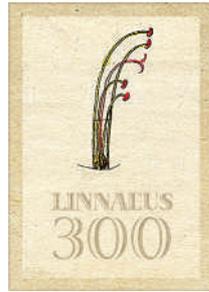


The species and the specious

For some, species are simply the things you save; but for taxonomists, the concept is much more complex. **Emma Marris** asks whether Linnaeus's legacy is cut out for conservation.

Conservationists around the world were delighted to hear that the United States was considering adding polar bears to the list of animals enjoying the protection of the Endangered Species Act — the cornerstone of US environmental law since 1973. But some experts may have greeted the news with a wry smile. Polar bears might well be threatened by the rapidly changing climate of the Arctic — but whether they actually constitute a species is up for debate.



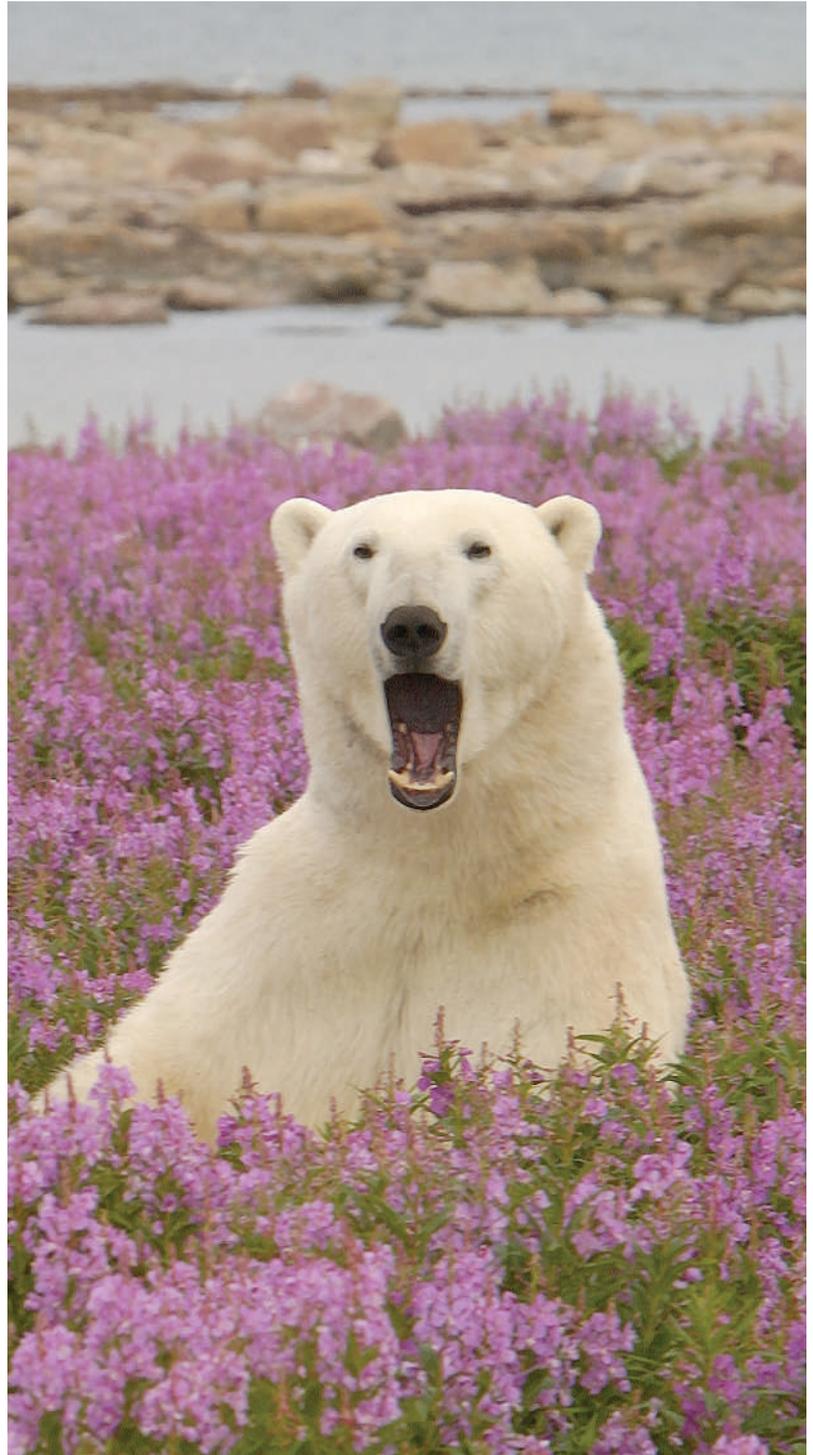
Genetic studies have shown that some brown bears (*Ursus arctos*) are more closely related to polar bears (*U. maritimus*) than they are to some other brown bears¹. According to some interpretations of the word species, this means that if brown bears are a species, then polar bears are not. This is not, in itself, an insurmountable obstacle to protection under the act, which can be quite flexible on taxonomic matters. But negotiating that flexibility is far from easy: when modern taxonomy comes up against a conservation agenda, things can get very complex. Not everything that humans want to save is covered by an easy definition, whether it is in terms of genes, anatomy or ecological role.

Take a less iconic mammal that has been in the act's purview rather longer: Preble's meadow jumping mouse (*Zapus hudsonius preblei*). It's a threatened tea-cup-sized rodent with comically large feet and a counterbalancing tail, and spends its life hopping about the foothills of the Front Range in Colorado and Wyoming. Or that's how some would have it. Others say that the subspecies, named after the naturalist Edward Alexander Preble, is a spurious one, and that the creatures called by that name are just plain old meadow jumping mice (*Zapus hudsonius*), a species with which the United States is crawling.

To protect and serve

The disagreement is not just a matter of status games between mice. The streamside habitat preferred by the foothill mice is also prime real-estate land for residential and commercial development. The degree of protection accorded to the mice thus has implications for developers.

After petitions were filed by a group calling itself the Coloradans for Water Conservation and Development and the State of Wyoming's Office of the Governor in 2005, the US Fish and Wildlife Service announced that it planned to drop Preble's mouse from its list of threatened species and subspecies because of new genetics work by a group led by Rob Roy Ramey when he was at the Denver Museum of Nature and Science². Papers and rhetoric began to fly. A group led by Tim King from the US Geological Survey in Kearneysville, West Virginia, was commissioned by the Fish and Wildlife



A proposal to list polar bears as protected avoids the issue of whether they are a species.

VISUAL&WRITTEN SL/ALAMY

Service to do further genetic tests. It disagreed with Ramey and his group³. In the end, the agency called in an outside group — the Sustainable Ecosystems Institute of Portland, Oregon, to make the call. In July 2006, the group laid down its verdict: the subspecies exists. The Fish and Wildlife Service is now digesting this ruling at typical government speed.

Although it might be tempting just to see a story of evil developers and good conservationists, the mice highlight a more fundamental problem. The act includes in its definition of species ‘subspecies’ and ‘distinct population segments’ but offers no definitions for either of these categories. The government agencies that enforce the act do provide guidance but the researchers called on by the government to determine objectively whether various groups of organisms are listable are mostly left to their own devices. Devices that have, over the years, littered the scientific literature with at least two dozen definitions of the concept of a species.

“We have more definitions than I can even remember,” says Scott Stepan, a molecular systematist at Florida State University in Tallahassee, and a member of the deciding panel at the Sustainable Ecosystems Institute. Although most biologists agree that species are real entities — they exist without humans around to assign them — the distinctions are not clean-cut.

The reason why the relation between this mouse and that mouse can't be nailed down with jurisprudential exactitude is the same reason that there are any mice in the first place: evolution. The problem is that the idea of a distinct species predates Darwin's insights into their origins. Carl Linnaeus thought that species were made separate from one another by God, and that they stayed that way. But Darwin showed us otherwise. As one species splits into two over the millennia, there is no magic generation in which they are clearly separate. “It is kind of like asking when you are a child and when you are an adult — where is the boundary?” says Stepan.

Splitting hairs

Georgina Mace, head of the population biology programme at Imperial College, London, and two of her colleagues have chronicled how the number of species has changed under the rubric of ‘taxonomic inflation’⁴. “In well studied groups, the number of species is increasing very rapidly, and that is in large part from the elevation of subspecies to the species level,” says Mace.

According to their analysis, subspecies are becoming species not just at an increasing rate, but also and rather more problematically at varying rates in different parts of the natural world. For example, ant taxonomists have decided that anything that's worth separating should be separated at the species level, and have no truck with subspecies at all. Butterfly taxonomists, however, like the triple-barrelled name approach and dote on subspecies. As a result, the numbers of ant species and butterfly species are not directly comparable.

The implications of taxonomic inflation for conservation are wide-ranging, from increasing the number of endemic species in well studied areas and heating up ‘hotspots’ to making it almost impossible to figure out whether rates of extinction are slowing down or speeding up. Severe inflation can also, as in economics, lead to devaluation: if the smallest distinctions are raised up to the level that defines a species,



The meadow jumping mouse (*Zapus hudsonius*) is rampant throughout the United States.

the idea of a species loses some of its power.

What is driving the inflation? According to Mace, much of it can be traced to the adoption of the phylogenetic species concept over the older biological species concept. In the biological species concept, if two fertile creatures cannot produce fertile offspring then they're not the same species, although there is some wiggle room for groups that have rare hybrids but keep their gene pools more or less separate.

The phylogenetic species concept rests on the idea of diagnosable differences. If one population has a particular characteristic: a red head, say, or a particular curve of a bill — and the characteristic can be shown to be inherited, it is taken as evidence of a unique evolutionary history, which would qualify the population as a distinct species. By the phylogenetic species concept, any difference that can be placed on a common limb of a family tree could count as a separate species, but how far up the branch the pruning shears are applied does, in practice, vary between taxonomists. “We can all agree on the data, but we can't all agree on how to apply the names,” says Jack Dumbacher, a molecular ecologist at the California Academy of Sciences in San Francisco.

Lack of definition

The phylogenetic approach can lead to a preference for splitting over lumping. It can also call older taxonomy into doubt, as in the case of the polar and brown bears. Although the two types of bear are distinct populations that lead different lives, studies of mitochondrial DNA suggest that brown bears do not share a common ancestor that does not also have polar bears as descendants; if you want to find one point on the tree from which all brown bears branch out, you will have to accept polar-bear branches in the same cluster.

By at least one reckoning, the phylogenetic approach comes up with 48% more species than the biological species concept does for the same group of organisms⁵. More species mean smaller groups and smaller ranges, so the groups are more likely to qualify as endangered. If subspecies are ascending to the species level, it may be reasonable to assume that heretofore un-named sub-subspecies — the sorts of thing that the Endangered Species Act already recognizes as ‘distinct population segments’ — are rising to the level of subspecies, and so on up the chain. And that may secure their conservation more attention.

The fact that it is now so easy to get gene sequences has contributed to the new ascendancy of phylogenetic over biological concepts. “We are able to slice the genetic pie thinner and thinner,” says Craig Manson, who was assistant secretary for the Fish and Wildlife Service and the National Park Service from 2002 to 2005. Now teaching law at the University of the Pacific, McGeorge School of Law, Manson sees the Endangered Species Act as a creation of its time — a time when genetic data were still scarce and no one could fore-

“We have more definitions for a species than I can even remember.” — Scott Stepan



Rob Ramey argues that Preble's mice are no different from the common meadow jumping mouse.

see the coming orgy of re- and sub-classification. In today's world, he says "the act is sort of working — [but] not very well". The act has no clear thresholds below which a group of organisms is not considered a unit for protection purposes. "I think there needs to be a conference at the national level with the best experts in the scientific community that can be found, and let's hear this issue," says Manson. "It was one of the things I intended to do, and I just didn't get it done."

However, one corner of the United States has gone quiet over the definition for the tricky category of 'distinct population segment' — the smallest taxonomic unit that is listable. In 1991, Robin Waples of the National Marine Fisheries Service in Portland, Oregon, came out with his idea of how the term ought to be defined, and it stuck, at least for his agency⁶. 'National Marine Fish' shares the job of enforcing the Endangered Species Act with the Fish and Wildlife Service, and deals with the anadromous creatures — those that divide their lifecycle between salt and fresh water — as well as the truly marine animals. Although this might seem a smallish niche, in terms of the Endangered Species Act it's a big thing; of the ten listed populations in the United States on which most money is spent, eight are anadromous salmon or steelhead (rainbow trout). Anadromous fish nearly always return to their natal stream to reproduce, and so fish from

different streams, even though they might brush scales in the wide ocean during their rambling years, are almost completely isolated when it comes to breeding. Waples requirements for a distinct population segment are: "it must be substantially reproductively isolated from other conspecific population units", and "it must represent an important component in the evolutionary legacy of the species".

So in the case of the chinook salmon (*Oncorhynchus tshawytscha*, which, as it happens, is considered by many to be the tastiest), those that spawn in the Columbia River basin are divided up into at least eight distinct population segments on the basis of their specific location and the timing of their runs. Some of the salmon travel to the ocean in spring, others in the summer and autumn. Although there are many more than eight populations in the basin, their listing groups them together into units of a manageable size.

Micromanagement

As Waples describes it, the distinct population segment combines a biological description of the relationships with a clear value judgement as to whether a population is important. "You really need something besides science to decide where on that level you are going to focus," he says. "There are hundreds of thousands of distinct stocks. It was not the intention of the framers of the Endangered Species Act to micromanage at that level."

Surprisingly, the gambit of defining a unit with a level of value judgement did not result in a rush of litigation, even in the highly fraught conservationist world of the Pacific Northwest. Waples says that the approach has become enough of an institution that it would take "a pretty compelling case" for things to change. As a result, although regulated industries and environmentalists might square off on other matters, such as how listed fish are going to be protected, the distinct population segment does not come up.

But although the Fish and Wildlife Service signed on to similar guidance language to that used by National Marine Fish — its guidelines on 'discreteness' and 'significance' are modelled on Waples' approach — experts mostly agree that it is less likely to list groups with only shallow genetic distinctness. "On this issue," says Manson, "they have never been in agreement, and they have grown further apart."

Without agreed ways of making judgement calls, personal feelings about conservation in general and about individual organisms in particular, can end up influencing ideas about classification. Ramey, the man whose genetic analysis nearly de-Prebled Preble's meadow jumping mouse, says that his differences with his detractors are "conceptual and philosophical". Conceptually, he says the fact that when at the museum (he now works independently) he had defined a threshold for what he would consider a subspecies before he did the analysis is proof that he was taking an unbiased look at the mouse. The others, he says, disagreed with his thresholds because they started off wanting the mouse to be a subspecies. But the report by the Sustainable Ecosystems Institute concentrates



not on concepts but on data, and rejects much of Ramey's evidence as being based on insufficient and poor quality data and contaminated samples. Ramey replies that his evidence does not hinge on those data points alone. After a slightly sharp series of exchanges on the Ramey work in the pages of *Animal Conservation*, experts seem to remain divided over the case. "If we look at the history of taxonomy, we often see that there have been many species named and then later synonymized," adds Dumbacher, who also sat on the Preble's mouse panel. "It may be that in the future, when the right studies are done, Preble's jumping mouse might be synonymized."

Criticisms of his data notwithstanding, Ramey says that his threshold is the right one, and that the level of difference between the Front Range mice and the rest is just too slight, in a world of limited resources, to justify any strenuous efforts to protect them. "We have to be willing to set priorities and stick to them. Right now, if you look at it, everything is a priority," he says.

Some suggest that the answer to all these problems is to ditch the taxonomic approach and shift to a totally different model of conservation law, such as ecosystem-based conservation. Many conservationists are thinking about

"We can all agree on the data, but we can't all agree on how to apply the names." — Jack Dumbacher

concepts such as putting value on ecosystem services, such as water filtration and carbon sequestration. Mace sketches one possible ecosystem conservation model, in which several species' ranges are overlaid until a clear unit of space emerges. "You may have to deal with extreme specialists and those who like the edges of ecosystems separately," she adds. But when asked whether she thinks an approach like this will catch on in the near future, she sighs. "No," she says. "I think it is going to be very difficult because of the amount of expectation in policy-makers and legislators about the reality of the species concept. They really believe in it." ■

Emma Marris is a correspondent for Nature in Washington DC.

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The big name hunters

Professional taxonomists often bristle at non-professionals who name new species without going through peer review. But are amateur naturalists really bad for science? **Brendan Borrell** reports.

The death adders of Australia are not adders at all. Their closest relatives are cobras and coral snakes, but early naturalists were fooled by the snakes' stout body and triangular head. Even today, their taxonomy is a riddle: no one really knows where one species of death adder ends and the next begins.

In the late 1990s, only three species of death adder had been recognized, but herpetologists suspected that there were at least twice as many. Ken Aplin, then a curator at the Western Australian Museum in Perth, had spent years collecting data to back up that hunch. But before his study could be published, Raymond Hoser, a herpetologist not affiliated with an academic institution, described five new species of the snake in a 1998 issue of *Monitor*, a hobbyist magazine he edited for the Victorian Herpetological Society. Under the taxonomic code of the International Commission on Zoological Nomenclature (ICZN), Hoser's names — printed and disseminated to society members — take priority over any subsequent descriptions of the species. Aplin had been scooped¹.

In the competitive world of taxonomy, countless amateurs have found success by collaborating with academics. Many professionals welcome their contributions; amateur enthusiasts are, in essence, a free workforce at a time when funding for basic taxonomy is waning. But cases such as Hoser's make some scientists wary of such contributions.

Hoser, who runs the snake-removal service Snakebusters in Melbourne, paints the picture as a classic case of academic élitism. "The description of me as an amateur is complete rubbish," he says. "There's no one in history who has spent so



much time dealing with, looking at, catching and breeding death adders as myself." But his critics say it is not Hoser's credentials that they challenge. "A steady drip of shoddy descriptions" is how Wolfgang Wüster, an evolutionary biologist at the University of Wales in Bangor, describes Hoser's work. In a published critique, he and other leading herpetologists argue that Hoser "almost invariably fails to provide adequate information on his species, on their types, or on the material he has examined", making it difficult to repeat and test the observations². Hoser, for his part, says that his descriptions contain more than adequate information.

Seek, locate, describe

But the ICZN, the group in charge of setting the ground rules for taxonomy, says it cannot police the quality of every published description. "It's a very tricky area to work in," says Andrew Polaszek, executive secretary for the organization. The commission, he says, will arbitrate only on pure nomenclature issues. In such a dispute, it will assess whether a Latin name put forward for a new species is valid under the taxonomic code. The code states that authors need to print the description of their species on paper, designate a type specimen, and list features that distinguish it from others. So just because a description is valid doesn't mean it is good. "The commission does not like to get involved in subjective taxonomy," Polaszek says.

Some taxonomists have proposed that the ICZN change its rules so that new species can be described only in peer-reviewed journals or through some other formal