

GLACIER MASS-BALANCE MEASUREMENTS: A MANUAL FOR FIELD AND OFFICE WORK. By G. ØSTREM and M. BRUGMAN. Saskatoon: National Hydrological Research Institute, 1991. NHRI Science Report No. 4. 224 p., 65 figs., bib., glossary. Softbound. No price given. (Available from NHRI, 11 Innovation Boulevard, Saskatoon, Saskatchewan, Canada S7N 3H5.)

It is splendid to see a new edition of *Glacier Mass-Balance Measurements: A Manual for Field and Office Work* in print. As noted in the preface, supplies of the second edition of the *Manual* (last printed in 1969) were exhausted in 1980 and copies of the old manual became highly prized possessions within the glaciological community. The old manual served as the authoritative reference for glacier mass-balance methodology in Canada and Norway for many years; the new expanded and revised version is sure to continue in that role. Indeed, the new fieldbook-sized format will make the book even easier to pack into the mountains.

Gunnar Østrem (now retired but maintaining an active role at the Norwegian Water Resources and Energy Administration) has been a major participant in glacier mass-balance measurement in Canada and Norway for many years. Recently, he helped establish a glacier mass-balance measurement program at Arctic College, Iqaluit. Mindy Brugman is currently in charge of Canada's glacier mass-balance measurement field program at the National Hydrological Research Institute.

Glacier mass-balance measurement is a process by which the growth and decay of a glacier is monitored. In a given period, a glacier receiving the same mass of rain and snow (accumulation) as it loses to melt and runoff (ablation) is said to be in balance. If accumulation exceeds ablation, mass balance is said to be positive; the glacier thickens and may advance. Conversely, if ablation exceeds accumulation, mass balance is negative; the glacier thins and may retreat. Glacier mass-balance data are critical in studies of alpine river hydrology and climate change. Although measuring glacier mass balance may seem straightforward, field work is complicated by limited time, limited resources, difficult terrain, and unpredictable weather. Additionally, drifting snow, refreezing meltwater, and local variations in precipitation complicate the measurement of ablation and accumulation. Many questions arise: How often and at what times of year should snow accumulation and ice melt be measured? Should measurements be made on the same date every year or when snowpack conditions are equivalent? At how many locations should measurements be made? What period should be taken as the mass-balance year? How reliably can accumulation and ablation measurements be extrapolated over the entire glacier surface?

Answers to these questions, and many others, have spawned a multitude of methodologies the world over. Until glacier mass-balance terminology was standardized in the late 1960s, comparison of results from different countries was difficult. In two key chapters on data reduction and plotting, Østrem and Brugman propose standard graph and table formats for data presentation. These formats have been the *de facto* standard for many years in Canada, Norway,

and other countries (primarily owing to previous editions of the *Manual*). Indeed, these standards were reaffirmed at an internationally attended Workshop on Glacier Mass Balance Standards held in Seattle in November 1990.

In another important chapter, the authors compare eleven different data-collection methods and three reporting systems (one based on end-of-melt and end-of-snowfall observations, another on fixed observation dates, and the last on a combination of the two). Some of these data-collection methods were designed for situations where the traditional method, which involves a glacier-wide stake network, is unworkable. Measuring the mass balance of a large high arctic ice cap is an example of such a situation.

In the remaining ten chapters (excluding the introductory and suggested readings chapters), Østrem and Brugman discuss the details of taking glacier mass-balance measurements. The most accurate data collection methodologies rely on stake networks; if data are collected at unsuitable locations or if stakes are improperly maintained, then the most sincere efforts may be wasted. To guide the reader, two chapters cover the selection of suitable glaciers for study and the design and maintenance of stake networks. Perhaps the most useful chapters, from the viewpoint of a field worker, are the six central chapters dealing with surveying in a mountain environment and with measurements of accumulation, ablation, meteorological parameters, water discharge, and sediment load. One of the strengths of this book is that the authors pepper these chapters with descriptions of tricks, tips, and useful gadgets. It is this collection of lore — which paper filter to use; how best to number samples; how to locate buried stakes; how to prevent survey stakes from melting down into the glacier — that is invaluable and can save hours of toil and heartache for the neophyte glaciologist. Finally, two chapters provide an overview of the extent of the global glacier mass-balance monitoring network (which is poor at best) and hints for field organization.

Approximately one-third of the text is made up of appendices providing worldwide overviews of glacier mass-balance observations (written by C.S.L. Ommanney, R.M. Koerner, and L. Mayo), standard data forms, and data collection programs for data loggers. There is even an appendix describing how to build and anchor a glacier hut (should snow bury the door, a snow shovel fastened under the peak of the roof would be handy!).

This book is intended to be used primarily by workers concerned with making glacier mass-balance measurements, but it is also useful to those seeking to understand how glacier mass-balance data are collected, how they are interpreted, and what their limitations are (for example, researchers investigating the possible effects of global warming on continental hydrology should read this book). *Glacier Mass-Balance Measurements* can be used in glaciology courses at the senior level post-secondary and graduate levels. I have also used this book as a reference text for a first-year course at Yukon College.

Although the *Manual* concentrates on the mass-balance methodology used in Canada and Norway, the methods

espoused by Østrem and Brugman are used the world over; this book is sure to be an invaluable reference.

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WILDLIFE MANAGEMENT AND SUBSISTENCE HUNTING IN ALASKA. By HENRY P. HUNTINGTON. London: Belhaven Press, in association with the Scott Polar Research Institute, University of Cambridge; and Seattle: University of Washington Press, 1992. xvii + 177 p., 19 figs., 3 tables, index, bib. Hardbound. £32.50; US\$50.00.

Henry P. Huntington's *Wildlife Management and Subsistence Hunting in Alaska* examines "currently active management and regulatory regimes . . . to discover what characteristics are shared by effective regimes." Huntington defines effective management as that which 1) protects wildlife populations and 2) "allows local people to provide for their needs," where a need is "a nutritional, cultural, or spiritual requirement that cannot be readily or adequately replaced." He deliberately focuses only on the interactions between wildlife management regimes and local subsistence hunters. Another delimitation is that most of the management regimes discussed pertain to "northern Alaska," defined as the North Slope Borough. The book's conclusions are intended to have broader applicability, however.

The first three of the book's eight chapters are introductory. The first chapter illustrates Huntington's multidisciplinary approach, which incorporates elements of wildlife management, anthropology, political science, and polar studies. The second is a short but informative history of wildlife management in Great Britain and the United States, which concludes with issues in contemporary Alaska. The third chapter is a brief overview of the history, culture, and economy of the Inupiat of the North Slope. The continuing nutritional, social, and cultural importance of subsistence hunting despite economic development is emphasized.

The next four chapters describe and evaluate various federal, state, local, and cooperative wildlife management regimes. Chapter four begins with a discussion of international treaties governing migratory waterfowl, whales, polar bears, and caribou. It then describes the two federal laws that most affect subsistence hunting in Alaska, the Marine Mammal Protection Act and the Alaska National Interest Lands Conservation Act (ANILCA). Finally, the chapter reviews the roles of the Fish and Wildlife Service, the National Marine Fisheries Service, the National Park Service, the Bureau of Land Management (BLM), and the Minerals Management Service in land and subsistence management.

Several examples of the activities of each federal agency are evaluated. One case is the National Park Service's implementation of ANILCA's provision requiring that subsistence resource commissions, consisting largely of local

hunters, develop subsistence hunting plans for national parks in Alaska. Another example is BLM's reintroduction of muskoxen to several areas of the North Slope Borough. Huntington views the latter as a successful program because it effectively involved local hunters, while the establishment of park subsistence resource commissions is a program that was intended to provide meaningful local involvement but has so far not done so. The reasons for this failure are not fully analyzed, however, pointing to a limitation in the book's evaluative method. While Huntington acknowledges that factors such as an agency's responsibilities to other interest groups or its professional culture may affect its interaction with subsistence hunters, he places these factors outside the scope of his analysis. Consideration of such factors would have assisted the reader in understanding why effective involvement of subsistence hunters in management systems often does not occur.

Chapter five examines the state's regulatory process, including the local advisory committee system, the Alaska Board of Game, and the Alaska Department of Fish and Game. As Huntington acknowledges, this chapter was written before an Alaska Supreme Court decision (in the *McDowell* case) fundamentally changed the way in which the state of Alaska could implement the subsistence provisions of federal law (ANILCA) and Alaska's own subsistence statute. Nevertheless, the chapter contains several important observations about the state system, such as some of the difficulties encountered by Alaska Native people when they participate in a formal regulatory process that itself attempts to respond to competing, statewide interests.

The chapter also gives examples of state subsistence regulations that reflect a view of hunting "as a recreational pursuit, not the economic basis of a way of life." Examples include individual bag limits for caribou and other game, which may inhibit sharing, and requirements that hunters obtain tags before hunting brown bears. The latter requirement contradicts cultural prohibitions against speaking openly about hunting bears out of respect for the animals. Huntington contends that such regulations serve no conservation goals. Further, because they have been adopted with little local input and have no local relevance, they are largely ignored and result in disinterest or hostility towards resource management in general. According to Huntington, adopting more culturally appropriate regulations in consultation with local hunters should result in better compliance with conservation efforts and better information for resource managers.

Chapter six reviews efforts by the North Slope Borough to develop its own resource programs. Although the borough lacks regulatory authority, it has formed a Department of Wildlife Management, a Fish and Game Management Committee, and a Science Advisory Committee to conduct research and promote local involvement in state, federal, and international management systems. According to Huntington, these organizations provide local involvement where the state and federal systems fail to do so. He notes, however, that the cost of these programs will place them out of reach of most local governments.

Of particular interest is the discussion in chapter seven of several examples of cooperative management regimes in