Saving the Spotted Owl [1]

OBJECTIVE: Apply the concept associated with and the implementation of eigenvalues and eigenvectors to solve real and relevant problems

In 1990, the Northern Spotted Owl became the center of a nationwide controversy over the use and misuse of majestic forests in the Pacific Northwest. Environmentalists convinced the Federal government that the owl was threatened with extinction if logging continued in the old-growth forests (with trees over 200 years old), where owls prefer to live. The timber industry, anticipating the loss of 30,000 to 100,000 jobs as a result of new governmental restrictions on logging, argued that the owl should not be classified as a "threatened species" and cited a number of published scientific reports its case [2]

Caught in the crossfire of two lobbying groups, mathematical ecologists intensified their drive to understand the population dynamics of the Spotted Owls. The life cycle of the Spotted Owl divides naturally into three stages: juvenile (up to 1 year old), subadult (1 to 2 years old), and adult (over 2 years). The owl mates for life during the subadult and adult stages, begins to breed as an adult, and lives for up to 20 years. Each owl pair requires 100 hectares (4 square miles) for its home territory. A critical time in the life cycle is when the juveniles leave the nest. To survive and become a subadult, a juvenile must find a new home range (and usually a mate).

A first step in the studying of population dynamics is to model the population at yearly intervals, at times denoted by $y = 0, 1, 2, \ldots$ Usually one assumes that there is a $1:1$ ratio of males to females in life stage and courts only the females. The population at year y can be described a vector $xy = \langle j_y, s_y, a_y \rangle$, where the variables j_y, s_y, a_y are the numbers of owls in the juvenile, subadult, and adult stages, respectively.

Using the actual field data from demographic studies, R. Lamberson and co-workers considered the following stage-matrix model [3].

Here the number of new juvenile females in year $y+1$ is .33 times the number of adult females in year y (based on the average birth rate per owl pair). Also, 18% of juveniles survive to become subadults and 71% of the subadults and 94% of the adults survive to be counted as adults.

The stage-matrix model is a difference equation of the form $x_{y+1} = Ax_y$. Such an equation is often called a dynamical system (or a discrete dynamical system) because it describes the changes in a system as time passes in discrete increments.

The 18% juvenile survival rate in the Lamerson stage-matrix is the entry affected most by the amount of old-growth forest available. Actually, 60% of the juveniles normally survive to leave the nest, but in the Willow Creek region of California studied by Lamberson and his colleagues, a much smaller percentage of the juveniles that left the nest were able to find new home ranges. The rest perished during the search process.

A significant reason for the failure of owls to find new home ranges is the increasing fragmentation of old-growth timber stands due to the clear cutting of scattered areas on old-growth land. When an owl leaves the protective canopy of the forest and crosses a clear-cut area, the risk of attack by predators increases dramatically.

1. Use your knowledge of eigenvalues and eigenvectors to determine if the Spotted Owls will survive.

2. What is the exact percentage of juveniles that need to survive to ensure the survival of the Northwestern Spotted Owl?

---

[1] Lay, David C., Linear Algebra and its Applications, Addison-Wesley Publishing Company: 2004, pp. 271-272.

[2] "The Great Spotted Owl War," Readers Digest, November 1992, pp.91-95.

[3] R.H. Lamberson, R. McKelvey, B.R. Noon, and C. Voss. "A Dynamic Analysis of the Viabilty of the Northern Spotted Owl in a Fragmented Forest Environment," Conservative Biology 6 (1992): 505 - 512.