Appendix I. Population Viability Analysis

By Dr. Peter Brussard

POPULATION VIABILITY – AN OVERVIEW

Basic Population Dynamics

The size of a sage grouse population in any given year equals the size of the population in the previous year plus the number of young birds recruited that year ("births") plus any older birds that have moved into the population ("immigration) minus the birds that died ("deaths") and left ("emigration") during the year. If births and immigration are larger than deaths and emigration, the population increases (the growth rate is positive); if births and immigration are less than deaths and emigration, the population declines (the growth rate is negative).

Viable populations

A viable population is defined as one that is capable of maintaining itself without significant manipulation over an agreed upon time frame and with an agreed-upon degree of certitude. The time frame and degree of certitude are partly a matter of human choice and partly a matter of biological reality. For example, it might be decided that every sage grouse population in Nevada should have at least a 95% probability of persistence for 100 years in order to be considered viable. This viability criterion may be quite reasonable for large populations in close proximity to other populations. However, a small population isolated on a remote mountain range may never meet this viability criterion. The area of suitable habitat may be small and could never support more than a few dozen birds under the best of circumstances, and a population of that size is quite vulnerable to various random events (see below).

Population extinction

Most population extinctions occur because of systematic, deterministic factors, habitat loss and degradation being the most important. Managers do have some control over these factors. Population extinctions also can occur because of random (stochastic) factors over which management has little or no control.

- *Catastrophes*. Catastrophes can cause extinction even in quite large populations. A pertinent example is major fire that kills most of a Sage Grouse population and destroys its habitat.

- *Environmental stochasticity*. This category includes uncertainties of death or reproduction related to the vagaries of weather, disease, predation, or resource availability that affect an entire population simultaneously. This type of random variation can impact a large population significantly.

- *Demographic stochasticity*. This includes random variation among individual hens in the age of first reproduction, the number of eggs laid, the number that hatch, the chicks that survive, and in their own survivorship. This type of uncertainty can impact very small populations; in larger populations this kind of variability tends to even out and has relatively little impact.

- *Genetic stochasticity*. Random changes in a population's genetic makeup that have deleterious effects on the ability of individuals to survive and reproduce are included in this category. These events result from inbreeding (the mating of close relatives) and genetic drift (the random loss of genetic variation that can be essential to fitness and adaptation). Genetic stochasticity can make a bad demographic situation in a small population much worse.

The important point is that a sage grouse population with a positive growth rate in good, secure habitat still can go extinct because of random events.

Population Viability Analysis (PVA)

A PVA is an assessment of the persistence probability of a population based on habitat and population parameters. A PVA can be applied either to a single population or a population system (metapopulation). Well-connected populations are usually treated as metapopulations, but single, isolated populations are generally dealt with separately.

A PVA must be based on specifically-stated goals. For example, the goal for one PVA might be simply to assess the immediate probability of extinction of a population, while the goal for another PVA might be to assess its probabilities of extinction under various levels of hunting pressure. PVA's are treated as hypotheses, subject to future refinement as new data come in or a better understanding is gained of underlying processes. PVA's can either be quantitative or qualitative.

The basic assumption of a PVA is that the population is stationary or increasing or, if not, that systematic mortality can be controlled. If the population is declining or systematic mortality cannot be controlled, a PVA is not necessary. The population will go extinct at a rate directly proportional to its decline and the longevity of individual organisms.

Quantitative PVA's

Quantitative PVA's can be applied either to single populations or to metapopulations. At a minimum, necessary data include variation in population size over time, age-specific recruitment and mortality, annual variation in life history characteristics, and the frequency and severity of events that affect population growth (e.g., variation in weather patterns). For a metapopulation PVA, data on these parameters must be available for each subpopulation.

Once these data are available, a deterministic population model is constructed, usually by using one of several "canned" programs (e.g., Ramas, Stella). Stochastic variance is then incorporated in the model. Individual demographic stochasticity is estimated from annual variation in life history characteristics, and environmental stochasticity is estimated from the frequency and severity of events that affect population growth.

Simulation modeling is then used estimate time-to-extinction from random forces. Thus, a specific prediction of population persistence time can be made in the form of, "this population (or population system) has an X percent probability of persistence for Y number of years. If data are available, predictions of persistence times under various management strategies also can be made.

Qualitative PVA's

Clearly, quantitative PVA's are very data intensive. In most cases the relevant data are not available, and time and money are usually too short to obtain them. However, a qualitative PVA can be performed by organizing whatever information is available on habitat and population parameters and by obtaining missing information in the form of expert opinion from knowledgeable and experienced biologists.

Thus, a qualitative PVA can be made for each of the 60 sage grouse populations. This approach will yield a verbal descriptor of extinction probability in a short, but meaningful, time frame: high, moderate, or low. Information should be organized as follows:

I. Habitat/population distribution (displayed as a base map with a series of overlays)

   A. Current habitat availability

      - Vegetation types
      - Spatial/temporal variation in quality
      - Occupied or unoccupied
      - Connectivity
      - Land ownership/management

   B. Current population distribution

      - genetic/morphological variation

II. Potential habitat distribution and condition in the future

   A. Systematic factors that may degrade habitat quality or quantity (e.g., cheatgrass invasion, conversion to agriculture, installation of a power line.)

   B. Random factors that may degrade habitat quality or quantity (e.g., estimated probability of a major fire)

   C. Habitat improvement under different management alternatives (e.g., restoration

III. Single population dynamics (spatially-resolved data to accompany maps)

   A. Trend – is the population increasing, decreasing, or stationary over time?

   B. Systematic factors – how do things over which management has control potentially affect population numbers (e.g., hunting, predator management)?

   C. Random factors – estimated probability of various stochastic factors that might influence vital rates (e.g., droughts, spring hailstorms)

IV. Population system dynamics

A. Patch arrangements

B. Likely correlations in environmental stochasticity

Considerable “hypothesis” testing can be done with these maps and associated data. In addition, this procedure provides an assessment of current knowledge and the information needed to push the analysis further.