Nobody—not in the U. S. National Park Service, anyway—ever claimed that maintaining natural environments while providing for their use and enjoyment was easy, or cheap.

Notes:

1 Paper prepared for a panel discussion on "Economic Values of Wildlife" at the 1987 Meeting of the Northwest Section of The Wildlife Society, Juneau, Alaska, March 30-April 2, 1987.

2 Loomis, J. B., G. Peterson, and C. Swanson. 1987. The conceptual foundation for valuing wildlife and fishery resources. Paper presented at the annual meeting of N. W. Section of The Wildlife Society, Juneau, AK, March 30-April 2, 1987.

3 Evison, B. 1987. N. P. S. memorandum to Alaska Region Superintendents: "Action Item, Create usable resource inventories for each park." March 11, 1987.

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Reviews

El Niño in the Galápagos Islands: The 1982-1983 Event," edited by Gary Robinson and Eugenia M. del Pino. Published by the Charles Darwin Foundation for the Galápagos Islands, Quito, Ecuador, 1985. xxvi + 534pp. [Available, while supply lasts, for US$12.00 plus postage, from Fundación Charles Darwin, Casilla 3891, Quito, Ecuador.] Reviewed by *Lloyd L. Loope.*

This book documents the extreme climatic and biological events that took place in the Galápagos Islands between October 1982 and August 1983. 'El Niño' is a naturally recurring phenomenon (at 3-15 year intervals) in that part of the Pacific that involves failure of SE trade winds, warmer ocean temperatures, less upwelling of nutrient-rich cooler water, heavier than normal precipitation, and stronger than normal waves and tides. Many of us first became aware of the 'El Niño' phenomenon through news reports of the 1972 event which triggered a drastic decline in the Peruvian anchovy fishery, and sent poultry prices up in the United States. The 1982-83 event was also the subject of many news reports—involving flooding on the west coast of the United States, unprecedented drought and destructive fires in Australia, and abandonment of Christmas Island by its huge seabird colonies. During January-March 1983, the period of El Niño's climax in the Galápagos, Hawaii had an unprecendented drought, which thoroughly dried moss-covered logs in Hawaii's rainforests.

The consensus of the book's authors is that the 1982-83 event was the most extreme such event in a 100-year period. In a 12-month period of 1982-83, the Darwin Station on Santa Cruz Island, which normally receives less than 10 inches of annual rainfall, received 130 inches of

rain. Simultaneously, near-surface ocean temperatures rose 2°-5° C and the food supplies of ocean-dwelling animals declined dramatically. The biological effects of this event were striking, with the rough generalization applicable that marine organisms were affected negatively while many terrestrial organisms flourished.

The book is comprised of 30 papers, with 14 in Spanish and 16 in English. Abstracts of all papers are given in both languages. Many of the authors are scientists who happened by chance to be working in the Galápagos at the time of the event. Most of them had data on normal baseline conditions of the populations with which they were working. Others are perceptive local observers. Still others are international experts on the "El Niño" phenomenon. The editors, Gary Robinson (City College of Santa Barbara) and Eugenia M. del Pino (Catholic University, Quito), have done an excellent job of recruiting contributions that complement each other and provide an excellent overview of the event. I will attempt to hit some of th high points from my perspective as a terrestrial plant ecologist interested in plant-animal interactions.

Peter Kramer's foreward to the book calls attention to the value of the story it tells as a "basic conservation lesson." "Populations and biotic communities must be sufficiently protected and large enough to be safe not only when average environmental conditions prevail, but also during times of climatic extremes and stress."

Part I, entitled "Oceanography," provides information on the complex interrelationships among flunctuations in climate, sea level, near surface temperatures, salinity, nutrients, and phytoplankton biomass. A crucial contribution was made by researchers from Duke University and the Ecuadorian Fisheries Institute (Kogelschatz *et al.*) who by chance happened to start a time sequence of detailed monitoring of ocean conditions off Isla Santa Cruz in June 1982 in order to document the "normal" baseline conditions; with 18 months of triweekly sampling at depths of 0, 10, 25, and 60 meters, they were able to document both the "normal" and extreme El Niño conditions. At the height of the El Niño event, inorganic nutrients were greatly depleted in the upper 25 meters of water; phytoplankton biomass was reduced to 30 percent of the normal level. Changes in distribution and density of phytoplankton were readily detectable with satellite-derived color images of the Galápagos Archipelago and adjacent waters.

The article by Godfrey Merlen, which comprises Part II, provides a valuable synthesis of the event from the viewpoint of an experienced local observer. Merlen has long been a resident of Puerto Ayora, Santa Cruz, and was working as a National Park Naturalist Guide during 1982-83. He describes eloquently the heavy rainfall events and accompanying consequences—spectacular lightning, roof leaks, electrical failures, a sharp increase in fire ants, dying marine life, luxuriant verdure of vegetation, etc.

Part III deals with effects on marine life. Gary Robinson provides an excellent overview of this topic, and nine accompanying papers fill in details for particular taxa. Widespread mortality occurred for many

types of corals, many endemic fishes, sessile invertebrates, sea lions, and other species that normally thrive in the relatively cool waters around the Galápagos. Marine iguanas declined by 30-55 percent; flightless cormorants by 45 percent; Galápagos penguins by 78 percent. On the other hand, species characteristic of Pacific warm water areas increased. Robinson suggests that rare events such as the 1982-83 El Niño may have important evolutionary effects through severely depleting and isolating populations, setting the stage for the production of new species.

Effects on the terrestrial fauna and flora are given in Part IV. Ole Hamann's contribution details the spectacularly positive immediate effects of the heavy rainfall on Galápagos vegetation. "When water was no longer a limiting factor for plant growth, a great number of species were able, not only to germinate and grow, but also flower and fruit abundantly, both in arid and in humid vegetation types." However, some species (e.g., *Opuntia* spp. and *Bursera graveolens*) were negatively affected by waterlogging of the soil, which often resulted in physical collapse of root systems. Hamann also makes an interesting point regarding the possible role of extreme El Niño conditions in colonization of the archipelago and individual islands within the archipelago by new plant species through facilitation both of transport and establishment.

The paper by Weber and Beck of the University of Colorado Museum describes devastation to Galápagos lichens and mosses. Crustose, foliose and fruticose lichens were destroyed through physical souring of water and through rotting. Mosses of watercourses and of the forest floor were washed away or covered by flourishing herbs and vines. The most common bryophytes of the highlands thrived so well that they tended to crowd out relatively rare mosses and large foliose lichens.

The paper by P. R. and B. R. Grant on responses of Galápagos finches and their habitat to the heavy rainfall is one of the more definitive in the volume, thanks to intensive documentation of habitat ecology and population dynamics of these birds by the Grants and coworkers on several of the more pristine islands during a decade of study. Several species of plants fed upon by finches underwent an extended flowering season under these conditions. *Croton scouleri*, for example, which normally flowers once or twice a year, was found to flower 5 to 7 times, with a proportional increase of seed production. Insect populations flourished (though they later crashed before the rains ended, perhaps because of a buildup of parasitoids or because of a defensive response of the plants). Feeders on seeds and insects, the finch species studied produced four or more clutches of eggs in a year (*vs.* one clutch in a normal year). The biological potential of the large cactus ground finch under the heavy rainfall conditions was indicated by one highly successful pair that laid 29 eggs in 7 clutches during the 9-month period and fledged 20 young! However, the maximum size attained by the overall breeding population was only 50 percent above levels of the previous year, probably because of high levels of nest desertion and of predation on fledglings by mockingbirds.

Their longevity, slow metabolic rate, and low mortality rate enable the famous Galápagos tortoises to "wait out" extreme environmental conditions, as detailed by Linda Cayot of Syracuse University. They were perhaps the least affected of all Galápagos organisms by the 1982-83 event.

Part V is entitled "Man and the El Niño Event." I must confess that I gathered less detail from this section since all five papers are in Spanish. The heavy rains were disastrous for the major road in the islands, on Santa Cruz from the Baltra ferry to Puerto Ayora, as well as for a newly constructed children's park on San Cristóbal. In both cases, planners grossly underestimated the potential maximum rainfall events of the islands. Unavoidably, the normal cultivated flora around houses in towns of the arid zone suffered from too much moisture. Many fast growing, moisture-loving tropical plants, including fruit trees, thrived around habitations of Puerto Ayora after 10 months of wet weather; a few months after the normal drought conditions returned, they had perished. Agricultural enterprise in the Galápagos is normally favored by rainfall events, yet this El Niño weather provided far too much of a good thing. Rough seas, heavy rains, and lack of sun made for unhappy tourists. The local human population had a higher incidence of disease during the inclement weather.

Kramer is certainly correct in urging consideration of this case history as a basic conservation lesson. It provides a superbly documented example of the potentially overwhelming ecological importance of infrequent meteorological events. I would go further perhaps in suggesting its use as supplementary reading in beginning ecology classes, perhaps even in basic biology college courses, in conjunction with films on the Galápagos. The archipelago has admirably served for well over a century as a conceptual microcosm of evolutionary processes, made famous by Darwin's writings and by David Lack's book, "Darwin's Finches." As is the case with evolutionary interpretations, the low species numbers and relatively simple ecosystems of this isolated archipelago make ecological interactions more understandable. This book is a classic treatise on within-site environmental variation and its effects on organisms.

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