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Some Effects of the March 27, 1964 Earthquake on the Ecology of the Copper River Delta, Alaska

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Introduction

On March 27, 1964, the Alaskan Good Friday earthquake produced some rather spectacular effects. Many of the effects were of immediate importance, such as the destruction of buildings and bridges, and received much attention; other effects were simply initiated at the moment the earthquake occurred. The ultimate effects of the latter category may not be realized for many years. A specific example of this would be the raising of the Copper River Delta an average of 6.3 feet (Reimnitz and Marshall, 1965).

This paper is an attempt to outline briefly some of the ecological work which has been accomplished on the Copper River Delta relating to the nesting habitat of the Dusky Canada Goose (*Branta canadensis occidentalis*) during the summers of 1965 and 1966. This bird breeds on the delta and winters in the Willamette Valley, Oregon, returning to the delta again in the spring of each year. Much additional data has been gathered and will be evaluated with the completion of work to take place during the summer of 1967. As the author is pursuing this investigation in partial fulfillment of the requirements for the degree of Ph.D. in the Department of Botany at Washington State University, it is intended that a more thorough treatment of all the data will follow.

The Study Area

Location and Description

The Copper River Delta lies to the south and east of Cordova, Alaska, adjacent to Prince William Sound. The delta presents a rather flat area dominated by the alluvial deposits of the Copper River and numerous glacial streams flowing into the Gulf of Alaska immediately to the south. To the north gravels dominate but desist rather abruptly to the south. Finer textured materials characterize the remainder of the delta with sandy soil found near the Eyak and Copper Rivers to the west and east respectively. The interior portions of the delta are dominated by very fine textured materials.

Prior to the earthquake much of the Copper River Delta in the principal nesting area of the Dusky Canada Goose had been inundated to varying degrees by diluted sea water during the highest tides of the year. Other tides brought sea water into the delta which would cover only part of the slough banks (Shepherd, 1965). The post-earthquake conditions are such that the land surface has been raised to the extent that the highest tides now come up only to the lowermost portions of pre-earthquake vegetation along the slough banks, with the majority of the tides covering only part of the bare mudbanks--now being invaded by plants.

Not only has the level of the water changed, but the water flowing in the sloughs is no longer salty, even at the high tides. This is apparently a result of the tremendous amount of fresh water flowing off the delta acting more or less as a "plug" (Crow, 1965; Shepherd, 1965). A great deal of precipitation falls on the delta and it is therefore presumed that desalinization will proceed.

Goose Nesting

The uplift is of particular ecological interest due to the general restriction of the Dusky Canada Goose to the delta and principally to one kind of vegetation. The vegetation in question is dominated by forbs and grasses growing at the uppermost, rather level, portion of slough banks over a rather restricted area. The Bureau of Sport Fisheries and Wildlife 1959 Annual Waterfowl Report for Alaska by Trainer lists 97 percent of the nests (218 of 224) located within the forb-grass vegetation including small shrub fragments within the general forb-grass area. The high degree of fidelity may of course have been conditioned by the washing out of nests at sites of lower elevation. Higher, more mesophytic sites may have been vulnerable to increased predation. Regardless of the speculative reasons behind the restriction of goose nesting, the fact remains that nearly all of the nesting actually took place in one type of plant community. This plant community normally remained clear of the high tides, being inundated only by a few exceptionally high tides. The more mesophytic types nearly always remained clear of all tides.

Because of the importance of the forb-grass vegetation to the goose population, the study was aimed at evaluating certain parameters of the various plant communities. This was done in order to assess the ecosystem changes that must surely follow the uplift of the delta.

Methods

The first summer of field study was centered around reconnaissance work. This included the collection and tentative identification of voucher specimens. The principal objective was the visitation of a large number of sites over as much of the study area as possible in order to select thoroughly representative sites for more intensive study. At each site attention was paid to location, tidal influence, edaphic properties and other site characteristics. At each site stands were analyzed by means of a Braun-Blanquet technique modified by Daubenmire (1959). According to this method the coverage of each species falling within an estimated 100 square meter plot is recorded. Coverage classes employed are listed below.

Class	Range	Midpoint of Range
1	0- 5%	2.5%
2	5- 25%	15.0%
3	25- 50%	37.5%
4	50- 75%	62.5%
5	75- 95%	85.0%
6	95-100%	97.5%

A polygon is imagined around the undisturbed foliage of each plant, or species, which is taken as its coverage. The coverage of each species is then estimated and its class recorded.

Upon completion of the reconnaissance work, quantitative details for specific stands were gathered by locating a macroplot of given area, including a number of 20 cm by 50 cm microplots delimited by a metal frame. Coverage techniques and classes used in the reconnaissance apply to the microplots. If a plant is not located within the microplots of a stand but is found within the macroplot, a plus is recorded in the data tables to indicate its presence. Calculations involved the summation and division of coverage class midpoints. For example, if 10 microplots of a stand analyzed yielded coverage estimates of 2, 1, 0, 2, 2, 2, 3, 1, 2, and 2, the sum of the midpoints is 132.5. The average coverage value would be 13% and the frequency 90%.

Transect studies involved setting out 20 cm by 50 cm microplots at right angles to the transect line and evaluating each plot for coverage as outlined above. The number of flowers (or fruits) and the tallest specimens of each species were recorded within the microplots. This was done since changes in the vigor and vitality of species may precede changes in coverage or the introduction of new species in a succession.

Soil samples were also taken at each stand and at particular points along transects. These samples were taken to a depth of 1 dm with a common garden trowel and placed in paper bags to dry. Analysis took place at Washington State University.

It is important to note that each study site has been marked with either cedar stakes, metal posts, or both. Relocation and analysis of the sites studied at some time in the future should yield interesting details on plant succession and its relationship to goose nesting.

Results and Discussion

The various types of plant communities were analyzed in detail in 1966. Those plants most often present in the macro-plots of the stands analyzed have been listed in Table 1. In the region of greatest goose nesting density, one typically finds a narrow zone of pure *Carex lyngbyei* at the lowermost vegetation line and slough banks. Progressing up the bank, a zone dominated by *Carex lyngbyei* and *Eleocharis kamtschatica* is next encountered. An analagous but more complex sedge community is located on the very gently sloping portion of the landscape internal to the slough bank. This basin may also contain zonal pond communities normally dominated by *Potomogeton* sp., *Myriophyllum spicatum*, *Hippurus tetraphylla*, or *Carex lyngbyei*. *Hippurus tetraphylla* is replaced by *H. vulgaris* in ponds farther from the sea and apparently less saline. On the highest portion of the landscape within the region of maximum good nesting, one encounters a rather lush community of forbs and grasses. Before the earthquake, as mentioned earlier, certain high tides covered the forb-grass vegetation. Apparently due to the relatively level land-surface and the denseness of the vegetation the velocity of the very muddy water was slowed, enhancing the deposition of particles. These natural levees are very distinct in most places along slough banks over much of the delta.

This forb-grass community is of special interest because of its nesting utilization; however, during the summers which have followed the earthquake many successful nests have been located in other communities. Specifically, geese - as well as other waterfowl - are nesting in the various sedge communities, principally along the banks, which under pre-earthquake conditions would have been washed out.

It should be pointed out that small changes in relief in the general nesting area may be associated with rather striking changes in the vegetation as well as the fauna. For example, ecotones were nearly always very abrupt even where the apparent changes in elevation were quite gradual (Fig. 1). This generalization appeared to be true for other areas on the delta as well.

A brief discussion of more mesophytic sites shall be given because of the successional implications. The plant communities analyzed occupied positions along slough banks at least analagous to the position of the forb-grass vegetation.

Proceeding landward on similar textured soils, communities dominated by Sweet Gale (*Myrica gale*), willow (*Salix* sp.), alder (*Alnus sinuata*), and Sitka Spruce (*Picea sitchensis*) are encountered. It should be pointed out that some of the spruce communities do contain young Western Hemlock (*Tsuga heterophylla*) trees. The hemlock is generally assumed by most authors to be the climax dominant of most well drained, topographically suitable sites along this region of the coast. Detailed analysis, as well as reconnaissance work, revealed sites at which succession had

photo

Figure 1. A distinct ecotone in the area of maximum goose nesting. The forb-grass vegetation is to the left and the sedge bank vegetation to the right. August 1966.

differed from the idealized scheme. The differences were primarily the omission of one or more of the definite seral stages. For example, sites were often observed with no trace of Sweet Gale beneath willow.

Vegetation transect work has revealed some rather interesting post-earthquake changes. Species characteristic of the forb-grass vegetation are migrating laterally--both down the banks and into the basins. This migration is not limited to the presently vegetated zones but is apparent on the previously bare mud banks. Plants of more mesophytic communities are also invading successfully along the slough banks. Specifically, willow and alder are found in the sedge along the banks as well as on bare mud. Changes in the coverage of species is exemplified by data presented in Fig. 2. It is important to note the differences between 1965 and 1966 for the various zones, as this lends evidence useful in interpreting the direction of the putative successional changes. Although changes such as coverage are inconclusive for any one year, these data in conjunction with other observations seem to be useful in predicting present successional trends. Fig. 2 depicts _Carex lyngbyei_ as not significantly changing in any of the zones, but the data in Fig. 3 may presently give one a better means of evaluating the status of this species. Since the vigor and vitality of a species may vary between community types, data of this sort may also be useful for prediction if treated cautiously to avoid overemphasizing normal yearly differences. In the more mesophytic communities where _Carex lyngbyei_ is present the flowering

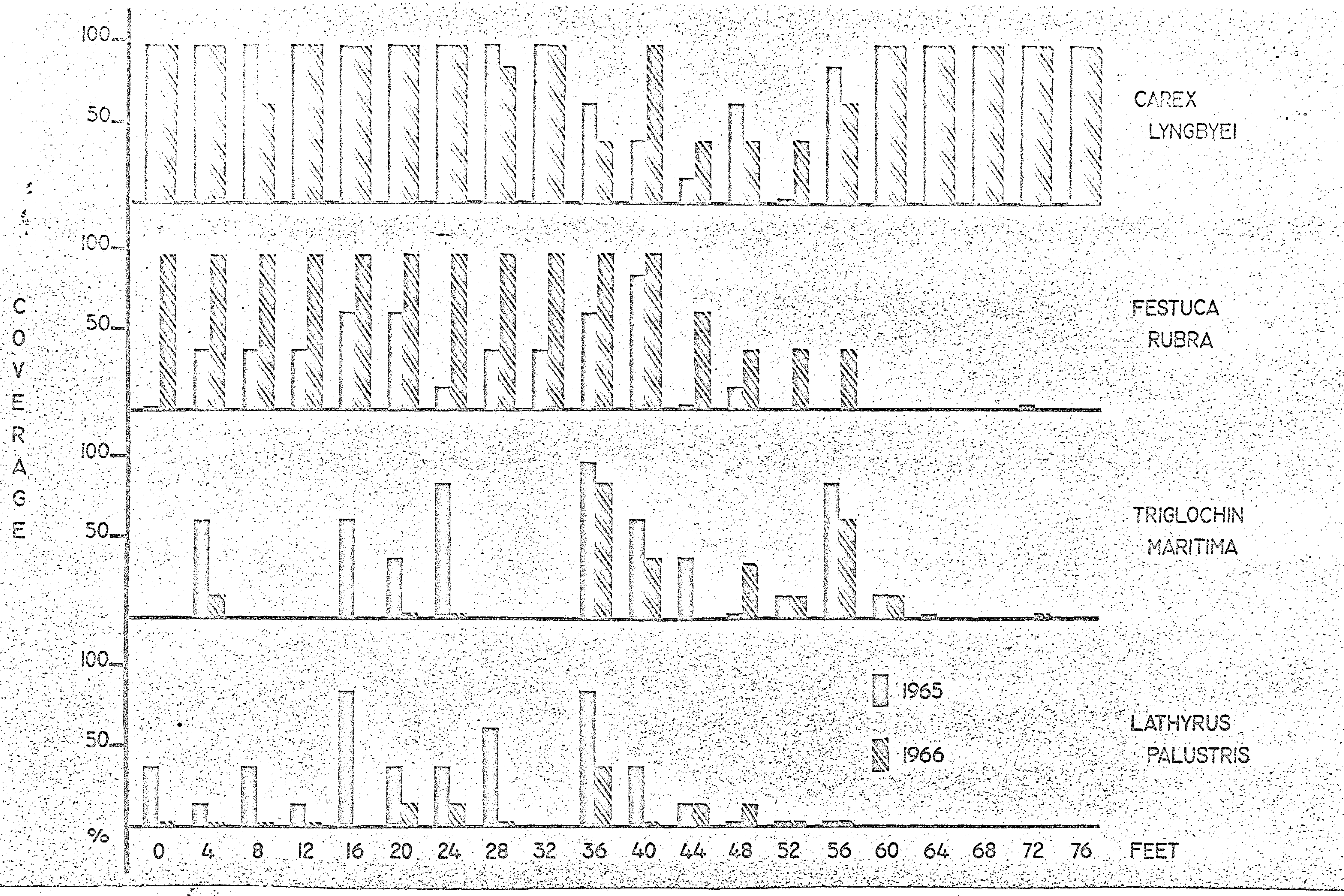

Figure 2. Changes in coverage of selected species over a one year period. Zero to 36 feet approximately locates the internal sedge vegetation, 36 to 56 feet the forb-grass, and 56 to 76 the sedge bank.

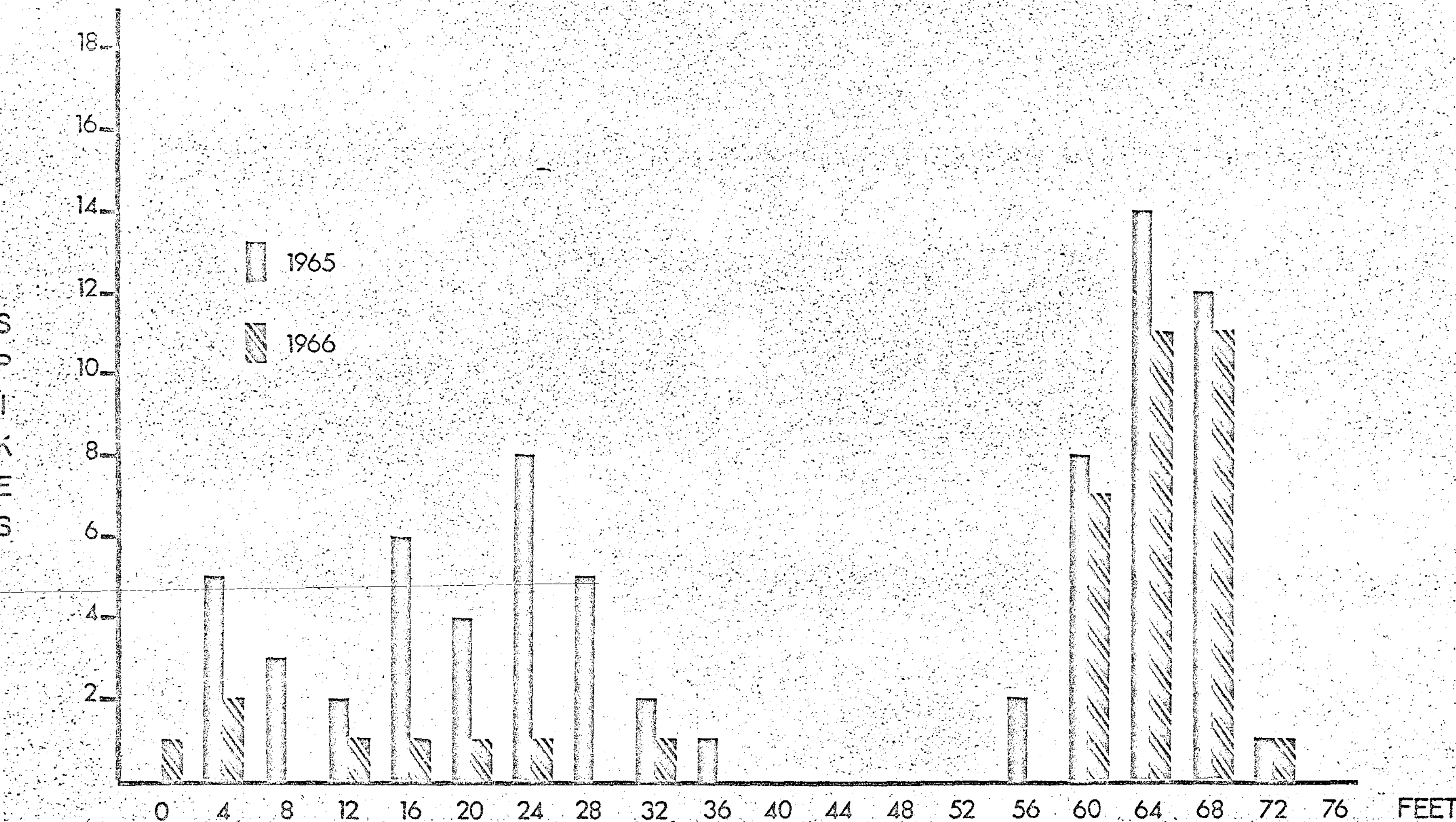

Figure 3. Changes in flowering of <u>Carex lyngbyei</u> over a one-year period. Zero to 36 feet approximately locates the internal sedge vegetation, 36 to 56 feet the forb-grass, and 56 to 76 the sedge bank.

photo

Figure 4. Rather typical view of the forb-grass, to the left, and slough bank vegetation, to the right. Notice the slough with exposed mudbank in the upper right. August 1965.

is greatly reduced--it is also greatly reduced in very wet habitats. These data then suggest that the putative increased mesophytism is being realized.

Beekom, et al., (1953) have observed that desalinization may occur with a surplus of 150 mm of rainfall and that leaching may occur rather rapidly under suitable conditions. Results of soil analyses from 1965 and 1966 show no high salt concentrations in the soils of the forb-grass vegetation. For that matter, the only soils which showed any signs of salt effects were those below pre-earthquake vegetation lines and a few samples from transects directly adjacent to the sea.

Regarding the nesting population of geese, it then seems that the increased area available for nesting is rather transient and an ultimate decrease in nesting vegetation is expected. Additional data not treated herein are aimed at defining as precisely as possible the ecologic potential of the various post-earthquake habitats.

Summary

The uplift of the Copper River Delta by the infamous March 27, 1964 earthquake has initiated major changes. Such changes include the desalinization and amelioriation of inundated areas resulting in habitats becoming increasingly favorable to plant communities more mesophytic than pre-earthquake communities. One such area affected has been employed by the Dusky Canada Goose as a nesting habitat. Transient expansion of nesting area should in a short time be followed by a decline in suitable nesting habitat due to the invasion and development of plant communities in which nesting fidelity is very low.

Acknowledgements

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	Water-line Sedge	Sedge Bank	Internal Sedge	Forb-Grass	Sweet Gale	Willow	Alder	Spruce
Carex lyngbyei	+	+	+	+	+	+		
Eleocharis kamtschatica		+	+					
Cicuta douglasii			+					
C. mackenzieana			+					
Calamagrostis nutkaensis			+	+	+			
Lathyrus palustris			+	+	+			
Triglochin maritima			+	+	+			
Hedysarium alpinum americanum				+				
Calamagrostis inexpansa				+				
Salix arctica				+				
Chrysanthemum arcticum				+				
Parnassia palustris				+				
Plantago macrocarpa				+				
Polygonum viviparum				+				
Rhinanthus minor groenlandicus				+				
Dodecatheon macrocarpum				+	+			
Stellaria humifusa				+	+			
Carex pluriflora				+	+			
Poa macrocalyx				+	+			
Deschampsia beringensis				+	+			
Festuca rubra				+	+			
Potentilla pacifica				+	+			
Iris setosa				+	+			
Ligusticum hultenii				+	+	+		
Myrica gale					+	+		
Caltha palustris					+	+		
Sanguisorba sitchensis					+	+	+	
Equisetum pratense					+	+	+	
Salix sp.						+	+	
Calamagrostis canadensis						+	+	
Alnus sinuata							+	+
Viola epipsila repens							+	
Athyrium felix-femina							+	
Rubus stellatus							+	
R. arcticus							+	+
Arctagrostis arundinacea							+	+
Dryopteris austriaca							+	+
D. linnaeana								+
Circaea alpina								+
Hylocomium splendens								+
Cornus canadensis								+
Pyrola uniflora								+
Viburnun edule								+
Vaccinium alaskense								+
Carex laeviculmis								+
Trientalis europea								+
Rubus spectabalis								+
Potentilla palustris						+		+

Table 1. The distribution of plants in relation to types of vegetation. The communities are listed from left to right in order of increasing elevation of the landscape.