What is Population Viability Analysis (PVA)?
One definition: a quantitative analysis of population dynamics, with the goal of assessing extinction risk.

PVA is a process involving:
(1) demographic data for the species of interest and
(2) some kind of mathematical analysis of those data.
The product of the analysis is (at least) (3) some quantitative prediction of extinction risk.

The development and use of PVA has been (at least partially) driven by certain policy/legislation, especially the National Forest Management Act (1976)

What is meant by "population dynamics"?
Population sizes change over time. Why?
Many things affect population size: competition and other interactions, population structure, environmental variation, disturbance and succession, chance events, habitat attributes (habitat quantity, quality, configuration, and connectivity)

Let's take a look at three (simple) models of population growth
1. Exponential growth
In a "closed" population (no immigration or emigration), population growth can be modeled as a function of the per capita birth rate (b) and the per capita death rate (d). The intrinsic rate of increase (r), or more generically, the population growth rate, is the difference between the birth and death rates (r=b-d). We can use this model to predict population size at any desired point in time in the future if we know just two things: (1) the population size at some point in time (either the present or the past) and (2) r, the intrinsic rate of increase!

Question: What does this model suggest about how many individuals are needed for a "viable" population?
Why don't populations follow the "J-curve" predicted by the exponential model?

2. Logistic growth
In this model, the population growth rate declines with increasing population size. Birth rates go down and/or death rates go up as the population gets bigger. (Why?) The result is that the population has a "carrying capacity", a stable population size that it tends towards.

Question: What does this model suggest about how many individuals are needed for a "viable" population?

Alternatively, it may be that the population growth rate increases with population size when the population is small. That is, birth rates go up and death rates go down as population size increases (**Allee effect**). Why might this happen? Examples?

3. Structured population growth
What is meant by "structure"?

Individuals in a population often differ in their contribution to population growth (or decline) because they differ in their chances of survival or successful reproduction. This may be because of differences in age, developmental stage, or size.

What does a structured population model look like?
It's a matrix. More specifically, it's referred to as a "transition" or "projection" matrix. The matrix model allows you to project into the future how many individuals there will be in the different classes, and the total population size.

Analysis of a matrix population model yields a number of useful things:
a. The dominant eigenvalue (λ). This is the growth rate to which the population eventually converges.
b. Sensitivities. These are the sensitivity of λ, the asymptotic population growth rate, to an absolute change in each element in the projection matrix. The sensitivities allow one to see what would happen to the population growth rate (and hence, extinction probability) if we could improve survival and fecundity values in the projection matrix, one at a time, by a particular value. In the loggerhead turtle example, we can answer the question: would it be better to focus conservation efforts on improving the survival of hatchlings or large juveniles or adults? How much bang do you get for your management buck?
c. Elasticities. Elasticites tell us the proportional change in the population growth rate that will result from a proportional change in each matrix element. How much percent change in the population growth rate will result from some given percent change in each life history transition (survival or fecundity)? As above, we can answer the question: would it be better to focus conservation efforts on improving the survival of hatchlings or large juveniles or adults of loggerhead turtles?

So which do we use to guide management, sensitivities or elasticites? Generally, elasticities are considered more useful for management considerations.

4. Stochastic models
a. environmental stochasticity
In reality, the environment varies from one year to the next. Some years may be good, others bad, for a population of an endangered species. We want to be able to say what the trend is for that population. On average, is it growing or declining?
Some populations grow or decline with regular or somewhat predictable changes in their environment; that is, as a community recovers and changes after some sort of disturbance (e. g. fire, flood, hurricanes or other storms). This also can be modeled. Especially with respect to fire, which is now controlled in many natural communities, we can ask questions like, how often should we conduct controlled burns for an endangered species to persist in that community?

b. demographic stochasticity
Very small populations are vulnerable to extinction via demographic stochasticity. The analogy is tossing a coin (in the case of survival vs. death, or offspring being male vs. female) or rolling a die (for example, when the number of offspring can be a number between 1 and 6).

c. genetic stochasticity

You learned about this in the lecture on conservation genetics. Small populations tend to loose genetic diversity via inbreeding, genetic drift, or combinations of the two.

Rule of thumb:
Demographic and genetic stochasticity can cause extinction in populations <50. Environmental stochasticity can still cause extinction in populations >50.

5. Landscape-scale or metapopulation models

Four attributes of habitat affect population growth and viability: **quantity, quality, configuration, and connectivity**. Two general principles may be distilled from the theory of island biogeography (MacArthur and Wilson 1967), and metapopulation theory (Levins 1969). Populations in smaller habitat patches are more likely to go extinct, and unoccupied habitat patches are less likely to be colonized the further they are from occupied habitat patches.
Places where populations are growing are referred to as **sources**, and places where populations are shrinking are referred to as **sinks**. Sink populations may be rescued by source populations (the "**rescue effect**").

Some last thoughts on PVA:
The answer to the question "How big does a population need to be for there to be high certainty that it will not go extinct?" will depend on the organism. The problem is quite complex. PVA requires a lot of species and situation-specific data, which takes time, work, and money, whereas managers want answers (predictions about extinction) now. Few species will get thorough PVA. When should PVA be used and what type of PVA (how complex)? Predictions from PVA can only be as good as the data that go into the analysis, and we can only have degrees of confidence in the predictions from PVA. Populations should not be managed to their "minimum viable population" size. You should learn to be critical consumers of PVA literature. One of the greatest strengths of PVA is the ability to play "what if" games with the model. That is, what if management were to increase patch sizes or connectivity? What if adult survival could be improved?

Sources that I used for this lecture and sources of additional information

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