
Misdirections in Conservation Biology

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Abstract: *The hypothesis that conservation biology is proceeding along two separate trajectories (Caughley 1994) has provoked extensive discussion. Caughley's dichotomy, a "small-population" paradigm versus a "declining-population" paradigm, has recently been exemplified in discussion of management strategies for conservation of the Javan gibbon (*Hylobates moloch*). Recommendations from extensive fieldwork focused on reducing the major known threat to the species—habitat destruction—and proposed a strategy of forest management and protection. A population and habitat viability analysis focused on an entirely different issue—low genetic diversity—and proposed a program of single-species genetic management. It is not surprising that geneticists see inbreeding as a major conservation problem, and it is not unusual that ecologists focus on how ecology relates to conservation. A problem results when managers assume that addressing only one or the other of these factors is the appropriate conservation action. Conservation biologists must learn to thoroughly analyze every conservation problem before trying to solve it. We must actively involve experts from all fields in forming and reviewing conservation strategies. If only captive breeding specialists or ecologists are invited to address a problem, then the techniques employed to solve it will be irrevocably biased. We do not all see the world in the same way, even within the relatively small field of conservation. To achieve effective conservation action, we must learn to balance and capitalize on our different perspectives.*

Dirección Errónea en Conservación Biológica

Resumen: *La hipótesis que propone que la conservación biológica está siguiendo dos trayectorias separadas (Caughley 1994) ha provocado discusiones extensas. La dicotomía de Caughley; el paradigma de "población pequeña" contra el paradigma de "población en declive" ha sido ejemplificado recientemente en las discusiones sobre estrategias de manejo para la conservación del gibbon de Java (*Hylobates moloch*). Las recomendaciones hechas a partir de trabajo de campo extensivo se han enfocado en reducir las amenazas más importantes conocidas para la especie—destrucción del hábitat—y han propuesto una estrategia de manejo y protección del bosque. Un análisis de viabilidad poblacional y del hábitat se ha enfocado en un asunto completamente diferente—la baja diversidad genética—y ha propuesto un programa de manejo genético de especies individuales. No es una sorpresa que los genéticos ven a la intracruza como un problema mayor de la conservación y no es raro que los ecologistas se enfoquen en estudiar como la ecología se relaciona con la conservación. Un problema surge cuando los manejadores asumen que dedicarse a solo uno de estos factores es la acción adecuada de conservación. Los biólogos conservacionistas deben aprender a analizar cuidadosamente cada problema de conservación antes de intentar resolverlo. Debemos involucrar activamente a expertos de todos los campos para formar (y revisar estrictamente) estrategias de conservación. Si solo se invita a especialistas en reproducción en cautiverio y ecólogos para atender un problema, entonces, las técnicas empleadas para resolverlo estarán irremediablemente sesgadas. No todos vemos al mundo de la misma manera—aún dentro del relativamente pequeño campo de la conservación. Para realizar acciones efectivas de conservación debemos aprender a balancear y capitalizar nuestras diferentes perspectivas.*

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Paper submitted August 30, 1999; revised manuscript accepted August 23, 2000.*

Introduction

Graeme Caughley (1994) highlights a fundamental dichotomy within conservation biology: the declining-population versus the small-population paradigm. The declining-population paradigm, according to Caughley, focuses on identifying and ameliorating factors that are extrinsic to an endangered population, such as habitat loss and hunting—the “cause of smallness and its cure.” The small-population paradigm concentrates on reducing threats intrinsic to the population itself, such as genetic and demographic stochasticity—“the effects of smallness on the persistence of a population.” Caughley argues that neither paradigm can solve the problems of conservation biology on its own and recommends “a cautious mixing of the two” (Caughley 1994).

Caughley suggests that conservation biologists often use the methodologies of one paradigm without first ascertaining whether the methodologies are the most effective response to the conservation problem at hand. Of special concern to Caughley is the indiscriminate use of the tools of the small-population paradigm. Because managers of small populations see small population size as a problem, they may focus on solving only this component of the conservation problem. This approach does not resolve other key issues, such as the reasons the population is small.

Caughley's observations have provoked indignation. Viewing the situation from within one of Caughley's paradigms, it has proved easy to see his dichotomy as false. Hedrick et al. (1996) argue that the dichotomy does not exist and that an arbitrary separation of approaches may unprofitably polarize conservation biologists. Other researchers see a fundamental truth behind Caughley's hypothesis. Caro and Laurenson (1994) assert that unwarranted attention has been placed on genetic factors as a cause of cheetah (*Acinonyx jubatus*) mortality in the wild, when ecological factors are probably as important. Rabinowitz (1995) suggests that managers have concentrated exclusively on saving Sumatran rhinos (*Dicerorhinus sumatrensis*) in zoos, to the detriment of wild rhino populations. Snyder et al. (1996) argue that many species are being recommended for captive breeding that will not benefit from it. Other practitioners have reported similarly one-sided conservation “solutions” (Frazer 1992; Meffe 1992; Wilson et al. 1994; Harcourt 1995; Hutchins et al. 1995).

These criticisms should not be taken to suggest that the small-population paradigm is unimportant. Levels of genetic diversity can tell us a great deal about the extinction probability of species such as the Granville fritillary butterfly (*Melitaea cinxia*) (Saccheri et al. 1998). Small-population management, focusing on maintaining genetic diversity, is clearly important in such cases. Indeed, for some conservation problems, the tools of the declining-population paradigm may be entirely irrelevant

(e.g., DeMauro 1993). In other situations, use of the tools of the small-population paradigm may be equally inappropriate.

I argue that conservation biologists may not always have used the resources of the small-population paradigm effectively. Further, I suggest that the tools and solutions of the small-population paradigm may in some situations have distracted attention and resources away from more important conservation threats. Tools such as population and habitat viability analysis (PHVA) are extremely effective in some cases. This does not mean, however, that these tools cannot be improved. Equally important, it appears that we may still need to learn when and when not to use them. To illustrate my argument, I discuss the case of the Javan gibbon (*Hylobates moloch*), in which the small- and declining-population paradigms arrived at very different solutions to the same conservation problem.

The Javan Gibbon

The Javan gibbon is endemic to western Java. The species is restricted to floristically rich patches of relatively undisturbed lowland or low montane rain forest. Its presence provides a good indication of forest health (Kappeler 1984). Prior to 1992 there had been only one comprehensive study of the status and distribution of the species. Kappeler (1984) estimated the total population to be between 2400 and 7900 individuals in 1978, with large populations in the Gunung Halimun and Ujung Kulon National Parks.

Field Research

Between March 1992 and April 1994, Martarinza, various colleagues, and I surveyed forests in western and central Java (Asquith et al. 1995). We concentrated on forested areas where Kappeler (1984) had reported the presence of gibbons, but we also surveyed other potential gibbon habitat. To relocate Kappeler's areas, we used his forest patch map, topographic maps, and recent land-use maps (RePPPProt 1989). At each forest patch, we contacted officials at the local wildlife department (PHPA) or forestry department (Perhutani) or village leaders. Based on these informants' advice, we ascertained whether gibbons were known to be present in the area, which locations to search, and information on forest patch status, threats, and use. We searched each patch, making additional qualitative assessments of forest quality and threats. If gibbons were not found on the first day, we searched a second day.

We used the land-use maps and the density estimates of Kappeler (1984) to estimate gibbon populations in the forest patches. Although Kappeler's data are over 20 years old, his is the only long-term study of *Hylobates*

moloch, and we therefore consider his estimates the best available for undisturbed forest. In highly disturbed areas, Kappeler's data no longer hold true, so we used them only for areas our fieldwork identified as undisturbed forests. Kappeler's values have been corroborated by more recent studies that estimated gibbon densities (e.g., Kool 1992).

Kappeler (1984) found that gibbon densities varied with elevation. In 1978, densities were 4–13 gibbons/km² at 0–500 m, 2–7 gibbons/km² at 500–1000 m; and, 1–3 gibbons/km² at 1000–1500 m (Kappeler 1984). We used a conservative estimate of 6.5 gibbons/km² in lowland forest (0–1000 m) and 2 gibbons/km² in low montane forest (1000–2000 m). We used land-use maps (RePPProt 1989, 1:250 000) to calculate forest area at each patch. Based on our fieldwork, we then made a qualitative best estimate of what proportion of each patch was suitable gibbon habitat (i.e., undisturbed forest) and used the RePPProt maps to calculate the area of gibbon habitat in each patch between 0–1000 m and 1000–2000 m elevation. We then multiplied gibbon density by

the size of the patch within each elevation band. For smaller areas we did not report population totals because the inherent error in our calculations would have been magnified at small population levels. We therefore reported population estimates only from patches that could have supported more than 100 individuals.

Including the areas where he discovered “few” gibbons, Kappeler (1984) found that *Hylobates moloch* inhabited 37 forest patches in 22 areas in western and central Java, plus potentially another 3 patches in 2 areas, for a total of 40 patches in 24 areas (Table 1). We resurveyed all but one of these areas (Gunung Lawet), plus the area around Gunung Salak where Kappeler had not found gibbons. Full details of the locations surveyed, the status of gibbons, reasons for low numbers, and disturbance levels are given by Asquith et al. (1995). We found no signs of significant hunting of Javan gibbons, but Kappeler (1984) argues that in the case of small remaining patches of forest, or of marginal habitat conditions, hunting can easily result in the extermination of local populations.

Table 1. Results of Javan gibbon field surveys in 1978 and 1994 (adapted from Asquith et al. 1995).

Location	1978 ^a	1994 ^a	Patches in 1994 (losses since 1978)	Pressure level ^b	Reason for few or no gibbons ^c	Estimated area (km ²) ^d	Estimated population
Ujung Kulon	×	×	1	L	small patch		
G. Honje	+	+	1	L		85	550
G. Halimun	+	+	3	M		270	870
G. Jayanti	+	×	1	H	small patch		
Lengkong	+	×	1	H	forest loss		
G. Porang	+	×	1	H	small patch		
G. Salak	–	+	2	M		70	140
Telagawarna	+	–	1	H			
G. Gede-Pangrango	+	+	1	L		medium	<100
G. Kencana	+	–	0 (1)	H	forest loss		
G. Malang	+	–	0 (2)	H	forest loss		
Sanggabuana	?	+	2	H		medium	<100
Bojongpicung	?	×	1	H	small patch		
Pasir Susuru	+	×	1	H	small patch		
G. Masigit	+	–	0 (3)	H	forest loss		
G. Simpang	+	+	3 (1)	L		140	600
G. Tilu	×	+	1	L		medium	<100
G. Tangkuban Perahu	×	–	0 (1)	H	forest loss		
G. Malabar	+	–	1 (1)	H	forest loss		
G. Bukittinggul	×	–	0 (1)	H	forest loss		
G. Kendang ^e	+	+	1 (1)	H		120	250
G. Wayang ^e	+	+	1 (1)	H		85	300
Leuweung Sancang	+	×	2 (3)	M	forest loss		
G. Slamet	×	+	1	H		medium	<100
G. Lawet	×	?	?	?	?		

^aStatus of gibbons: +, forest inhabited by gibbons; –, no evidence of gibbons; ×, few gibbons. (Kappeler's [1984] definition is not known, but Asquith et al. [1995] defined “few” gibbons as <25. This assessment is based on patch size and density estimates.)

^bPressure refers to a qualitative level of threat to the forest from forest clearing or logging: H, high; M, medium; L, low.

^cForest loss refers to documented cases of deforestation since 1978. Forested habitat may also have been lost from a “small patch,” but we have no definitive evidence that this occurred between 1978 and 1994.

^dAreas are given only for forests that Asquith et al. (1995) calculated could support more than 100 gibbons. The category “medium” refers to medium-sized forests, which Asquith et al. (1995) calculated could support between 25 and 100 gibbons. See text for explanation of calculations.

^eG. Kendang is one of the G. Papandayan patches and G. Wayang is one of the G. Limbung patches of Kappeler (1984).

Direct acoustic or visual evidence showed that gibbons still inhabited 22 patches in 16 areas, plus 2 additional patches in the Gunung Salak area. We found no evidence of gibbons inhabiting 16 of Kappeler's patches in 11 areas. Most of these patches (12) were no longer suitable gibbon habitat, and 4 appeared to have some areas of potential habitat but were too small to support gibbons. At most sites where gibbons were found, they were heard or seen early on the first day of observation. At only two sites did we qualitatively assess that the habitat could still support substantial gibbon populations, but by the second day of surveying we had not detected any gibbons.

We estimated that only six patches of forest in Java may currently support gibbon populations larger than 100 individuals and that fewer than 3000 of the surviving gibbons are in these forests. In an 85-km² tract of apparently pristine forest near Gunung Wayang (lat 7°25'S, long 107°45'N), gibbons were present, and we estimated that the area could support up to 300 individuals. According to local Perhutani officials, this area was due to be logged in 1995, so protection of the forest would have required immediate action. We also found gibbons in an unprotected 120-km² "forest plantation" on the south side of Gunung Papandayan, near the village of Arjuna (lat 7°20'S, long 107°35'N). We estimated that this area could support approximately 250 gibbons.

Although many of the gibbon populations that have disappeared were already small in 1978, some gibbon populations have suffered local extinctions due to further habitat loss. Every study of the Javan gibbon has concluded that habitat loss is the major threat to the species (Kappeler 1984; MacKinnon 1986; Kool 1992; Asquith 1993; Nijman & Van Balen 1998).

We concurred with this view. Because many gibbon populations appear too small to be viable, we concluded that populations in isolated small forest patches should not be conservation priorities. Instead, we recommended that Javan gibbon conservation efforts concentrate on protecting and managing the small number of larger forests where such efforts are most likely to succeed (Asquith 1995; Asquith et al. 1995) (Table 2). This strategy will not only protect the larger gibbon populations in their natural habitat but will also protect other critically endangered species, such as the Javan langur (*Presbytis comata*), and it will maintain Java's remaining forests for watershed protection and fuelwood production (Kappeler 1984; Kool 1992; Whitten et al. 1996).

Javan Gibbon Population and Habitat Viability Analysis

Immediately following our fieldwork, a population and habitat viability analysis (PHVA) workshop was held in Cisarua, west Java, with the objective of formulating a Javan gibbon conservation strategy. Over 50 people participated in the workshop, including members of the In-

donesian Primatological Society, representatives of various U.S., Australian, and Indonesian zoos, and the Captive Breeding Specialist Group (CBSG) of the World Conservation Union.

The workshop participants spent 4 days collating available knowledge of the Javan Gibbon and its habitat. The VORTEX computer model (Lacy 1993) was then used to assess the probability of extinction in populations of various sizes. At the end of the workshop, conservation recommendations were discussed and a draft action plan was prepared. This action plan was the basis of the Javan gibbon and Javan langur PHVA report (Supriatna et al. 1994).

In its summary, the PHVA report states that there are between 400 and 2000 gibbons left in Java. The first number, based on the number of gibbons that workshop participants had actually seen, was "considered too conservative," whereas the second estimate, based on extrapolation of known gibbon densities and habitat extent, was viewed as "too large to be realistic." Even though the estimate of 400 gibbons is considered too conservative, however, the report's action plan later states without qualification that there are approximately 400 gibbons left in Java. Based on this population size, the action plan recommends "active genetic and demographic management" and, for the smaller populations, consideration of "rapid habitat expansion (*sic*), genetic supplementation, translocation, and captive propagation." The report was presented to the Indonesian government on 12 July 1994. The first 5 recommendations of the PHVA report are given in Table 2. Of the report's 31 recommendations, 21 address small-population management and captive breeding, 4 recommend further data collection, and 6 involve local community development. Not one PHVA report recommendation addresses the fact that Java still has large unprotected tracts of forest with potentially large gibbon populations.

Declining- and Small-Population Paradigms and Javan Gibbon Conservation

The fieldwork and the PHVA workshop led to radically different strategies for gibbon conservation (Table 2). Implicit in the recommendations of Asquith et al. (1995) is the notion that populations of <25 individuals should not be conservation priorities and that resources are better spent on reducing threats to larger, more sustainable populations. In contrast, the PHVA suggests that the smaller populations be considered candidates for a range of expensive, technical management solutions. These contrasting perspectives fit Caughley's dichotomy between a declining-population paradigm and a small-population paradigm.

Recommendations, based on 4 months of fieldwork, concentrate on the known major threat to the species—habitat destruction—and proposed a strategy of forest management and protection. Interpretation of the PHVA

Table 2. Recommendations for Javan gibbon conservation based on the field survey (Asquith et al. 1995) and based on the population and habitat viability analysis (Supriatna et al. 1994).

Priority recommendations based on the field survey

1. Protected status for the Gunung Wayang forest.
2. Further research and monitoring of gibbons in Gunung Simpang Nature Reserve and the forest plantation south of Arjuna to determine the viability of populations in these areas. If necessary, both areas should be afforded increased protection.
3. Protected status for the Gunung Salak forest plantation. This should involve cooperation with the Salak Geothermal Project.
4. Improved protection of the Gunung Halimun and Ujung Kulon National Parks.
5. If further action is required, reintroduction of gibbons to Gunung Payung in Ujung Kulon is more feasible than ex situ conservation.

Priority recommendations based on the PHVA*

1. The combined sub-populations of approximately 400 Javan gibbons “will need to be managed as a metapopulation through some form of genetic supplementation.”
2. Populations of 200 or fewer individuals will require “monitoring and periodic genetic supplementation.”
3. Protection of “stable populations of 100 or fewer individuals . . . from removals should be of the highest priority.”
4. Populations “smaller than 27 gibbons are not viable over 100 years. . . . If these populations are to survive they will require active genetic and demographic management as part of the metapopulation.”
5. “Populations of fewer than 10 individuals . . . need to be considered as candidates for rapid habitat expansion, genetic supplementation, translocation and captive propagation.”

*The population and habitat viability analysis (PHVA) recommendations are the first five recommendations in the section “Javan Gibbon and Langur Action Plan” of Supriatna et al. (1994:99–102) that propose specific management actions. The action plan has another 26 recommendations, including further field surveys, local community development, and captive management.

focuses on an entirely different issue—low genetic diversity—and suggests a program of single-species genetic management, giving nonviable remnant gibbon populations the same conservation priority as potentially large viable populations.

Moreover, the PHVA plan’s recommendations are prefaced by the statement that “simulations for gibbon populations assumed that there would be no future loss of protected habitat and no loss from hunting or poaching” (Supriatna et al. 1994:99). All the PHVA recommendations for gibbon conservation are thus predicated on analyses that assumed the two major known threats to the species do not exist.

Recommendations for the Javan gibbon based on the PHVA advise the Indonesian government to concentrate its sparse conservation resources on minimizing the genetic degradation of one species over the next century. The alternative management strategy—addressing the fact that although a significant number of Java’s forests have been maintained intact, these forests and all their species remain poorly protected and are under constant threat—was ignored in the PHVA process. Instead of first asking what the problem was and how to solve it (Is the Javan gibbon endangered? How do we best protect it?), the Javan gibbon PHVA incorporated the a priori assumption that small-population demographics are driving the gibbon to extinction.

Discussion

At the Javan gibbon PHVA workshop it was implicitly assumed that low genetic diversity was the fundamental conservation problem. Given this premise, it is not sur-

prising that genetic management was proposed as the appropriate solution to the problem. The Javan gibbon is not the only species for which low genetic diversity has been assumed to be the problem prior to a threats analysis.

North American populations of the critically endangered Karner Blue butterfly (*Lycaeides melissa samuelis*) crashed by an estimated 90% in the 12 years prior 1992, because of “habitat conversion to human use and with the disruption of historic disturbance regimes” (Grundel et al. 1998) and “changes in habitat resulting from silviculture and urbanization” (Clough 1992). Rather than start with this assessment of habitat change as the cause of the Karner decline, the first objective of a 1992 PHVA workshop was to “determine the number and distribution of breeding individuals required for specific probabilities of survival and preservation of genetic diversity for specified periods of time” (World Conservation Union/Species Survival Commission Captive Breeding Specialist Group 1992).

Seven of the eight workshop objectives then addressed the preservation of genetic diversity. Although decreased heterozygosity is likely to be a problem for many isolated populations, even in species such as the Granville fritillary butterfly, where the risk of inbreeding-induced extinctions has been shown, “demographic and environmental factors are likely to be the primary determinants of extinction risk” (Saccheri et al. 1998). If even the species that *are* genetically threatened face greater risks from other sources, it makes little sense to focus on genetic issues prior to starting a conservation analysis.

Demographic models such as VORTEX (Lacy 1993) have become increasingly popular in analyses such as

PHVAs (Groom & Pascual 1998). Although P(H)VA is a valid and sufficiently accurate tool for categorizing and managing endangered species (Brook et al. 2000; c.f. Brook et al. 1997), the use of computer models to project population dynamics unnecessarily constrains conservation decision making. Most current models force managers to see extinctions as single-species issues rather than holistic environmental problems.

The PHVA model users are also required to view the problem as one of demographics. Even though demographic analyses have provided useful insight into the survival prospects of the mountain gorilla (*Gorilla gorilla*), they miss the crucial component of gorilla conservation: understanding of the ecological mechanisms that cause demographic perturbations (Harcourt 1995). Basing conservation action plans solely on demographic analyses unnecessarily limits their conclusions to demographic factors (Harcourt 1995).

If demographic models are to be used in conservation analyses, it is imperative that an appropriate model be used to answer the question at hand (Lindenmayer et al. 1995; Brook et al. 1999). Lindenmayer and colleagues used a variety of demographic models to address the conservation of an endangered Australian marsupial, employing an appropriately specific model for each particular question.

Lindenmayer and Lacy (1995) used the computer model VORTEX (Lacy 1993) to estimate the metapopulation viability of Leadbeater's Possum (*Gymnobelideus leadbeateri*), whereas Lindenmayer and Possingham (1996) used the computer program ALEX (Possingham & Davies 1995) to model complex temporal and spatial responses to habitat disturbance. This excellent series of papers highlights the necessity of making sure we are asking the right questions before we use demographic models to address conservation problems (Groom & Pascual 1998).

In contrast, many PHVAs, including that of the Javan gibbon, have indiscriminately used the computer model VORTEX. This model is a valuable and elegant program for analyzing population demographics. Unlike other demographic models such as ALEX, however, VORTEX has heavy data requirements. Because few of the relevant data are available for most endangered species, users are forced to estimate many of the critical parameters. A computer model for which most of the parameters are guesswork is unreliable at best, and valuable conservation resources can be spent making estimates for the model. A substantial proportion of the Javan gibbon workshop was spent forcing participants to estimate numbers they had no ability or authority to estimate. Conservation managers should stop unthinkingly using VORTEX as the model of choice for conservation problems; other models may be better. Users should critically appraise the strengths and weaknesses of the available demographic models before applying them (Lindenmayer et al. 1995; Groom & Pascual 1998).

The laudable objective of producing PHVA reports as quickly as possible has an unfortunate downside: many PHVAs do not go through "the bracing cold shower of peer review" (Caughley 1994). The Javan gibbon PHVA was no exception to this trend because it was submitted directly to the Indonesian government. An external reviewer could have contrasted the document with previously published literature (Kappeler 1984; MacKinnon 1986; Kool 1992; Asquith 1993) and noted its limited perspective. The PHVA document was reviewed only by the people who wrote it, however, thus precluding identification of its biases.

It is also likely that the choice of coordinator and key participants limited the perspective of conference attendees. Many of the leaders of the PHVA process, by definition, have small-population management as their primary focus. To compound this potential bias, the Javan gibbon PHVA did not provide a mechanism for voicing dissent. At the start of the conference, data and recommendations were presented that contrasted with the conclusions of the PHVA. Although some participants disagreed with many of the PHVA's major recommendations, their fundamental disapproval was not registered. Instead, the report was sent to the Indonesian government accompanied by the statement that "consensus was reached."

The PHVA process, as envisioned by the Captive (now Conservation) Breeding Specialist Group, has the laudable goals of providing "neutral and objective fora" with a "full range of stakeholders" to implement "a 'bottom-up' in situ approach to species conservation" (Ellis & Seal 1995). In many cases the PHVA process has successfully assisted the development of effective conservation strategies, but the success of some PHVAs should not blind us to the possibility that the process could be improved.

The case of the Javan gibbon is one example where the PHVA process did not work. For this species, the PHVA was biased toward the belief that stochastic demographics and changes in gene frequency were the major threats to gibbon survival. The PHVA facilitators' world view, the use of computer software that focuses primarily on demographic and genetic risks to populations, the lack of external review, and the lack of attention to different perspectives led to an erroneous conclusion and a potentially dangerous set of recommendations for action. The PHVA recommendations focused on reducing one perceived threat while ignoring another equally, if not more, plausible threat.

Misdirections in Conservation Biology

Some conservation biologists appear to identify a broad solution before they analyze the problem. This stems from the fact that each of us brings our own unique perspectives and biases to conservation problems. It is not

surprising that geneticists see the cheetah's low allozyme diversity as a conservation problem (O'Brien et al. 1983), and it is not unusual that field ecologists focus on studying how ecological effects relate to cheetah conservation (Caro & Laurenson 1994). Neither world view is wrong, and both are necessary to solve conservation problems. The fatal error is when a manager unquestioningly assumes that addressing one or the other of these factors is the most appropriate conservation action.

Although there are undoubtedly instances in which the declining-population paradigm has been overemphasized in solving conservation problems, there appear to be many more examples suggesting that the perspectives, technologies, and solutions of the small-population paradigm dominate our discipline. Rabinowitz (1995) asserts that an overemphasis on the small-population perspective (Maguire et al. 1987) is already leading to the extinction of the Sumatran rhino "[T]he implication that captive breeding can save the rhino makes the failure of in situ conservation less serious . . . creat[ing] a self-fulfilling prophecy that wild populations have a low probability of survival" (Rabinowitz 1995).

A number of other conservation practitioners have found the prescriptions of the small-population paradigm unnecessarily constraining (Frazer 1992; Meffe 1992; Hutchins et al. 1995; Wilson et al. 1994). Before applying the strategies of our own particular world view to a problem, we should always ask whether such an approach is the most appropriate and whether another perspective could better address the problem at hand.

Caughley's dichotomy between the small- and declining-population paradigms emphasizes that we do not all see the world in the same way, even within the relatively small field of conservation biology. To achieve effective conservation action we must learn to balance and capitalize on our different perspectives. Although this may seem self-evident, balance has not been achieved during the formation of at least one recent conservation strategy.

The most important lesson from such failures is that we should carefully analyze the actual conservation problem before trying to solve it. Assuming that a species is in danger from stochastic demographic forces, and using a computer program that focuses on population demographics, will probably lead us to conclude that small-population demographics is the source of the problem. More appropriately, an approach that first asks what the problem is and then chooses a methodology that most efficiently addresses this problem, is more likely to achieve effective results. We must also involve experts from all fields of biology (and from outside biology) in forming conservation strategies. If only captive breeding specialists, or systematists, or ecologists are invited to address a problem, then the techniques employed to solve it will be inevitably biased.

It is critical that reports are reviewed by outside ex-

perts (Meffe et al. 1998). This will increase the probability that factual inaccuracies are corrected and that all stakeholders are represented. Neither endangered species nor conservation biologists benefit when an unreviewed report sent to government agencies recommends one strategy and a peer-reviewed journal article later recommends an entirely opposite strategy (e.g., Supriatna et al. 1994; Asquith et al. 1995).

Hedrick et al. (1996) note that the significance of one or the other paradigm has been overemphasized in the past: "it behooves conservation biologists . . . to carefully qualify the implications of their findings and not to overemphasize their significance." All practitioners of conservation biology—ecologists, systematists, geneticists, managers, and fieldworkers alike—should take the lessons of this advice to heart.

Acknowledgments

I thank Martarinza and R. Sinaga for the opportunity to work with them on the Javan gibbon survey; R. Juito, G. Djanubudiman, H. Wibisono, A. Yanuar, Taufan, K. Mandagi, A. Lubis, C. Luttrell, and numerous PHPA, and Perhutani staff for assistance in the field; YABSHI for providing logistical assistance; J. Supriatna and R. Tilson for the invitation to attend the Javan gibbon and langur population and habitat viability analysis; J. Brown, J. Earnhardt, and T. Pope for discussion; and A. E. Arnold, C. van Schaik, T. Whitten, S. Thompson, T. Struhsaker, K. MacKinnon, L. Snook, V. Nijman, M. Kappeler, M. Groom, G. Meffe, and three reviewers for improving the manuscript. Fieldwork was supported by the Chicago Zoological Society, and preparation of the manuscript was funded by a Dr. Scholl Fellowship from the Lincoln Park Zoological Society.

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