Reserves.

What we're interested in here is in how to design reserves. Unfortunately, theory and practice are often two different things. We'll start with the theoretical approach and see how it's actually implemented.

History:

The idea of reserves is ancient. There are some nice examples of reserves from ancient China in the text.

Reserves have been used to in the past to protect sacred species or even the rights of hunters.

In more recent times, many reserves were set up after information about the ecology of individual species was gathered.

- This included habitat information, ecology, etc.

Recently there has been a shift away from this to more theoretical approaches based on size, shape, etc. as derived from such things as island biogeography.

Very recently, things seem to be headed back the other way.

Objectives:

This is obvious, and we'll get back to this, but the point is that unless one has a clear idea of what one is trying to do, why bother?

IUCN classifies reserves based on objectives such as:

- scientific/national park/national monument/managed reserve etc.

- this allows comparison between countries.

Currently about 5.2% of the world's surface exists in reserves.

The problem is often a trade-off between preserving species and preserving the ecology.

- note that this ignores parks set up for entirely different reasons such as the grand canyon.

- incidentally, many areas provide good habitat for reasons having nothing to do with conserving species.

- e.g. Hanford atomic energy reservation - though this area is used for weapons research, since access is severely restricted, the local environment is "protected".

- similar thing can be said for many military installations.

- also, a reserve for many animals is not necessarily better than a reserve for just a few animals

- there are many variables that need to be considered.

Some words on maintaining/managing a reserve:

This depends on the objectives of the reserve, but management considerations include the amount of intervention:

- if the main objective is to conserve specific species, that may mean constant intervention to prevent forest fires, drought, predation, etc.

- if the main objective is ecosystem preservation (or the process of nature), then intervention is often minimized ("let it burn", or even, "burn it" - of course, this can backfire).

- or, of course, some intermediate level of intervention may be required depending on these objectives.

Theory of reserve design:

Island biogeography and reserve design:

This has had a lot of influence on reserve design. Probably a bit too much to be useful.

The basic idea is taken from MacArthur and Wilson's studies of island biogeography:

There is a relationship between size, extinction, and colonization rates of islands - this has been extended to reserves.

(basically, the larger (&closer) the island, the less likely something is to go extinct, and the more likely it is to be colonized).

Applying this idea to reserves (i.e., reserves are "islands") was pretty straight forward and didn't require a large intellectual leap.

Unfortunately this has led to lots of argument, and things like basic ecology were often overlooked in favor of theoretical approach based solely on area. In particular a debate over “one large” vs. “several small” reserves has been contentious (we’ll get back to this one).

Also note that the theory of island biogeography doesn’t directly address such issues as habitat quality.

Size of the reserve

Temporarily ignoring the above, the size of a reserve has to be large enough to protect the species of interest.

- grizzly bears need a much larger area than butterflies:

  - a reserve for between 50 and 90 grizzly bears requires roughly 1,000 to 13,500 square kilometers (a rather large area).

  - a reserve for 25 different species of butterflies might only need a few hectares.

- if we know a decent amount about the ecology and natural history of the organisms in question, we can get good initial estimates with something like the population viability analyses we discussed earlier (e.g.., remember the red kangaroo).

  - remember, however, that we generally don’t have good information on confirming our estimates in practice.

  - a few hints come from small natural populations that have become isolated in (for example) mountain tops and elsewhere (i.e., are these patches “big enough” to sustain a population).

SLOSS

Do we want a **S**ingle **L**arge reserve **O**r **S**everal **S**maller reserves?

Frustrating, but again we have to answer “it depends”. In particular we need to know:

1) The difference in extinction probabilities/rates of a small and large population (note we need to know the

"difference" - often it's obvious a large population will do better).

2) The number of populations

3) The correlations of environmental fluctuations (do they all fluctuate the same way - when one is dry, are all environments dry?)

4) The probability of re-colonization

Note the influence of island biogeography on all this.

A sample study using the mountain gorilla concluded:

- three small patches did better than one large patch if no re-colonization was allowed and environmental fluctuations did not correlate between the patches.

- but if environmental correlation was introduced, the smaller patches started to do worse, depending on the strength of the correlation.

- if re-colonization was allowed, the smaller patches did better.

A bit confusing, no? Suppose you had to go out and design a reserve system for mountain gorillas tomorrow???

Just to confuse things - if a species needs protection from exploitation, then a single large patch is probably easier to patrol and/or control.

Finally, we need to emphasize habitat quality a bit more. Some strange things can happen:

- Some species are well adapted to appearing and disappearing habitats (better, perhaps, cyclical fluctuations).

  - This obviously needs to be considered, and depending on the dispersal ability of the species may dictate several smaller reserves or one rather large reserve that can encompass all the needed fluctuations.

- Comment: this section is a bit confusing.

Shape of reserve

What type of reserve?

- one argument is "as circular as possible"
  - this minimizes the edge effect.
  - also minimizes the need to disperse and recolonize distant parts of the reserve (they're not so distant).
- another argument (aren't you getting tired of all the possibilities?) is long narrow reserves that try to encompass as many different microclimates as possible (by, for example, arranging themselves at right angle towards rainfall, altitude, etc. - think of a line going from a valley up a mountain.)
  - this would capture a maximum diversity of habitat
  - unfortunately, also maximizes extinction, since each species will only be minimally represented.
- but perhaps a reserve that tries to allow for some heterogeneity isn't too bad providing it doesn't overdo this.

Where to put the reserve?

Once we've decided (or failed to decide!) on some of the above factors, where do we put our reserve(s)?

Obviously we need to consider:

- budget
- ability to "get" the land
- enacting legislation to protect our reserve(s)
- dealing with problems caused by people living on (or using) the surrounding land (or sometimes even living in the reserve we're trying to set up).

A number of "algorithms" have been developed that can help us make our decision as to how and where to place our reserve(s). Be careful to use common sense - its' too easy just to plug stuff into one of these and have it spit something out. Use these as an aid, not a cure-all solution.

The most important thing we need is an objective. Why are we setting up this reserve?

At a minimum we should:

1) State the objective(s) clearly

2) Find areas (patches) that might be available to meet our objective(s).

3) Survey the species living in these areas (better, get abundance estimates for each species).

4) Figure out where you want to start and add one or a few patches to your reserve. Be careful about existing reserves - they may or may not benefit your objectives.

5) Figure out how to add more areas (patches) to your system if this is part of the objective (i.e, if you decided on a system of reserves, or several small patches, etc.)

Step 5 is a bit more complicated. We need to consider:

- how much redundancy (for example, how many similar patches do we need).

- should we choose patches to minimize distance and maximize dispersal ability?

- should we choose patches to maximize distance and protect against environmental correlation (different patches will be affected differently by the environment)?

- should we try to minimize patch size and thus minimize cost?

- if cost is not an issue (e.g., it's government owned land), should we go for the largest possible patch?

- should we go for the largest size to minimize maintenance costs?

Note how the objective can determine the outcome.

- If we were to try to set up a system of reserves to capture the maximum number of swallowtails, we'd start with those areas with the greatest diversity (Philippines and Madagascar), then add areas in other countries with less diversity as we can.

- If our objective were to ensure persistence of individual species of swallowtail, we would pick areas with less diverse habitat, since these might persist over a longer period of time.

Let's take a look at the example of using populations objectives for getting at reserves:

We won't go through everything in box 10.3, but let's follow the general outline:

1) State objective (e.g., capture a given portion of the range of species "x").

2) Include existing or other reserves (with possible different objectives).

3) Select sites with unique occurrences of the species of interest.

4) Find the next rarest species, and add area that represents that species AND adds the greatest number of additional species (other things we may be interested in).

Modify 4 based on:

5) - nearest site (if 4 gives several choices, choose reserve nearest to the original.

6) - if 5 still gives choices, pick site that contributes largest number of species not well represented.

7) if 6 still allows for choices, then pick the one that helps the rarest species.

8) if 7 still allows for choices, then pick to help the rarest group of species.

9) based on 8, pick to help the original species under consideration (see details in text)

10) if there are still choices, pick the smallest site.

11) if there are still choices, pick first suitable site on list

12) return to step 4.

Again, a little confusing, no?

But essentially what it does is to pick a system of reserves in such a way to maximize the persistence of individual species and assemblages of species.

Suppose we were trying to protect all the worlds species of owls. the objective is to maximize protection for as many different owls as possible. Strict application of this algorithm yields the figure on page 324.

Note that this requires 58 reserves to be set up (there are about 200 species of owl in the world).

But there are other methods of choosing reserves:

- use environments to pick reserves.

    - pick set of sites to try to represent different habitats

    -idea is that this will “capture” the organisms living there

use different taxonomic units (e.g. families) instead of species.

Whatever method we decide on, some type of evaluation should be implemented (did we do it right).

- unfortunately this takes a long time, and there are few instances where we can say “we did it right” (or wrong!).

- some experiments are in progress however.

- there have been some parks and reserves in existence for a long time, but many were not set up with the specific goal of protecting a single species (or suite of species).

- some studies have shown that specific species need more area (or reserves), but in fairness, these reserves were not set up with the species under study in mind.

- the impact of island biogeography is also still being evaluated.

- some good indications might be gotten using species with shorter life cycles (e.g. butterflies).

Corridors

The idea is obvious:

- allows for dispersal of individuals

- thus helps gene flow between reserves

- declining populations in one reserve might be helped by those in another.

But there is some doubt. In particular, corridors might:

- spread disease and fire

- increase competition with domestic animals

- increase exposure to hunting, predation, etc.

(for the last two, it should be apparent that a long skinny corridor is more difficult to patrol, control, etc. than a more compact area - it's also likely to be much more expensive since it probably crosses several different properties.)

Apparently the arguments got kind of nasty.

Some experiments using corridors would help clear up some of these issues (see text).

Even eight years after the publication of our text, this issue has not been fully addressed.

Nevertheless, it seems the idea of "corridors" has obvious benefits in some situations:

- allowing access to a required resource (e.g. toad tunnels that permit toads to gain access to breeding ponds).

- building tunnels or bridges in such a way so that animals can use them to get from one side of the road to another.

- Fairfax County Parkway in Ft. Belvoir is designed with bridges big enough to accommodate deer (in part due to input from GMU).

- many roads and other projects are now being designed to take animal movements into account.

Animal movements should also be kept in mind when considering corridors. For example:

- annual migrations (incl. movement to breeding areas)

- daily movements

- juvenile dispersal

- range shifts (in response to changing climate, etc.)