

How should we best manage an endangered population?

It's all about birth, death and money

By Peter Baxter (UQld, Brisbane Node, AEDA)

It's one of our biggest conservation challenges: how should we focus our efforts in attempting to save an endangered population of plants or animals. Changes in population size occur through either births or deaths (migration – the movement in or out of the population – also affects population size, but let's stick with births and deaths for now). So in many cases the decision of how to boost a population boils down to whether we should try to increase the survival rate of individuals, or increase their reproductive output ("fecundity"), things demographers refer to as the population's vital rates.

And the same question applies for controlling pest populations, but in reverse. How should we try to reduce a pest population: by reducing the birth rate or increasing the death rate? Whether we want to reduce the long-term population growth rate or increase it, the most efficient management option depends on the vital rate that has the greatest per-dollar effect on the population in which you're interested.

(St)age-structured models & turtles

So, which vital rate should we focus on, survival or fecundity? One common way of tackling this question relies on a demographic analysis that examines different life-stages (eg, ages, or different sizes) of the population. By using these life-stages to examine demographic characteristics – the survival within different life-stages, the organism's progression from one stage to another, and its reproductive output at each stage – population ecologists can find out which of these components are most important for the long-term growth rate of the population.

For example, a common finding for long-lived species is that the survival of adults is the main driver behind population growth, suggesting that – all else being equal – increasing adult survival may be the best way to boost the population growth rate. So far so good, *all else being equal*.

The first application of this method examined loggerhead turtle demographics in the southeastern USA (Crouse et al, 1989). They found that the most critical parts of the turtle life-cycle were juvenile and sub-adult survival. At the time, turtle conservation efforts were focused on protecting eggs and helping hatchlings to make it out to sea, but, consistent with the model's predictions, the installation of Turtle Excluding Devices (TEDs) on trawlers led to a decrease in adult mortality with further modelling suggesting possible recovery of turtle populations in the region. Although the loggerhead turtle remains classified as endangered, this early apparent success led to the structured-population model approach being widely adapted in conservation analyses, often becoming a standard output in conservation software packages.

One critical aspect of the turtle story, however, is that the installation of TEDs on trawlers was relatively straightforward, legally binding and therefore widely adapted. However, not all cases are so clear cut when deciding whether you should place a greater emphasis on managing survival or fecundity.

One important aspect of the decision making process that is often ignored is the cost of the proposed management. It's critical when deciding how you'll spread your investment to take into account the difficulty – or expense – in improving either survival or fecundity. Because in most situations different management actions come with very different price tags, and in the real world these can't be ignored.

Incorporating management costs

Indeed, merely looking at the vital rate that has the biggest influence on population growth rate and then concluding that that's the most appropriate one to manage can actually be quite illogical when management costs are ignored.

One approach to incorporating management costs into your decision process is to first analyse how a particular investment on a particular vital rate will change that rate. Then we can combine this with the effect that changing that vital rate has on the overall population growth rate. This simply gives the improvement in population growth rate per amount spent on improving a particular vital rate. This is the 'efficiency' of spending money on that vital rate – a straightforward cost-benefit or 'bang-for-buck' approach.

So we can find, for example, how much \$1 invested in increasing survival will cause the population to grow, and compare this with \$1 invested in increasing fecundity to find the best way to spend our money (of course, the dollar amounts could be some other measure of management effort).

It's not just simple, it's also a sensible approach to deciding how to invest your resources. To do otherwise, and ignore costs, may result in a huge waste of limited conservation funding. Having said that, for almost two decades the two parts of the process have been kept separate – many studies just found the most influential vital rate and then advocated that managers focus on that, often without discussing the practicalities, costs or difficulties of doing so. It's a bit like getting advice on what's the fastest way of getting to the shops and being told to buy a helicopter when a bike would have been a wiser way to go.

Managing for helmeted honeyeaters

So, how might this process work in a real life conservation situation? Let's consider management options for the helmeted honeyeater (*Lichenostomus melanops cassidix*), an endangered bird in Victoria that also happens to be the state's bird emblem. The traditional demographic approach suggested that managing survival would be about four times better than managing reproduction (see figure 1). However, it's incredibly difficult and costly to increase survival

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Notes on the model

Of course, this structured-model approach contains many simplifications and assumptions. However, our work on a more sophisticated model – one that simulates the fate under various conditions of every individual bird in a helmeted honeyeater population – also indicates (albeit less strongly) that protecting nests is the way to go.

Over the long term conditions will change and it's likely that the efficiency of managing our selected vital rate will eventually drop (for example survival rates can never be increased beyond 100% no matter how much money we pour into survival management). At some stage then it's likely that the other vital rate will become just as efficient to manage. At that stage we should manage both survival and reproduction together equally. Which is not to say that management money should be split 50:50 between survival and fecundity, but rather in the ratio of their unit costs (eg, cost of increasing each by 0.01), so the bang-for-buck is the same for each, and the overall bang-for-buck is maximised.

And what about uncertainty? With all those approximations and assumptions in the model (including the assumption that the model is appropriate at all), we can't be exactly sure of the costs, the effects of costs on the vital rates, and the knock-on effects on the population growth rate. However, work in progress suggests that to account for uncertainty, a degree of bet-hedging between different management options may be appropriate, while still devoting the majority of funding to managing the vital rate with the highest efficiency value.

More info: p.baxter@uq.edu.au

References

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The helmeted honeyeater, Victoria's state bird emblem and an endangered species. In attempting to save it should we focus on its survival rates or reproduction rates? (Photo by Ian Smales.)

rates. The nearest approach would be to buy land to generate new habitat for juvenile birds to disperse to.

On the other hand, increasing breeding success is relatively straightforward, involving the protection of nests from predators. Therefore, it doesn't come as a great surprise that when you include the management costs in the analysis (as discussed) it becomes clear that managing reproduction is a more efficient way of increasing population growth (see figure 1). In fact it's more than eight times as efficient as managing survival.

Once again, instead of blithely accepting previous paradigms, a considered approach that accounts for costs points to a completely new way of doing things. Our new approach, enables managers to include costs in population management decisions, and delivers better outcomes for conservation for the same cost. It revolutionises a traditional and tired approach to species conservation.

Figure 1. Schematic representation of the traditional and novel approaches to deciding which vital rate is better to devote management resources to, using the helmeted honeyeater as an example. The traditional method (top) indicates that managing survival (yellow) is about four times better than managing fecundity (green). Accounting for the costs of managing either vital rate (bottom) overturns this view as reproductive success is so much cheaper to manipulate. As a result, spending money on increasing reproductive output has more than eight times the effect on the population growth rate than spending the same amount on increasing survival.

