A PRELIMINARY EVALUATION OF EARTHQUAKE DAMAGE TO WATERFOWL HABITAT IN SOUTHCENTRAL ALASKA[1]

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Tectonic uplift and subsidence accompanying the March 27, 1964, earthquake affected an area of 34,000 square miles in southcentral Alaska including considerable intertidal waterfowl habitat. East of a line running through Seward, and the western portion of Prince William Sound, coastal land levels rose as much as 7.5 feet; west of this zone, the land level subsided as much as 5.4 feet. This severe land uplift altered 300 square miles of high density waterfowl nesting habitat on the Copper River Delta and severely damaged by subsidence over 25 square miles of tidal marsh in the Cook Inlet, Knik, and Turnagain Arm areas.

Cook Inlet

While the Cook Inlet area is of small importance in the statewide waterfowl production picture, it is most important from a recreational hunting standpoint. Over one-third of the licensed waterfowl hunters in the State of Alaska hunt out of Anchorage--most utilizing the adjacent marshes which can be reached by car or airplane. It is estimated that prior to the earthquake over 10,000 hunter days were spent annually in the waterfowl marshes of Cook Inlet.

Losses of huntable marsh resulting from land subsidence amounted to approximately 25 square miles. Thus, over 2,000 man hours of hunting effort must be directed elsewhere.

Tidal marshes bordering Kachemak Bay in southern Cook Inlet were hardest hit by tidal inundation. Several portions of northern Cook Inlet, especially the Portage Flats area, are now flooded during most high tides. Minor changes have been noted on the Chickaloon Flats, Eklutna Flats, Palmer Hay Flats, Susitna Flats, and the Trading Bay-Redoubt Bay area on the west side of Cook Inlet.

Loss of nesting habitat is extremely difficult to assess since no formal studies of nesting had been attempted in the Cook Inlet area. However, there has been a definite loss of huntable marsh due to tidal innundation in those areas in which land subsidence occurred. Future prospects for the flooded areas appear unfavorable, except in the case where it would be possible to construct dikes. In this way some of the hunting pressure may be diverted into reclaimed areas.

Copper River Delta

The intertidal portions of the Copper River Delta provide the major nesting habitat for the Dusky Canada Goose (*Branta canadensis occidentalis*), a rather unique and small population of geese which winters in the Willamette Valley of Oregon returning and nesting each spring to a restricted breeding area on the Delta of the Copper River. Nesting densities

[1]A contribution of Federal Aid to Wildlife Restoration W-15-R.

of this goose have been recorded at over 100 nests per square mile and probably average between 40 and 50 nests per square mile on the intensely utilized portion of the Delta. Other waterfowl, especially Pintail and Scaup, nest commonly throughout the Delta and densities of 50 nests per square mile are not unusual. Most important to these nesting waterfowl is a forb and grass community that formerly occurred at the extreme high tide level, but has now been uplifted nearly 6 feet. This drastic change in land level over a habitat closely adjusted to tidal fluctuations will no doubt create extensive changes in the plant and animal ecology of this area.

Because background data concerning waterfowl populations on the Delta were available and this catastrophic event presented a unique opportunity to study plant succession on a recently disturbed area, the Copper River Delta was selected for intensive study by the Department of Fish and Game. Work on this project was initiated in May of 1964.

Study Area

The Copper River Delta is a flat expanse of alluvial deposits formed from the Copper River and several smaller, adjacent, glacial streams which discharge into the Gulf of Alaska by way of the Delta. These flats lie immediately east of Prince William Sound from Point Whiteshed eastwest along the gulf shore for approximately 50 miles to Cape Martin.

Along the entire shoreline of the Delta at a distance of four to seven miles offshore, is a single line of bar-shaped islands. An extensive shallow bay, sheltered from the open ocean, lies between the mainland shore and these islands. The mainland shore touches on this now partially dry bay about four miles from the islands and extends inland to a rugged range of mountains seven to ten miles distant. In the past the entire terrain of this flat was only a few feet above sea level.

The plant ecology of this area is closely associated with soil texture and drainage factors; therefore, an interesting pattern of vegetative distribution is apparent on the Delta. In the better drained sands and gravels of the flats, near the Copper River Highway, thick stands of alder (Alnus crispa) and willow (Salix spp.) are common. Where the ground is slightly higher one finds small stands of cottonwood (Populus spp.), Sitka Spruce (Picea sitchensis) and western hemlock (Tsuga mertensiana). Progressing to the outer Delta the alluvial deposits become finer and more graded. These silt deposits support two major terrestrial plant communities--sedge and mixed forb. The former occurs at ground levels more frequently flooded by tidal action and the latter on low natural levees bordering tidal sloughs. The mixed forb community was the level of greatest drift accumulation in the past and is often referred to as the driftwood zone.

Interspersed among these tidal sloughs are many shallow, formerly brackish, ponds which support a simple plant community dominated by stands of mare's tail (Hippuris sp.), sedge (Carex spp.), and pondweeds (Potamogeton spp.). Further inland these ponds become deeper, contain fresh water and support a more complex vegetation including dense stands of horsetail (Equisetum spp.). The loose unstable sands of the offshore bars are largely stabilized by a beach rye (Elymus mollis) community. The large sand dunes at the mouth of the Copper River support stands of beach rye, alders, and cottonwood.

Physical Effects of the Earthquake

Immediately following the earthquake considerable physical damage was apparent on the Copper River Delta. Large ground fissures criss-crossed the flats draining ponds and diverting water courses. Huge blocks of unstable silts bordering the sloughs had slumped and filled many sloughs above the present water level. Portions of sloughs which were never dry even on a minus tide were exposed and many have become completely dry.

Ponds which were formerly brackish rapidly became salt free, or in some instances completely dry, as tidal ranges are now insufficient to replenish pond water levels. Rainfall has replenished some ponds with water, but these appeared to be drying as the dryer part of summer approached. In turn the heavy rainfall of this area had begun to severely erode slough banks and other areas where fissuring had occurred.

Large expanses of intertidal mud flats adjacent to the shoreline of the flats were exposed and now remain bare except during the higher tides. The extent of this area, including the mouth of the Copper River probably exceeds 20 square miles.

Influences of the Present Habitat Changes on Waterfowl Production

These physical habitat changes were the conditions which greeted returning migrants in April and May of 1964. Unfortunately that spring was one of the latest ever recorded and nesting was delayed until far beyond the average dates. However, nesting densities based on a sample area of nearly one square mile suggested that dusky goose populations may have been higher than in previous years, although the nesting population of dabbling and diving ducks appeared somewhat lower. In addition, the number of nesting trumpeter swan was less than 50 per cent of past populations. In the spring of 1965 a substantial population of geese and swans initiated nests on the Delta but a much lower population of ducks was present.

Comparison of goose and duck clutch sizes revealed no point which could be related to habitat changes except that a reduction in clutch size was apparent in both geese and swans in 1964 (Table 1).

Table 1

Comparison of Trumpeter Swan, Dusky Canada Goose and Duck Clutch Sizes on the Copper River Delta

	1959		1964		1965	
Species	Aver. Clutch	No. Nests	Aver. Clutch	No. Nests	Aver. Clutch	No. Nests
Trumpeter Swan	4.8	(38)	3.9	(12)	4.8	(17)
Dusky Canada Goose	5.6	(194)	4.3	(114)	5.8	(140)
Dabbling and Diving Ducks	6.9	(122)	7.3	(35)	7.3	(21)

The clutch size data, especially in the case of the swans and geese suggest the late spring may have been partially responsible for the reduced clutch size in 1964.

In 1964, fewer trumpeter swans were found nesting on the east side of the Delta, whereas an increase in swans was noted on the western portion. One might speculate this was an effect of the earthquake, although more realistically this movement in 1964 was probably a direct result of the late spring, since much ice and snow was still present to the east on June 17 and may have precluded early nesting on the Martin River Flats. However, in 1965, nearly twice as many swan were noted establishing nests and nesting territories on the western side of the Delta. Most of the new nests were located in formerly brackish or semi-brackish ponds. This expansion into new areas may be in response to both population pressures and the availability of new habitat.

Probably the data of most interest at present are those which pertain to nesting success of the dusky Canada goose. Prior to 1964 tidal flooding of nests and storms probably presented the most significant threat to nesting success with predation, largely avian, of slight consequence. Following the earthquake, accessibility of the outer Delta and the densely populated nesting grounds was simplified by the drying of sloughs and wet areas. Thus, coyotes, foxes, and other mammals have become increasingly abundant on the outer Delta during the past two summers. This extension of the hunting range of these species has resulted in increased nest predation (Table 2).

Table 2

Dusky Canada Goose Nesting Success
on the Copper River Delta

Year	No. Nests	Hatched		Abandoned		Flooded		Destroyed	
		No.	%	No.	%	No.	%	No.	%
1959	222	198	89.2	7	3.2	14	6.3	3	1.3
1964	102	84	82.4	8	7.8	0	0	10	9.8
1965	195	114	58.5	24	12.3	0	0	57	29.2

Losses to mammalian predation may exceed a level which is compensatory to nesting failures caused by flooding and other factors which are no longer operative. If this is the case then, limited predator control may be warranted during the nesting and brood season. However, such measures should be evaluated fully as habitat conditions change. In the past year microtines have become greatly abundant and could possibly create a primary food source thus creating a more favorable predator-prey relationship.

Future of the Copper River Delta Habitat

Evidence of unstable land conditions are present in the silt de-

deposits of the Copper River Delta where two separate forest horizons are visible at 14 and 9 feet below the present ground vegetation. Carbon 14 dating of spruce wood from these horizons suggested that the lower forest horizon was approximately 1,000 years old. Decayed vegetation is present in the deep silts covering the spruce forests, hinting that silt deposition and re-vegetation was gradual. These past changes may have accompanied tectonic land disturbance and/or a gradual rising of water levels.

In an area of high rainfall, such as the Copper River Delta, one would expect rather rapid vegetation changes in plant communities so highly regulated in their distribution by tidal activity and salt tolerance. Former salt concentrations should, or will soon be, leached out of the soils; thus paving the way for pioneering by other species of plants. Concentrated salts in the Delta soils are no longer being replenished. Moreover, since virtually no tidal inundation is occurring on the present plant communities a wide area should undergo changes.

Invasion and pioneering of the bare ground is perhaps more spectacular and obvious. New sedge seedlings can be found in abundance between the present 10 foot tide level and the permanent stands of sedge at the previous 10 feet tide level. Eventual development of this habitat will probably not provide more than 8 square miles of suitable nesting cover. This amount of cover would possibly compensate for the loss of present nesting habitat. However, an unknown factor in this loss and gain of habitat is the relative rate at which both develop new vegetation and whether or not there will be suitable cover to support a huntable population of dusky geese.

PROCEEDINGS

OF

FORTY-FIFTH ANNUAL CONFERENCE

OF

WESTERN ASSOCIATION OF STATE GAME AND FISH COMMISSIONERS

ANCHORAGE, ALASKA

JULY 7-9, 1965