegetation projects.

A small amount of American beachgrass resprouted in spring 1986, and was dug up. Resprouting only occurred in the areas where eradication had been accomplished by digging. Areas sprayed with Roundup did not resprout. Future control of the species on this site should be by spot-spraying rather than digging.

Figure 12: Elymus plantings in September 1985 (top) and October 1986 (bottom). Note the more vigorous condition of the stand at the end of the first growing season.

3. RED FESCUE

A small triangular shaped area in the southern corner of the project site was planted with a commercial strain of the native dune species red fescue (Festuca rubra). This was done at the request of the Humboldt Bay Harbor, Recreation and Conservation District in order to provide a recreational area for local children. The species was chosen based on its ability to withstand trampling. Detailed planting specifications can be found in the Management Recommendations for the project (Pickart 1986c). Due to inexact measurements of the area to be planted, both seeds and fertilizer were overapplied excessively. The area grew vigorously through early winter, but began browning prior to the end of the rainy season. It is probable that a fertilizer burn occurred late in the winter as the fertilizer release rate increased. During the summer the species is dormant and above ground plant material dries up. In September 1986, with the onset of winter rains, moderate greening up was observed (Figure 13). It is too early to determine whether the area will adequately recover from the burn or whether remedial planting will be necessary.

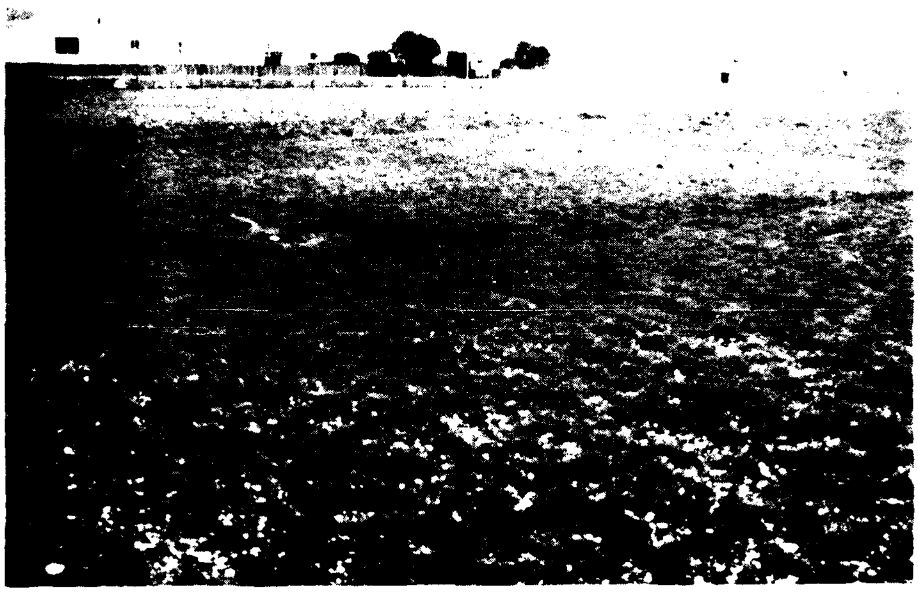


Figure 13: Red fescue area greening up after onset of rainy season (October 1986).

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SECTION 4

PHASE II MONITORING REPORT

BUHNE POINT SHORELINE EROSION DEMONSTRATION PROJECT

PHASE TWO MONITORING REPORT

Prepared By:

Andrea Pickart

For the
Natural Resources Division
Humboldt County
Department of Public Works

December 1986

Submitted To:

U.S. Army Corps of Engineers
San Francisco District
Contract No. DACW07-85-C-0037

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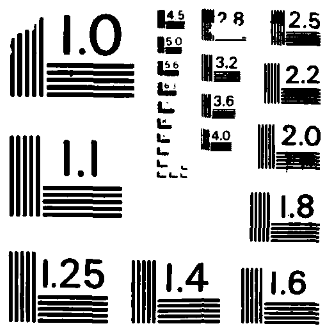

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

INTRODUCTION

In 1984 an eroded 23 acre sand spit was restored through jetty construction and fill (using dredge spoils) by the Corps of Engineers at King Salmon on Humboldt Bay, California. An experimental planting was developed by the Public Works Department of Humboldt County to test revegetation methods using native plants. This first phase of revegetation included quantitative experimental plantings initiated in March 1985 which were monitored over a two year period. Nine species of native dune species were subjected to 9 experimental treatments to determine the effect of the treatments on initial germination, end-of-season cover and first year survival. First year methods and results (as well as a full site description) are documented in Pickart (1986). In the second year, only end-of-season cover was examined. This report documents the results of second year monitoring. Methods and first year results will be recounted briefly and as they apply to second year results.

METHODS

Two large study areas were created to test nine native dune species planted as seeds. Locations of the two areas (shown in Figure 1) were selected to optimize homogeneity of microenvironment. Each study area consisted of a rectangular grid 19m by 24m delineated into 1m x 1m plots in blocks of four. Each row of 20 plots represented a single treatment applied to four replicates of five species randomized across the row. Four species and a mix were used in Study Area 1 (the mix was not tested for reasons documented in Pickart (1986) and five species were placed in Study Area 2 (see Table 1 for list of species used). The same eight treatments were applied to the two study areas, with an additional treatment tested in Study Area 2 only. The ninth treatment does not apply to Phase 2 testing so is not included in this report. The eight treatments monitored in Phase 2 are described below. Figures 2 and 3 show the arrangement of species and treatments in the two study areas.

Control. A control application rate was developed for each species based on a recommended "monoculture" rate (see Table 2). The control treatment consisted of hand-sown seeds applied at control rates and raked to a depth of 2 inches.

2x Control. Seeds were hand-sown at two times the control rate and raked to a depth of 2 inches.

1/2 Control. Seeds were hand-sown at one half the control rate and raked to a depth of 2 inches.

Compost. Seeds were hand-sown at the control rate at 2 inches depth into redwood compost (25 lbs. per plot) incorporated 4-6 inches. Compost contained approximately 1% added nitrogen.

Slow-release fertilizer. Seeds were hand-sown at the control rate and raked to a depth of 2 inches. Osmocote slow-release fertilizer (14:14:14) was applied at 10 lbs. per 100 sq. ft. (mid-range of manufacturer's suggested rate) and incorporated to 3 inches.

Soluble fertilizer. Seeds were hand-sown at the control rate and raked to a depth of 2 inches. Coarse particle ammonium sulfate (21:0:0) was applied at .7 pounds per acre and incorporated to a depth of 2 inches.

Jute matting. Seeds were hand-sown at the control rate and raked to a depth of 2 inches. The row was covered with a roll of coarse fiber netting designed to provide substrate stabilization. The matting was fastened with wood stakes.

Hydromulch. Seeds were hand-sown at the control rate and raked to a depth of 2 inches. 1500 lbs. per acre of Spra-mulch (wood fiber) was applied under pressure in a slurry which also contained 1 lb. per 100 sq. ft. soluble fertilizer (ammonium phosphate, 16:20:0).

Both Study Areas were irrigated through two summers from April (or the cessation of the rainy season) through October. Fertilizer treatments were not reapplied the second year. Second year monitoring consisted of end-of-season calculations of cover. Vertical slides of each replicate were projected, and plant outlines were delineated and then planimetered.

Figure 1: Location of Study Areas 1 and 2.

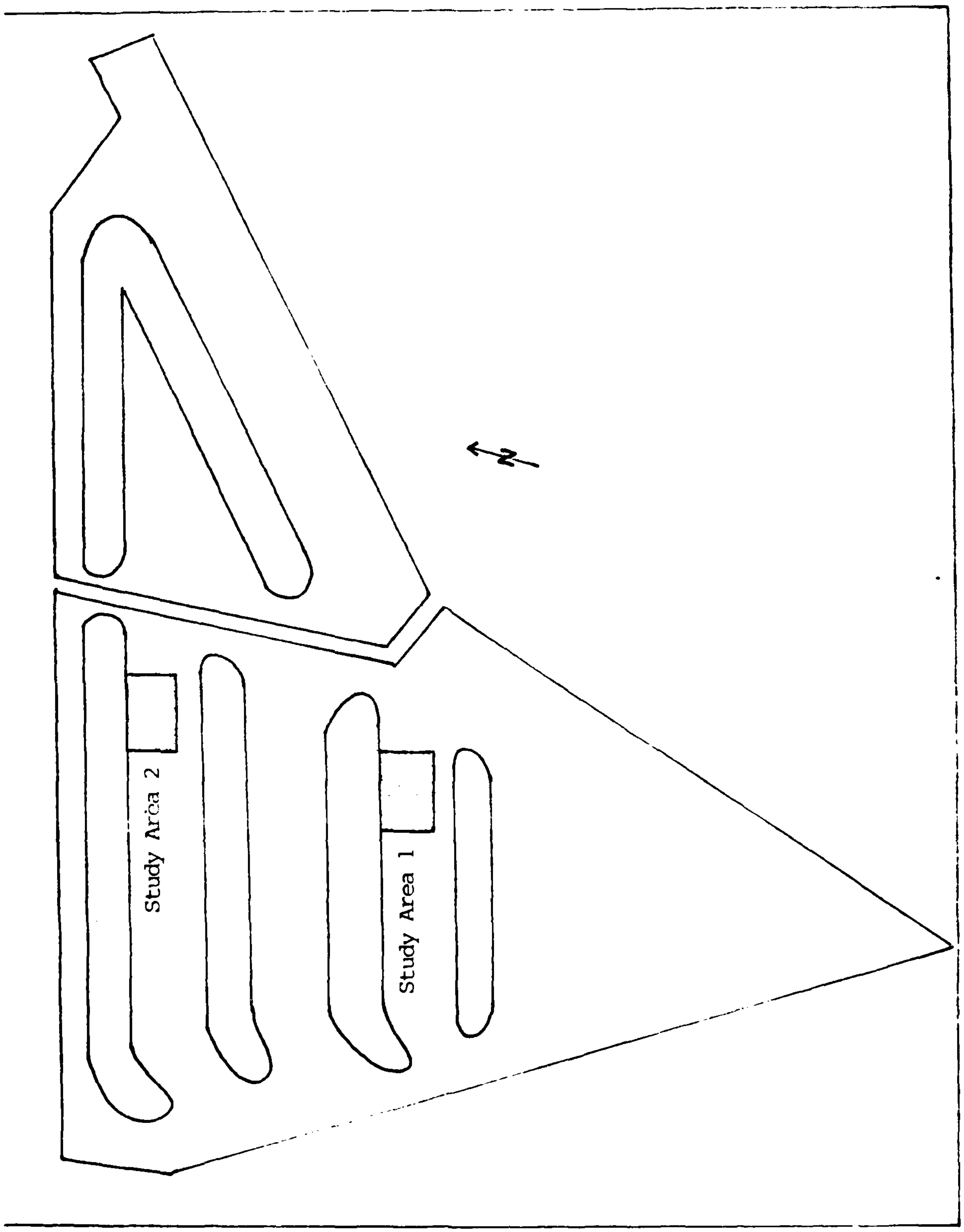

Table 1: Species tested in Study Areas 1 and 2.

Abronia latifolia	sand verbena
Ambrosia chamissonis	beach bur
Artemisia pycnocephala	beach sagewort
Calystegia soldanella	beach morning glory
Camissonia cheiranthifolia	beach evening primrose]
Erigeron glaucus	seaside daisy
Eriogonum latifolium	beach buckwheat
Lathyrus littoralis	beach pea
Tanacetum douglasii	dune tansy

Figure 2: Layout of Study Area 1 (irrigation corridors not shown).

2C	.5C	RC	CP	SF	FT	JM	HM
MX	AC	AC	CC	EL	EL	AC	MX
CC	AC	MX	CC	EL	AL	EL	EL
AC	EL	AL	MX	MX	MX	CC	AL
MX	MX	MX	AL	AC	AC	EL	AC
AL	CC	AL	EL	AC	MX	MX	AL
AL	MX	EL	CC	CC	CC	EL	EL
EL	MX	AL	AC	AL	AC	CC	AC
CC	EL	EL	MX	AL	AC	CC	CC
AL	CC	AC	AC	AL	EL	MX	AC
CC	EL	EL	MX	EL	CC	CC	AL
AC	CC	CC	AC	EL	EL	AC	CC
AL	AC	EL	EL	MX	MX	AC	EL
EL	AL	CC	EL	AL	AL	AC	CC
MX	AC	CC	AL	CC	AC	AL	EL
EL	MX	MX	AL	MX	CC	AL	MX
AC	EL	AC	CC	AC	AL	AC	CC
MX	AL	MX	AC	AC	MX	EL	AC
CC	AL	CC	EL	MX	AL	MX	MX
AC	CC	AC	MX	CC	EL	AL	AL
EL	AL	AL	AL	CC	CC	MX	MX

<u>TREATMENT CODES</u>

HM Hydromulch
JM Jute matting
FT Soluble fertilizer
SF Slow release fertilizer
CP Compost
RC Control
.5C 1/2 Control rate
2C 2X Control rate

<u>SPECIES CODES</u>

AL *Abronia latifolia*
AC *Ambrosia chamissonis*
EL *Eriogonum latifolium*
CC *Camissonia cheiranthifolia*
MX Mix (not tested)

Figure 3: Layout of Study Area 2 (irrigation corridors not shown).

2C	.5C	RC	CP	SF	FT	JM	HM
TD	LL	AP	LL	CS	LL	EG	TD
CS	AP	CS	AP	CS	EG	LL	AP
EG	AP	TD	LL	LL	LL	AP	CS
CS	CS	TD	TD	TD	AP	TD	EG
TD	LL	CS	AP	TD	TD	CS	TD
LL	CS	EG	AP	LL	EG	EG	TD
AP	AP	AP	LL	CS	EG	EG	EG
EG	LL	EG	CS	EG	TD	AP	LL
CS	EG	CS	LL	LL	TD	AP	AP
LL	TD	AP	TD	AP	EG	TD	CS
TD	EG	EG	CS	AP	CS	LL	LL
AP	TD	TD	AP	EG	LL	TD	EG
AP	CS	LL	TD	EG	CS	LL	LL
EG	TD	EG	EG	EG	CS	TD	AP
CS	AP	TD	CS	CS	AP	CS	CS
AP	CS	LL	EG	TD	LL	AP	EG
TD	LL	LL	TD	TD	AP	EG	AP
LL	EG	CS	EG	LL	CS	LL	CS
LL	TD	LL	CS	AP	AP	CS	TD
EG	EG	AP	EG	AP	TD	CS	LL

TREATMENT CODES

HM Hydromulch
JM Jute matting
FT Soluble fertilizer
SF Slow release fertilizer
CP Compost
RC Control
.5C 1/2 Control rate
2C 2X Control rate

SPECIES CODES

AP *Artemisia pycnocephala*
CS *Calystegia soldanella*
EG *Erigeron glaucus*
LL *Lathyrus littoralis*
TD *Tanacetum douglasii*

Table 2: Monoculture application rate and approximate number of seeds per plot.

Species	Monoculture rate (lbs./acre)	Approximate seeds per 1m2 plot
Abronia latifolia	40	200
Ambrosia chamissonis	30	250
Artemisia pycnocephala	10	6800
Calystegia soldanella	20	44
Camissonia cheiranthifolia	1	930
Erigeron glaucus	15	5500
Eriogonum latifolium	15	5540
Lathyrus littoralis	20	30
Tanacetum douglasii	20	3760

Analysis of second year cover results followed methods utilized in the Phase One analysis (Pickart 1986). A One-Way ANOVA was performed for each individual species to identify significant differences among treatments ($p < .05$), followed by multiple comparison tests to locate differences. These tests permitted an assessment of longer term (two year) effectiveness of treatments used. Limited comparisons could be made between first and second year results using this test by identifying changes in significance levels for species between first and second years. To more precisely identify changes between first and second year cover, a paired t-test (Zar 1984) was used to compare individual species-treatment means.

RESULTS

A one-way ANOVA was performed on second year cover data for each species to identify significant differences between treatments. The analysis revealed significant differences ($p < .05$) in cover among treatments for six of the nine species. The three species which did not exhibit signifcant differences were *Erigeron*, *Calystegia*, and *Lathyrus*. These three species also failed to exhibit differences among treatments in the first year cover analysis. In the first year, *Eriogonum* also failed to show significant differences, but by the completion of second year monitoring, one treatment for this species exhibited significantly higher cover.

Figures 4-9 illustrate the results of multiple comparison testing (Spojotvall and Stoline's T′ method) (Sokal and Rohlf 1981) to locate significant differences ($p < .05$). Upper and lower comparison limits around the mean of each treatment are plotted in order of increasing means (Sokal and Rohlf 1981). Where the comparison limits of two treatments overlap, the two treatments are not significantly different. A dotted line is shown on the graphs where significant differences occur; treatment intervals below the line are significantly different from those above. For most species two groups of treatments of relatively higher and lower cover occur. Because intervals around the mean are plotted, comparison limits may exceed 100% cover (e.g. in cases where mean cover is very high). The actual cover value (mean) falls in the center of the interval and will never exceed 100%.

Treatment trends for the second year are more pronounced than the first year. For four of the six species exhibiting significant differences, slow-release fertilizer is the only treatment which distinguishes itself, in that it is the only treatment which exhibits a significant difference in cover for all six species. Cover for slow-release fertilizer was significantly higher than all other treatments for *Camissonia*, five of eight treatments for *Eriogonum* and *Tanacetum*, and two of eight treatments for *Abronia*. In the case of *Ambrosia*,two treatments (hydromulch and slow-release fertilizer) were significantly higher than all other treatments, and for *Artemisia* three treatments (hydromulch, compost and slow-release fertilizer) were significantly higher than all other treatments.

To identify cover changes between the first and second year a paired t-test was performed on each set of replicates for a given species treatment. Significant differences between year 1 and year 2 ($p < .05$) are shown in Table 3, and species/treatment means (for both years) are shown in Table 4. A significant positive cover increase is denoted by + and significant cover loss is indicated by -. Trends were observable for only two species: *Artemisia* (cover increase for six of eight treatments) and *Camissonia* (cover loss for three of eight treatments). *Eriogonum* exhibited a mixture of cover increase (two treatments) and cover loss (two treatments). No trends are detectable for treatments independent of species.

Figure 4: Results of multiple comparisons for *Lupinus latifolius*.

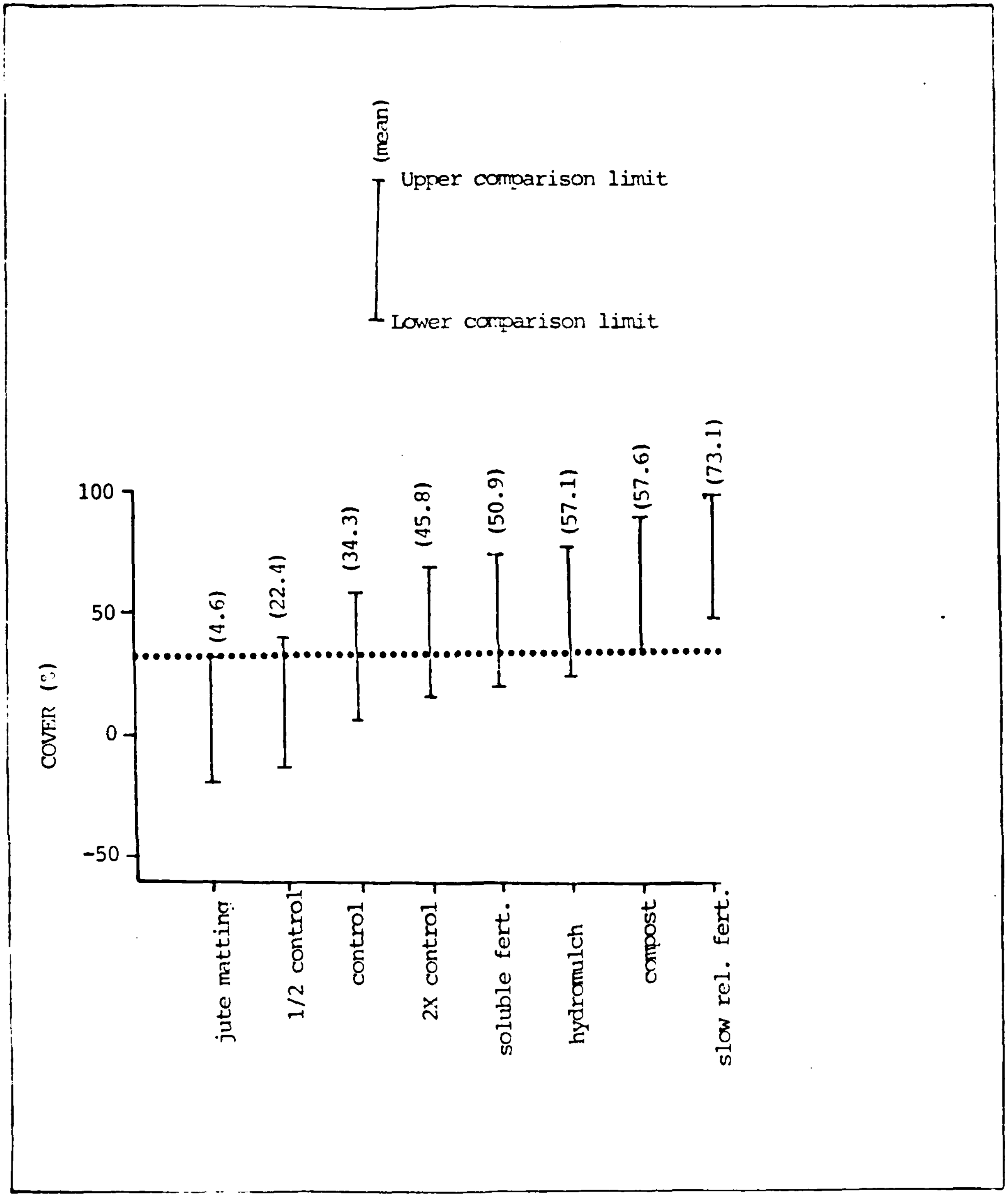

Figure 5: Results of multiple comparisons for *Ambrosia chamissonis*.

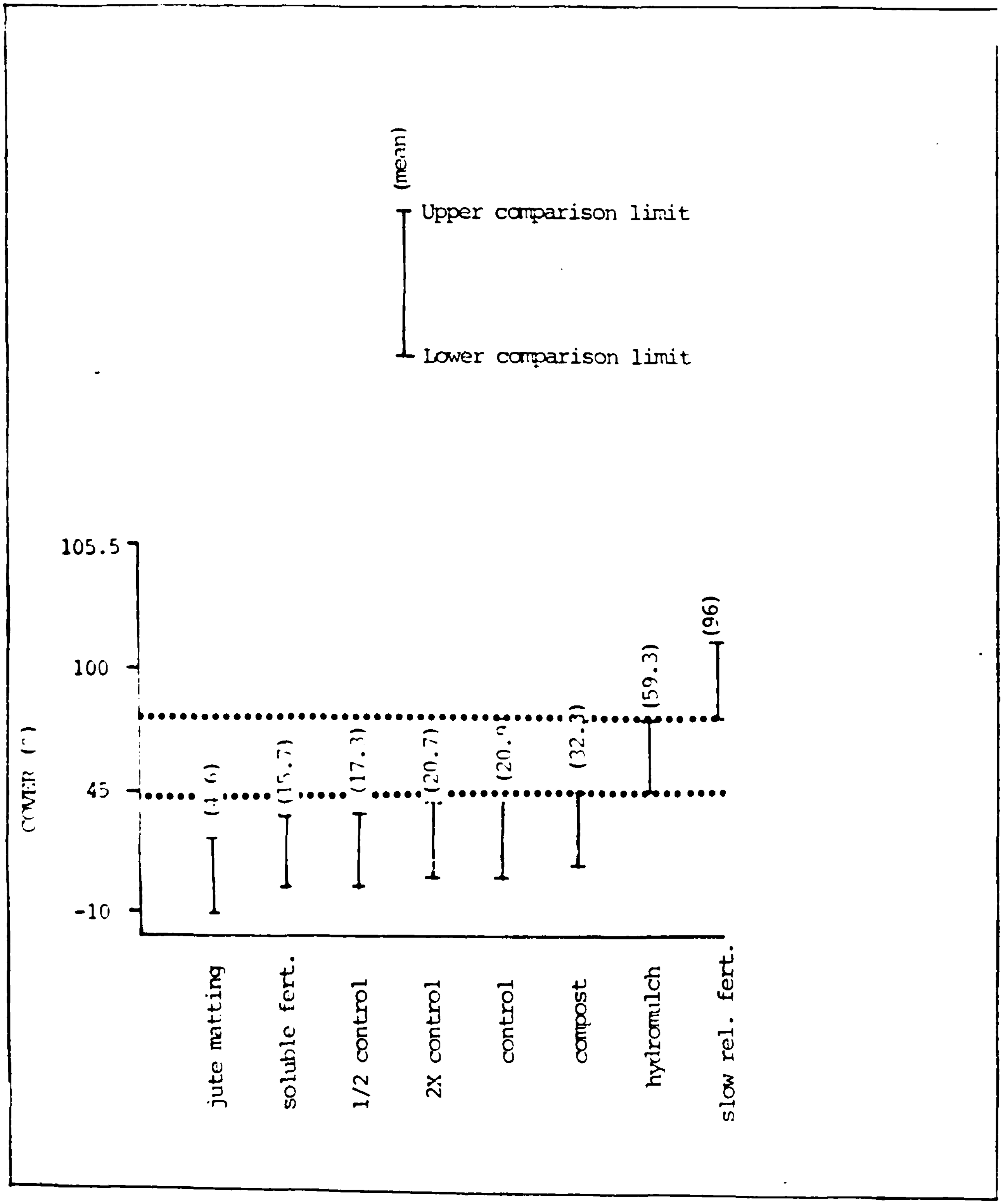

Figure 6: Results of multiple comparison for *Artemisia* [illegible].

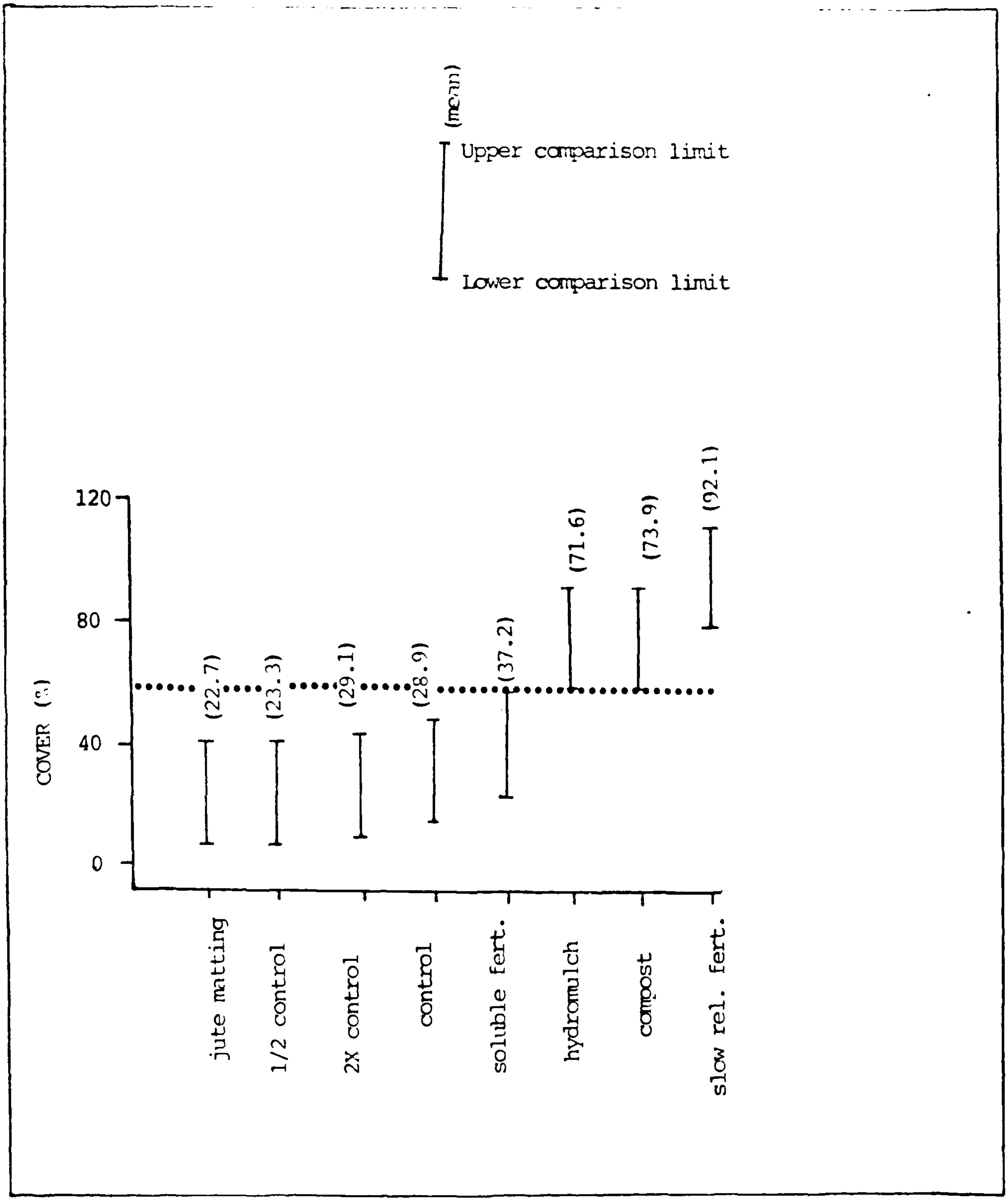

Figure 7: Results of multiple comparison for [illegible]

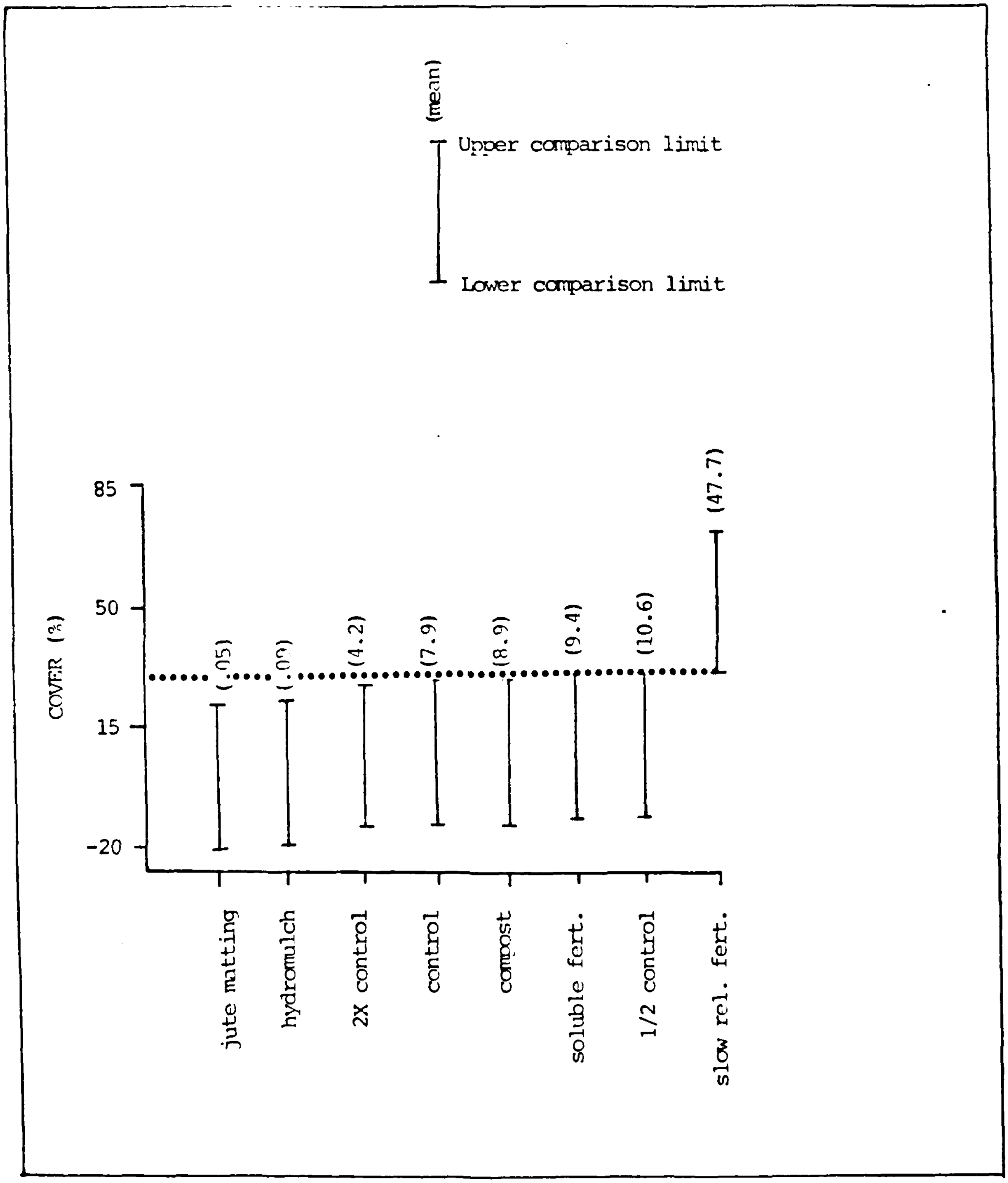

Figure 6: Results of multiple comparison for _[illegible] latif[illegible]_ .

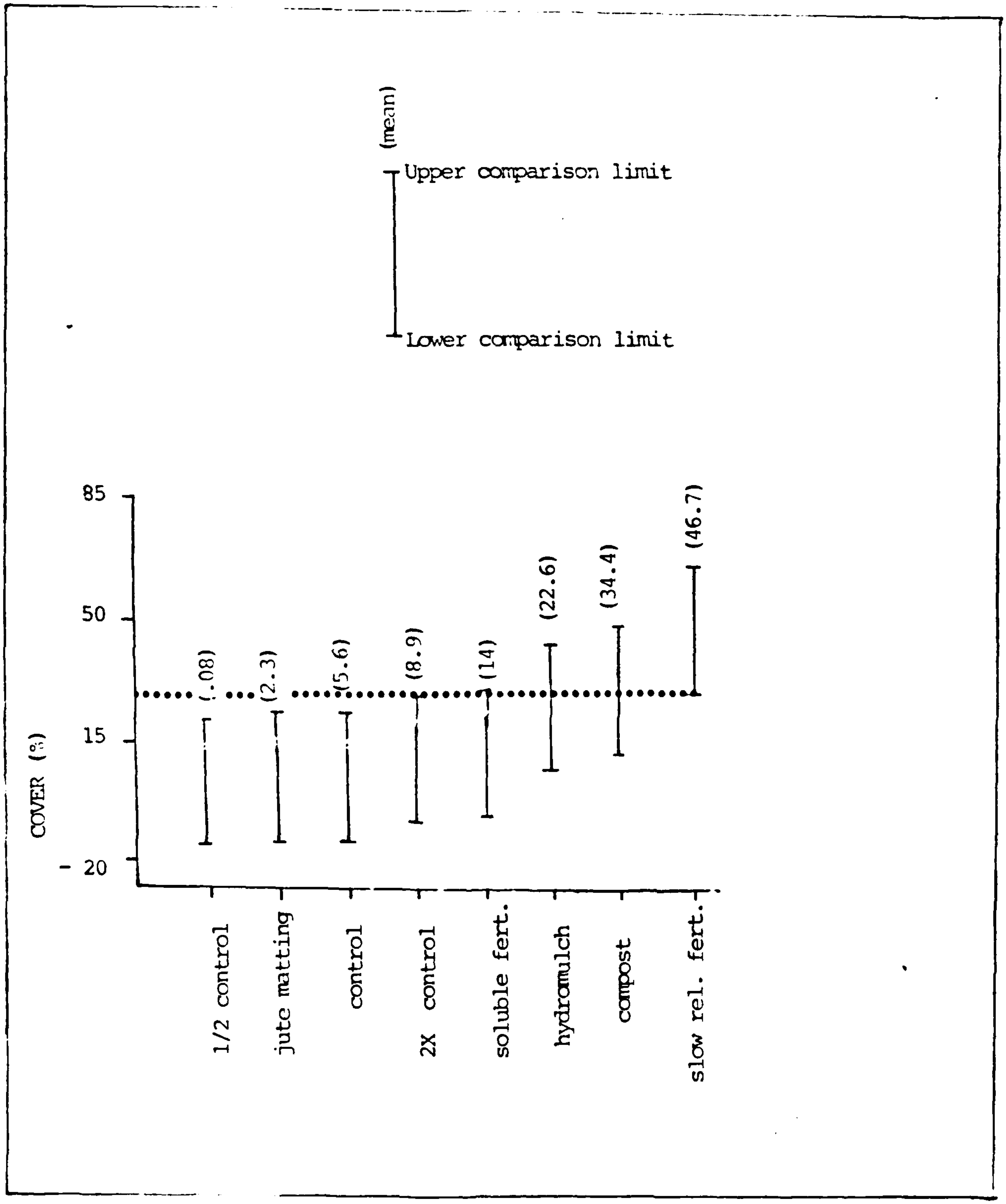

Figure 9: Results of multiple comparison for *[illegible]* *[illegible]*.

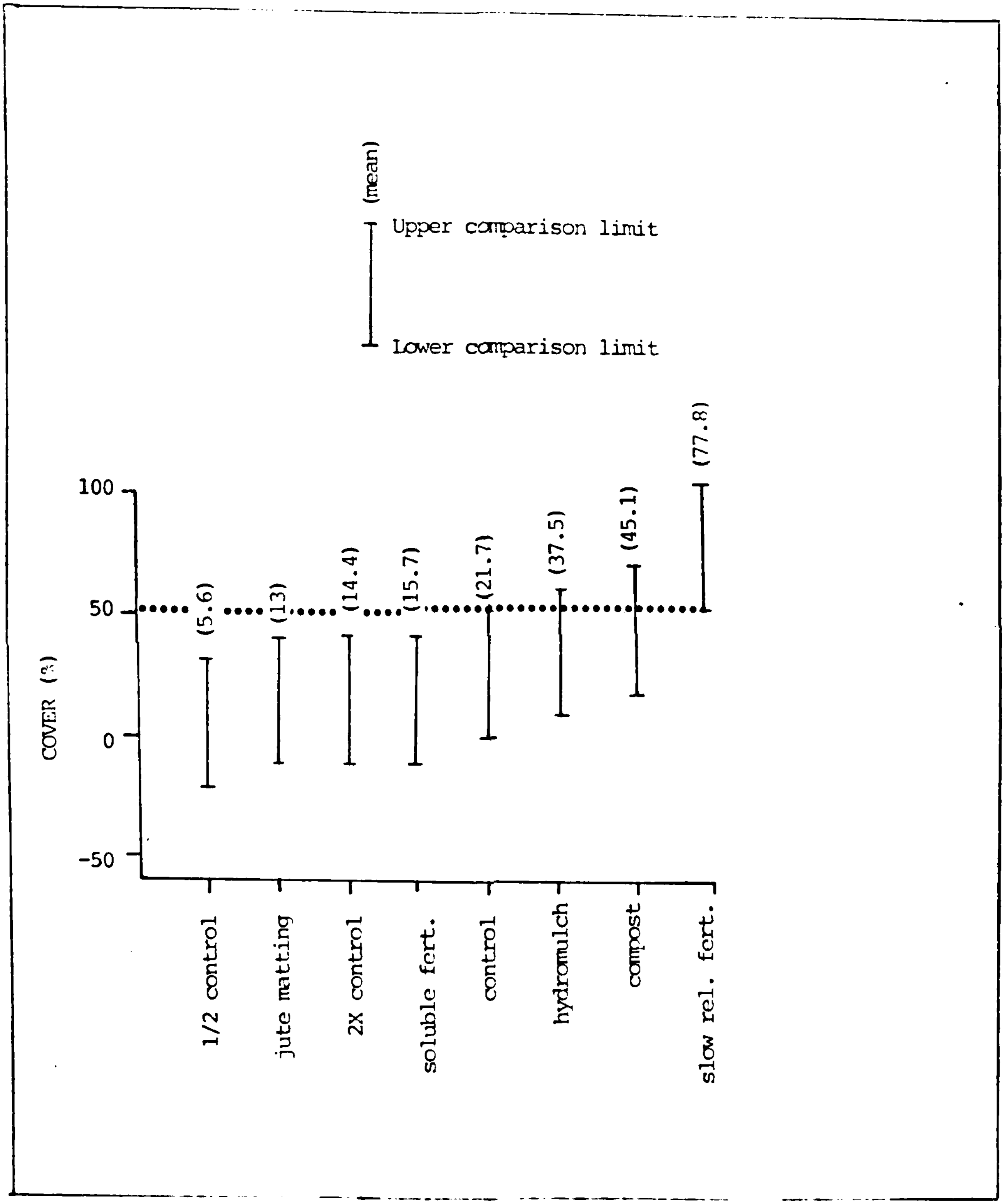

Table 3: Results of paired t-tests to identify significant cover changes from year 1 to year 2. Significant cover increases ($p < .05$) are indicated as +, significant losses are shown as -.

	HM	JM	FT	SF	CP	RC	.5C	2C
Abronia latifolia								
Ambrosia chamissonis								
Artemisia pycnocephala		+	+		+	+	+	+
Camissonia cheiranthifolia			-		-	-		
Calystegia soldanella								
Erigeron glaucus							+	
Eriogonum latifolium		-		+	+	-		
Lathyrus littoralis						+		
Tanacetum douglasii							+	

Treatment codes:
HM: hydromulch
JM: jute matting
FT: soluble fertilizer
SF: slow release fertilizer
CP: compost
RC: control
.5C: 1/2 control application rate
2C: 2x control application rate

Table 4: Mean cover (in percent) for first (1) and second (2) year monitoring.

	HM		JM		FT		SF		CP		RC		.5C		2C	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Abronia latifolia	51	65	9	5	59	51	74	73	90	77	23	34	19	22	26	40
Ambrosia chamissonis	58	59	5	5	19	16	76	96	30	32	15	21	8	17	11	21
Artemisia pycnocephala	18	36	15	23	27	37	64	93	51	74	22	29	15	23	20	29
Camissonia cheiranthifolia	29	1	4	1	41	9	62	27	81	9	20	8	17	11	14	4
Calystegia soldanella		*	1	3	1	2	5	4	1	1	1	1	1	1	4	3
Erigeron glaucus	18	29	1	3	2	4	6	30	1	6	4	9	0	1	3	5
Eriogonum latifolium	22	23	6	2	12	14	22	47	20	34	9	6	7	1	9	21
Lathyrus littoralis	21	31	10	17	5	20	8	8	11	8	20	44	7	29	15	36
Tanacetum douglasii	41	37	8	13	13	16	66	78	35	45	17	22	4	6	11	14

* n=1 due to poor germination, sample size too small too test

DISCUSSION

The results of the second year cover analysis differ from the first year in that slow-release fertilizer is more clearly distinguished from all other treatments. In the first year, all enhanced nutrient treatments (hydromulch, soluble fertilizer, slow-release fertilizer and compost) resulted in significantly higher cover for all species which exhibited significant differences among treatments. In the second year, only slow-release fertilizer showed consistently higher cover. Hydromulch and compost were significantly higher than all treatments except slow release fertilizer for one or two species.

Another difference between first and second year results is the presence of significant differences in cover for Eriogonum. In the first year this species attained only moderate stature even under fertilized conditions and was therefore not distinguished from the control. By the end of the second year the slow-release fertilizer treatment was significantly higher in cover than all treatments except hydromulch and compost.

These trends are easily explained by the nature of the treatments applied. Leaching of nutrients occurred in all fertilized plots during the 85-86 winter. Although the slow-release formulation is specified at four months, nutrient testing during the winter indicated that nutrient levels were still very high 9 months after application and despite the leaching effect of rains (Clark 1986). Only the slow-release fertilizer treatment provided adequate nutrient levels for maintenance and/or continued growth in the second year. This conclusion is not clearly supported by the results of the paired t-tests. Trends for different treatments are not detectable using this test. However, if individual means are considered (Table 4), these trends may be observed. The high variance and low sample size of species/treatment plots prevented these differences from appearing significant.

The paired t-test did provide two interesting species observations. Artemisia was the only species to show significantly higher cover the second year, while Camissonia exhibited cover losses, even under the slow-release fertilizer treatment. Unlike many dune perennials such as Ambrosia, Abronia and Camissonia, Artemisia does not die back in winter months, which would account for significant cover gains in the second year. However, the ability of the species to significantly increase in cover the second year even under control situations indicates that it is very effective in exploiting low levels of nutrients. The significant losses shown by Camissonia are the result of second year growth falling far short of first year growth. The prostrate stems of this species die off in the winter months, leaving only the central rosette. In some cases the first year rosette died also, but when it survived it frequently showed poor growth, presumably the result of decreased nutrient levels. Eriogonum showed conflicting results of cover gain and loss, but these results are consistent with expectations when treatments are examined. Losses occurred under jute matting and control situations, while increases resulted in slow-release fertilizer and compost treatments. Like Artemisia, this species does not die back in winter, so cover increases would be expected under at least the slow-release fertilizer treatment. Losses in jute matting and control situations were due to high levels of mortality of young plants. These individuals showed severe nutrient depletion symptons in the first year and did not survive the second year.

SUMMARY

Results from the second year are consistent with expectations based on first year results. The superiority of the slow-release fertilizer treatment with respect to cover is greater in the second year. This is due to the extended nutrient release period. Other fertilized treatments (hydromulch, compost, soluble fertilizer) suffered from decreased nutrient levels the second year. In an actual planting project, it is assumed that soluble fertilizers would be reapplied in the second year, which would probably reduce the margin of superiority of slow-release fertilizer.

Of the species tested, Artemisia showed the greatest trend toward significant cover increase. Abronia, Ambrosia and Lathyrus retained their original high cover values, Calystegia, Erigeron and Tanacetum retained their original low values, and Camissonia showed decreased cover values from year 1 to year 2. Eriogonum showed losses under controls and increases under several fertilized treatments.

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Clark, K. 1986. Buhne Point Nutrient Analysis. Humboldt County Public Works Department.

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APPENDIX D

PHASE III PLANTING

PHASE III PLANTING,

BUHNE POINT SHORELINE

EROSION DEMONSTRATION PROJECT

DECEMBER 20, 1986

ARTEMISIA PYCNOCEPHALA

Gail Newton and Associates
Biological Consultants
P.O. Box 234
Arcata, CA
95521

ation Mapping • Rare Plant Survey • Habitat Analysis • Revegetation • Mitigation Design & Implementation (707) 442-4158

PHASE III PLANTING:

BUHNE POINT SHORELINE EROSION

DEMONSTRATION PROJECT

LOCATION:	HUMBOLDT BAY, HUMBOLDT COUNTY, CALIFORNIA
SUBMITTED TO:	COUNTY OF HUMBOLDT DEPARTMENT OF PUBLIC WORKS NATURAL RESOURCES DIVISION 1106 SECOND STREET EUREKA, CALIFORNIA 95501
DATE:	DECEMBER 19, 1986
SUBMITTED BY:	GAIL NEWTON AND ASSOCIATES BIOLOGICAL CONSULTANTS P.O. BOX 234 ARCATA, CALIFORNIA 95521

INTRODUCTION

In 1984, an artificial dune system was created from dredge spoils at Buhne Point to protect an area known as King Salmon from tidal erosion. The dune system was planted with native species in April 1985 (Phase I), November 1985 (Phase II), and in December 1986 (Phase III). The contents of this report discusses the final (Phase III) planting which took place on December 18, 1986.

The purpose of the Phase III planting was twofold: to stabilize an unvegetated area on the north end of the project site and to investigate fertilizer application rates. The unvegetated area, which totals 1.691 acres, is bounded by the north jetty on the east side, Buhne Drive on the south, the fence line on the west, and the beach berm on the north (see Map 1). The area was seeded with a prescribed seed mix applied at 20 pounds/acre and fertilizer (Osmocote 13-13-13) applied at three rates, 400, 200, and 50 pounds/acre. The mulch (Spra-mulch) was applied at a total of 2000 pounds/acre, in one application of 500 pounds/acre and one of 1500 pounds/acre.

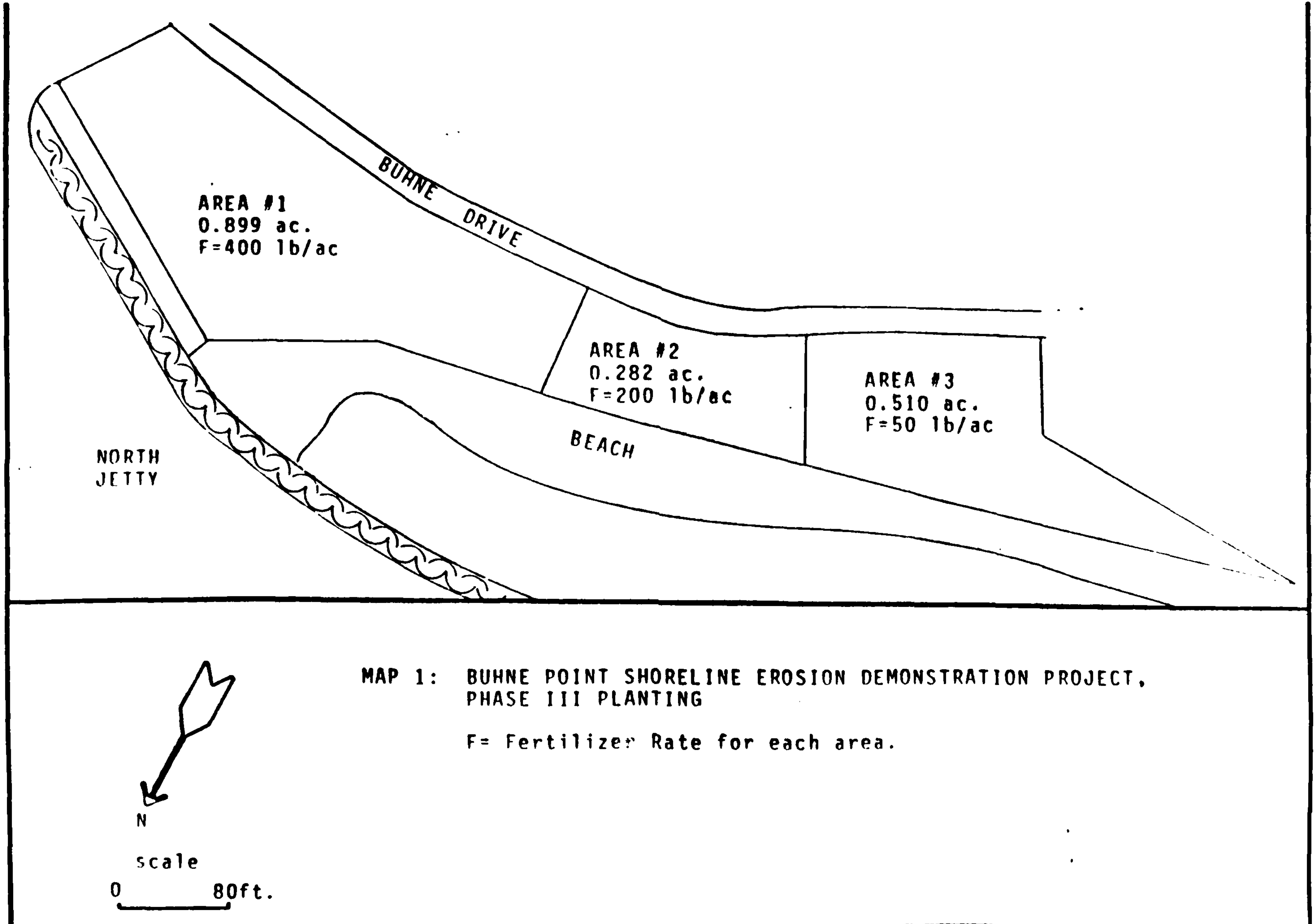
PLANTING DESIGN

The site was divided into three areas based on placement of the existing sprinkler heads, in the event the Harbor District decides to irrigate the plantings. These areas are referred to, beginning from the north end, as area #1 (0.899 acres), area #2 (0.282 acres), and area #3 (0.510 acres). Area #1 was fertilized at 400 pounds/acre, area #2 was fertilized at 200 pounds/acre, and area #3 was fertilized at 50 pounds/acre. (See Map 1.)

Prior to seeding of the areas, the hydro-seeder and hoses were rinsed three times as observed by the consultant and were verified to be as free from contaminants as possible. Each area was then hydro-seeded by Cal-Kirk using the fertilizer and seed mix weighed and provided by GNA; the mulch (500 pounds/acre) was weighed and provided by Cal-Kirk. Following the seeding, all areas were hydro-mulched with the remaining Spra-mulch (1500 pounds/acre).

FERTILIZER APPLICATIONS

The Phase I Planting evaluated different types of fertilizer, resulting in the recommendation of Osmocote 13-13-13. The Phase II Planting experimented with four different seeding methods and five different fertilizer rates. Due to an overapplication of seed mix in Phase II, the five different



MAP 1: BUHNE POINT SHORELINE EROSION DEMONSTRATION PROJECT, PHASE III PLANTING

F= Fertilizer Rate for each area.

fertlizer rates could not be adequately evaluated. Therefore, the Phase III Planting was designed to investigate three different levels of fertilizer application, 400 pounds/acre in area #1, 200 pounds/acre in area #2, and 50 pounds/acre in area #3. The seed mix, which is discussed in the following section, was held constant through all areas.

DISCUSSION ON SEED MIX APPLICATIONS

The seeds used for the Phase III Planting were left over from the Phase I and Phase II Plantings. These seeds were treated with a fungicide and an insecticide and stored in airtight containers in a vacant county building. The air temperature and humidity of the building were not controlled; therefore, the storage conditions were less than optimum. To ascertain losses in seed viability under these storage conditions with time, ten seed samples were sent to the State Seed Lab for testing. The results of the 1986 seed tests as well as results from 1985 seed tests are presented in Appendix 1. The results seem to indicate that *Artemisia* collected in 1984 lost about 50% viability from 1985 to 1986. Therefore, *Artemisia* collected in 1985 was used for the Phase III Planting.

The species mixture and application rates are listed in Table 1. The monoculture application rates used are those suggested by Pickart (1986a) where quantities were not limiting. These seed application rates are somewhat different from the Phase I and the Phase II rates.

TABLE 1: SEED APPLICATION RATES FOR PHASE III PLANTING

SPECIES	MONOCULTURE APPLICATION RATE	POUNDS/ACRE
Abronia latifolia	40	7.22
Ambrosia chamissonis	30	5.42
Artemisia pycnocephala	5	0.90
Camissonia cheiranthifolia	1.5	0.271
Erigeron glaucus	2*	0.361
Eriogonum latifolium	10	1.80
Lathyrus littoralis	1.5*	0.271
Solidago spathulata	20	3.61
Tanacetum douglasii	0.7*	0.127

* quantities limiting

MIX APPLICATION RATE:

The seed mix was applied at 20 pounds per acre in the Phase III Planting. Pickart (1986a) suggested that the mix be sown at a rate of 25 pounds of mix/acre. The Phase I mix was applied at 20 pounds/acre and did not contain *Artemisia*. *Artemisia* has proven to be a very competitive species. The overall coverage of the Phase I Plantings was observed to be close to optimum. The overall coverage of the Phase II Plantings was far too dense and comprised mainly *Artemisia* and *Camissonia* (previously discussed in Qualitative Evaluation of Phase II Planting, Pickart 1986b). Based on the cover values obtained in the Phase I Planting and the addition of *Artemisia* to the mix, I believe 20 pounds/acre of mix will yield better results than 25 pounds/acre.

QUANTITY OF EACH SPECIES WITHIN MIX:

The Phase I Planting Document (Newton 1985) discussed the critical nature of the seed mix: "The rate at which the seeds are sown is critical. If the rate is too low, there will be too few plants to cover the area. If the rate is too high, competition among plants may reduce the size and quality of surviving plants." The latter problem of too high rates can currently be observed on the site--the Phase II Plantings.

To understand the difference between the Phase I Planting and the Phase II Planting, one needs to review the rates at which each species was sown and the actual field application rate of the mix (See Table 2). In summary, all seeds of the Phase II Planting were to be applied at 25.3 pounds/acre and the monoculture rates were changed somewhat; however, in the field the mix was overapplied resulting in even higher rates throughout. When developing seeds mixes, one must pay close attention to the recommended monoculture application rates and the resulting poundage of seed for each species applied per acre. A small change in the monoculture application rates and/or a change in the number of species in the mix will correspondingly change both the ratio of each species within the mix and the resulting pounds/acre. When reviewing Phase II data in Table 2, it is obvious that the pounds/acre of *Artemisia* and *Camissonia*, which both have literally millions of seeds/pound, are extremely high when compared to the Phase I rates.

Another factor to take into consideration when comparing the application rates of Phase I and Phase II is the "functional" pounds/acre of mix. The Phase I Planting contained four species which did not germinate the first season in any appreciable quantities (*Calystegia soldanella*, *Erigeron glaucus*, *Orthocarpus purpurascens* var. *latifolius*, and *Polygonum paronychia*). Therefore, the "functional" poundage of mix/acre, or the pounds of seeds applied of germinating species, was only 15.5 pounds/acre. The corresponding functional poundage of mix/acre for Phase II was planned to be 25.3, but was actually 33 and 40 pounds/acre (due to overapplication of the seed mix).

SPECIES	# SEEDS/POUND[3]	PHASE I: PLAN @ 20LBS/AC AND FIELD MONO	PHASE I: PLAN @ 20LBS/AC AND FIELD LBS/ACRE	PHASE II: PLAN AT 25.3LB/AC MONO[1]	PHASE II: PLAN AT 25.3LB/AC LBS/ACRE	PHASE II: FIELD AT 33LBS/AC LBS/ACRE	PHASE II: FIELD AT 40LBS/AC LBS/ACRE
ABLA	20,348	40	3.982	40	7.059	9.207	11.160
AMCH	34,270	30	2.976	35	6.199	8.086	9.801
ARPY	1,829,822	(15)[2]	(1.493)[2]	19	3.416	4.456	5.401
CACH	3,729,726	1	0.100	2	0.354	0.462	0.560
ERLA	384,199	15	1.493	15	2.657	3.466	4.201
LALI	5,874	20	1.991	10	1.695	2.211	2.680
SOSP	N/D	15	1.493	15	2.707	3.531	4.280
TADO	748,440	20	1.991	7	1.214	1.583	1.919
CASO	8,908	20	1.991	—	—	—	—
ERGL	1,486,674	15	1.493	—	—	—	—
ORPU	N/D	5	0.498	—	—	—	—
POPA	72,228	20	1.991	—	—	—	—

MONO=Monoculture application rate; PLAN=Planned application rate; FIELD=Actual (Field) application rate.

For Key to Species Codes see Appendix 2.

1 Monoculture application rates for Phase II are approximate.

2 ARPY was not included in the general mix in Phase I but was included in the mix applied in the experimental plots at the above rates in Phase I.

3 Number of Seeds/Pound from Pickart (1986a) with the exception of POPA, which is from Newton (1986b).

MONITORING

I suggest that the Phase III Planting be monitored for a minimum of one year. Monitoring of the site would be ideal for an HSU student's senior thesis. Contact with the Biology and/or Natural Resources Department at HSU should be made by Feburary 1987 to arrange for the monitoring study. The monitoring should consist of permanent plots established within each area and sampled as to:

1. Date of 50% emergence.
2. Vegetation height.
3. Total vegetation cover.
4. Plot species composition and cover.

REFERENCES

Newton, G.A. 1985. Phase One Planting: Methods and Cost Analysis. Buhne Point Shoreline Erosion Demonstration Project. Unpublished report available from Humboldt County Department of Public Works, Natural Resources Division.

Pickart, A. 1986a. Phase One Monitoring Report, Buhne Point Shoreline Erosion Demonstration Project. Unpublished report available from Humboldt County Department of Public Works, Natural Resources Division.

Pickart, A. 1986b. Qualitative evaluation of Phase Two Planting, Buhne Point Shoreline Erosion Demonstration Project. Unpublished report available from Humboldt County Department of Public Works, Natural Resources Division.

APPENDIX 1: SEED VIABILITY: DATA FROM THE STATE SEED LAB

SPECIES	1984 SEEDS TESTED IN 1985		1984 SEEDS TESTED IN 1986		1985 SEEDS TESTED IN 1986	
	VIABLE	NON-VIABLE	VIABLE	NON-VIABLE	VIABLE	NON-VIABLE
ARLA	47%	53%	51%	49%	37%	63%
AMCH	38%	62%	22%	78%	40%	60%
ARPY	88%	12%	48%	52%	89%	11%
CACH	95%	5%	80%	20%	66%	34%
SOSP	91%	9%	29%	71%	31%	67%

For Key to Species Codes see Appendix 2.

Due to the large amount of extraneous factors included in these tests, there can be no conclusive data as to loss in viability with time. However, it seems likely that the small-seeded species (ARPY, CACH, SOSP) should loose viability with time. Given the above values, it is probable these data do indicate a significant loss of viability for 1984 ARPY between 1985 and 1986.

APPENDIX 2: SPECIES CODES

SCIENTIFIC NAME	CODE	COMMON NAME
Abronia latifolia	ABLA	yellow sand verbena
Ambrosia chamissonis	AMCH	beach bur
Artemisia pycnocephala	ARPY	beach sagewort
Calystegia soldanella	CASO	beach morning glory
Camissonia cheiranthifolia	CACH	beach evening primrose
Erigeron glaucus	ERGL	seaside daisy
Eriogonum latifolium	ERLA	seaside buckwheat
Lathyrus littoralis	LALI	beach pea
Orthocarpus purpurascens var. latifolius	ORPU	owl's clover
Polygonum paronychia	POPA	beach knotwort
Solidago spathulata	SOSP	goldenrod
Tanacetum douglasii	TADO	dune tansy

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