The How-Much-Is-Enough Myth

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Introduction

Imagine the following newspaper headlines: 33% of Florida Proposed for Conservation; Analysis Shows 250,000 Hectares Needed for Grouse Habitat; and Scientists say 40% of Region Should Be Protected. Headlines such as these occasionally appear in the mass media and are intended to inform (or inflame) public debates surrounding biodiversity conservation and habitat protection. My imaginary headlines were the actual conclusions of scientists (Grimm & Storch 2000; Kautz & Cox 2001; Nachlinger et al. 2001, respectively) who have unintentionally perpetuated a myth—the erroneous idea that the amount of conservation necessary for the survival of species or the integrity of ecosystems can be determined solely through objective, evidence-based science. Although their analyses were objective and evidence-based, their conclusions were actually rooted in ethical values. Because they failed to acknowledge their value judgments, these scientists succumbed to the how-much-is-enough myth. Scientists unaware of the myth may unintentionally convey misleading information to policy makers, and policy makers unaware of the myth may unknowingly relinquish their responsibilities to scientists. The purposes of this essay are to explain the myth and to offer recommendations for avoiding it.

How much is enough? is one of the most important questions in conservation biology. The question continues to be a focus of research (e.g., Rodrigues & Gaston 2001; Reed et al. 2003; Brook et al. 2006) because (1) progress in conservation must ultimately be gauged against the answers and (2) it lies at the core of many complex environmental policy decisions. Such policy decisions often pit biodiversity conservation against economic development and, hence, quite understandably, elicit acrimonious debate. The answers to the question, how much is enough?, have enormous implications for both biodiversity and human well-being. Therefore, how the answers are found may be just as important as the answers themselves. The process should be informed by science, but scientists must be aware of science's limitations in answering the question.

More specifically, the question concerns the number of individuals, number of populations, or area of land needed for the long-term persistence of populations, survival of species, or integrity of ecosystems. The minimum viable population (MVP) concept is an operational formulation of the question with regards to populations (Shaffer 1981). The MVP is typically expressed as the minimum number of individuals needed in a particular population to yield a probability of persistence, p, over T years. Thirty years ago, Soulé (1987) and Shaffer (1987) recognized that MVP cannot be determined by science alone. They believed the answer depended on value judgments by society. The patent implication is that the values of p and T, which express the risk of extinction, should be determined through a political process. Because no actions can ever assure the survival of a population or species (i.e., $p = 1$), the question, how much is enough?, is really asking how much risk will society accept or tolerate? Should p equal 0.99, 0.95, or 0.50? Whether the basis for acceptable risk is a utilitarian philosophy, principles of stewardship, or doctrines on species rights, the degree of acceptable risk is an ethical judgment (i.e., a quantitative expression of what society ought to do).

The subjective values and politics inherent to answering the question, how much is enough?, have been acknowledged repeatedly (e.g., Soulé 1987; Haight 1995; Scott et al. 1995; Noss 1996*a*; Tear et al. 2005). Unfortunately, there are numerous instances where scientists have failed to adequately acknowledge the question's ethical dimensions or society's role or both (e.g., Soulé & Sanjayan 1998; Shaffer et al. 2002; Pressey et al. 2003; Svancara et al. 2005). These scientists have perpetuated the 2 misconceptions that constitute the how-much-is-enough myth: (1) the question can be answered solely through objective, evidence-based science and (2) it can be answered free from economic concerns and removed from political discourse.

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Objective, Evidence-Based Science

MVP is undeniably rooted in attitudes about risk, but might other answers to the question, how much is enough?, be unsullied by subjective values? Many conservation assessments have attempted to estimate the land area needed to represent and preserve the biodiversity of a region (Rodrigues & Gaston 2001; Svancara et al. 2005). Conservation assessments use empirical data and usually employ site-selection algorithms (e.g., Lombard et al. 1997; Noss et al. 2002), population viability analysis (Kautz & Cox 2001), or both (Moilanen & Cabeza 2002; Carroll et al. 2003). Consequently, conservation assessments ostensibly produce objective, evidence-based results. All such assessments, however, must specify subjective a priori targets for representation or viability, and the results are strongly influenced by these targets (Svancara et al. 2005). Targets are typically expressed as number of occurrences for species, percentage of historical area for vegetation types, or as values for p and T. Noss et al. (2002) typify how such targets are chosen. They state that their targets were those they "felt comfortable with." In other words, the protection targets were actually based on the scientists' feelings about acceptable risk to biodiversity. Unfortunately, not all conservation assessments have been as forthright as Noss et al. (2002), and the ethical value judgments underlying many conservation assessments have been unstated or obscure (e.g., Soulé & Sanjayan 1998; Grimm & Storch 2000; Kautz & Cox 2001; Shaffer et al. 2002; Wielgus 2002; Carroll et al. 2003; Pressey et al. 2003; Reed et al. 2003; Svancara et al. 2005; Brook et al. 2006).

Economic Concerns and Political Discourse

The second part of the myth is that the question, how much is enough?, can be answered free from economic concerns and removed from political discourse. An economic perspective on MVP demonstrates the necessity of linking the question with the broader interests of society. Haight et al. (2002) estimated the cost of reducing extinction risk for the San Joaquin Kit Fox (*Vulpes macrotis mutica*). Their analysis demonstrated the diminishing returns of the extinction risk–cost curve; the per-unit cost in risk reduction was about 30 times greater at $p = 0.985$ than at $p = 0.925$ ($T = 100$ years). Montgomery et al. (1994) examined the costs of saving the Northern Spotted Owl (*Strix occidentalis caurinus*) from extinction. They estimated the cost of increasing the survival probability from 0.90 to 0.91 would be $1.4 billion and increasing it from 0.94 to 0.95 would cost $3.8 billion ($T = 150$ years). Clearly, the price of risk avoidance is substantial.

When estimating MVP size, conservation biologists typically set p to 0.90 or 0.95 (Carroll et al. 1996; Sanderson 2006), but sometimes they set it as high as 0.99 (e.g., Reed et al. 2003). Considering the aforementioned costs of risk avoidance, these values for acceptable extinction risk may be somewhat unrealistic; however, conservation biologists may be no more risk averse than the general public. For instance, Burgman (2005) performed an informal experiment with about 1250 college students. In response to an impartial set of questions, the acceptable extinction risk expressed by nearly all students was either 0.90 or 0.95. The agreement between conservation biologists and students is not especially remarkable because these groups have one particular thing in common—an utter lack of economic constraints. If resource limitations, competing demands, and opportunity costs are ignored, then simply setting p to 0.95 is a trivial decision. In the real world, society must make difficult choices on the allocation of scarce resources among numerous worthwhile causes (Shogren et al. 1999). Resource-allocation problems such as this pose troubling ethical dilemmas. For instance, should society direct more funding toward biodiversity conservation or toward social welfare programs? Of course, society continually grapples with such dilemmas through political discourse, and conservation biologists have a vital role to play in the political arena—rational discourse requires comprehensive, accurate, and objective information.

No rational person wants to impose unnecessary risks on biodiversity. But the acceptable level of risk and society's willingness to pay for it will depend, in part, on how much society values biodiversity. Of course, there are many reasons to value biodiversity highly: it provides valuable material resources (Pimental et al. 1997), its conservation helps to maintain essential ecosystem services (Westman 1977; Costanza et al. 1997), it is a major attraction in ecotourism (Myers 1996), and our interactions with it impart psychological health and other intangible benefits. The fate of biodiversity, however, should not be decided solely through an accounting of costs and benefits. Our obligation to conserve natural resources for future generations is a well-established ethical principle, and a responsibility to be good stewards of nature—as articulated by Leopold's (1949) land ethic, for instance—is also widely acknowledged. On the other hand, property rights (Dwyer et al. 1995) and individual liberty (Peterson et al. 2004) are political ideals that may conflict with biodiversity conservation. An amalgam of ethical principles influences society's collective attitude toward biodiversity conservation, but this attitude is tempered by the economic axioms of resource scarcity and competing human needs.

Stealth Policy Advocacy

The proper role of scientists in policy making has been an ongoing debate in conservation biology (Noss 1996*b*;

Meffe 2007). The debate has focused on the appropriateness of policy advocacy by scientists. Recently, Lackey (2007) shifted the debate by admonishing scientists for "stealth policy advocacy." Lackey's principal example was the use of value-laden words such as *degradation*, *improvement*, and *ecosystem health* in scientific discourse. I contend that scientists who fall victim to the how-much-is-enough myth, even unintentionally, are also guilty of stealth policy advocacy. The how-much-is-enough myth, however, is a much more egregious form of stealth policy advocacy. Interpreting research results with value-laden words establishes a biased perspective that may favor certain conservation policies, but when conservation assessments subjectively set a priori targets and the targets largely determine the minimum area needed for conservation, then those assessments are effectively advocating a conservation policy.

To avoid stealth policy advocacy, I recommend the following. First, scientists should understand that (1) subjective a priori targets are expressions of acceptable risk, (2) attitudes toward anthropogenic extinction risk are based on ethical values, and (3) ethical value judgments are well outside the realm of science. Second, scientists must appreciate the need for transparency when publishing assessments or research results that may directly influence conservation policy. Therefore, when scientists base a conservation assessment or MVP estimate on only one set of subjective a priori targets, they should clearly state that it represents just one policy option from a wider range of potential options. Subjective a priori targets in academic research studies are sometimes described as arbitrary, but such targets imitate real-world policy choices based on ethical values. Therefore, the same caveats should be stated for arbitrary targets too.

Third, whenever practical, scientists should do conservation assessments or MVP estimates for a range of a priori targets. The range of targets should fully inform decision makers, even including targets that might make conservation biologists uncomfortable. This is not a novel idea, but it is rarely practiced—a minority of population viability analyses (e.g., Haight 1995; Lindenmayer & Possingham 1996; Haight et al. 2002) and conservation assessments (e.g., Rebelo & Siegfried 1992; Heijnis et al. 1999) report results for a range of targets. To maintain the objectivity of an assessment, scientists should refrain from favoring a particular set of a priori targets within the published assessment. Recommendations or advocacy should occur through some other medium or forum. Fourth, conservation biologists should work with economists to evaluate the relative costs of different risk levels. Policy makers should not be expected to choose among options without information about absolute and marginal costs. Extinction risk should be framed in terms of cost–benefit trade-offs. Scientists who publish answers to the question, how much is enough?, should at least mention the nexus with economics.

The success of many conservation efforts depends on the leadership of policy makers. Unfortunately, many policy makers have no formal training in formulating policy; they were elected, appointed, or rose through the ranks to a position of authority. Therefore, the fifth recommendation addresses the education of policy makers. Within your organization, whether it be governmental or nongovernmental, sponsor a seminar or workshop to educate policy makers about the roles of scientists versus those of policy makers. Be emphatic about their crucial role in answering the question, how much is enough?

Finally, promoting one's own values is legitimate behavior in democratic societies, and scientists can be impassioned advocates for the preservation of biodiversity (Meine & Meffe 1996), but scientists also have a special duty to publicly distinguish their ethical judgments from their scientific ones. Failing this duty is unprofessional.

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