detail, such as the ecology of animals and polycyclic logging systems.

As appears to be inevitable given the vast array of topics, the treatment is not even throughout. The chapter on soils, contributed by C. P. Burnham, which follows chapters on climate, growth, and nutrient cycling, remains isolated from the mainstream of the book. Its concepts and correlations do not permeate the treatment of relevant topics such as shifting cultivation or more detailed environmental correlations with the climatic formation types. For example, the section in the following chapter on "the causes of the very curious structure and the xeromorphic physiognomy of heath forest" has a confusing and indecisive discussion of alternative ecophysiological and edaphic processes. The explanations could probably have been clarified by appropriate support in the soils chapter, since oligotrophic scleromorphy has now been well studied throughout the tropics. In the discussion of heath forests chemical defense mechanisms suffer an uncharacteristically trenchant dismissal.

The list and descriptions of the forest formations of the region, which are really the core of the book, remain much the same as in the first edition. The Indonesian forests are less well documented than those in Malaysia. As the late Marius Jacobs observed, it would seem that much closer consultation with the scattered authorities on the local vegetation is necessary to improve and consolidate the typology. Given the recent rapid progress of tropical ecological research based on Bogor and Kepong, one may hope that indigenous ecological perspectives will soon be provided in book form to amplify the present work.

In light of the greatly accelerated exploitation and clearing of the forests over the past decade, Whitmore has strengthened the sections dealing with the relations between humans and the tropical rain forest and has expanded the last chapter, "Looking ahead." The importance of the rain forest is noted laconically by characterization of three roles, "protective, productive, and prestigious," in relation to the "two faces of the human condition." The problem boils down to utilization now or permanent protection of the myriads of indigenous plant and animal species—or both if possible. The difficulties of management—let alone of scientific criteria and other desiderata—are noted in relation to encroachment by people and goals of national development. Given the doubtful viability of relatively small forest isolates, Whitmore admonishes those conservationists "who do not realize that many conservation values are compatible with managed as opposed to virgin forests" and repeats his plea for research into forest management for timber production, the life of the native animals, and visits by tourists.

Solutions are not yet in sight anywhere to reconcile all these conflicting requirements, which extend beyond biophysical to human ecology and beyond the tropical rain forest to uncertain ecosystems that are far more complex. In this diligent and singular book, Whitmore has taken traditional ecology and scientific and humanitarian concerns as far as a botanist can. One hopes that the more sharply focused "bird's eye view" he has attempted in the second edition will help convince the public and decision-makers in the region to keep their options open by saving what they cannot recreate of their remaining natural world.

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Pandas in the Wild

The Giant Pandas of Wolong. GEORGE B. SCHALLER, HU JINCHU, PAN WENSHI, and ZHU JING. University of Chicago Press, Chicago, 1985. xx, 298 pp., illus. $25.

There are probably no more than a dozen of the approximately 4000 mammals that are recognized by the vast majority of people, regardless of where they live and what language they speak. Most people, if ever exposed, remember and are able to name elephants, tigers, bears, rhinoceroses, and gorillas. The giant panda probably tops this list of charismatic megafauna in terms of attractiveness and mass appeal. It is big, conspicuously marked, lives in an exotic and remote habitat, and has a variety of other unique and interesting morphological and behavioral features (see D. Morris and R. Morris, *Men and Pandas*, McGraw-Hill, 1966). Curiously, we have less knowledge of the natural history and biology of giant pandas than of any comparably popular mammal, despite our fascination with this species.

Giant pandas became media figures in the 1930's when live animals were first exhibited in Western zoos. However, detailed studies of the species' natural history were only initiated when the Chinese began to conduct censuses and biological surveys in the 1960's. At the time, the Chinese were interacting little with the international community. Thus the results of several expeditions to giant panda habitat were generally unavailable outside China until 1979 and 1980, when the government of the People's Republic initiated discussions with the World Wildlife Fund to promote a collaborative research program to study giant panda biology. Its goals were: "(1) research on the ecology and behavior of free-ranging Giant Pandas . . . , (2) working on Emergency Plan to deal with natural disasters [as they affected giant pandas; between 1974 to 1976 nearly 140 giant panda carcasses were recovered, the deaths presumed to be a result of starvation after a bamboo species flowered and died in one region], (3) studies on pandas in captivity, including reproductive biology, nutrition, behaviour, and handrearing of newborn pandas" (p. xiv).

This volume summarizes the findings of extensive studies of giant panda behavior and ecology in the Wolong Reserve; presented are the results of investigations by Chinese scientists between 1978 and 1980 and of the collaborative work with Western scientists conducted between 1981 and 1982. The book also includes data from several other collaborating scientists who conducted analyses both in and outside China for the authors.

The volume is unique not only in its inception and development but also in offering the first glimpse of the giant panda within its remote montane home in western China. It sets as its major goal to answer the question "How is the giant panda adapted to bamboo?".

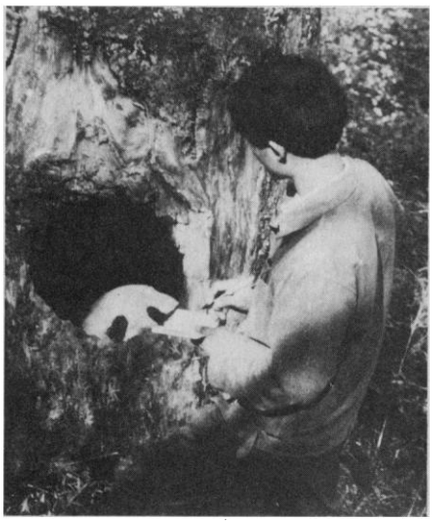
The study site is in the Wolong Man and Biosphere Reserve, 160 kilometers northwest of Chengdu in western Sichuan. The authors provide descriptions of the vegetation and its distribution within the Reserve as well as climatic, topographic, and other habitat information. The description of the study area is the first in such detail for this unique temperate ecosystem. A more complete comparison with other, comparable temperate habitats might have underscored its incredible biological diversity and high degree of endemism.

The giant panda and its major food resource, bamboo, are focused on very closely, and neither is considered as part of this region's diverse fauna and flora. For example, nearly 30 percent of the book is devoted to discussions of panda feeding behavior and an analysis of the composition and nutritional content of bamboo. By contrast, the discussion of vegetation structure and ecology does not delve deeply into the interaction of bamboo with the trees, shrubs, and un-

dergrowth or into the giant panda's interaction with other, cohabiting vertebrates.

One major new finding is that pandas must have access to at least two bamboo species within a small area and be able to migrate to another suitable habitat if the bamboo in one habitat flowers and dies. The giant panda's precarious status has worsened in historical times, as the need for agricultural land has devoured old panda habitat, especially migratory routes and areas upon which pandas relied for additional food resources during periods of especially severe nutritional stress. Also, Schaller and coworkers have shown dramatic differences in the nutritional quality of bamboo of different species, between different parts (stems, leaves, and shoots) of the plant, and between parts of differing age, as well as between seasons.

Through trapping, marking, and radiotelemetry, the authors provide the first information on home range size, movements, activity budgets, and behavior of giant pandas in the wild, based on results from seven individuals followed for varying time periods over the 18-month study. Giant pandas seem to be active about 60 percent of the time, the majority of which is devoted, not surprisingly, to feeding on bamboo, 99 percent of their total diet. Giant pandas are solitary, and males were found to have only slightly larger home ranges than females (3.9 to 6.4 square kilometers). Both sexes may travel seasonally long distances to find adequate food. Despite the enormous



"Gao Huahang takes notes on a wild female in a maternity den near the Fengtongzhai Reserve. [From *The Giant Pandas of Wolong*; courtesy of Forest Department, Baoxing]

time giant pandas spend ingesting and processing food, the authors suggest that the poor nutritional quality of bamboo means that these herbivorous carnivores are existing at all times close to their energetic limits.

The authors rarely saw giant pandas during this study. Indeed, each encounter with a panda seems to receive special notice, with transcriptions of field notes included. The limited descriptions of wild giant panda behavior are supplemented by descriptions of captives that offer few new data, given previous descriptions by other authors. In some cases, these observations are followed by conclusions about giant panda natural history and evolution that could not be reached in an 18-month study of any animal with a potential life-span of well over 20 years.

The final chapters, on communication and reproductive behavior and the comparison with related species, include a discussion of the giant panda's taxonomic position. The authors compare many panda characteristics with those of bears, raccoons, and red pandas but do not assess the relative importance of each factor with regard to giant panda phylogeny. Schaller *et al.* conclude that giant pandas are most closely related to red pandas and that both species are allied with the bears, which is not fully supported by the most recent biochemical and cytological analyses (O'Brien, personal communication).

The authors do not address the conservation program in any detail. This will be the subject of a future book. We look forward to this and additional future reports on the demography, population dynamics, social and mating systems, behavior, and genetics of the giant panda as they are completed by this unique collaborative research program.

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"The female Zhen has climbed into the low branches of a hemlock to avoid a courting male." [From *The Giant Pandas of Wolong*; photograph by George Schaller]

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Analog Signal Processing and Instrumentation.

(Continued on page 906)