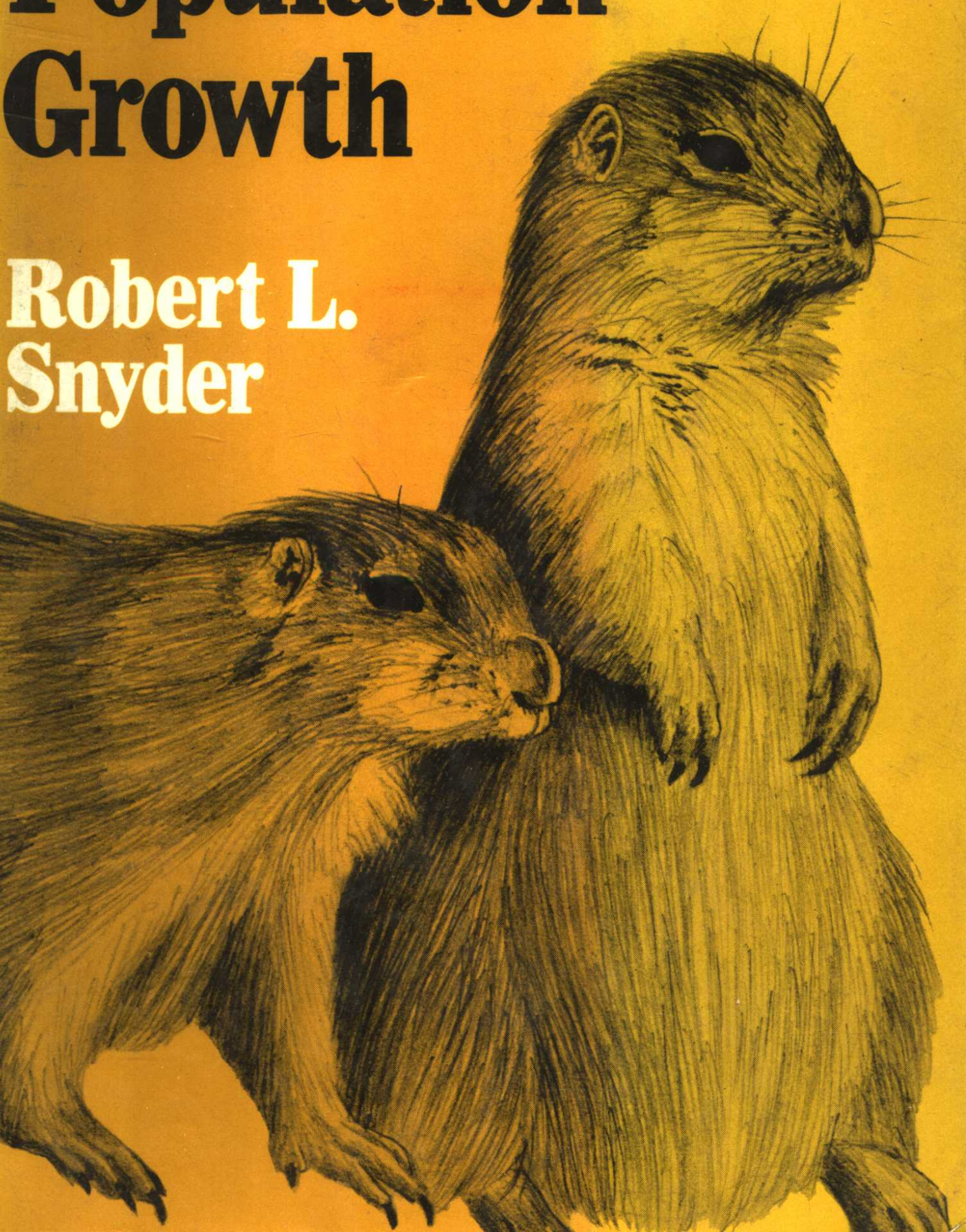
The Biology of Population Growth

Robert L. Snyder



THE BIOLOGY OF POPULATION GROWTH

BIOLOGY AND ENVIRONMENT
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ROBERT L. SNYDER

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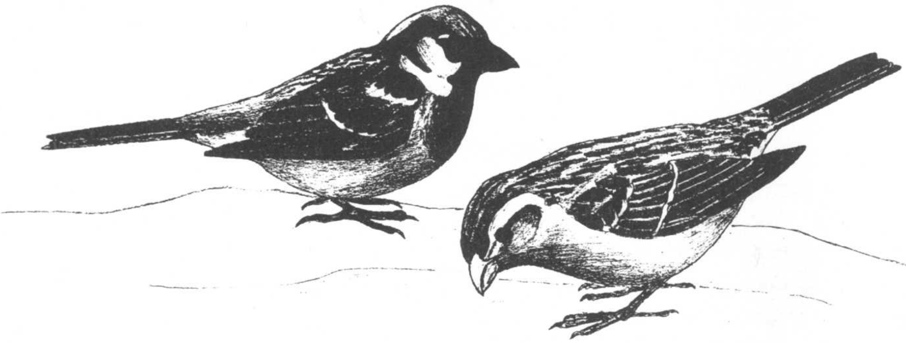

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1 ECOLOGY AND POPULATION

The purpose of this book is to present a contemporary view of an important ecological principle – that living organisms are integrated groups or populations of individuals dependent upon one another and upon elements of the environment for their existence and perpetuation. The science of ecology is the study of the relationships between living organisms and their environment. One aspect of this science treats living organisms relevant to their physical environment, which is merely the study of the physical conditions required for life on this earth. A second aspect of ecology is concerned with an individual organism's relationship to other living matter in its universe. Some of the more obvious biotic or biological relationships are represented by forms of parasitism and predation, such interactions being between organisms unrelated genetically. The most complex and possibly the most important biotic relationships exist between related organisms or organisms of the same species. The treatment of genetically related organisms as integrated groups or evolved aggregations of interacting organisms simplifies conceptualization and leads to applicable laws of ecology or at least workable hypotheses. At the very least, this way of looking at living organisms is a convenient way of organizing pertinent information about reproduction, mortality, and animal behavior.

Today the mass communications media tend to use a single word to symbolize each important complex problem pressuring mankind. Thus, 'energy crisis' covers the entire problem of utilizing fossil fuels without destroying ourselves in the process. 'Ecology' stands for the problem of the wholesale destruction of wildlife habitat that accompanies technological and social progress. And 'population' represents a vague uneasiness about the possibility of there being too many people in the world. The average person, understandably confused, is caused to wonder whether the problems are really as bad as portrayed.

The population problem is the underlying theme of this book. The array of complex ecological interactions which determine the numbers of animals and plants that exist in a given area through time should eventually be understood in terms of the basic principles governing these interactions. Unfortunately, population biology is still in its developmental stages. Several principles of population dynamics have been proposed, tested in the laboratory, and studied in the field, but ecologists cannot agree on their validity or applicability. There are two opposing schools of thought about what controls population growth. One school believes that extrinsic agents such as food supply, weather, predators, and disease are responsible for regulating population size. The other looks to intrinsic mechanisms, inherent characteristics of the population members collectively.

We humans occupy a unique position in the ecological world. Down through the ages we have had a profound effect on populations of plants and animals, having caused the extinction of many species and the extirpation of others from vast regions. In a word, we have played havoc with the natural scheme of things.

Man may have reached the stage in history when he can exercise some control over populations – perhaps even his own. Therefore, it behooves us all to attempt to understand the principles of ecology in general and those of population in particular. What about the disagreements between the ecologists themselves? Arguments about details, particulars, and 'laws' should not be an insurmountable obstacle to the study of populations. History has taught us that conflict and disagreement are inevitable in scientific fields. What was dogma yesterday may be disproven tomorrow. What appears to have been two unalterable opposing schools has a way of blending in time. It often happens that both sides were partly right. Ultimately, the readers must judge for themselves on the basis of the evidence presented. Such is the case with this book.

Both plants and animals make up the living universe and it is impossible to treat one without the other. However, the animal kingdom is infinitely more complex organismically, and many of its members have unique properties such as the power of locomotion and a highly developed nervous system which enable them to respond to environmental exigencies in ways impossible for members of the plant kingdom. Therefore, in this book plants will have to take a back seat. The emphasis will be on animal populations.

Population Problems

Assessment of environmental impact requires certain judgments about the values of the organisms affected. If these were entirely monetary, the problem would be simple. A 16-ounce can of salmon in 1975 sold from $.89 to $3.65 depending on the species. Thus, a ten-pound Atlantic salmon *(Salmo salar)* might have been valued at approximately $30.00 based on its food value. However, in 1975 the province of New

Brunswick in Canada figured that each salmon caught by a non-resident angler was worth many hundreds of dollars to its residents. In the same sense, earthworms might sell for 25 cents a dozen for fish bait, but their value in an ecosystem which depends on these invertebrates to break down humus into chemical forms used as nutrients by plant species is inestimable. Ultimate evaluation in any case depends on how many and what kinds of plants and animals are involved. To handle this kind of problem, biologists have evolved the principle of population.

Population

The word 'population' is derived from 'populus' meaning people. To sociologists a population is the total number of persons inhabiting a country, city, district, or area. Biologists evidently borrowed the term to define the total number of organisms inhabiting an area or region. Statisticians include both animate and inanimate units in their populations. Their precise definition is any finite or infinite aggregation of individuals, not necessarily animate, subject to statistical study.

We are indebted to the American statistician Raymond Pearl for developing a precise definition of population for ecology:

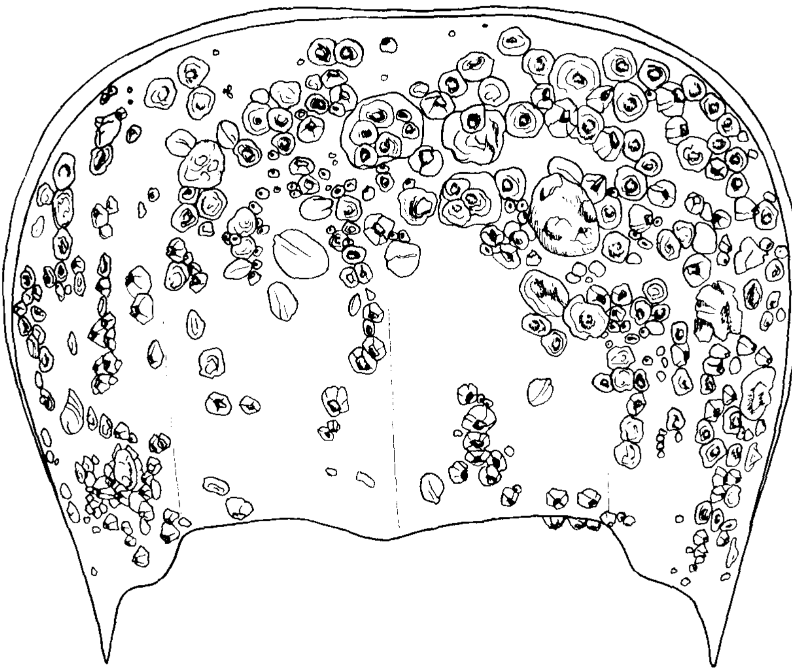
> A population is a group of living individuals set in a frame that is limited and defined in respect of both time and space. The biology of populations is consequently a division or department of group biology in general. The essential and differentiating feature of group biology is that it considers groups as wholes. It aims to describe the attributes and behavior of a group as such, that is an entity in itself, and not as the simple sum of the separate attributes and behaviour of the single individual organisms that together make up the groups.

The barnacles on the shell of the horseshoe crab in Figure 1 can be considered collectively as a population.

Biosphere

What is now recognized as population biology was not created in a fortnight, but evolved as a natural consequence of the development of ecology as a science. Animal and plant life occupies the whole surface of the earth including land and sea. The whole space occupied by living organisms is called the biosphere. This thin film of air, water, and soil is roughly ten miles deep, or one four-hundredth of the earth's radius. Ecosphere is another word for the same space. Plant geographers

Figure 1. A Population of Barnacles on the Shell of a Horseshoe Crab *(Limulus* sp.)



were the first to give serious attention to studies of the biosphere in an ecological context. They were concerned with the numbers and forms of plant life represented in various habitat conditions. Thus, the botanists had a classification and nomenclature worked out for the major divisions of the biosphere before zoologists were much interested in the problem. Although animal ecologists naturally borrowed much of their terminology from the phytogeographic system, they did make some revisions because of the inherent differences between plants and animals. Also, as with most classification schemes, it should be admitted that no unanimity exists with respect to both fundamental subdivisions and terms. However, this is not an insurmountable problem as long as precise definitions are employed. Population students can use the terms interchangeably as long as the meanings are clear.

Niche

The primary topographic unit is the biotope or niche. Such a unit has been described as an area showing uniformity in the principal habitat conditions, and in current usage has come to mean the place where a species lives. Discussions of niches usually imply a degree of exclusiveness in which the microhabitat, the smallest possible subdivision that insures uniformity of conditions met nowhere else, is occupied by a single species. Actually, the originators of the term 'ecological niche' were not nearly so precise. Joseph Grinnell defined a niche as the entire range of physical environments that a species was found in. Charles Elton envisioned it as an animal's place in the biotic environment. His conceptualization was eloquent: 'It is therefore convenient to have some term to describe the status of an animal in its community, to indicate what it is *doing,* and not merely what it looks like, and the term used is "niche".'

Naturally, such a fundamental unit in the classification scheme of ecology would become the subject of much theoretical discussion. American ecologists G. E. Hutchinson and Robert MacArthur, for example, have developed the concept of the multidimensional fundamental niche. In this, the position of a population is defined in relation to as many axes as an investigator can measure. According to MacArthur, there is no limit to these, hence the fundamental niche has an infinity of dimensions.

The biotope as an ecological subdivision of the biosphere is as basic as the concept of the species is in the systematic classification of living things. And as species are combined into genera and these into families and orders, the biotopes can be grouped according to their resemblances into biochores.

The biochores and superbiochores are finally combined into still higher groupings which are called biocycles by some and ecosystems by others. In America the ecosystem has attained common usage. The biosphere can be divided into three fundamentally distinct ecosystems: ocean, fresh water, and land. Each ecosystem contains animal species that are almost exclusively adapted to their own peculiar habitat conditions. Certain species live in more than one ecosystem at different times during their life cycles, for example, salmon, eels, and shad occur in the ocean and in fresh water; amphibia, in fresh water and on land; and some birds in all three, but they are so much a minority that they prove the principle of exclusion.

Ecosystems have their respective fauna and flora called biota when both plants and animals are included in one category. The plants considered with regard to their ecological relations rather than their taxonomic affinities are called the phytome and the animal life, similarly considered the zoöme.[1]

Communities

Historically, both zoologists and botanists have recognized so-called natural assemblages of organisms which are typical of certain habitat conditions. The birch-beech-maple forests of north-central Pennsylvania, for example, have indicator species of certain trees, shrubs, grasses, etc. typically found in nearly every part of the biochore. Moreover, such forests have typically certain animal species, black bears *(Ursus americanus)*, gray squirrels, *(Sciurus carolinensis)*, great horned owls *(Bubo virginianus)*, porcupines *(Erethizon dorsatum)* and bobcats *(Lynx rufus)*, to name the most important. Other animals, the white-tailed deer *(Odocoileus virginianus)* and wild turkey *(Maleagris gallapavo)*, for example, are plentiful there today, but such species are not usually considered type species because they are widespread in other forest associations as well. The plants and animals are so characteristic of the great area covered by the dominant birch-beech-maple vegetation that to find an atypical form would be reason enough to suspect a significant local variation in soil fertility, water table, or hydrogen ion concentration (pH).

The natural groupings of plant and animal species within certain easily discernible habitat conditions led to the formulation of the community concept. The major community is defined as a natural assemblage of organisms which, together with its habitat, has reached a survival level such that it is relatively independent of adjacent assemblages of equal rank; to this extent, given radiant energy, it is self-sustaining.[2] Thus, in the birch-beech-maple forest the ecologist would find that the phytome was dependent upon the soil nutrients, porosity of the soil, the subsurface characteristics, rainfall, topography, etc. and that the animal species were adapted to utilize the birch-beech-maple forest for food and shelter. Certain predacious species associated with the herbivores complete this community.

The community concept is considered an essential element of modern ecology. The community is a primary study unit. By defining the overall self-sustaining subdivision of the ecosystem, the ecologist is able to separate its interrelated parts to determine how the whole system operates.

The Gene Theory

Living organisms are physicochemical structures capable of utilizing solar energy, directly or indirectly, to grow and multiply; some achieve mobility or at least movement of certain parts. Organisms exist in many

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