

THE FOCUS AND ROLE OF BIOLOGICAL RESEARCH IN GIANT PANDA CONSERVATION

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Abstract: The Ministry of Forestry of the Peoples Republic of China and World Wide Fund for Nature have cooperated since 1980 in an effort to conserve the giant panda (*Ailuropoda melanoleuca*) in the wild in China. This conservation project has 4 major components: biological research, population survey, management planning, and training. This paper first evaluates the focus and results of the biological research using a framework based on population viability analysis and life-history theory. Demographic parameters and the causes of their variation are still poorly understood. A number of habitat-related ecological processes are relatively well understood. Second the paper assesses the dominant role of biological research in the project. The principal threats to panda population viability are anthropogenic: habitat loss and poaching. However, this conservation project has not sufficiently addressed the socio-economic conditions and behaviors that cause and influence the threats to panda persistence. Incorporating social scientists along with biological scientists in a team of investigators at the inception of a conservation project should make the project more successful.

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The Chinese Ministry of Forestry (MoF) and the World Wide Fund for Nature (WWF) have cooperated since 1980 in efforts to conserve the giant panda in the Peoples Republic of China (PRC). Wildlife Conservation International (WCI) cooperated in this project from 1980 to 1986. The project goal is to conserve a viable wild population of giant pandas in perpetuity, thereby avoiding extinction of this endangered species.

The project has included more than 12 years of cooperative research, a population survey, and an initial management plan produced by the 2 principal agencies (MoF and WWF 1989) and modified by the MoF for ratification by the Chinese State Council in 1992 (MoF 1992). However, panda populations and habitat continue to shrink, and the conservation project has not reversed this trend (Schaller 1993). It is appropriate to analyze the project, to determine whether effort was well spent, what components were lacking, and how best to proceed. Currently the persistence of wild populations of all ursids in southeast Asia and South America is in serious doubt (Servheen 1990), and these species are receiving or will receive conservation attention.

Between 1985 and 1988 I worked for WCI and WWF as a field research scientist on the panda conservation project in Sichuan, China. In this paper my intention is to evaluate some of the successes and failures of the biological research and management planning aspects of the project. My specific objectives are to: (1) briefly describe the components of the giant panda conservation project; (2) evaluate the focus of one component, biological research, in the light of population viability analysis and life-history theory; and (3) comment on the role of biological research relative to other project components in attaining the project goal, as judged by actions recommended in the

management plans.

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COMPONENTS OF THE CONSERVATION PROJECT

Before WWF and WCI became involved, the Chinese government had put considerable effort into giant panda conservation. Twelve natural reserves, with the goal of conserving panda habitat, were established between 1963 and 1979 (Schaller et al. 1985). A preliminary population survey in 1974 and 1975 produced an estimate of 1,000-1,100 animals in the wild, and demonstrated that panda distribution was fragmented on 2 scales as a result of expanding human activities in mountain valleys. Insurmountable gaps of agricultural land and major rivers separated pandas living in each of 6 mountain ranges (Fig. 1). Each range had its own distinctive panda habitats—montane forests with understory of various bamboo species growing in altitudinal bands. At a smaller scale within a range, loss of low elevation forests had forced remaining pandas to higher elevations with little opportunity for movement between habitat fragments. The PRC/WWF/WCI giant panda project, begun in 1980, has 4 components: biological research, population survey, management planning, and training.

Biological Research

The biological research has employed from 10 to 50 people continuously from 1980 to the present, and has been by far the largest component. The field research

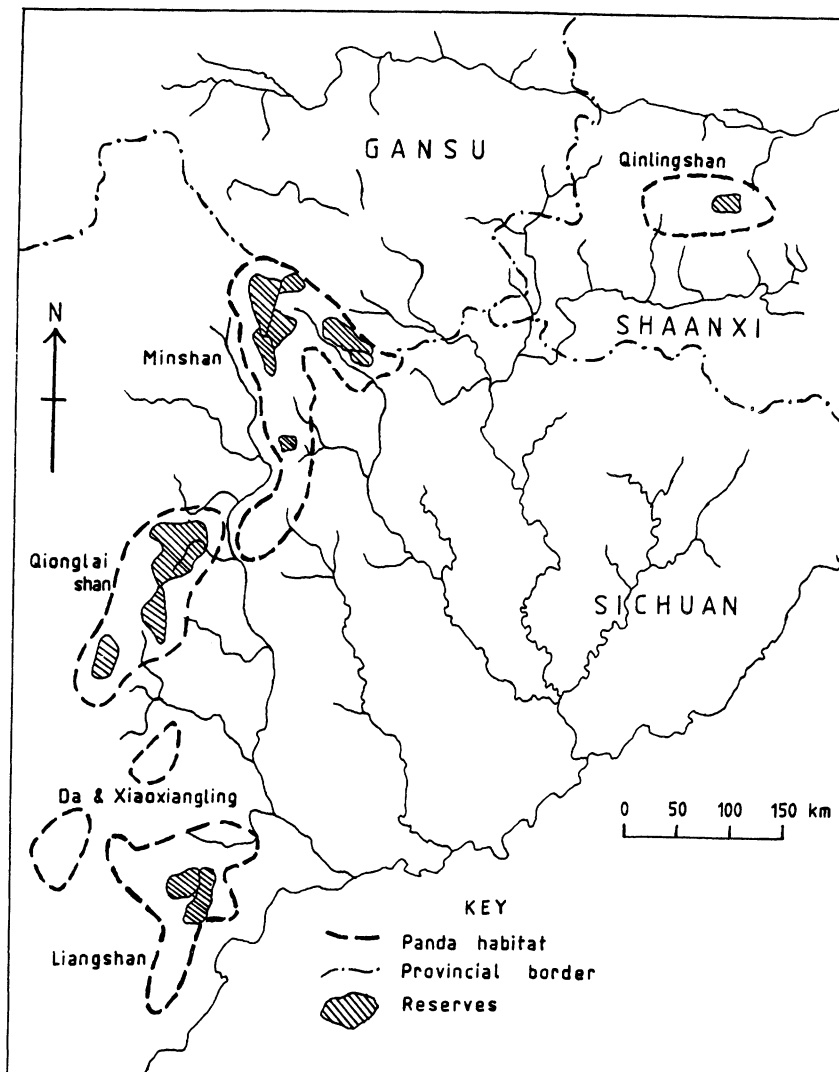


Fig. 1. The 6 mountain ranges in southcentral China with giant panda habitat, and locations of 12 panda reserves established by 1980.

consisted of 2 studies of wild pandas, 1 in each of the 2 largest mountain ranges with pandas: Wolong Reserve in the Qionglai shan, and Tangjiahe Reserve in the Minshan (Fig. 1). In addition a captive facility and research laboratory was built in Wolong Reserve to breed pandas and study reproductive behavior. Overall, the goal was to provide data on ecological processes and natural behaviors most affecting population dynamics, and relate these data to management actions.

Initially the research consisted of quantifying patterns of behavior, and long-term monitoring of known individuals to quantify population parameters (Schaller et al. 1985). Studies began in Wolong, but ran concurrently in Tangjiahe after 1984 (Schaller et al. 1989). From 1983, research focussed mainly on 3

topics: (1) the impact of bamboo flowering on behavior and food resources (Johnson et al. 1988a; Reid et al. 1989; Taylor and Qin 1987, 1988c, 1989a,b, 1992, 1993a,b; Taylor et al. 1991a,b), (2) panda habitat selection and habitat structure (Taylor and Qin 1987, 1988a,b, 1993b; Reid and Hu 1991; Reid et al. 1991c), and (3) community ecology focussing on potential competitive interactions of giant pandas with Asiatic black bears (*Ursus thibetanus*) (Schaller et al. 1989, Reid et al. 1991a) and red pandas (*Ailurus fulgens*) (Johnson et al. 1988b, Reid et al. 1991b).

Population Survey

From 1985 to 1988 a team of 35 biologists, led by Ken Johnson, Shao Kaiqing, Liu Zhixue, and Jiang

Fuquan, undertook a ground survey of the entire panda range to map the abundance and distribution of pandas, their bamboo and forest habitats, and the activities of people in and around these habitats. The team used line-transect sampling of bed-site densities as a population estimation technique. This was derived from the detailed behavioral studies in Wolong Reserve. The initial and revised management plans (MoF and WWF 1989, MoF 1992) used the data on habitat distribution and preliminary population estimates as the basis for detailed recommendations on land tenure changes necessary for panda conservation.

Management Planning

The management planning exercise began in 1986 when a team of approximately 10 biologists and managers led by Dr. John MacKinnon and Bi Fengzhou started integrating information from the biological research, the population survey, investigations of habitat distribution and change using remote sensing (De Wulf et al. 1988), and the legal and institutional framework for wildlife conservation in the PRC. They produced the *Management Plan for the Giant Panda and its Habitat* (MoF and WWF 1989). The initial document has been modified somewhat for formal approval by the Chinese government (MoF 1992). However, the major recommendations (Table 1) are not changed. Successful panda conservation will depend on judicious implementation of the latest MoF plan.

Training

Foreign field biologists became involved in the panda project to teach Chinese counterparts radio telemetry and ecological sampling skills. They have acted as role models for scientists in China, where wildlife biology is a rare and poorly understood vocation. In 1986 this element of the training expanded to include 4 other programs: (1) a lecture and field course in protected area management designed for reserve directors and higher officials (Machlis and Marsh 1988); (2) field courses in biophysical inventory techniques for reserve biologists; (3) field courses in patrolling reserves for wardens; and (4) sending young Chinese biologists to overseas universities for graduate level degrees in resource management.

THE FOCUS OF THE BIOLOGICAL RESEARCH

Given limited time and resources and the intricacies of ecological processes, conservation researchers with the responsibility of ensuring persistence of a species

must carefully answer the question: on what biological processes should we focus our research? Two schemes help provide a comprehensive and systematic approach to identifying processes affecting population persistence. These are population viability analysis (Shaffer 1981, 1990; Gilpin and Soule 1986), and life-history theory (Southwood 1988). Many biologists would implicitly apply these general approaches, at least in part, in answering the above question. An explicit, comprehensive scheme of options should enable researchers to better define research priorities, specify objectives, and evaluate progress.

Population Viability Analysis

General.—Population Viability Analysis (PVA) is a comprehensive approach identifying demographic and genetic factors that put a population at risk of extinction, and describing how these factors operate (Shaffer 1981, 1990; Gilpin and Soule 1986). The key parameters to be quantified are population carrying capacity (K), population growth rate (r) or the difference between rates of birth (b) and death (d), and, most important, the variance in r (Vr) (Goodman 1987). When estimating K , biologists must differentiate between saturation of the habitat with respect to food, and saturation with respect to other conditions such as social spacing. Substantially different estimates may result. Vr affects extinction probability dramatically because it incorporates all the stochastic environmental effects on birth and death rates.

Systematic factors affecting birth and death rates, such as human-induced habitat loss or mortality, are assumed incorporated in b and d as measured, and are generally not considered further in PVA (Shaffer 1981). In practice this does not seem reasonable since both systematic and stochastic environmental changes are incorporated in empirical measures of b , d and Vr . Unless data are from a pristine environment, it will be very hard to disentangle the two. Management actions are best suited to addressing systematic factors.

To apply PVA, researchers must quantify the distribution in time and space of all populations of a species (the metapopulation structure), the flux within each of those populations (a number of separate PVAs), and the flux between populations. Published PVAs have required a long time series of demographic data, and the researchers stressed the dangers of extrapolating between populations or assuming that the data were sufficiently comprehensive (Shaffer 1983, Menges 1990, Murphy et al. 1990). The task of acquiring sufficient data for a PVA in the time available is virtually impossible for long-lived, secretive animals

Table 1. Goals, methods, and adequacy of knowledge for proposed giant panda management plan interventions in 5 sets of institutions. "?" means the issue was not addressed in the plans. Adequacy of knowledge is subjectively judged as good (G), moderate (M), or poor (P).

Institution	Goal	Methods	Type and adequacy of knowledge	
Land tenure	Increase reserve size	Relocate or phase-out timber cutting units	Locations	G
			Compensation economics	M
	Establish new reserves	Resettle communities	Resettlement economy Resettlement culture	P P
Economic	Harvest trees by selection logging	Legislation/regulations Technology ?	Harvest economics	P
			Forest ecology	M
	Develop alternative energy	Hydro-electric or solar ?	Engineering	P
Economic	Foster common property resource management	Collective ownership ? Sustained harvest ? Education ? Ecotourism	Community organization and traditions	P
			Poaching economics	P
			Tourist economics	M
Cultural	Foster sustained use	Collective ownership ? Traditional values ? Education	Community organization and traditions	P
Legal	Establish disincentives for poaching, habitat degradation	Legislation Law enforcement	Legislation	G
			Sociology and economics of patrolling	P
Political	Foster political will	Education Diplomacy Personal trust Economic incentives	Power structures	M
			Cultural attitudes	P
			Development economics	P

such as the giant panda, and most ursids.

However, parameter values for r , K and Vr can be approximated from allometric relationships among mammals (Belovsky 1987). Population projections can then be made without field study. Although these must be viewed as tentative projections, the sensitivity of persistence to changes in parameter values can be estimated from repeated model projections (Shaffer 1983, Bunnell and Tait 1980). Population viability analysis is a useful conceptual framework because it forces researchers to focus on all demographic parameters in building a model, and researchers can use empirical data directly in projections.

Panda Project.—The cooperative research has gathered some data pertinent to a PVA. The data on metapopulation structure and change are the best. The survey team mapped the distribution of all panda populations, estimated density for each, and quantified habitat loss across the entire range since the mid 1970s. There are 24 distinct populations, most of which have less than 50 animals (MoF 1992). Such small populations, even if left intact, have low probability of persistence for demographic (Belovsky 1987, Goodman 1987) and genetic reasons (Lande and Barrowclough

1987).

The population level demographic data are generally poor because of low sample size, resulting from poor live-capture success. Future efforts must focus on novel techniques and baits. Density estimates from the Wolong study area give 1.9 km²/panda at peak food availability before bamboo die-back (Schaller et al. 1985), and 2.1 km²/panda after loss of 82% of the standing crop of preferred bamboo in a die-back, at which point panda feeding exceeded the regeneration capacity of the bamboo (Reid et al. 1989). Carrying capacity (K) is apparently mediated by interference competition (some exclusive space use and marking) at peak food availability, and exploitative competition when food is more scarce. Absolute density estimates are difficult to make and often lack precision. For monitoring specific populations, managers will have to rely on indices of relative abundance based on spoor.

In 5 of the 11 parturition seasons (involving 5 adult females) it was unclear whether the female had actually given birth. In each case she was not accompanied by a yearling, but her movements never suggested she was using a maternity den. Since timing of parturition is quite variable in this species, female(s) could have lost

cub(s) soon after birth. A pregnancy test, for use on wild pandas, would help clarify the birth rates.

Certain reproductive hormones are found in higher concentrations in feces during mid to late pregnancy than at other times. This is true of estrogen in feral mares (Kirkpatrick et al. 1990), cattle (*Bos taurus*) and muskoxen (*Ovibos moschatus*) (DeSaulniers et al. 1989), and of progesterin in caribou (*Rangifer tarandus*) (Messier et al. 1990) and some primates (Wasser et al. 1988). These assay techniques should be tested on pandas.

Neonatal mortality is high in the wild. Only 1 of 6 known juveniles survived its first year. The fates of 4 were never determined. Since young pandas are altricial at birth, not moving in a coordinated, independent manner until approximately 90 days (Schaller et al. 1985), they could be subject to predation and hypothermic stress when unaccompanied. One was killed by a predator. This may have been a case of infanticide (Catton 1987). Leopards (*Panthera pardus*) occasionally eat young pandas (Schaller et al. 1985). These risks will depend in part on the availability of suitable maternity dens (in hollow conifers or caves).

Similar evidence for low neonate survival comes from a life table analysis, based on aged panda carcasses found in the wild, which shows poor survivorship of young to 1 year of age (Wei et al. 1989). Survival of captive-born young is also poor. Of 37 litters (51 young) born in zoos between 1963 and 1983, only 19 young survived beyond 2 months (Schaller et al. 1985:159). Future work should focus on monitoring cub survival, perhaps through radio telemetry, and the experimental enhancement of maternity den abundance, especially in habitats where hollow trees no longer exist.

High neonatal mortality is also associated with inbreeding depression in some species (Ralls and Ballou 1983). Data on genetic profiles of captive or wild giant pandas are lacking. This must be rectified especially since most populations are already small and fragmented.

Seven of 11 radio-collared adults died, 2 from poaching, 2 from parasite infestation, and 3 of other natural causes. The most troublesome cause of adult death is poaching, which has increased dramatically since 1985, with 56 pandas known poached through the species' entire range from 1984 to 1988 (Qiu 1990, Schaller 1990). Increased poaching seems directly related to economic liberalization in the PRC, which replaced state-controlled pricing and marketing of many natural resources, such as timber (Repetto 1988), with free access to domestic and export markets. The export

market for panda pelts, though illegal, now operates through middlemen in Sichuan. National legislation to deter panda poaching, including the death penalty, is in place (Wildlife Conservation Law, 1988), but enforcement is insufficient (Zhu 1989, Schaller 1993). Poaching is a critical concern because decreased survivorship of adults, especially females, in a species with a low reproductive rate will have a dramatic effect on population persistence (Shaffer 1983).

Captive populations have not produced much information for PVA. They are not self-sustaining. Few captive adults, especially males, are reproductively active, and neonatal and adult survival is poor (Schaller et al. 1985). There is much room for research here. Genetic profiles are necessary to determine current levels of heterozygosity, and to direct mating attempts. At least as important is the need to experiment with husbandry alternatives rather than the current practice of housing pandas individually. Pandas housed in pairs, notably in zoos outside China, have had relatively high mating success (O'Brien and Knight 1987), suggesting that familiarity may facilitate mating. Aggregations of mating males around oestrus females in the wild (Schaller et al. 1985) probably provide necessary social stimulation and learning of mating performance.

The project lacks data on variance in rate of population growth (V_r) and on dispersal and gene flow between populations.

Life-History Theory

General.—When direct measurements of demographic parameters are too difficult or time-consuming, researchers can shortcut a complete PVA and use other theoretical approaches to investigate the sensitivity of those parameters to ongoing ecological processes. Life-history theory, the integration of age- and sex-specific birth and death rates, is one theoretical approach. Current synthesis presents life histories as compromises between 3 types of selection: competition (traditionally K -selection), disturbance (traditionally r -selection), and adversity or stress (Southwood 1988, Partridge and Harvey 1988). Southwood (1988) categorizes those compromises as differential investment between 5 categories of survival tactics: food harvesting, reproductive activities, defense to avoid death, escape in space and time, and physiological adaptations to inclement physical conditions.

This is a comprehensive scheme directing a search for adaptations affecting life history and, consequently, PVA parameters. Researchers should enquire how each of the 5 survival tactics is expressed in the study animal's anatomy, physiology, or behavior. Specialized

adaptations generally suggest strong selection, and a relative inflexibility to changes in those environmental conditions that select for optimal expression or functioning of the trait(s). Key adaptations are best identified by empirical study of the organism. Strong clues also come from allometric comparisons, and by inference from taxonomically related species (Peters 1983, Belovsky 1987).

Panda Project.—In this section I use the 5 survival tactics (Southwood 1988) as a framework for discussing progress in ecological research on pandas and illustrate how conservation recommendations result.

The panda's obvious anatomical adaptations enhance food harvesting (radial sesamoid enlargement, robust molars [Davis 1964]), but its lack of obvious adaptations to enhance digestion of a fibrous food with resulting low digestive efficiency (Dierenfeld et al. 1982), led Schaller et al. (1985) to look closely at the many behavioral tactics for survival on such a specialized diet of bamboo. Patterns of diet selection, movement, and activity all appeared adapted to maximize energy intake rates. Tactics for food harvesting dominated the suite of adaptations exhibited by pandas. However, it is not yet clear whether pandas that have access to more of the preferred growth forms, nutritional levels, and dispersion patterns of bamboos, also have improved reproductive rate or survivorship. Such responses to a relaxation of the limiting effects of food are assumed and are likely, but ideally should be investigated more closely. Opportunities for such investigation exist in the Minshan at present, and in the Qionglaihan in 5 to 10 years, as bamboo clones, regenerating after a dieback, produce culms large enough for panda foraging. The resulting rapid increase in the standing crop of food should make food acquisition easier for pandas.

Most biological research on the panda project further investigated some aspect of the panda's tactics for food harvesting, and the processes affecting food availability. Pandas selected their feeding sites on relatively flat terrain where the bamboo growth provided the most efficiently ingestible biomass (Reid and Hu 1991). In the Wolong study area, the best growing conditions for bamboo preferred by pandas were under a selectively cut forest, rather than a clearcut or uncut (climax) forest (Reid et al. 1991c). A mature forest canopy similar to climax can regenerate in selectively cut stands but will very rarely do so in clearcuts (Taylor and Qin 1988a,b). These studies indicate that selective cutting is the best timber harvest regime for panda habitat retention in this bamboo ecosystem (Taylor and Qin 1989a).

The extremely poor regeneration of *Bashania fangiana* bamboo from seed in clearcuts compared to mature forest (Taylor and Qin 1988c; 1993a) means that managers cannot rely on seral processes to regenerate habitat in clearcuts and will have to actively restore these areas by first replanting canopy tree seedlings and later bamboo. The best opportunity for planting tree seedlings comes soon after bamboo dieback, when competition from the slowly regenerating bamboo is minimal (Taylor and Qin 1989b, Taylor et al. 1991a).

Schaller et al. (1985) summarized the biology of panda reproduction, the second life-history tactic, stressing the altricial nature of the neonate, the specialized nature of maternity dens, the late age at reproductive maturation, and the low litter size. A species with such tactics can only persist with high survivorship and a relatively uncompromised birth rate. These facts emphasize again that managers must eliminate poaching, maintain overmature conifers for maternity dens (Schaller et al. 1985, Taylor and Qin 1989a, MoF and WWF 1989), and investigate the high infant mortality rate.

Pandas do not have specialized defense tactics (the third life-history topic) to avoid predation, except their ability to climb trees. Large clearcuts, though often supporting much bamboo, do not provide escape opportunities, making them suboptimal habitats.

Pandas apparently do behave so as to escape adverse conditions. They tend to move to lower elevations to avoid winter snow and cold (Schaller et al. 1985). Bamboo flowering and dieback, though infrequent, can also produce adverse conditions. Following flowering in the Qionglaihan in 1983, about 80% of the standing crop of *Bashania fangiana*, the panda's primary food, died (Reid et al. 1989). Pandas responded by increasing home ranges, decreasing diet selectivity, and, most important, shifting to an adjacent, unflowered bamboo food resource (Johnson et al. 1988a, Reid et al. 1989). The option of feeding on a second or third bamboo when one flowers is essential for population persistence. A number of panda populations do not now have such choice. Their persistence depends on habitat restoration (MoF and WWF 1989).

Pandas do not have any obvious physiological adaptations to inclement physical conditions, the fifth life-history tactic, though they currently occupy the margins of their historical range, living at altitudes with a marked seasonal climate, and in mountains with rugged topography. They do not hibernate, and their energy budgets show only slight surplus of intake over costs (Schaller et al. 1985). They may compensate

behaviorally. For example, they select feeding sites on relatively level ground (Reid and Hu 1991). It is unclear whether survivorship or reproductive output are compromised by the energetic costs of surviving in current habitats, compared to other historical range. The timing of adult mortalities and the causes of juvenile mortality might provide clues. Given the uncertainty and the lack of alternative range, management must focus on making remaining panda habitats as suitable as possible for the animals.

THE ROLE OF BIOLOGICAL RESEARCH

Sufficiency of Biological Research

The previous review of factors affecting, or inferred to affect, demographic parameters demonstrates that human activity profoundly impacts panda population persistence. The most significant results are increased mortality from poaching, reduced effective population size and rates of gene flow through habitat fragmentation, and decreased habitat quality (with inferred decreases in birth rate and density, and increases in death rate) through timber harvesting. Even when a bamboo dieback substantially reduces food availability, the extent to which humans have manipulated forests containing alternative bamboos is the key to understanding whether pandas will starve (Reid et al. 1989).

Biological research is most often insufficient to implement a conservation goal. Biological knowledge must be integrated with knowledge of human behaviors to find suitable and successful ways of changing human behavior. The management plans implicitly identify the need for intervention in at least 5 sets of human institutions (Table 1). However, the plans do not contain sufficient information for successful implementation of most of the proposed interventions (Table 1). In particular the plans lack depth in 2 areas: (1) detailed economic analyses of proposed changes in timber harvesting regimes and resettlement schemes; and (2) understanding of the cultural traditions, community organization, and economic status of agriculturalists living in or around reserves. The economic analysis is essential to evaluate whether and how a shift in timber harvest from clearcutting to selective cutting in panda habitat outside reserves can be accomplished. Knowledge of local community organization and traditions is essential to make resettlement schemes work politically and economically, to distribute benefits from ecotourism to local people as they see fit, and to protect common property resources

such as wildlife with local interest, consent, and involvement.

Most local people living in and near reserves are poor subsistence farmers and members of ethnic minority tribes, whereas most reserve administrators are Han Chinese from an urban background. There is frequently antagonism between the 2 groups. Locals often destroy habitat to acquire necessary wood for basic energy needs. They poach wildlife, including pandas, to supplement a subsistence living through sale of animal pelts, organs, and glands. Very basic economic needs drive their behaviors, which are at the same time the key threats to panda persistence. Managers frequently act weakly in enforcing regulations, even in reserves, because of the difficult economic conditions of locals (Schaller 1993). Given the obvious need for strong reserve protection and changes in harmful behaviors, the panda project must direct stronger patrolling and enforcement, and must develop sustainable alternative energy and income schemes for locals.

Economic Development.—Integrating social and economic development of local people with conservation activities has become a central theme in protected area management (McNeely 1989, McNeely and Miller 1984). The hurdles are diverse. Projects must include personnel who understand the lessons of previous international rural development experiences. Biologists rarely have such training. Unfortunately the panda project did not include social scientists to address economic and anthropological issues. Projects must explicitly outline the linkages between betterment of local social and economic conditions and the changes in harmful behaviors of local people that are assumed to follow. These linkages must be strong for conservation benefits to result (Wells and Brandon 1992).

The management plans identify opportunities for ecotourism with profits staying locally, and the need to make reserve patrolling a financially rewarding and valued job. The contributory values (Norton 1989) of panda conservation to other ecosystem processes, such as forest conservation, watershed stabilization, and maintenance of diverse faunal and floral gene pools for medicines and food, all need to be explored in greater detail. Removal of mountain forests, the panda's habitats, has increased soil erosion and flooding, and made river flows more erratic with drastic consequences for irrigation and farming regimes in the Chengdu Basin (Han 1989). Panda habitat retention and restoration can contribute substantially to local and provincial economies. This must become a central argument in support of management plan

implementation, and a central topic of more detailed investigation.

Political Will.—Conservation initiatives cannot be implemented without the will of the politicians, decision makers, and local people. Yet policy makers, politicians, and managers often have to make politically difficult decisions. Conservation professionals, although they are rarely political decision makers, must actively foster political will.

Fostering political will depends on developing both a shared conservation goal and a common trust between collaborating groups. In the panda project the major groups are the Chinese government, the foreign conservation community, and agricultural communities in and around panda habitat. Panda conservation still lacks a commitment by all parties to a shared goal of conservation in the wild. North American, and more generally Western, cultures have developed a strong cultural affinity with wild animals in wild habitats. Such an affinity is rare in current Chinese culture and experience. Consequently, Chinese often hold the attitude that animals are able to lead better lives when kept in captivity rather than left in the wild. The poor success of captive panda husbandry proves this wrong. From a Western perspective, conserving pandas only in zoos is insufficient. The Western ethical justification for conservation lies in the psychological, spiritual, and economic values the animals and their habitats, with associated species, all enhance. Managers must increase their efforts for the conservation of wild panda populations.

When parties do not immediately share a common goal, they must derive one through mutually agreed policies. Economic incentive and education are established approaches, and are recognized in general terms in the plans (MoF and WWF 1989, MoF 1992). These approaches have more chance of success if the parties share cultural and ethical values. Unfortunately this is not immediately the case in China. A social consensus that wildlife is an open access resource requiring collective governmental protection from over-exploitation by private interests has strong roots in North America in this century (Gilbert and Dodds 1987). By contrast in China, the opening of market economies for the private exploitation of common property resources, through direct harvest, seems to be driving the increased threats on panda and other wildlife populations (Schaller 1993). There is little legacy of regulatory control because markets for animal parts were monopolized by the state prior to the 1980s. Where regulations have recently been put in place (e.g., the Wildlife Conservation Law 1988), there appears to

be little legacy of cultural or ethical constraints, such as traditional communal management (Berkes and Feeny 1990), compelling people to abide by the law (Zhu 1989).

Education can play a short-term role by informing people locally and regionally about conservation efforts. In the long term it can play a more potent role by changing people's value systems regarding animals and ecosystem processes. However, education can only be effective when it recognizes existing cultural values. These still need to be better explored in the panda context, where ethnic minorities are those living closest to wild habitats.

Education of locals cannot counteract the extreme economic incentive for panda poaching. Poachers can obtain more than twenty times an annual salary for a panda pelt, because there are wealthy buyers in Japan, Taiwan, and Hong Kong (Schaller 1993). Foreign greed drives poaching. This problem can only be addressed by better reserve patrolling and enforcement, along with effective enforcement of CITES regulations and development of social sanctions against acquiring panda pelts in the wealthy southeast Asian nations.

Political will flows also from mutual trust. Trust can be fostered at many scales in personal or social interactions, from the role model a field biologist provides for colleagues not experienced in such a lifestyle, to the media attention and international reputation a whole nation can attract by implementing measures affecting the fate of a well-loved animal such as the giant panda. Trust is built on a consistent commitment on the part of each member of the intervening group, normally the foreign agency, to trying to understand the cultural traditions, attitudes, and language of the other groups. It is a question of caring and communicating well while also trying to implement change.

CONCLUSION

Project Components

The 4 project components—biological research, population survey, management planning, and training—were all necessary, but have been insufficient because panda populations continue to decline. An extra component, socioeconomic research, was largely overlooked, but will be essential for successful implementation of the management plan.

The Focus of Biological Research

Information gathered by researchers has fallen short

of an ideal result, especially in quantifying demographic parameters and genetic profiles. The focus of the research was not incorrect, but constraints of time, logistics and politics precluded following all avenues. There is no obvious block of research that should have been avoided in favor of other options. Researchers from Beijing University are now successfully quantifying demographic parameters for wild pandas in the Qinlingshan (Lu and Pan 1989).

Most of the biological research has been conducted in only 2 of the 6 mountain systems, and with only 5 of the approximately 33 bamboo species (Yi 1985) growing in panda range. This geographical focus was necessary, and study areas were wisely chosen, including areas already impacted by human activity. However, research findings can rarely be extrapolated between ecosystems, and some studies will have to be replicated in other bamboo forest habitats. The comprehensive work of the population survey team has partly compensated for the lack of data from other systems.

I have used PVA and life-history frameworks to comprehensively evaluate, *post facto*, the biological research. These frameworks overlap in subject matter, but complement each other. Population viability analysis stresses patterns of data for predictive modelling in a probabilistic sense (Shaffer 1990), though no model yet exists to integrate both demographic and genetic data. The life-history approach highlights processes, including long term, natural selection as evidenced by adaptation, and short term, ecological and behavioral processes affecting and reflecting the adaptations. I believe that most conservation research programs will benefit from conscious initial and periodic evaluation using PVA and life-history frameworks.

The Role of Biological Research

The panda project emphasized biological information above all other data, and inadequately pursued acquisition of socioeconomic and anthropological data. As is evident from this review, and more generally (McNeely 1989), conservation is primarily a social problem because social forces driving harmful human behaviors are at the root of virtually all conservation threats. Now that a management plan (MoF 1992) is in the early stages of implementation, the conservation effort should incorporate social science research, and stronger liaison with local peoples as integral project components. To do this, the project should add Chinese and foreign social scientists such as economists and anthropologists to the team of specialists previously

dominated by biologists. Incorporating social scientists in a team approach will benefit conservation efforts for many species and ecosystems on all continents.

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