Geologic factors in the prehistoric establishment of organisms endemic to eolian dunes near Antioch, California

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by

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INTRODUCTION

Among geologic topics pertaining to endangered inhabitants of Antioch dunes, probably the most important are distribution of eolian sand in central California, which would constrain methods of migration; the age of the Antioch dunes, which might determine rates of speciation; and climatic change since establishment of the dunes, a significant variable for organisms at the limit of their geographic range.

The Fish and Wildlife Service grant has allowed me to explore aspects of each of these topics. The grant not only underwrote 1000 ft of auger drilling at 14 sites near Antioch, it also freed funds within the U.S. Geological Survey for closely related drilling at Tulare Lake bed in the southern San Joaquin Valley. The following summaries draw both on previously available data and on results of these recent drilling programs.

DISTRIBUTION OF EOLIAN SAND IN CENTRAL CALIFORNIA

The recent drilling near Antioch confirms that eolian sand at the Antioch Preserve is continuous with the sheet of eolian sand that, as suspected by Carpenter and Cosby (1939), underlies much of the flatlands between the Mt. Diablo foothills and the western margin of the Sacramento - San Joaquin Delta.

It is likely, however, that this sheet has always been isolated from other dune fields in central California, such as those that cover parts of the eastern San Joaquin Valley (Marchand and Allwardt, 1981) and underlie parts of Oakland and San Francisco Bay (Cooper, 1967; Atwater and others, 1977). No eolian sand is known between Oakland and Antioch, and southeast of Brentwood the Antioch field terminates against the San Joaquin River (Atwater, 1982).

AGE OF THE ANTIOCH DUNES

Judging solely from local evidence, most of the exposed eolian sand near Antioch accumulated at some time between 10,000 and 40,000 years ago. This bracketing is required by previously available radiocarbon dates: eolian sand in the western Delta post-dates alluvium 38,000-46,000 radiocarbon years old and, as first shown by G. K. Gilbert (1917, pl. IV), pre-dates the sea-level rise of the past 10,000 years (Atwater, 1982). Further, the recent drilling near Antioch shows that some of the dune sand interfingers with, and hence is probably coeval with, alluvial-fan deposits roughly 22,000 radiocarbon years old.

From a broader perspective it is likely that most of the exposed dune sand near Antioch accumulated during the most recent major glaciation of the Sierra Nevada. This glaciation, called Tioga, occurred about 12,000-26,000 radiocarbon years ago according to results of the recent drilling at Tulare Lake. Tulare Lake formed behind a dam of glacially eroded sand and silt deposited by the Kings River. Similar detritus spilled overbank along other principal rivers of the eastern Central Valley (Arkley, 1962; Janda and Croft, 1967; Shlemon, 1971; Marchand and Allwardt, 1981), much like hydraulic mining debris spread across farmland along the Yuba and Feather Rivers (Gilbert, 1917). Glacially eroded sand and silt must also have spilled onto floodplains along the Valley's arterial drainages at the sites of the western Delta and Suisun Bay, areas made terrestial by glacial lowering of sea level. Summertime winds sweeping these glacial-age floodplains would have picked up the sand and deposited it as dunes to the east and southeast, thus generating the dune field of eastern Contra Costa County.

If the foregoing model applies generally to Pleistocene ice ages, then the cyclic nature of late Pleistocene climate (Broecker and Van Donk, 1970) implies that dunes could have formed near Antioch at least five times during the past one-half million years. Evidence of two discrete episodes of eolian deposition is in fact exposed in a river bluff immediately adjoining the Preserve, (Atwater, 1982). Here, approximately 15 m of young (probably Tioga-age) dune sand overlies 1.5-2.0 m of older dune sand. Conceivably this dune sand formed during the penultimate major glaciation of the Sierra Nevada. Evidence from Tulare Lake suggests that this glaciation occurred about 140,000 years ago. Thus a hiatus of 100,000 years may separate the last two episodes of sand-dune formation near Antioch.

CLIMATIC CHANGE SINCE ESTABLISHMENT OF THE DUNES

If sand dunes near Antioch indeed formed during major Sierra Nevada glaciations, then the climate during eolian deposition must have been significantly cooler and/or wetter than at present. It is not inconceivable that, like the site of Mountain View (Atwater and others, 1977, p. 6), the Antioch area supported stands of incense cedar during the Tioga glaciation.

To gage climatic change at Antioch since the end of Tioga glaciation, the best available approach is to use the pollen record that Adam and others (1981) have obtained from nearby Clear Lake. This record suggests that roughly modern climates have prevailed throughout the past 10,000 years.

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