George W. Cox

Conservation Biology

second edition

concepts

and

applications

chapter

24

Harvesting Natural Populations

Harvesting populations of wild plants and animals is still a major human activity. Some human populations, such as the North American Inuit, still rely heavily on wild plants and animals for food. Aside from a few intensive aquacultural operations, most fisheries' harvests are taken from wild populations of fish, shellfish, and plants such as kelps. Likewise, although modern forestry increasingly emphasizes the production of timber on intensive "tree farms," timber harvests worldwide still mostly involve the cutting of natural forest stands. Can such harvests be made on a sound, continuing basis? And if so, how?

In this chapter we shall consider some of the scientific theory on which the harvesting of natural populations is based. Application of such theory, even if it is sound, involves social, economic, and political considerations that extend beyond the realm of science. Indeed, some resource ecologists believe that it is more realistic to view resources as managing people rather than people as managing resources (Ludwig et al. 1993). The benefits or profits that can be gained from rapid, overexploitation of many resources often fuel political actions opposed to long-term, sustainable management plans. In other cases, societal desires may oppose harvesting resources even when sustainable harvests appear possible.

Major sectors of the human economy depend on harvesting resources that are renewed primarily by natural ecological processes.

Outline

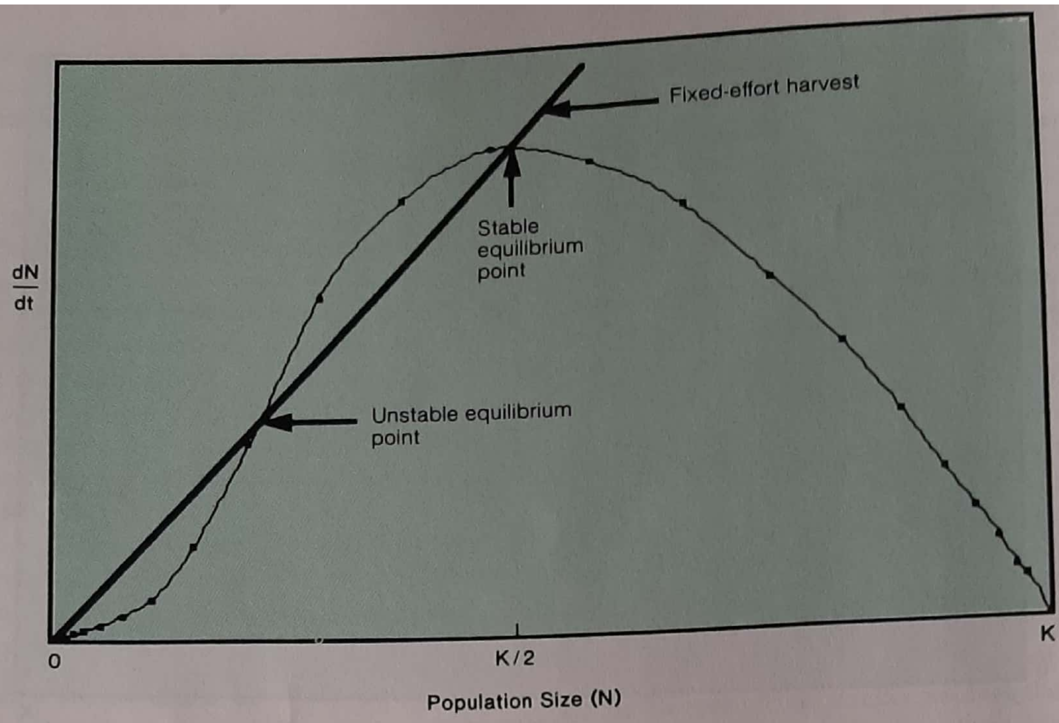

FIGURE 24.5
Curves of population growth per unit time may have more than one equilibrium point, the lower of which is unstable, as indicated in Figure 24.4A.

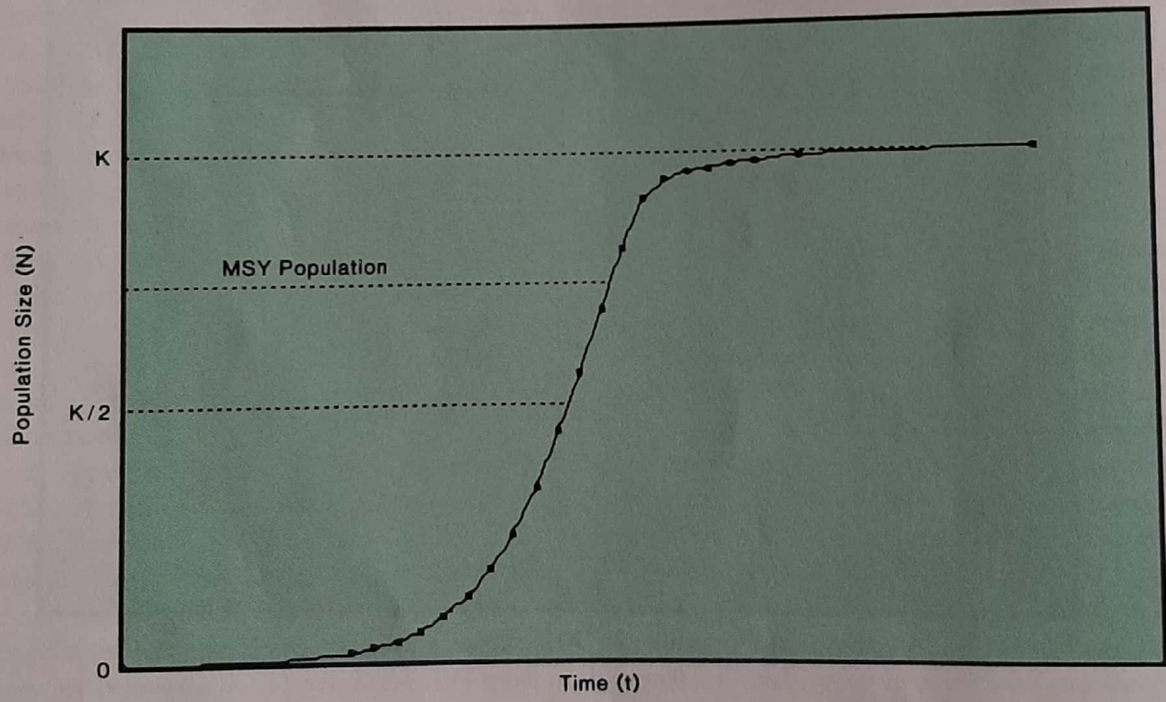

FIGURE 24.6
The shape of population growth curves of many species causes the MSY population to lie closer to K than predicted by the simple logistic relation.

DYNAMIC POOL MODELS

Simple logistic models do not explicitly take the age structure of the population into account, nor do they explicitly consider such relationships as recruitment rate, body growth rate, natural mortality rate, and harvest rate of individuals of various ages or sizes. Dynamic pool models (Pitcher & Hart 1982; Getz & Haight 1989) describe the numbers or biomass of different age (or size) classes as a function of these different processes, each of which is described by one or more equations.

Dynamic pool models can become very complicated, but are structured in the general fashion indicated in Figure 24.7.

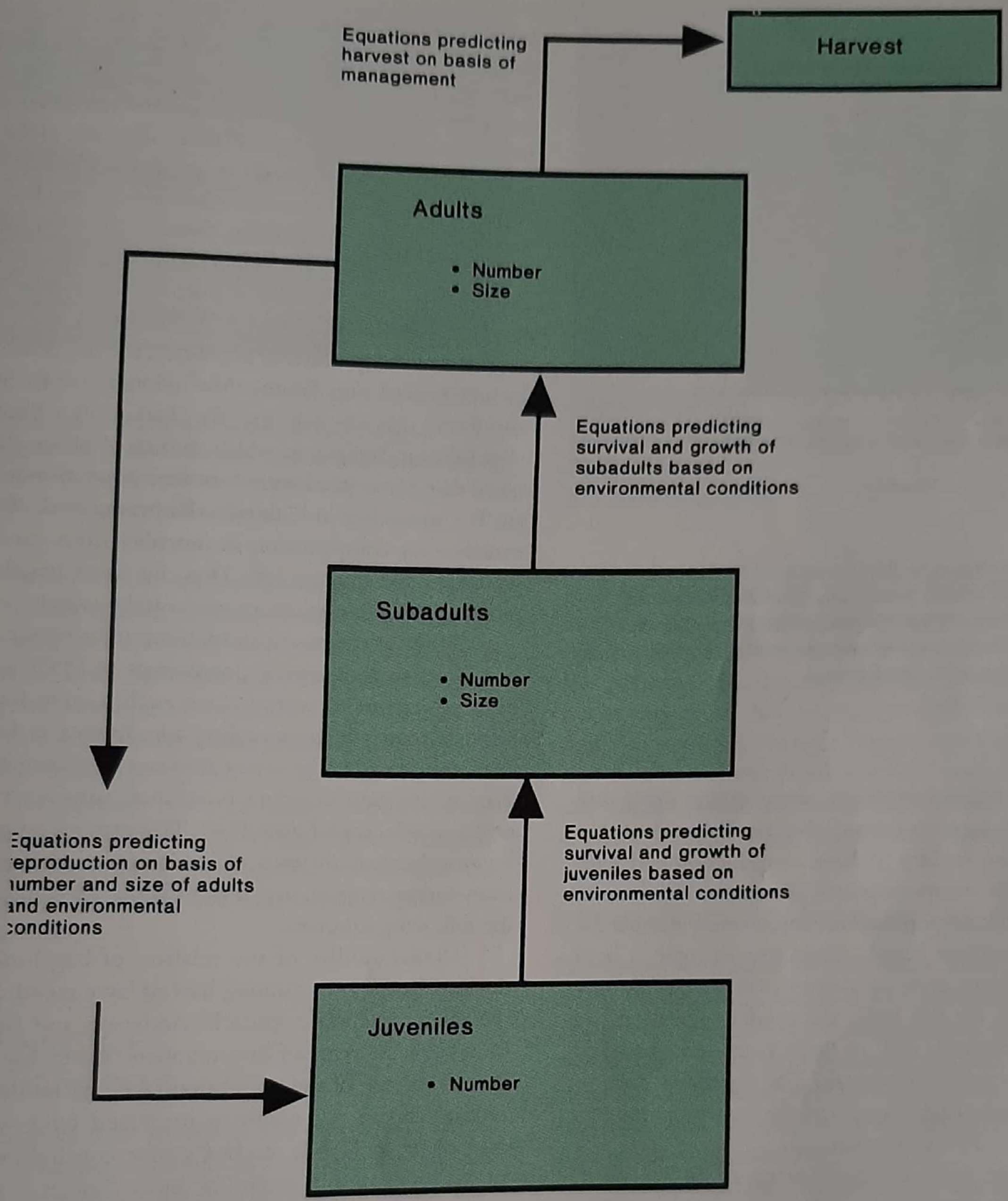

FIGURE 24.7

A simple example of a dynamic pool model for a population with three age classes.

The population is divided into several age or size classes. Recruitment into the youngest or smallest class is calculated as a function of the population of adult organisms (older or larger size classes) and other important environmental variables. The growth of individuals is described mathematically; together with mortality factors, this determines the number and biomass of individuals in older or larger classes. Natural mortality is related mathematically to factors such as predation, physical conditions, and degree of compensation with harvesting mortality. Mortality due to harvesting is determined by management practices, such as regulation of net size, bag limit, length of harvest season, and so forth. Thus, a dynamic pool model consists of a set of many equations.

HARVEST MANAGEMENT IN PRACTICE

How effective is regulation of harvest in promoting high productivity in exploited populations? Does reduction of populations to some level below the carrying capacity increase reproduction, improve health, and reduce natural mortality? From a conservation standpoint, does controlled harvesting promote healthier populations and greater ecosystem stability? How effective are short-term adjustments in harvest as management tools? Unfortunately, although many examples can be cited of how populations have behaved under particular management schemes, almost no carefully designed experiments address these questions (Caughley 1984).

FIGURE 24.9

Analyses of the influence of liberal and restrictive bag limits for mallard ducks suggest that natural mortality and hunting harvest are neither perfectly additive nor completely compensatory.

(U.S. Fish and Wildlife Service photo by Glen Smart)

FIGURE 24.10

Clear-cutting has been the primary technique of forest harvest in the Pacific Northwest.

(U.S. Forest Service photo)

Thus, for waterfowl, it appears that simple concepts of purely additive or compensatory mortality from hunting and natural causes are inadequate. The exact nature of this relationship is uncertain, and is evidently influenced greatly by many factors, such as breeding and wintering habitat quality. As a consequence, a new approach, termed **adaptive management,** is being advocated for waterfowl management (Nichols et al. 1995; Williams & Johnson 1995). This approach is one of management under uncertainty, with the goal of reducing uncertainty. Major alternative management options are defined, one is applied, and the effect on population dynamics is monitored and used to refine options for subsequent management.

Shortcomings of Population Models

A major shortcoming of most models is that they usually focus on the population dynamics of a single exploited species, and do not consider the ecosystem as a whole. Harvests that reduce the population of one herbivore to 50% of its carrying capacity, for example, may free food resources for use by other herbivores. Increase in the populations of these species may ultimately utilize the initial excess of resources, in effect establishing a new, lower carrying capacity for the exploited species. Or, as in the case of the Antarctic krill fishery, exploitation of a species at one trophic level may reduce populations of other species of higher trophic levels, some of which may be of equal or even greater value in the long run (Beddington & May 1980).

Few models have attempted, however, to consider the role of an exploited species in relation to other species in its food chain, or to species that are competitors or have close symbiotic or commensal ties. Simple predator-prey models, like the logistic single-species model, contain many hidden assumptions that may violate ecological reason (Yodzis 1994).

On top of this, populations of some species are subject to exploitation in different locations. The Pacific whiting, *Merluccius productus*, a migratory fish of the Pacific coast of North America, illustrates the complexity of managing migratory fish (Getz & Haight 1989). Whiting spawn in waters off southern California and Mexico. As young fish, they are prey to various other fish, but as they grow they become predators on young of some of these same species. As they migrate north in summer, they are harvested by fisheries based at several ports in the United States and Canada. Thus, harvesting strategy must consider a complicated set of ecological, economic, and political relationships.

How Should Forests be Managed?

Ecosystems dominated by trees range from pristine old-growth forests to intensively managed tree plantations. Enormous controversy has arisen over the management of forests that retain high diversity of structure and composition, both on public and private lands. Whether lightly or intensively managed, however, their ecosystem character must be recognized if sustainability is to be achieved (Maser 1994).

For forests from which timber harvests are taken, two major systems of management have been used: even-aged and uneven-aged stand management. Even-aged management emphasizes plantations of single tree species of the same age, which are managed to maximize growth to some predetermined size and harvested at about the same time. The most common pattern of harvesting is clear-cutting, in which all trees are cut and all harvestable timber removed at one time (Fig. 24.10). Regeneration may occur from the natural seed bank, from seed broadcast onto the site after cutting, or from seedlings planted after cutting. About two-thirds of United States timber is harvested in this fashion.

Modified forms of clear-cutting include **shelterwood cutting** and **seed-tree cutting.** In shelterwood cutting the mature trees are removed in several loggings over several years. This retains a partial canopy that favors germination and early growth of a new generation of trees, and is used for species that require shade during their early life. All mature trees are nevertheless

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