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DYNAMICS OF THE RECOVERY OF DAMAGED TUNDRA VEGETATION

Preliminary results of revegetation experiments of maritime tundra with *Elymus mollis* on Adak Island, Alaska.

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PROGRESS REPORT

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Abstract

The vegetation of the central Aleutian Islands, Alaska is maritime tundra (Amundsen, 1977). While maritime tundra is not characterized by the presence of permafrost, the soil temperatures remain low (5-7^0 C) year around (Williams, 1980). The low soil temperature, a high level of soil moisture, and a low level of incident solar radiation are thought to delay the development of the vegetation. Natural revegetation of natural or man made open areas is relatively slow. Disturbed areas from World War II military activity are not completely revegetated after almost 40 years. Because of the windy and wet climate of the region, exposed soil is unstable and subject to extensive freeze-thaw action and erosion. Insults to the vegetation, both marine and aeolian, are common.

Successful reproduction by seed is uncommon among species of this flora. The primary means of reproduction appears to be by vegetative propagules which are usually fragments of the shoot and rhizome. While the transport of the fragments by wind and water aids in the dispersal of the propagules, the same action often removes these fragments from open areas. This later activity further delays the revegetation of open and disturbed areas.

Elymus mollis Trin. is the most successful major native species found to date as it fragments due to wind and water action and transplants easily. Transplanting experiments with sprigs of *Elymus mollis* Trin. have been conducted on Adak Island, Alaska since 1977. Preliminary results indicate that *Elymus mollis* may be transplanted for revegetation with a survival rate of at least 90 percent. Experiments were set up in 1979 to determine appropriate planting density, sprig rhizome length, and best time of year for transplanting. Preliminary results for these experiments are reported here. The length of the rhizome is the only clearly significant result through 1981. Treatment effects are expected to be more fully evaluated in future growing seasons.

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Introduction

Natural recovery of the maritime tundra in disturbed areas of the Aleutians is very slow (Amundsen and Clebsch, 1971; Amundsen, 1977; Williams, 1980). Disturbances from the 1940's through the present may be easily noted on the landscape and dated from construction reports. Due to the low energy budget climate of the Aleutians, and limited sexual reproduction of most species, meaningful recovery of vegetation must be aided by the active efforts of man.

The native flora of the region was surveyed for potential species for revegetation. Introduced species were not considered because currently introduced species in the region are not vigorous without active, continuing management, and the introduction of new species in a region of mostly natural vegetation is not ecologically advisable. Additional criteria for potential revegetation species are:

1. Natural colonizers of open areas
2. Possess root and shoot structures sufficient to stabilize the soil on a year around basis
3. May be artificially propagated
4. Can be planted or transplanted with acceptable success

Elymus mollis Trin., a beach grass of the native flora, meets all of these criteria fairly well. It is the dominant plant in the dune community and is commonly found naturally colonizing other open and disturbed areas (Amundsen, 1977 or 1977 report).

Research on the practicality of using beach grass for revegetation began in 1977 (1977 and 1978 reports, Williams, 1980) on Adak Island, Alaska (51^0 55' N, 176^0 40'W). Trial transplanting in 1977 at the beach near the Adak townsite demonstrated in the 1978, 1979 and 1980 growing seasons that the species could be transplanted with a survival of at least 90 percent when not further disturbed. The initial transplant plots have also shown mineral soil stabilization potential.

In 1978 several additional test plots were established in different soil types with different planting methods. Test plots, each of 60-80 sprigs of Elymus mollis, were

planted on gravel fill, exposed peat and in an abandoned quonset site. A small hole was dug for each plant. A sprig of beach grass consists of a portion of the shoot, rhizome and roots. In the 1979 growing season, 98 percent of 210 sprigs were surviving with new growth sufficient for maintenance of the original shoots and the production of three to five new tillers on each of the test areas. Similar survival continued through 1980 and was observed and photographed in 1981.

Beach grass sprigs were also transplanted to terrace areas at higher elevations on Mt. Moffett in July, 1978 by being pinned to the surface of bare areas and over other vegetation. Ninety percent of the 20 plants pinned in each area were surviving in the 1979 growing season. Twenty additional plants were also transplanted by digging holes into the bare area. All of these planted sprigs were surviving in 1980.

Adjacent to the 1977 planting on the beach near the Adak townsite, a plot of 80 rhizome pieces, with all green shoot material removed, were planted in sand in September, 1978. During the summer of 1979, a total of 72 of these plants were observed with aboveground shoots. However, the shoot production of 20 percent of these individuals may not be sufficient for survival to the next growing season. Construction has since destroyed this test site.

Background

In the course of our continuing programs on the patterns and processes of disturbed landscape maritime tundra revegetation, we have undertaken a study of natural revegetation by Elymus mollis Trin., the native dunegrass, in the Aleutian ecosystem. This species is the dominant member of the beach and dune community where it forms dense stands of high biomass (see map in Appendix). The species has also been observed, throughout our years of research, established on disturbed areas inland. These

disturbances may be the bare surface of solifluction terraces or they may result from vegetation removal and scarring as the result of man's activities. Much of the damage resulted from World War II occupation. The surprising aspect of dunegrass colonization on such areas is the presumed depauperate nutritional supply and harsh climate the species encounters. Considering the success of this grass in natural colonization, it is our suggestion that with careful management, Elymus mollis can be shown to be useful in revegetation programs in the Aleutians. Such a revegetation operation could easily be feasible in other areas of its natural range based upon extrapolations of our data.

The importance of using native species in conservation programs has been well discussed by Mitchell (1973). Native species succeed in a region through the long, intricate process of evolution. By natural selection, the most fit individuals are selected for in a specific environment. This is especially true in the extreme Aleutian Islands environment. Introduced species, not native to the area, have not had the advantage of this selective evolution. By using native species successful recolonization at low maintenance cost may be achieved.

A second major consideration of the use of native species in revegetation programs is the conservation of the natural flora. It has been shown many times that introduction of an exotic species which results in a successful establishment may bring about major perturbations in the native vegetation. The potential success of an exotic is inherent in its competitive ability. If the exotic species is successful in establishment, some native species likely have been displaced. In California, the original grasslands of perennial bunch grasses have all but succumbed to introduced European weed species (Barbour and Major, 1977). The extremely high number of endangered and threatened taxa in Hawaii (over 800) is a product of native species being overtaken by exotic introductions (Ripley, 1975). The preservation of the native flora is of major importance in the overall concept of the Aleutian Chain as a National Wildlife Refuge

and International Biosphere Reserve (Franklin, 1976).

Experimental Inquiries and Strategies

After assessing the results of plantings in 1977 and 1978, a series of experiments were designed to determine the answers to several questions critical to the practical use of Elymus mollis for revegetation. These questions and experiments are as follows:

1. Does the density of transplanted individuals affect the success of revegetation of different types of disturbed areas? A series of transplant plots of densities ranging from 400 plants per square meter to 9 plants per square meter were established in three different types of disturbed areas, peat soil, mineral soil, and sand.

2. Does the length of the rhizome included with the transplanted sprig significantly affect transplant success? A series of transplant plots with rhizome lengths ranging from 2 to 14 cm. were planted at uniform densities.

3. Does the time of year of transplanting affect the success of transplanting? Plots of sprigs were transplanted and sampled for new growth and recovery from transplanting at two week intervals throughout the growing season.

4. Is there some part of the plant smaller than a sprig consisting of an aboveground shoot and attached piece of the rhizome which can be successfully transplanted? Plots of rhizome, rhizoid, and aboveground shoot pieces were planted in two types of disturbed areas.

Methods

1. Beach Grass Sprig Preparation. Sprigs of Elymus mollis were dug up for transplanting at an active sand mine near Clam Lagoon on Adak. The technique used for digging was to loosen the sand under the shoots to a depth of about 20 cm. The shoots

could then be pulled up with a 10 cm. or longer piece of rhizome attached. After removal from the sand the leaves were cut off about 10 cm. above the top of the leaf sheath. This is the sprig. Pruning the shoot is a common technique used in transplanting to increase the survival of sprigs. Pruning the shoot also aids the handling of the sprigs and allows more precise measurements of new growth after recovery from transplanting. A final step, often necessary, was to cut off excess rhizome material when the overall rhizome length exceeded 12-15 cm. It is difficult to plant beach grass sprigs with rhizomes of greater length.

2. Soil Preparation for Experimental Plots. The soil for all plots was spaded thoroughly to a depth of about 20 cm. The spading, turning over of the soil and removal of the large clods and rocks, was similar to methods commonly used in gardening. Holes for the individual sprigs were made by hand with a trowel. In all cases these holes were deep enough to transplant the sprig so that the base of the current leaf sheaths was below the soil surface. When possible, the sprigs were transplanted to their original depth.

Experimental Design and Results to Date

1. Density Plots. Plots of 6 densities of sprigs were planted in two types of disturbed areas in July, 1979. Each of these plots consisted of a grid of 49 sprigs with distances between plants of 5, 10, 15, 20, 25, and 50 cm. A series of density plots were planted in a disturbed peat site (a dump reclamation area) near Finger Bay and in a disturbed sand site near Zeto point. Plots with interplant distances of 5, 15, and 25 cm. were planted in mineral soil on an exposed ridge above an old quarry on Mt. Moffett.

Intensive measurements of new growth and survival in early September, 1979 indicated that the plants in plots with an interplant distance of less than 15 cm. tended to be more vigorous than the less dense plots. The increased vigor of the more dense plots is attributed to mutual protection from disturbance by wind. Significant differences ($p < 0.05$ from one-way anova) in new growth between locations were observed by early September, 1979. The full effect of the density treatments cannot be assessed until survival and growth after several winter seasons. In 1980 and 1981, 15 cm. spacing still proved optimal.

2. Rhizome Length Plots. Plots of sprigs with different rhizome lengths were planted in July, 1979 at the Finger Bay site. Each plot consisted of a grid of 49 sprigs with an intermediate distance of 10-15 cm. Four rhizome lengths of 2, 6, 10, and 14 cm. were used in treatments. The lengths were measured from the base of the current leaf sheaths.

The length of rhizome necessary for a successful sprig is important to know for two practical reasons. First it determines how much of the plant must be dug up from the source population. This digging is directly related to how much effort must be expended in sprig preparation. Rhizome length also determines how deep the soil of the revegetation site must be spaded and prepared. If long rhizomes were necessary and the soil at the revegetation sites was shallow, Elymus mollis would not be suitable for revegetation.

Preliminary results from measurement of new growth and survival indicate that the effect of rhizome length is not significant when the rhizome length is greater than six centimeters. The plot of sprigs with the two centimeter rhizome length had an increased proportion of dead plants in September, 1979 and a significiantly ($p < 0.05$ one-tailed t-test of two means) reduced amount of new growth. Once again the

treatment effect may not be fully observed until several growing seasons have passed. A rhizome length of six cm. still appears most practical through 1981.

3. Time of Year Transplants. During the period of early July to early September, plots of 36 sprigs each were planted at two week intervals (1979). These time of year plots were planted in three disturbances types, open peat, sand, and mineral soil. At two week intervals after planting, 6 plants from each plot were dug up and shoot elongation, and number and length of new roots were recorded as characteristics of early transplant success.

The time of year of transplanting was considered to be potentially important for two reasons. First the growing season in the Aleutians is short (mid-June to mid-September). The second reason is that samples of the height and air dry weight of natural populations of Elymus mollis indicate that the full above ground growth is complete early in the growing season. Since disturbance and revegetation activities are not restricted to this time period, it is important to know if Elymus mollis can be successfully transplanted at other times.

The only change observed in the biomass of beach grass during the growing season was a significant ($p < 0.05$ one tailed t-test of two means) greater rhizome density later in the season. This may indicate that material is being allocated to storage and not shoot production during the late growing season. Transplanting and resulting shoot growth during recovery may affect this biomass allocation pattern which may be essential for survival over several winters.

No consistent significant differences were observed between the time of year plots within any time period of sampling after planting. The number and length of new roots at the peat sites were significant ($p < 0.05$ one-way anova) between the planting periods when measured two weeks after planting. However, these differences

were not significant in later sampling periods through 1980. The length of new growth at the sand site was significantly ($p < 0.05$ one-tailed t-test of two means) different when sampled two weeks after transplanting. This difference was also significant at the end of the growing season in September, 1979.

The plants remaining in the time of year transplant plots were sampled in the 1980 growing season. This provided a more critical evaluation of the effect of the time of year on transplanting success, but no real response change was noted.

4. Transplanting Other Plant Parts. Because Elymus mollis has never been reported to produce viable seeds in the Aleutians (Williams, 1980), to check dispersal mechanisms numerous plots with fragments of rhizomes, rhizoids, shoots, and the culm region above and below the leaf sheath bases were also planted. An experimental series of different size pieces and planting depths was set up. This effort was made to discover if some smaller part than the sprig could be successfully propagated. The production of new individuals from smaller pieces of parent plant material would enhance the practical application of Elymus mollis for revegetation.

By early September, 1979, (and through 1981), no sprouts of beach grass were observed from the planting of plant pieces. However, new sprouts were observed from rhizome fragments that were collected after being washed up at the beach shoreline. When planted these fragments grew. This is an important discovery explaining the occurrence of transport of Elymus mollis from one area to another. New shoots of beach grass from wind transported rhizome fragments were also observed near the location of the transplant plots at Zeto Point.

Conclusions

The revegetation experiments with dunegrass on Adak Island Alaska have provided the following conclusions:

1. Sprigs, consisting of shoots, rhizomes, and roots, may be transplanted by either burial of rhizome and roots in the soil or by attachment of the same portions to the surface of the soil. Only rhizome length was statistically significant.

2. Transplanted plants have survived at least 3 years with a survival rate of greater than 90 percent over a wide range of soil types and planting conditions.

3. The short term success of revegetation efforts can be estimated from the survival rate observed 2-3 months after transplanting.

4. The critical region for vegetation propagation (successful transplanting) of dunegrass is a length of 3 cm. above and below the base of the leaf sheaths. Other rhizome fragments not containing this region will not survive (see No. 8 below).

5. Fragments of dunegrass can survive transplanting after transport in sea water.

6. The time of transplanting is not significant during July, August and early September.

7. The plants in higher spatial density plots are visably more vigorous and enhance the stabilization and retention of soil more than those in lower density plots. Spacing of 15 cm. seems optimal.

8. Rhizome lengths of 6 cm. are adequate and effective for sprigs used in revegetation.

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Introduction to Appendices

Research by biological scientists from the University of Tennessee began in the central Aleutian Islands in 1967 and has continued, now seasonally, to the present. When nuclear testing and follow-up assessments on Amchitka were concluded (as far as we were concerned) we shifted our research emphasis on vegetational dynamics, particularly recovery of disturbed areas, to Adak.

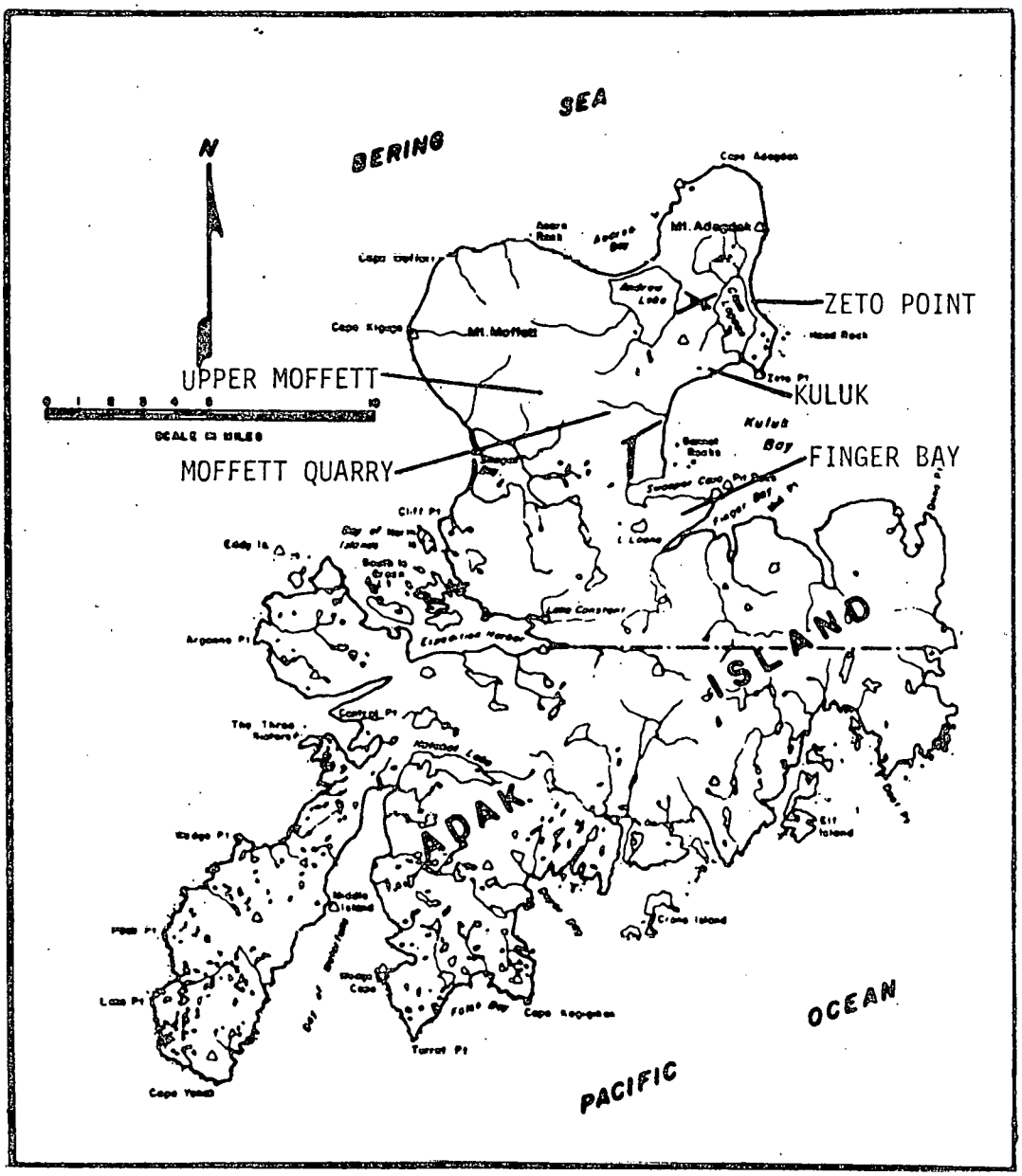
Although underground nuclear testing and associated support activities did cause some permanent damage to the Amchitka landscape, these perturbations were minor, when compared to the lasting evidence of landscape disturbances which occurred during World War II and for some time thereafter. An important part of our mission was to predict further negative alteration of the terrestrial (and aquatic) systems, particularly with increased economic development in the Bering Sea region.

To our knowledge, no other research on coastal vegetation (with the important exception of the work of Dr. William Mitchell and his team) is going on across north coastal Alaska. We believe we are the only Aleutian effort. We are particularly concerned with the vegetative recovery of disturbed sites, using native species.

List of Appendices:

1. General location of current study sites (map).
2. Photographs of representative transplant plots.
3. Tables indicating transplant variations, plant condition and transplant survival.
4. The Adak marsh.
5. Standard commercial planting mixes used previously.
6. Excavation and viability of *Elymus* roots.
7. Afforestation efforts.
8. Activities related to our studies.
9. Future (and current) hazards to Aleutian beaches.
10. Identification of nematode fauna found associated with *Elymus*.

Appendix 1.



Location of long-term transplant plots, beach and inland.

Appendix 2. Plates 1 - 5 showing *Elymus* transplant plots in 1981.

Plate 1. Elymus planted on mixed peat-mineral soil during July 1979. Site very exposed to wind. Frost heave and surface fluffing occur here. Picture August 1981. Finger Bay Dump.

Plate 2. High density planting 1979 on reclaimed peat soil. All plantings survive. Invaders are Achillea and Equisetum. Plot 1 m from closed vegetation. Finger Bay Dump. Picture August 1981.

Plate 3. Elymus planted on reclaimed peat-mineral soil, summer 1978. Plot at margin of closed vegetation. Calamagrostis and Achillea have become established in stabilizing Elymus. Picture August 1981. Finger Bay.

Plate 4. Sand and boulder overwash of Elymus plots as fore-dune was sea breached during late fall storm in 1980. Fourteen of sixteen plots survived 10 cm sand accumulation. Planted in 1979. Picture August 1981. Zeto Point.

Plate 5. Elymus plot surviving 1980 overwash shown in Plate 4. Planted 1979 with 15 x 15 cm spacing. Note foredune vegetation remnant caught on marker pipe (contains beach Honkenya) at left center. Pylon is 18" tall. Picture taken August 1981. Zeto Point.

Appendix 3. Four tables of measurements and survival of *Elymus* transplants through September, 1980.

Table 1. Revegetation Experiments with dunegrass on Adak Island, Alaska.

Location	Type of Treatment	Number of Variations	Number of Plants per Treatment
Upper Moffett	Planting Method	3	20
Finger Bay	Soil Type	3	64-80
Finger Bay	Time of Planting	5	36
Zeto Point	Time of Planting	5	36
Moffett Quarry	Time of Planting	4	20
Finger Bay	Planting Density	6	49
Zeto Point	Planting Density	6	49
Moffett Quarry	Planting Density	3	49
Finger Bay	Rhizome Length	4	49

Table 2. Average height and condition code of Elymus plants from each spatial density plot (1980).

Plot	Average height[A] (cm)	Average Condition[B]
Finger Bay 5x5[C]	11.6	2.9
Finger Bay 10x10	11.9	2.6
Finger Bay 15x15	8.6	2.2
Finger Bay 20x20	6.9	2.3
Finger Bay 25x25	6.2	2.0
Finger Bay 50x50	6.6	2.1
Zeto Point 5x5	9.7	3.0
Zeto Point 10x10	7.8	2.8
Zeto Point 15x15	5.6	2.4
Zeto Point 20x20	5.6	2.6
Zeto Point 25x25	3.6	2.1
Zeto Point 50x50	2.4	2.5
Moffett Quarry 5x5	5.5	2.3
Moffett Quarry 15x15	4.4	1.9
Moffett Quarry 25x25	4.0	D

[A] The height of the top of the leaf sheath was measured for 13 plants in each plot.

[B] All plants were coded in each plot. (0=dead, 1=poor, 2=average, 3=good).

[C] Inter-plant distance, centimeters.

[D] Plants were not coded in this plot (frost thrown).

Table 3. Survival rate of dunegrass transplants in revegetation experiments on Adak Island, Alaska

Experimental Unit	Number of Plants	Number Surviving in 1980	Percent Survival
1978 Plantings			
Moffett Upper Site, Planting Methods			
Pinned, bare soil	20	19	95.0
Pinned, in other vegetation	20	16	80.0
Planted grid (bare ground)	20	11	55.0
Total	60	46	76.6
Finger Bay, peat soil	64	59	92.1
Finger Bay, gravel soil	72	70	97.2
Quonset hole	82	80	97.5
Total	218	209	95.8
1979 Plantings			
Time of year plantings			
Finger Bay No. 1	18	14	77.7
Finger Bay No. 2	18	14	77.7
Finger Bay No. 3	24	21	87.5
Finger Bay No. 4	30	30	100.0
Finger Bay No. 5	36	36	100.0
Finger Bay Total	126	115	91.2
Zeto Point No. 1	18	14	77.7
Zeto Point No. 2	18	18	100.0
Zeto Point No. 3	24	24	100.0
Zeto Point No. 4	30	30	100.0
Zeto Point No. 5	36	35	97.2
Zeto Point Total	126	121	96.0
Moffett Quarry No. 1	10	10	100.0
Moffett Quarry No. 2	10	8	80.0
Moffett Quarry No. 3	15	15	100.0
Moffett Quarry No. 4	20	18	90.0
Moffett Quarry Total	55	51	92.7

Table 3. Continued (Survival rate through 1980)

Experimental Unit	Number Plants	Number Surviving in 1980	Percent Survival
Planting Density (1979)			
Finger Bay 5x5[a]	49	48	97.9
Finger Bay 10x10	49	47	95.9
Finger Bay 15x15	49	43	87.7
Finger Bay 20x20	49	44	89.7
Finger Bay 25x25	49	42	85.7
Finger Bay 50x50	49	47	95.9
Finger Bay Total	294	271	92.1
Zeto Point 5x5	49	48	97.9
Zeto Point 10x10	49	47	95.9
Zeto Point 15x15	49	43	87.7
Zeto Point 20x20	49	46	93.8
Zeto Point 25x25	49	38	77.5
Zeto Point 50x50	49	43	87.7
Zeto Point Total	294	265	90.1
Moffett Quarry 5x5	49	43	87.7
Moffett Quarry 15x15	49	42	85.7
Moffett Quarry 25x25	43	39	90.6
Moffett Quarry Total	141	124	87.9
Total, All Density Plots	729	660	90.5
Rhizome Length, Finger Bay			
2 cm. rhizome	49	42	85.7
6 cm. rhizome	49	44	89.7
10 cm. rhizome	49	46	93.8
14 cm. rhizome	49	44	89.7
Total, rhizome plots	196	176	89.7
Total, all experimental plots	1510	1378	91.2

[a] Inter-plant grid distance, centimeters.

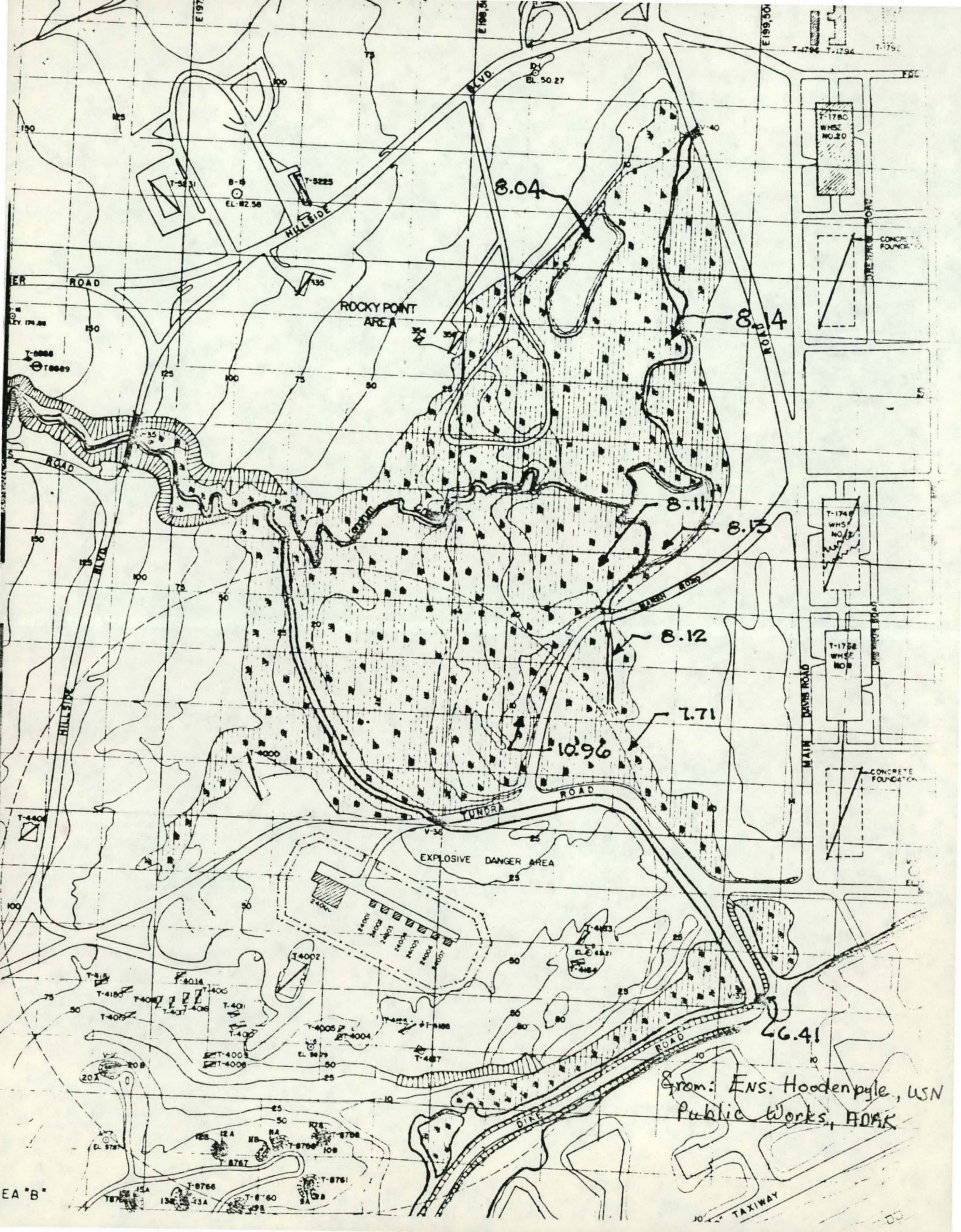
Table 4. Measurements of sand accumulation during 1979 and 1980 in density plots at Zeto Point, previous to overwash.

Plot[B]	Height of Mark[A] 1979	Height of Mark[A] 1980	Sand Accumulation Depth (cm)
5x5	24.5	21.0	3.5
10x10	25.0	20.0	5.0
15x15	28.0	25.0	3.0
20x20	24.8	22.0	2.8
25x25	27.2	28.0	0.8
50x50	28.0	28.0	0.0

[A] The height of a mark (notch) on a L-shaped steel rod buried in the center of the plot (centimeters).

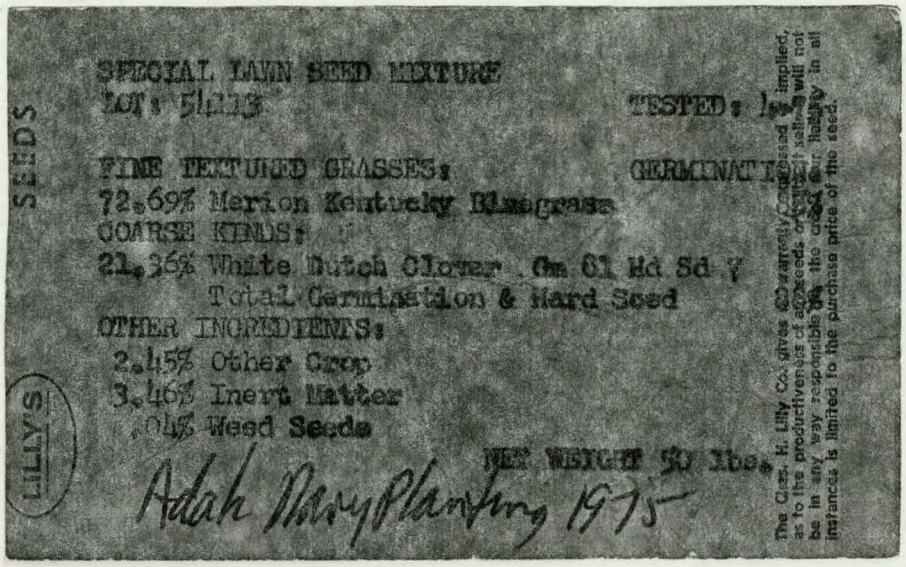
[B] Inter-plant grid distance.

Appendix 4. Elevations (feet above MSL) in the AUW marsh on Adak. This is one of the very few true marshes subject to seawater flooding in the Aleutians. The November 1981 storm covered most of the terrain with seawater. No halophytes have been found in detailed surveys.



From: Ens. Hoodenpyle, USN
Public Works, ADAK

Appendix 5. Standard commercial seed mix used for reclamation on Adak. Shipping label is reproduced.



Appendix 6. Report of high pressure water excavation of dunegrass roots by the Adak USN Fire Department. The activity took place in a currently eroding gully below concentrated building and road development.

Elymus root excavation

On 5 September 1979, the USN Fire Department of Adak cooperated in a dune gully high pressure water excavation of *Elymus* roots. Roots were found still attached to a depth of 3 meters.

Viable roots were found to a depth of 120 cm. Below this depth roots are brittle and yellowed when contrasted with the white flexible roots nearer the surface.

The live and dead root complex withstood 200 pounds per square inch of hose pressure (based on careful examination of the runoff down the gully).

The conclusion drawn was that the established *Elymus* stand promotes accretion of blowing sand from barren areas closer to the tide line, and that the *Elymus* not only traps and stabilizes the blowing sand, but continues to grow up through the accreted sand. The fore-dune excavated was about fifty meters inland from the high tide mark.

Experimental transplant plots (Zeto Point) have shown 3-5 cm. of sand accretion in a years time.

Appendix 7. Summary of afforestation efforts on Adak.

Afforestation efforts on Adak

To encourage civic (and military) involvement in an appreciation of the terrestrial landscape, a volunteer effort to plant tree seedlings was undertaken during the fall-winter of 1975-1976. The activity was part of the Adak participation in the national 1976 Bicentennial celebration.

Bare rooted seedlings were donated by several state tree nurseries. Plantings were done, entirely by volunteers, in areas designated as likely to be protected by persistent snow drifts to protect leaders during the very windy winters.

Earlier tree plantings have occurred at least on Adak, Amchitka and Unalaska. Some specimens, where protected by topographic or man made structures from the winter winds, have survived. None found have reproduced.

On Adak during 1975-76, some 3000 seedlings were planted, with varying expertise and subsequent survival.

State nurseries which responded and the species (only nursery common names supplied):

1. Alaska - White and Black Spruce, Alder, Larch, Sitka Spruce
2. Delaware - White Pine, Japanese Black Pine
3. Michigan - White Pine
4. New Jersey - White Pine
5. New Mexico - Engelmann Spruce
6. New York - Spruce, White Pine, Scots Pine
7. North Dakota - Blue Spruce, Paper Birch, Scots Pine, Siberian Larch
8. Utah - Alder, Cottonwood
9. A few Fir, Yew, and Hemlock were supplied from various sources.

In August 1976, four (of twelve total) protected plantings were surveyed by volunteers. Although graminoid meadow development made tree detection difficult, of the 516 seedlings found in the four areas examined, 50% of the individuals were in excellent condition.

Surveys have continued through 1981. About 50% of the plantings continue to be viable (showing short but new leaders in August of the six years).

The most successful species found are Blue Spruce, Larch, Paper Birch, Black Spruce and White Spruce. There is no indication of reproduction or layering in any specimens found.

The endeavor has shown that the physiological capability of some tree species allows survival, but that the development of woodlands is unlikely.

Incidentally, Alaska Airlines and Reeve Airways flew the seedlings to Adak at no charge. The survival rate is highest for the stock supplied by the North Dakota State Nursery.

Appendix 8

Other activities related to ecological research in the Aleutians by University of Tennessee ecologists:

1. Seventeen rumen samples from harvested caribou have been analyzed. Samples (August - November) indicate random feeding, with graminoids predominant. There is no apparent shortage of forage, nor is there evidence of overgrazing. Nutrient values of the forage have not been analyzed. The introduced caribou (early 1960's) are controlled by recreational hunting by island residents. Very large specimens are common. The Norway rat is the only other grazing mammal on the island and based on Amchitka studies, the impact of rat grazing is insignificant, as are the feeding habits of herbivorous avifauna.
2. Cooperation has been offered and accepted by the Adak School District, the University of Alaska Extension Service, the British Broadcasting Corporation, the Alaska Geographic Society, the U.S. Fish and Wildlife Service (with whom we have a long-term cooperative agreement), Sohio Alaska Petroleum, the Institute of Biology and Pedology of Vladivostok USSR, Reeve Aleutian Airways and most importantly the U.S. Navy, Adak Naval Air Station Command.

3. We are currently engaged in an advisory role to the corporations landscaping the new Adak school, particularly regarding drainage and establishment of native vegetation on the newly exposed school grounds.

Appendix 9

From a cursory survey of current public publications, commercial and governmental, the following information which may affect Aleutian coastlines has been noted: (All north of the Aleutian chain)

a. Proposed construction of dams on the Mackenzie watershed (which may cause a 15% drop in spring flow to the Beaufort Sea), on the Yukon River (Rampart) and on the Susitna (above Cook Inlet).

b. Energy and other commodity extraction and transport under way or proposed include:

   1. Natural gas extraction from the Beaufort Sea.
   2. Coal contracts proposed for 50 years for extraction of Alaskan coal for shipment to Korea, Taiwan, China and Japan. Much of the coal would be stripped and shipped from areas north of the Aleutians (Seward, Cook Inlet). There are also coal deposits on the coast of the Alaska Peninsula.
   3. Acceleration of sale of leases (and subsequent drilling) for gas and oil on the west coast of Northern Alaska.
   4. Timber harvest and shipment to the Orient.
   5. Increased fishing pressures as "new" taxa are harvested.

c. All of the above (a,b) proposed or current activities may be expected to impact Aleutian beaches, whether through shipwreck (not uncommon) or the loss or purposeful discharge of flotsam and jetsam at sea.

d. Natural storm effects on terrestrial landscapes, not related to previous human activities, may disrupt current conditions ranging from human activities along coastlines to alteration of habitat for important beach hauling sea mammals and littoral avifauna. Such disruptions may require active landscape recovery management in critical areas.