ORO--4180--6

DYNAMICS OF THE RECOVERY OF DAMAGED TUNDRA VEGETATION

Annual Progress Report

Clifford C. Amundsen

University of Tennessee
Knoxville 37916

PREPARED FOR THE U.S. ENERGY RESEARCH AND DEVELOPMENT

ADMINISTRATION UNDER CONTRACT NO. E - (40-1) - 4180

Report submitted: 28 May 1976

Clifford C. Amundsen

Clifford C. Amundsen
Principal Investigator

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ABSTRACT

A study, begun in 1971, continues to document the environmental factors which affect the recovery of damaged tundra landscapes. A measurement technique was developed on Amchitka Island to allow the rapid acquisition of data on species presence and frequency across areas disturbed at various times and in various ways. Samples across all examples of aspect, slope steepness and exposure are taken. Studies now include Adak Island and the Point Barrow area.

We have concluded that there was no directional secondary succession on the Aleutian tundra, although there was vigorous recovery on organic soils. Our study led to recommendations which resulted in less intensive reclamation management at a considerable financial saving and without further biological perturbation.

Because of the increasing activity on tundra landscapes, for energy extraction, transportation or production; military or other reasons, we have expanded our sampling to other tundra areas where landscape disruption is occurring, or is predicted.

TABLE OF CONTENTS

STATEMENT OF RESEARCH TO DATE

This report brings to current status the ongoing research concerning the dynamics of vegetative recovery or reestablishment on damaged tundra vegetation, at two Aleutian islands and at Point Barrow.

Research background. This research was undertaken in April, 1971, under AEC contract AT(40-1)-4180 and is funded through June, 1976. Previous research on the ecology of the terrestrial vegetation of Amchitka Island, Alaska, was begun by the author in the late summer of 1967, under a subcontractual arrangement with Battelle Memorial Institute, Columbus Laboratories, Prime AEC contract AT(26-1)-171. The 1967-1971 studies under the latter contract allowed an assessment of the Amchitka vegetation and characterizations of the ecological processes controlling or influencing the composition, structure, and productivity of the vegetation. This part of the study has been suspended since 1974.

The Amchitka work has resulted in one comprehensive report (Amundsen, 1972), a published summarization (Amundsen and Clebsch, 1971), a cooperative assessment of the effects of nuclear tests on the geomorphology and plant ecology of Amchitka (Everett and Amundsen, 1975) and a compilation of ecological material from the botanical point of view in a chapter for inclusion in a forthcoming volume on the Amchitka bioenvironment (chapter manuscript, May 1976, now at the printer for publication). Report ORO-4180-4 (April, 1974) contains a comprehensive discussion of the research to that time. Report ORO-4180-5, May 1975 covers FY 75 and this report covers FY 76.

Recovery studies. Given the background of the studies conducted through 1971 and earlier, our efforts in the spring of 1971 began with an attempt to understand the factors and processes which promote or retard the reestablishment or establishment of indigenous vegetation on sites disturbed by human activities on tundra landscapes. Our intent was to minimize consideration of any recovery occasioned by site preparation, fertilization, planting, or other manipulations.

Secondary succession or seral vegetative recovery on tundra landscapes has not been documented. Although the Aleutian maritime tundra differs from arctic tundra such as that at Barrow in many respects, such as no permafrost, low solar energy input and other factors, the flora, at the generic level, is typical of tundra, combining North American and Asian elements and many circumpolar genera, and some circumpolar species.

Research During FY 1976

The field research effort during FY 1976 (to date) can be divided into three phases, a team effort at Adak, a lesser effort at Barrow and a second team effort at Adak.

Adak, 13 June to 30 June 1975. With the cooperation of the U.S. Navy, Reeve Aleutian Airlines and the establishment of a cooperative agreement between the University of Tennessee and the U.S. Bureau of Sport Fisheries and Wildlife, Aleutian Islands National Wildlife Refuge, we were able to inititate intensive research on Adak Island. The research team included the author, Edward E. C. Clebsch, David K. Smith, and Donald H. Ross of the University of Tennessee and John W. Marr of the University of Colorado.

Adak has a large (total population app. 5000) U.S. Navy Base. Military use of the island has been continuous since the early 1940's. Disturbance to the tundra landscape is of the sort usually associated with construction, staging, and transportation. Military records allow the dating of certain disturbances and a chronological record of activities was made in order to evaluate the pattern and process of vegetative recovery on abandoned disturbed areas.

Using sampling techniques developed on Amchitka, pin-hit transects were taken across disturbances of different origin and various ages on several terrain types. A modification of the Amchitka method was the inclusion of D. K. Smith, a bryologist-ecologist, in the field team. The role of bryophytes in vegetational recovery has not been investigated before in the Aleutians. As an adjunct effort, the vascular and bryophyte flora was intensively collected. No previous intensive botanical effort is known from Adak, which has a larger and more diverse flora than Amchitka. The collections are being worked up.

As a courtesy, and to improve cooperation with the Navy, the commander's office was informally advised concerning establishment of vegetation on barren areas critical to the operation of the base and the well being of the population. Contact was established with the University of Alaska Experiment Station at Palmer to aid in these efforts.

Barrow, 1 July to 14 July 1975. Through an arrangement with the Naval Arctic Research Laboratory and The University of Alaska, the author and Donald H. Ross were able to spend two weeks sampling across various disturbances to the tundra in the Barrow area.

The Barrow area is part of Petroleum Reserve No. 4, established in 1923. The village of Barrow is over 100 years old. Disturbances to the area tundra we were concerned with were generally of two types, those associated with the producing gas well which supplies the local population and those created by the movement of various types of vehicles across the tundra on constructed and non-constructed roads (Hok, 1969).

Pin-hit transects were run across several disturbance types, divided primarily between wet and dry. Chronology of disturbances was more difficult to establish at Barrow than in our Aleutian experience, primarily because of the complexity of continuing disturbances, including many associated with the IBP tundra research effort. Bryophytes were not distinguished in the Barrow sampling due to my lack of expertise, but I spent time with D. K. Smith in the summer of 1972 at Barrow helping design his sampling techniques for a bryophyte study. Smith's dissertation (1974) and his available expertise will allow us to include bryophytes in our subsequent evaluations of vegetational recovery for the Barrow area.

I also had the good fortune to spend some time in the field with Dr. Jay McKendrick of the University of Alaska Experiment Station, Palmer, evaluating his experimental planted plots south of the laboratory.

D. H. Ross and I compiled a vascular plant check list for the immediate area using all information available. This check list was presented to the NARL operation. A copy is included in this report as an appendix.

Adak, 3 September to 21 September 1975. Four of the team (without J. W. Marr) returned to Adak to continue sampling and compare phenological differences in the vegetational aspect. The collection of the Adak flora was continued. The Navy provided a tug for two trips to the other side of the island (a round trip of some ninety miles) so that terrain undisturbed by heavy equipment could be examined and an evaluation of the impact of caribou begun.

Caribou were introduced on Adak in 1958 and 1959. Twenty three caribou calves (Rangifer tarandus granti) from the Nelchina herd (area northeast of Palmer, Alaska) were established by the Fish and Wildlife Service and the Department of Defense.

The first Adak born calves were seen in 1960 and by 1967 the herd contained almost 200 caribou. Recreational hunting by the people of Adak is employed as a means of keeping the herd size below 300.

The absence of biting insects and a reported low number of other parasites along with the small size of the herd, the lack of predators other than controlled hunters, and the unrestricted range (Adak has an area of nearly 300 square miles) has resulted in the development of some of the largest caribou in North America. (G. V. Byrd, F&WS, pers. comm.).

Preliminary reconnaissance in 1975 did not reveal my conspicuous overgrazing by the Adak herd and local observers were not familiar with the caribou's diet. With the cooperation of the Navy and the Fish and Wildlife Service we have just received the first batch (8) of rumen samples from caribou harvested on Adak this past winter. A. L. Brenkert and S. S. McCarrell have been employed part time to establish a reference slide collection, using our plant collections, which will allow microscopic identification of preferred caribou foods from the rumen samples. Preliminary examinations indicate that caribou prefer graminoid plants on Adak. It is of interest that caribou grazing in reclaimed areas on the north slope of Alaska also perfer graminoid plants when seeding and fertilization has increased the availability and productivity of grasses. I feel the Adak caribou have adapted to a new diet and the rumen analyses will continue.

During 15-16 July 1976, I contacted and met with officials of the Alaska Pipeline Office of the Department of the Interior in Anchorage. Dr. Dwight Hovland and General Andrew Rollins were very courteous but could offer no immediate opportunity to visit pipeline sites for periods long enough to accomplish any intensive samplings. At least our program was explained to them, and communication channels opened.

RESULTS TO DATE

We are still in the midst of analyses of our field data and working up our collections.

Smith's collections of bryophytes and his transect data concerning the role of bryophytes in vegetational recovery, both on Adak, constitute original work. Since verification of his identifications requires considerable time he estimates it will be late summer 1976 before he has a manuscript ready for submission. He has been working on his collections throughout the winter.

The caribou rumen samples are being separated and identified. Although we cannot hope to identify all the vegetative fragments, we will be able to typify caribou diets on Adak as the study progresses. We will continue to acquire rumens.

Our vegetative recovery sample data has been through a preliminary analysis. R. H. and K. G. Strand have assisted in this analysis. We have not yet had an opportunity to compare the Adak data to the Amchitka data taken in 1971, 1972 and subsequently, but we plan to do so in the future.

For both Adak and Barrow we have calculated the percent frequency of hits of species involved in recovery (Tables 1 and 2). On Adak, some 57 genera, of a probable 200 genera on the island, were encountered on the recovery transects. At Barrow, 18 of the 57 genera known were encountered on the recovery plots. Many of these genera have only one species in the respective floras. The high percentage of stable vegetational genera involved in recovery of disturbed areas indicates two observations made on Amchitka (Amundsen, 1974) hold true for Adak and Barrow, the flora is depauperate and pioneer or weedy genera do not have an important role in recovery, and their place is filled by perennial components of the undisturbed vegetation.

The high degree of participation of stable, established plant species in damaged tundra recovery suggests that introduction of exotic species for aesthetic reasons may be inefficient at best or even counterproductive if the introduced species do not yield to the native species over time.

Correlation matrices have been run for both the Adak and Barrow data. Preliminary interpretation of the Adak correlations substantiate arithmatic and observational data. For example:

1. The age of the disturbance is positively correlated with Empetrum (.53) and Linnea (.50), both stable vegetational genera.

TABLE 1. PERCENT FREQUENCY FOR ADAK SPECIES.

SPECIES	FREQUENCY	PERCENT
ACH	89	2.853
AGR	80	2.564
ANA	57	1.827
ANE	18	0.577
ANG	31	0.994
ARN	27	0.865
BAR	5	0.160
BGL	2	0.064
BRO	6	0.192
CAL	526	16.859
CAP	1	0.032
CAR	213	6.827
CHA	4	0.128
CLA	1	0.032
CON	1	0.032
COP	7	0.224
COR	2	0.064
DAC	3	0.096
DES	38	1.218
ELY	50	1.603
EMP	207	6.635
EPI	29	0.929
EQI	95	3.045
ERI	5	0.160
ERP	1	0.032
EUP	2	0.064
FES	80	2.564
FRU	1	0.032
GER	1	0.032
GEU	2	0.064
GRA	1	0.032
GRB	1	0.032
GVL	222	7.115
GYM	1	0.032
HAB	1	0.032
HER	32	1.026
IRP	2	0.064
JUN	75	2.404
LEP	5	0.160
LIC	35	1.122
LIN	10	0.321
LIT	162	5.192
LIV	171	5.481
LOI	13	0.417
LUP	66	2.115
LUZ	44	1.410
LVZ	1	0.032
LYG	3	0.096
LYP	11	0.353
MIN	134	4.295
MOS	278	8.910
ORG	8	0.256
PET	8	0.256
PLA	8	0.256
PLT	6	0.192
POA	107	3.429
RAN	10	0.321
ROC	37	1.186
RUB	1	0.032
SAG	3	0.096
SIB	21	0.673
STE	1	0.032
TAR	5	0.160
TOF	3	0.096
TRI	12	0.385
UIO	2	0.064
UNK	4	0.128
VER	4	0.128
WOD	28	0.897
TOTALS	3120	100.000

Table 2 Species Frequencies for Barrow

SPECIES	FREQUENCY	PERCENT
ALO	7	0.556
ARC	99	7.870
CAL	106	8.426
CAR	102	8.108
COC	10	0.795
DUP	5	0.397
ELY	4	0.318
ERI	7	0.556
FES	8	0.636
GVL	327	25.994
LIT	197	15.660
LSH	1	0.079
MOS	15	1.192
ORG	233	18.521
PET	16	1.272
PHI	38	3.021
POA	18	1.431
RAN	1	0.079
RIR	10	0.795
RUM	1	0.079
SAX	14	1.113
STE	9	0.715
UNK	2	0.159
WAT	28	2.226
TOTALS	1258	100.000

2. Increasing elevation correlated with *Sibbaldia* (.57) a depressed, mat forming plant which does well on exposed substrates.

3. *Anemone* correlates with *Coptis* (.57), *Erigeron* (.68) and *Plantago* (.58), all genera tolerant of continuously wet substrates.

4. *Arnica* correlates with *Heracleum* (.69) and *Platanthera* (.56), all moist meadow plants.

5. *Bromus* correlates with gravel (.70) where it is very often found.

6. Charcoal correlates with *Lupinus* (.52) which locally is a pioneer at old building sites and along roads.

7. *Deschampsia* correlates with *Sibbaldia* (.56), both showing preference for open ground.

8. *Elymus* correlates with *Linnea* (.74) both stable vegetational genera at lower elevations.

9. *Empetrum* correlates with *Loiseleuria* (.70) both intertwining subshrubs.

10. *Erigeron* correlates with *Plantago* (.87) generally on continuously wet soils.

11. *Linnea* correlates with *Lycopodium* (.55), often along edges of stable vegetation.

12. Liverwort correlates with *Luzula* (.53) generally doing well on open ground.

13. *Ligusticum* correlates with mineral soil (.52), usually on road berms.

14. Rock correlates with Sibbaldia (.54) which grows well, sometimes alone, in very stony substrates.

15. There were several other correlations greater than (.40) but more detailed analysis of this data is a future project.

At Barrow, correlations of the age and type of disturbance and several genera have not yet been explained. Elymus and Saxifraga (.69), and Eriophorum and moss (.61) can be expected together. It also seems clear that Phippsia prefers organic soil (.73) and does well in temporary standing water (.60). Bare organic substrate correlates with standing water (.85) showing that permanent ponds do not usually support higher plants.

Other analyses of the Adak and Barrow data included canonical analysis for correlations between habitat factors and plant genera as separate linear composites (Stewart and Love, 1968). An index of redundancy was calculated (Tables 3, 4). The high redundancy (Adak, .70, Barrow, .62) means habitat factors explain species presence to a considerable degree. We must continue this analysis, but the indications are clear that certain statements should be made concerning our work to date.

Table 3 Percent variance extracted by significant factors ($P \leq .05$)* for Adak

Factor	% Variance Extracted	Redundancy
1	32	.28
2	14	.12
3	27	.18

*Total redundancy for habitat factors given species is .70.

Table 4 Percent variance extracted by significant factors ($P \leq .05$)* for Barrow.

Factor	% Variance Extracted	Redundancy
1	24	.21
2	19	.16
3	8.5	.07

*Total redundancy for habitat factors given species is .62.

OBSERVATIONS AND CONCLUSIONS TO DATE

There is no demonstrable secondary succession on the maritime tundra landscapes of Adak and Amchitka. The disturbed tundra does recover, but the sequence of communities involved is not predictable from our data to date. The recovery of damaged tundra at Barrow is complicated by permafrost and summer drought, neither a factor in the Aleutians.

A very high percentage of the native flora is involved in the recovery process. Substrate management to encourage the re-establishment of native flora may be a more practical and efficient way to promote recovery or vegetative healing.

Habitat factors are a good predictor of plant taxa and community assemblages. It also appears the converse is true in some cases, that is, certain community assemblages of just a few taxa identify certain habitat factors. This is important for areas where establishment and growth are slow and long term records of environmental conditions are lacking. We may be approaching the quantification of plants and assemblages indicative of microhabitat conditions.

Recovery patterns discerned to date indicate habitat condition controls recovery in the maritime tundra. Drainage, the age of the disturbance, and the texture or composition of the substrate are most important. We probably do not have enough data to be comprehensive about the situation at Barrow, but construction related ponding is the worst problem identified there.

More consideration and less misdirected enthusiasm should be employed in revegetational projects where the response of the native plant communities to disturbance has not been studied. Time, effort, and money may be saved, and pestiferous introductions may be avoided.

REFERENCES

Amundsen, C. C. 1972. Plant ecology of Amchitka Island, Alaska. BMI - 171 - 139. N.T.I.S.

Amundsen, C. C. 1976. The terrestrial plant ecology (of Amchitka) ms accepted for ERDA, Bioenvironment of Amchitka - NVOO.

Amundsen, C. C. 1971-1975. Reports ORO - 4180 - 1, 2, 3, 4, 5.

Amundsen, C. C. and E. E. C. Clebsch. 1971. Dynamics of the terrestrial ecosystem vegetation of Amchitka Island, Alaska. Bioscience 21: 619-623.

Everett, K. R. and C. C. Amundsen. 1975. Geomorphology and plant ecology: an assessment of the impact of AEC nuclear tests on Amchitka. BMI 171-152 N.T.I.S. Springfield, VA 28 pp. plus appendices.

Hok, J. R. 1969. A reconnaissance of tractor trails and related phenomena on the north slope of Alaska. U. S. Dept. Interior, Bur. Land Management.

Smith, D. K. 1974. Floristic, ecologic and phytogeographic studies of the bryophytes in the Tundra around Barrow, Alaska. Ph.D Dissertation, University of Tennessee. 190 p.

Stewart, D. K. and W. A. Love. 1968. A general canonical correlation index. Psychological Bulletin 70, 160-163.

APPENDIX

CRO--4180--6

PLANTS OF BARROW JULY 1975 C. AMUNDSEN, D. ROSS, U.T.

Vascular plants	Hulten page #
Equisetaceae	
Equisetum arvense	38
Gramineae	
Hierochloe alpina	84
H. pauciflora	85
Alopecurus alpinus	90
Phippsia algida	92
Arctagrostis latifolia	94
Calamagrostis holmii	107
C. purpurascens	107
C. deschampsiodes	108
Deschampsia caespitosa	112
D. pumila	113
Trisetum spicatum	117
Poa alpina	129
P. arctica	129
P. alpigena	135
P. lanata	138
P. malacantha	139
Arctophila fulva	149
Dupontia fischeri	149
Puccinellia phyrganodes	155
P. langeana	157

I

T. alaskanum 949

This list of 129 taxa has been constructed by consulting Hultén (1968), Murray and Murray (1973) the sketchy collection of local (Barrow only) plants in the NARL herbarium and our own limited experience in the field here (Calamagrostis deschampsiodes or C. purpurascens, Ranunculus glacialis etc. were identified from rather incomplete specimens for example). This listing does not explore or resolve taxonomic differences which appear betwixt Hultén, Murray and Murray and the local collection.

C.C. Amundsen
University of Tennessee
9 July 1975