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CONSTANT AND PERIODIC RATE STOCKING AND HARVESTING FOR KOLMOGOROV-TYPE POPULATION INTERACTION MODELS

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To the memory of Geoffrey James Butler

ABSTRACT. Averaging methods are used to compare solutions to n-dimensional systems of ordinary differential equations with constant or periodic forcing. These results are applied to population models of Kolmogorov-type where per capita growth rates are either monotone decreasing (pioneer) or one-humped (climax) functions of weighted population densities. The asymptotic behavior of such systems may be controlled, to some extent, by stocking or harvesting a population.

1. Introduction. The effects of population density on the reproduction and survival of individuals of a species are widely studied and accepted, e.g., see [**1, 16, 11**]. Here we model the interaction of populations of animals or plants by a system of ordinary differential equations where the per capita replacement rate is a function (called the *fitness*) of a linear combination of the densities of the interacting populations. Other studies assuming this approach include Comins and Hassell [**3**], Hassell and Comins [**12**], Hofbauer, Hutson and Jansen [**13**], Cushing [**4, 5**], Selgrade and Namkoong [**19, 20**], Franke and Yakubu [**6**], and Selgrade [**18**]. These systems are generalizations of Lotka-Volterra equations where the fitnesses are linear functions of the densities.

For our study we take the population fitnesses to be either monotone decreasing functions or one-humped functions. Borrowing from the forestry terminology, we refer to the former as *pioneer* fitnesses and to the latter as *climax* fitnesses. Such a pioneer fitness is a decreasing function of density, it simply captures the detrimental effects of crowding on per capita replacement rates. Ricker [**17**] concludes that

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