chapters of a deep ocean that has changed sufficiently in temperature and extent since the Precambrian that major faunal changes must have occurred also. The authors believe that the high species diversity known from great depths cannot be related to constancy of environment, as most of the recent discussions have suggested, because of significant changes in bottom temperature since the mid-Mesozoic. Here they seem to have set up a straw man. I know of no deep-sea biologist today who does not believe that the deep-ocean environment has changed since the Mesozoic because of both continental drift and changes in the amount of deep water being formed at high latitudes. The difference between the deep sea and shallower depths is relative; the deep ocean, at least in the last 160 million years, although changing, has undergone changes at a slower rate than high-latitude shallow water or terrestrial environments, and today has by far the least amplitude of change of any biotic environment. In this lies the *relative* stability that seems to be at the heart of the species diversity problem.

A striking feature of this book is the large number of bottom photographs and artist's reconstructions of abyssal animals on the ocean floor. Many of the other illustrations and the tables are less successful. The captions for figures and tables are often not very helpful, and many figures contain symbols or designations that either are not necessary or are not explained anywhere. Several whole-page figures of virtually limbless isopods seem redundant; surely one or two would have been sufficient to illustrate the range of species and morphology.

Criticisms aside, I am not wholly displeased with this book. It puts forward an individual view of the biology of the deep ocean, often with considerable charm. Its survey of the older literature is good, and its attempt to deal with the deep-sea benthic system as a whole, changing in space and time, is commendable. It serves to mark the shift from descriptive work on deep-water benthos to experimental work on the deep-sea floor which will help to answer the many difficult problems remaining.

ERIC L. MILLS
*Department of Oceanography,*
*Dalhousie University,*
*Halifax, Nova Scotia, Canada*

## Faunal Distribution Patterns and Affinities

**The Dispersal Centres of Terrestrial Vertebrates in the Neotropical Realm.** A Study in the Evolution of the Neotropical Biota and Its Native Landscapes. PAUL MÜLLER. Junk, The Hague, 1973. vi, 244 pp., illus. Dfl. 65. Biogeographica, vol. 2.

The art and science of biogeography remain among the most intriguing and frustrating of enterprises in an intellectual world that seems nowadays to limit the biologist to laboratory experiments or to detailed quantitative analyses of populations in the field. Good biogeographers are able to discern recurring patterns among the multitudinous facts of species distributions, to chart the probable ecological and historical (geodynamic and evolutionary) forces contributing to the patterning, and to provide theories to explain the relationships between co-occurring species and their past dispersal. Some biogeographers are content with the descriptive approach, but not Paul Müller, who has attempted the first explanatory review of the distribution patterns of neotropical amphibians, reptiles, birds, and mammals.

The opening portions of this work are taken up with identifying and characterizing 40 major common distribution patterns (dispersal centers) for tropical Middle America and South America. Seventeen of the centers occur in tropical or subtropical latitudes dominated by broad-leaf evergreen forest, one is a cool temperate center, 19 are found under relatively dry conditions ranging from deciduous dry-seasonal forest to desert, and three are high montane centers located above timberline, including paramo and puna zones together with the tundra (permafrost) portions. While it is clear that the more complete evidence from birds and mammals biases this section and different results are possible if amphibians and reptiles are considered separately, it provides a major source of data on distributions and patterns, unencumbered by the usual attempts to draw boundaries between areas, since only the nuclear areas of overlapping distributions (the centers) are used for discussion and evaluation. A second section reviews the affinities of the centers to one another.

The most important segment of the book is the discussion (pp. 182–204) of the many stimulating ideas generated by the previous section. The following five conclusions are of particular importance:

1) The centers of dispersal are centers of origin for many present-day species and subspecies populations.

2) During the Pleistocene and to the present, significant glacial-related fluctuations in lowland tropical climates caused the expansion of humid evergreen forests and regression of the subhumid-to-xeric areas, alternating with dry periods when evergreen forest centers regressed and became widely separated by expanding subhumid-to-xeric areas; the most recent dry segment of the cycle was between 5000 and 2300 years ago.

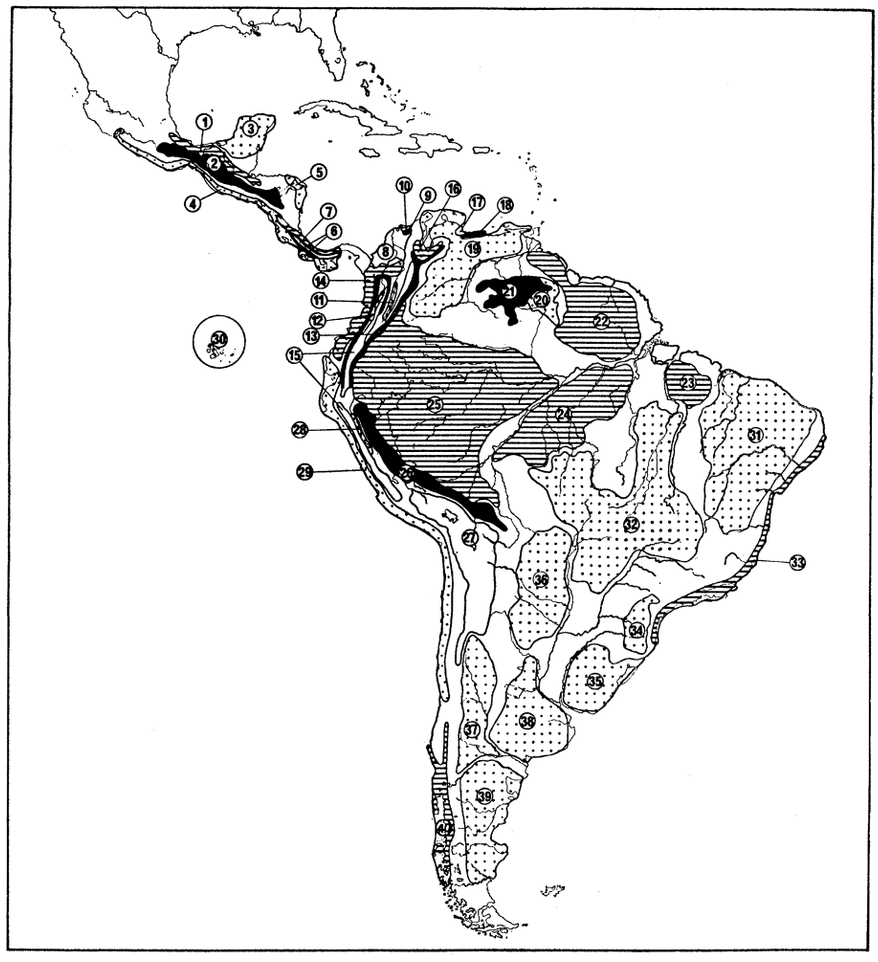
3) Present distribution patterns support the concept of a displacement of montane (1500 meters and up) groups downward during glacial maxima (25,000 years ago) to areas now occupied by lowland forest.

4) The most significant factor controlling speciation in the neotropics was the postglacial fluctuations with reduction and expansion of distribution refuges (centers) responsible for isolation and differentiation.

5) The fauna of the pampas of Argentina and the Parana pine (*Araucaria*) campo and campo cerrado of Brazil lends support to their long-term distinctiveness as natural units, rather than as disturbance zones of human occupation.

Conclusions 1 and 2 seem especially well documented by bird and mammal data. Conclusion 3 implies downward displacement of montane communities to such an extent that all of the lowland evergreen forests of Central America would have been eliminated. No evidence suggests that the current forests of that region or their distinctive animal associates have invaded this area during the last 11,000 years from northern South America. Such an invasion would have had to originate in the Choco forests, which might also have been eliminated by the temperature depression required by Müller. Factors other than maximum temperature displacement are therefore required to explain the similarities between several of these now isolated montane centers.

Conclusion 4 is also suspect. Many of the components of the dispersal centers doubtlessly have long Tertiary histories in the region. For example, the



The 40 dispersal centers identified by Müller. "Dispersal centres can be worked out by plotting the breeding ranges of species and subspecies on a map of the region under investigation. . . . The individual ranges overlap in 'areas of congruence' or 'nuclear areas' . . . regions where an unusually large number of ranges overlap . . . are what we call dispersal centres." [From *The Dispersal Centres of Terrestrial Vertebrates in the Neotropical Realm*]

Nothofagus dispersal center is typified by a series of frogs (*Telmatobufo, Batrachyla, Hylorina, Calyptocephalella,* and *Rhinoderma*) that must have occurred in temperate South America from the Paleocene onward (*Calyptocephalella* and other allied genera are known from Oligocene Patagonia). This center seems to include the remnants of the original southern temperate frog fauna of the Cretaceous that invaded and evolved in the tropical area through Cenozoic times into the modern diversity of leptodactyloids and tree frogs (Hylidae). Many other component species of Müller's centers must have had, at the very latest, an origin during other Pleistocene alternations in climates, earlier than the last glacial cycle.

Finally, the evidence for conclusion 5 is not convincing. It may well be that the distinctive fauna of the three mentioned areas consists of relicts of a complex forest community, with only that fragment that could adapt to more open situations surviving to the present.

Müller has opened the way for a fuller and more determined attack on these and other problems. His emphasis on only the most recent aspects of distribution in the region leaves this reader intrigued anew by the emerging outlines of a comprehensive biogeography of the neotropics, but frustrated by the narrow time span employed to explain the now, thanks to Müller, obvious patterns.

JAY M. SAVAGE
*Allan Hancock Foundation* and
*Department of Biological Sciences, University of Southern California, Los Angeles*

## Population Mathematics

**The Estimation of Animal Abundance and Related Parameters.** G. A. F. SEBER. Hafner, New York, 1973. xii, 506 pp., illus. $29.95.

This is a book that animal ecologists have long needed. Numerous techniques have been devised, over many years, for estimating the sizes of animal populations and, to quote its preface, "this book is an attempt to bring this material together." It is a most successful attempt.

It is a very compact book in spite of its length and provides an enormous amount of information in highly concentrated form. Although the intended audience is not explicitly described in the preface, the book is for users with considerable knowledge of, and familiarity with, mathematical statistics. I say "users" rather than "readers" deliberately. The book is essentially a manual, and will be found useful (it seems safe to say, indispensable) by all research workers who need to estimate animal population sizes, provided they do not flinch before the fairly heavy mathematics. The exposition is admirably clear.

A large supply of worked examples is given, and these enable the user to test his mastery of each technique. However, the examples cannot be made to serve merely as recipes by a user in a hurry who wishes to discover how to come up with a number (or a confidence interval) while neglecting the underlying theory. The examples cannot be followed without going through the discussions preceding them, and therefore cannot be applied uncomprehendingly. This will come as a disappointment to the lazy but is no doubt a good thing: it ensures that the user of a technique shall not be ignorant of the assumptions that must hold for it to be valid.

Fully two-thirds of the book is devoted to accounts of what may be called "capture-and-count" techniques of population estimation, that is, methods in which the entities sampled are individual animals as opposed to sample plots or quadrats the animals contained in which are counted. Capture-and-count techniques comprise mark-release methods, catch-effort methods, and change-in-ratio methods, and the book covers them comprehensively. No doubt these techniques are emphasized because they are peculiarly