The law of the jungle

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Forest mammals are food for people across Asia, Africa and South America. But with many species disappearing fast, can hunting be made sustainable? John Whitfield talks to the ecologists trying to balance supply and demand.

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Hung out to dry: conservationists fear that many forest mammal species will be wiped out by hunters.

In west and central Africa, it's estimated that one million tonnes of forest animals are killed for meat each year — equivalent to a daily quarter-pound burger for each of the forests' 30 million people. Road building and the spread of shotguns and wire snares have made hunting a more serious threat to forest wildlife even than deforestation. In 2000, Miss Waldron's red colobus monkey (*Procolobus badius waldroni*), once resident in Ghana and the Ivory Coast, was hunted to extinction. And it's not just an African problem: 12 species of mammal have disappeared from Vietnam's forests since 1975.

Yet banning bushmeat, as the flesh of wild animals is called, would deny forest dwellers an important source of protein. "You can't say 'don't hunt', because a lot of rural people depend on it," says Elizabeth Bennett, director of the Hunting and Wildlife Trade Program at the New York-based Wildlife Conservation Society (WCS). So rather than eliminating the bushmeat trade, conservationists and ecologists want to manage it.

The theoretical models used to analyse the impacts of hunting must be quick and easy to use on the ground — where most forest animals lead secretive lives hidden from ecologists — but also have to cover the gamut of species and environments. The results are rough, and ecologists differ over what are the best methods. But the approach is not hopeless: some damaging hunts have been curbed, whereas others seem to be sustainable, allowing conservation efforts to be focused on where they're needed most. And ultimately, conservationists have a duty to try and understand hunting, argues Richard Bodmer of the University of Kent in Canterbury, UK. "If you can't provide communities with information on how many animals they can hunt, you've failed."

John Robinson and Kent Redford, ecologists with the WCS, devised the most commonly used method for assessing the impact of bushmeat hunting[1]. Their model requires only an estimate of the population of a particular species in the region under study. This is usually inferred from counts of dung, nests, or sightings of animals made at a set of fixed points. Other parameters, such as a species' reproductive rate and lifespan, can be obtained from previous studies or calculated from body size. From these figures, the model gives the theoretical maximum sustainable harvest. "It shows you the best of all possible worlds," says Robinson. This is then compared to the actual harvest — which can be measured by interviewing hunters — to see whether a hunt is sustainable or not.

Robinson and Redford's analysis, which was published in 1991 and is used in Asia, Africa and Latin America, paints a stark picture. Tropical-forest mammals, say the duo, live at such low densities and breed so slowly that their meat can support only about one human hunter per square kilometre. When applied to the Malaysian province of Sarawak, the model showed that any commercial trade in wild meat — pigs, monkeys, deer and rodents, for example — was unsupportable. The WCS results persuaded the Malaysian government to ban all except subsistence hunting in Sarawak. Heather Eves, director of the Bushmeat Crisis Task Force, a consortium of conservation organizations and scientists based in Silver Spring, Maryland, believes that similar action is needed worldwide. "The tools we have today show that, across the board, commercial hunting of wildlife is unsustainable," she says.

But other models indicate that some animals can be, and are being, hunted at safe levels. Bodmer has developed the 'unified harvest model', a more detailed approach that builds on Robinson and Redford's work and combines several methods for analysing animal ecology and hunting[2,3]. "Using more than


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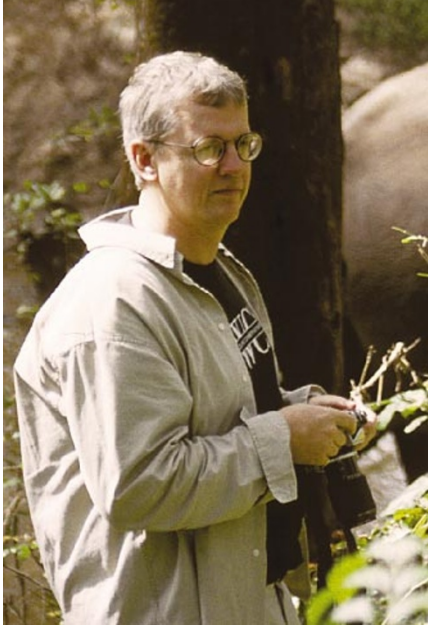
WCS

Kent Redford (above, left) and John Robinson want to assess the sustainability of current hunting.

one model will increase your confidence," says Bodmer — if the models agree, there's a better chance that researchers are on the right track.

The unified harvest model generates two numbers: the level at which a hunted population must be maintained for it not to decline, and the proportion of animals born each year that can be safely taken. Baseline population data come from areas where there is little or no hunting. Comparison with hunted areas shows how much the population has been depleted, and the number of pregnant animals killed gives a guide to the species' birth rate. As a ballpark figure, says Bodmer, the harvest of large, slow-breeding species should comprise only 20% of the newborns. For fast breeders, a harvest of 40% should be sustainable.

Working with communities in the Peruvian Amazon, Bodmer has calculated that the region's wild pigs, deer and large rodents seem to be standing up to the current level of hunting. Last July, at the annual meeting of the Society for Conservation Biology, held at the University of Kent, he showed that the more of a species that are killed, the more offspring the survivors produce, probably as a result of reduced competition for food. But forest inhabitants that have not evolved to cope with predators, such as the large, slow-breeding lowland tapir (*Tapirus terrestris*), are less flexible, and Bodmer advises against hunting them. He is optimistic that his message is being heard, saying that forest dwellers are keen to manage their hunting.

The methods used both by Robinson and Redford and by Bodmer are intended to assess existing hunts, rather than to guide future hunting — although Robinson says that his model has sometimes been used inappropriately to set harvest levels. The analyses can only show that hunts that exceed a theoretical maximum are definitely unsustainable; harvests that fall below this level might be damaging or they might not.

But some ecologists think that the methods cannot achieve even this modest goal. Eleanor Milner-Gulland of Imperial College, London, points out that errors of 30% in population estimates are common, and that methods that use these estimates to set hunting thresholds will mislead. "As soon as you subject the models to anything like realistic uncertainty they fall down," she says. "Thresholds for sustainable hunts go much lower if you incorporate uncertainty and bias."

Milner-Gulland wants hunting studies to take explicit account of our ignorance, and is developing alternative models that use bayesian statistics. Commonly used in fisheries science, these give results as a distribution of probabilities, rather than as a single number[4]. But balancing accuracy with usability can be tricky. Some researchers feel that it is important to create models that non-scientists from development agencies can use (see "A market solution?", below). Others wonder whether models such as Milner-Gulland's will be too difficult to apply. "Our model was very quick and dirty," admits Robinson, "but going to the other extreme isn't going to be very useful."

As well as being vulnerable to uncertainty, simple models can fail to account for biological reality. Last August, Philip Stephens of the University of Wyoming in Laramie and his colleagues described how ten different models fared at predicting the population dynamics and sustainable harvest from an intensively studied colony of marmots (*Marmota marmota*)[5] in Germany. Robinson and Redford's model overestimated the harvest, largely because it ignores social behaviour. Animals that live in groups, including marmots and many primates, can become extinct if their group size falls below a critical level. "You get a very sharp change between safe and dangerous levels of exploitation," says Stephens.

Given these problems, can ecological models ever hope to guide policy? Conservationists are aware of the deficiencies, but insist that models have a valuable role to play. As forests shrink and human populations grow, the best long-term hope for wildlife is to provide local people with alternative food sources. But in the meantime, understanding and regulating hunting is essential, as the projects in Malaysia and the Amazon have shown.

Science can't solve the problem, but those involved are adamant that it is part of the solution. And it needs to be implemented quickly. "We know very little about the ecology of most hunted species, but we know enough to be able to get some management on the ground," says Bennett. "The problem is so acute that if we wait it'll be too late." ■

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1. Redford, K. H. & Robinson, J. G. in *Neotropical Wildlife Use and Conservation* (eds Redford, K. H. & Robinson, J. G.) 415–429 (Univ. Chicago Press, Chicago, 1991).
2. Robinson, J. G. & Bodmer, R. E. *J. Wildl. Mgmt* **63,** 1–13 (1999).
3. Bodmer, R. E. & Robinson, J. G. in *People in Nature: Wildlife Conservation in the Neotropics* (eds Silvius, K., Bodmer, R. E. & Fragoso, J.) (Columbia Univ. Press, New York, in the press).
4. Milner-Gulland, E. J. & Resit Akçakaya, H. *Trends Ecol. Evol.* **16,** 686–692 (2001).
5. Stephens, P. A., Frey-Roos, F., Arnold, W. & Sutherland, W. J. *J. Anim. Ecol.* **39,** 629–642 (2002).
6. Clayton, L., Keeling, M. & Milner-Gulland, E. J. *Ecol. Appl.* **7,** 642–652 (1997).

Bushmeat Crisis Task Force
www.bushmeat.org

A market solution?

Persuading governments to implement conservation plans currently takes years of fieldwork, so Guy Cowlishaw of the Institute of Zoology in London is trying to speed things up. His team is studying the bushmeat chain from hunter to market. Once this is understood, he says, it may be possible to work out what's going on in the forest by perusing a market's stalls.

Cowlishaw's team is looking at Ghanaian hunters' taste in prey, and the point at which they switch to smaller species as big game becomes rare. "If you see a market with lots of small animals, it's almost certainly been overexploited," he says. The aim is to develop bioeconomic models that can measure the effects of hunting from information on price and availability. "We're trying to come up with simple rules of thumb that people in development agencies can use," says Cowlishaw.

The model has its critics, however. Eleanor Milner-Gulland, an ecologist at Imperial College, London, has found that, for wild-pig hunting in Indonesia, the market stayed the same while the population collapsed, as hunters simply went further in pursuit of game[6]. Animals eaten in the forest, and those discarded *en route* to market, can account for more than half of those killed, she adds.