More viability analysis.

Let’s review what we’ve done so far (this was a bit confusing, so it’s good to review):

We’ve looked at single population of animals, and have come up with an estimate of how big a reserve should be in order to make sure that this population survives. How? Simplified, what we did is as follows:

1) Get information on rain fall

2) From this, estimate plant growth

3) Determine how this affects animal growth

4) Since #1 fluctuates considerably, it is logical that #3 will fluctuate

4a) plug random (but realistic) numbers for rainfall into the model

4b) see impact on #3

4c) Repeat 4a until animal numbers drop below a viable population level

4d) Record this number as “time to extinction” (generally in years)

5) Repeat # 4 100 (or more) times to get “average time to extinction”.

6) Repeat 4 and 5 for different reserve sizes.

7) Since distribution is skewed toward shorter times, use “median time to extinction” instead. This can be done analytically (text), or simply by getting the median from the simulation

8) Once we know the “median time to extinction” for different reserve sizes, we can calculate the probability that the population will go extinct in a given number of years for different reserve sizes.

9) Fudge # 8 to take unexpected events into account.

Can we generalize this procedure? In other words, for red kangaroos, we followed the above outline. But what if we’re dealing with fruit flies? Bald eagles? Obviously, the above will need to be modified.

Unfortunately, many generalized approaches use a single species model (only one species is modeled). As will be seen, there are some serious shortcomings with this approach.

There are two methods available. We won't delve too deeply into this, since the math is very messy, and, in any case, there are no examples in the text.

1) Analytical. If one is willing to make certain assumptions (e.g., about mortality, fecundity, carrying capacity, etc.), an analytical approach can be used. Depending on the exact assumptions and how good your estimates are, the equations vary somewhat. They're presented on page 207 if you're interested, but we won't go into these.

2) Computer based. This is similar to what was done with the red kangaroos. One can either build one's own model, or use a "pre-packaged" model to do Population viability analysis (PVA).

- the text mentions VORTEX which does this, and is available for free (!) on the internet (http://pw1.netcom.com/~rlacy/vortex.html).

  - careful - it's about 12 megs in size (I haven't had time to explore it, so I can't say too much about it).

- this is still maintained, so I suspect it has changed considerably from the description in the book.

- sample data sets are also available.

- the basic idea is to plug in a number of parameters, and then ask for an estimate of the probability of extinction over different time intervals.

- even though the program has undoubtedly changed, what the authors mention in the text is still true:

  - the program will only do what the operator asks. The operator is responsible for:

    - entering everything correctly (often we only know "guesses" as to some of these parameters - obviously this affects the output!!!)

    - making sure that he/she knows enough biology to understand what the program is doing

    - making sure the answers make sense, and even if they do, treating these very carefully (perhaps as an "initial" guess as to what might happen, hopefully to be bolstered by more research).

This leads into the next topic. Assessing generalized PVA's. In particular, single species PVA's.

In a single species PVA, generally the only factor considered is density. We ignore the effects of food availability, etc.

- the assumption is that at higher densities, food (or whatever) becomes limiting, so "K", the carrying capacity should reflect this.

Two models are in common use:

- truncated exponential

- logistic

1) Truncated exponential

- main problem here is that both of the parameters needed have little to do with the actual ecology of the species and are hard to estimate. The text provides a few more details, but this will do.

2) logistic

- this is used a lot in ecology, though often in a slightly different context (we're trying to estimate how long a population will survive).

- since I think we've all had just about enough math, let's keep it simple.

- the parameters are a little easier to estimate

- note: just because someone puts "r" into an equation, doesn't mean it's the same "r" we've been talking about, or that we can just plug in an "r" that we've estimated. Be a little careful here.

- cutting through all the "stuff", what we want to do is run a logistic growth model on our population of kangaroos, and see how it compares with the more sophisticated model described above.

- We need to estimate our maximum rate of increase (this as .4 from our equation before)

- We also need to estimate carrying capacity. Since this is hard to estimate (the authors mention that it appears from field data that the population has never hit it's "maximum", so we don't know what it is), it was chosen in such a way to "make the parameters align" (this isn't explained terribly well).

- Essentially a density of 55 kangaroos/square kilometer was picked as an "average" carrying capacity. The actual carrying capacity varied and was adjusted once a year

  - (it is not quite clear from the description in the book, but it appears this was picked randomly once a year from a normal distribution with mean 55 and standard deviation 14.5)

- so using the logistic equation, and proceeding with the same types of computer games as above:

  - tweaking r every three months, then tweaking carrying capacity once a year, getting growth information, and keeping the model going until it crashes.

  - then repeating this numerous times to get the same types of "average or median time of survival".

  - we then get the same curve as before "probability of surviving 100 years" (figure 7.10).

- end result is that the logistic model implies that an area of 17 ha. is sufficient to ensure the survival of red kangaroos for 100 years.

  - remember, the previous estimate was 69 ha.

- so which is better?

  - the authors argue strongly that the multi-species model is better (it models the plants as well as the kangaroos).

  - this also would appear to be obvious.

- note also figure 7.8

  - the first graph shows kangaroo growth rates as responding to density (using the 100 year simulation).

  - the second graph shows kangaroo growth rates as responding to biomass.

- which shows a clearer trend? The bottom graph (in the top, the lines go all over the place).

    (the graphs might have been a little clearer if they'd just plotted points instead of lines).

- another problem is that there are several different ways of applying the logistic, and every method has it's proponents.

    - it's a bit confusing, and I don't think conservation biologists are doing themselves a favor by these arguments.

    - if one person comes out with "it'll be dead in 20 years" and another "it'll be dead in 50 years", what do policy makers do?

- bottom line for logistic:

    - if there's nothing else you can do (you don't know anything about the plants), this might be a good initial guess. Do more biology.

        - we said the same thing above, but now it's even more urgent.

So what about PVA?

- single species PVA is dangerous primarily because, in general, environmental factors are left out of the model. Both the logistic and truncated exponential consider only density and growth rates (but see below).

    - what about environmental fluctuations? This is only indirectly captured by carrying capacity?

- but to be positive, it has allowed several first estimates for reserve sizes for such species as the Grizzly or African elephant.

- presumably (this isn't explained very well) by tweaking carrying capacity, the effects of random events can be simulated on populations, and one can assess how a population might respond to certain events.

- A VERY important point.

    - PVA assumes that the problem is low numbers.

    - It never explains why the species declined, or what can be done to get the numbers back up (other than “making the reserve bigger”)

- we should know from our discussions in here that bigger reserve size isn’t always the answer (e.g., pollution, exotics, hunting, etc.).

- The Mediterranean Monk seal is a great example

  - a study indicated that if certain population parameters are crossed, then every effort should be made to ensure juvenile survival.

  - but the population is already in trouble!! What happened??

- this is the biggest shortcoming of PVA

  - it generally does nothing about diagnosis or management considerations.

- it is most useful in:

  - showing the vulnerability of small populations to random events

  - providing an initial estimate of reserve size.