sented by abstracts or briefs only (for example, that by Mintz and Arakawa on numerical simulation of global climate). One welcomes as strongly the inclusion of a brilliant series of studies by scientists from the Main Geophysical Observatory and the Arctic and Antarctic Scientific Research Institute of the U.S.S.R. For the first time, one can put North American studies alongside Russian to weigh differences and similarities of approach. A strong convergence of results and research methods is at once obvious. The Rand Corporation and the National Science Foundation are to be congratulated on a fine job, as is J. O. Fletcher, the editor.

The *Proceedings* begin with a series of papers on the interaction of climate and the arctic heat budget. The main object of enquiry here is the stability of past and present high-latitude climates in the light of new knowledge about the heat budget. Budyko and Fletcher (the pioneer in 1952 of North American floating stations in the Arctic basin) present reviews of the heat balance. Both papers examine changes in the budget that might occur if the permanent pack disappeared (which Budyko says is quite possible). Fletcher gives plausible budgets for both ice-free and "ice-in" arctic conditions. He finds, as might be expected, that greatly increased snowfall, and hence continental glaciation, would be a likely accompaniment of ice-free conditions. There follow papers by Mitchell (on stochastic modelling of air-sea interactions and climatic fluctuation), Girs (on the heat balance of the Soviet Arctic), Borisenkov (on atmospheric circulation), Müller (on the Axel Heiberg glaciers), Putnins (on Greenland), and Bloch (on sea-level changes and the polar albedo). The ensemble is an impressive examination of high-latitude climatic instability.

The second section is devoted to the quantitative evaluation of the heat budget itself. Untersteiner deals convincingly with the thermal regime and mass budget of the sea ice, and Wittmann and Schule follow him with a most impressive study, basically in map form, of the ice itself: a huge volume of data is condensed into a most reasonable space in their diagrams. Doronin, Marshunova, and Chernigovskiy follow with thorough studies on the characteristics of the heat and radiative exchanges, interspersed with a review by Badgley of the heat budget at the surface of the Arctic Ocean. Vowinckel and Orvig speculate as to possible changes in the radiative exchanges (a subject they cover more thoroughly elsewhere), and Businger treats the momentum and heat transfers in the boundary layer. The latter chapter has little special relevance to arctic conditions, being a broad survey of the field in general.

This question of relevance arises again in Section III, which deals with circulation models for the atmosphere. The papers by Yudin, Leith, Kasahjara, and Washington belong in a symposium on numerical weather prediction or on the general circulation: they are out of place in this context, because they do not bear directly enough on high-latitude circulation. On the other hand, Rakipova's study of the influence of arctic ice on zonal atmospheric temperature distribution is a splendid illustration of the growing body of climatic theory, most of it of Russian origin. Berkofsky and Shapiro present an investigation (dynamical in nature) of the effects of high-level heating on large-scale circulation of the lower atmosphere that is again rather remote from the main body of the report.

The remainder of the report deals with atmosphere-ocean interactions and models of oceanic circulation. Here, the paper by Coachman on supercooling during sea-ice formation is thorough, concise, and important, as is Farmer's theoretical study of time-dependent motion on long-term scales in a polar ocean. Bjerknes' study of the effects of equatorial ocean temperature anomalies on atmospheric motion is a little remote from the main business at hand.

In addition to the formal papers, there are reports from several working parties discussing future fields of research. This is a favourite tactic for such symposia, and presumably pleases the sponsor. For me, however, the real surprise and pleasure in reading this book came from the fact — rare enough to astonish — that an *invited* symposium produced so many good and original papers.

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WHOOPING CRANE POPULATION DYNAMICS ON THE NESTING GROUNDS, WOOD BUFFALO NATIONAL PARK, NORTHWEST TERRITORIES, CANADA. BY N. S. NOVAKOWSKI. *Canadian Wildlife Service Report Series, Number 1. Ottawa: Department of Indian Affairs and Northern Development, 1966. 11 x 8½ inches, 20 pages, illustrated. $0.50.*

This first number in a new series of Canadian Wildlife Service publications reports the results of twelve years of observations on the vital breeding area, the habits, and the population biology of one of North

America's largest and most famous bird species, the endangered whooping crane. Mr. Novakowski has been the chief Canadian Wildlife Service investigator of the whooping cranes' only known nesting grounds in the Sass River area west of Fort Smith, N. W. T. He has brought together information obtained since the time of the discovery of the nesting grounds in 1954.

The nesting habitat of the whooping crane is a network of small, shallow, bullrush-bordered ponds and low flatland vegetated with black spruce, tamarack, and willows. Nests are mounds of dead plant materials in the bullrush stands.

The nesting population of cranes in the Sass River area has averaged 8.6 individuals per year (6.2 as nesters and 2.4 as non-nesters). During active nesting, the pairs are confined to an area about nine miles square, but are spaced at least one mile from each other. In years when they do not nest, spatial separations break down. Adults leave the nest sites with their young about one week after the eggs hatch, and wander from one body of water to another throughout the rest of the summer. During September and October, other whooping cranes move into the Sass River area from unknown nesting grounds.

Since obviously, whooping cranes could not be killed for stomach analysis, food habits were deduced from samples of animal life taken from the bottoms of ponds, where cranes were seen feeding, by a device lowered from a helicopter. On this basis, insect larvae and crustaceans were presumed to comprise the chief summer diet. Fishes, which probably would not be obtained by the sampling method, were not mentioned.

Twenty-two of the 61 young whooping cranes that were counted on the wintering grounds on the Texas Gulf Coast from 1954 to 1965 are known to have been produced in the Sass River area by a maximum of 6 breeding pairs. The rest were produced in unknown areas. The over-all annual production did not change during those years, indicating that there had been very little recruitment into the breeding population which had had an average gain of only about one bird per year during the period. It appears that high mortality follows years of high production of young, seemingly indicating that the chief loss is of second-year birds. High spring and summer precipitation is correlated with poor nesting success.

The author calculated that during the period of study, 56 per cent of eggs laid were known to have hatched. Forty-four per cent either failed to hatch or the chick disappeared before observations were made. Of the chicks known to have hatched, 20 per cent survived until fall migration. The reviewer notes that some disagreement in the data appearing in two tables on the number of eggs laid and number of eggs hatched is reflected in slight differences in the percentages of mortality, depending on which tabulation is used.

The production of whooping crane chicks in the Sass River area has been confined to six well-defined nesting territories presumably occupied by the same adult nesting pairs each year. A map shows the location of the nest sites, and year occupied, identified with the pairs of cranes that utilized them. Discrepancies between the years of site utilization shown on the map and tabulations of production of young from those sites by year probably indicate that the nests either were not found or were not plotted each year.

To improve the population status of whooping cranes, the author suggests taking eggs from nests of wild birds and hatching and raising the chicks in captivity for ultimate release to the wild. It was proposed that the eggs be taken in wet years when high precipitation would very likely cause the loss of eggs or young if left in the nests. Also, it was suggested that consideration be given to taking young of the year on the wintering grounds after their first flight south, then holding them until sexually mature before release. The purpose would be to protect the birds during the vulnerable subadult period.

Mr. Novakowski has written a very interesting paper, particularly as it is the first published information on the behaviour of whooping cranes on their breeding grounds since the discovery of this area in 1954. The inclusion of more details on actual observations of the birds would not only have been extremely interesting but would have been meaningful to the reader.

The paper is beautifully illustrated (the cover is in colour) with photographs of whooping cranes in their Aransas refuge wintering home, by Luther Goldman of the U.S. Bureau of Sport Fisheries and Wildlife, and of crane nesting habitat, by Lawrence H. Walkinshaw of Battle Creek, Michigan, who has specialized in crane studies.

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