

# **BIODIVERSITY CONSERVATION: STUDIES IN ITS ECONOMICS AND MANAGEMENT, MAINLY IN YUNNAN, CHINA**

**Working Paper No. 26**

**Protected Areas, Agricultural Pests and  
Economic Damage: Conflicts with Elephants  
and Pests in Yunnan**

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Conflicts with Elephants and Pests in Yunnan<sup>1</sup>**

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Research for ACIAR project 40, *Economic impact and rural adjustments to nature conservation (biodiversity) programmes: A case study of Xishuangbanna Dai Autonomous Prefecture, Yunnan, China* is sponsored by the Australian Centre for International Agricultural Research (ACIAR), GPO Box 1571, Canberra, ACT, 2601, Australia. The following is a brief outline of the Project

Rural nature reserves can have negative as well as positive spillovers to the local region and policies need to be implemented to maximise the net economic benefits obtained locally. Thus an 'open' approach to the management and development of nature conservation (biodiversity) programmes is needed. The purpose of this study is to concentrate on these economic interconnections for Xishuangbanna National Nature Reserve and their implications for its management, and for rural economic development in the Xishuangbanna Dai Prefecture but with some comparative analysis for other parts of Yunnan

The Project will involve the following:

1. A relevant review relating to China and developing countries generally.
2. Cost-benefit evaluation of protection of the Reserve and/or assessment by other social evaluation techniques.
3. An examination of the growth and characteristics of tourism in and nearby the Reserve and economic opportunities generated by this will be examined.
4. The economics of pest control involving the Reserve will be considered. This involves the problem of pests straying from and into the Reserve, e.g., elephants.
5. The possibilities for limited commercial or subsistence use of the Reserve will be researched.
6. Financing the management of the Reserve will be examined. This will involve considering current sources of finance and patterns of outlays, by management of the Reserve, economic methods for increasing income from the Reserve and financial problems and issues such as degree of dependence on central funding.
7. Pressure to use the resources of the Reserve comes from nearby populations, and from villagers settled in the Reserve. Ways of coping with this problem will be considered.
8. The political economy of decision-making affecting the Reserve will be outlined.

**Commissioned Organization:** University of Queensland

**Collaborator:** Southwest Forestry College, Kunming, Yunnan, China

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# **PROTECTED AREAS, AGRICULTURAL PESTS AND ECONOMIC DAMAGE: CONFLICTS WITH ELEPHANTS AND PESTS IN YUNNAN**

## **Abstract**

Protected areas are often the source of agricultural pests and Xishuangbanna State Nature Reserve in Yunnan is no exception. The main pest associated with the Reserve is the Asian elephant *Elephas maximus* which causes damage outside the Reserve to agriculture as well as in the Reserve. However, these elephants are also an important attraction to tourists visiting Xishuangbanna. Xishuangbanna Prefecture contains the only remaining wild elephants in China. The present economic value of tourism within the Reserve is much less than the economic damage caused by elephants and other species protected by it. So whether the net economic value of protecting this species in Xishuangbanna is positive depends on other factors discussed or future tourism prospects. Methods of controlling pests from the Reserve are discussed, as is the scheme for compensating agriculturalists for damages caused by its pests. The problem of achieving an equitable solution to the pest problem is given considerable attention. The economics of reconciling the conflicting interests of those who either regard a species as a pest or as an asset is considered.

# PROTECTED AREAS, AGRICULTURAL PESTS AND ECONOMIC DAMAGE: CONFLICTS WITH ELEPHANTS AND PESTS IN YUNNAN

## 1. Introduction

It is popular at the present time to emphasize the benefits of protected areas and the conservation of species. Whilst this is reasonable, sight should not be lost of the fact that protected areas can be a source of negative spillovers to nearby farmers. Protected areas may for example increase fire risks to nearby farms or be a source of agricultural pests such as 'weeds' and animal agricultural pests such as elephants and wild pigs [1]. When animal species are protected in nature reserves and cause agricultural damage on nearby farms, the economic loss incurred results in a grievance of farmers against the nature reserve if they do not receive adequate compensation for such damage. Their dissatisfaction is further heightened if the animal species is completely protected both inside and outside the nature reserve, as in Xishuangbanna Prefecture.

Xishuangbanna Prefecture is located in the far south of Yunnan and is bordered by Laos and Myanmar (Burma). It has been classified as an area of megadiversity [2, 3] and consequently nature conservation in this prefecture is of worldwide interest. It contains the last remnants of China's population of Asian elephants *Elephas maximus* as well as a very high degree of botanic diversity. Tourism is a rapidly developing and important industry in the prefecture and Chinese authorities would like to reap economic benefits from the further development of nature-based tourism in the area.

There are two important nature reserves in the prefecture: Xishuangbanna State Nature Reserve and Nangunhe Nature Reserve. In 1989, Sukumar [4, pp. 18, 30] indicated that probably 100-230 head of elephants exist in these reserves. In 1994, Zhu Xiang estimated that numbers of elephants in Xishuangbanna to be on average around 150-250 and that their population had shown an increase in recent years. Nevertheless, this elephant population is very low and the distribution of elephants seriously reduced in comparison to that of China in historic times when the range of *Elephas maximus* extended to the Yantze (Chang) River.

While the nature reserves in Xishuangbanna help conserve nature species with some positive economic values, several of these species cause damage to the crops of local farmers at the

same time. Consequently, this is a source of social conflict and, as evidenced below, the agricultural damage caused by elephants is the most severe. On the other hand, elephants are one of the most important tourist drawcards from Xishuangbanna nature reserves, and have other economic values. This social conflict cannot be ignored from a conservation viewpoint because as Sukumar [4, p. 202] observes, ‘any grandiose plan for conservation without adequate provision for human interests is bound to fail’.

The purpose of this paper is to consider the animal pests emanating from nature reserves in Xishuangbanna in terms of their total economic value. In practice, this means concentrating on the Asian elephant. The conservation and appropriate management of endemic vertebrate species requires social conflicts to be resolved and therefore policy-makers in seeking practical solutions to conservation issues must go well beyond the total economic evaluation of such species.

The case material used here was collected on fieldwork in Xishuangbanna in October 1994. The problems observed are placed in a general context since they are not peculiar to this case. First, the total economic evaluation of an agricultural pest species such as *Elephas maximus* is discussed along with broad issues involved in conflict resolution and management of the species. It is observed that while much attention has been given to the economic evaluation of the African elephant *Loxodonta africana*, see for example [5], much less economic attention has been given to the Asian elephant, *Elephas maximus*. While both species have some economic values in common and cause similar damages there are differences as highlighted below.

The status of animal pests from Xishuangbanna State Nature Reserve, especially the elephant, is outlined. The control and management of vertebrate pests from the Reserve is then considered, including the measures which local farmers take to protect their property against these pests. Even when populations of wild animals are managed optimally from a social viewpoint, farmers are still liable to incur economic damage from such animals. The question then arises of whether farmers should be compensated and how. Considerable attention is given to compensation and social security schemes in relation to protected animal ‘pests’. The scope for local farmers to gain economic benefits from the conservation of such animals is discussed and the compensation scheme currently operating in Xishuangbanna Prefecture is critically analysed.

## 2. Total Economic Evaluation of the Species, Conflict Resolution and Control

Protected animals are often agricultural pests and this creates difficulties for their conservation and economic evaluation since some may regard them as assets. Sometimes the same individual may even see the same species as a pest in some contexts and as an asset in other contexts. For example, elephants may be regarded as pests by farmers and villagers in areas near nature reserves which contain them if they roam to their farms and cause damage. Nevertheless, these farmers and villagers may consider elephants positively if they remain in the nature reserve or do very little agricultural damage. On the other hand, tourists and those valuing the existence of such animals regard the populations of such animals as a positive asset. Given this conflict, how is a species to be valued from an economic viewpoint?

In cost-benefit analysis, economists have traditionally determined social benefits resulting from variations in the availability of resources by using the Kaldor- Hicks principle [6]. This principle, which is sometimes called the potential Paretian improvement principle, implies that social benefits are to be determined by adding the benefits or losses experienced by individuals or groups from the variation in the availability of a resource. This means that the effects of this variation on income distribution are ignored. For example, suppose that the resource is the level of population,  $P$ , of a species and let  $R(P)$  represent the total value placed on it by those who see the species as an asset [7] and let  $L(P)$  specify the economic loss suffered by those who see the species as a pest. Applying the Kaldor-.Hicks principle, the social economic benefit from the population of the species can be expressed as

$$V(P) = R(P) - L(P). \quad (1).$$

As a rule the population of a species can be varied by human intervention at a cost. The level of population of a species may be reduced below its 'natural' level at a cost, or can even be increased by expenditure designed to improve the habitat or other conditions experienced by the species. If  $\bar{P}$  represents the natural level of population of a species, the cost of varying its population may be of the form  $C(P, \bar{P})$ . Hence, extending the above view of economic welfare, social net benefit from the availability of the species is

$$B(P) = R(P) - L(P) - C(P, \bar{P}) \quad (2)$$

and the socially optimal level of population of the species is the one which maximises this expression.

Note that this model incorporates similar assumptions to those of the pest control model of Headley [8] as discussed in Tisdell [1, Ch. 9]. It is a simple model because it does not take account of the dynamics of management of a species. The calculus of variations and dynamic programming may be applied to model dynamics as has been done by Clark [9] and by Conrad and Clark [10] but at the expense of much greater complexity.

Usually application of the Kaldor-Hicks principle results in some degree of compromise between the parties with conflicting interests. For example, if some individuals regard the species as an asset and others see it as a pest, the socially optimal level of population of the species based on the maximisation of expression [2] will normally result (i) in a smaller population of the species than is optimal for those viewing the species positively and (ii) a higher level of population of the species than is desirable from the point of view of those who regard the species negatively [11, Appendix]. In this socially 'ideal' situation, conflict will continue to exist between the parties and will need to be 'managed' by regulators. As part of such management, compensation schemes for economic damage by a species may for example be introduced, as has been done in Xishuangbanna.

The whole question of the social value to place on the population of a species is an extremely complex one but it is now more widely appreciated that economic values must include not only direct, but indirect values. The notion of total economic value, consisting of direct and indirect use and non-use values, has for instance been popularised by Pearce et al., [12] and has been applied to valuation of the African elephant [5, pp. 17-21] in a general way.

Barbier et al., [5, p. 18] suggest that the greatest direct economic use value of the African elephant is for tourism, ivory, meat and hides. In terms of export earnings, tourism may be the most important economic benefit from the African elephant. In terms of its natural ecological functions, the African elephant also has indirect use value because it has 'the ability to diversify savanna and forest ecosystems, and as seed dispensers, reduce bushlands, expand grasslands and reduce the incidence of the tsetse fly' [5, p. 19]. This may improve conditions for grazers and other species. The Asian elephant may perform similar functions. Furthermore, the African elephant was considered to have significant non-use values, such as existence value, bequest and option value.

In comparison, the Asian elephant also has significant tourism value but no studies of the type undertaken by Brown and Henry [13] for the non-consumptive value of elephants for



tourism purposes in Kenya appear to have been undertaken in Asia. In this respect, however, it should be noted that in some parts of Asia such as Xishuangbanna, it is difficult to see elephants because of their low densities and because they are confined as a rule, to tropical rainforests or similar vegetation thereby reducing their visibility in comparison to the savannah areas of Africa. This may therefore provide the animals with smaller economic tourism potential than in Africa. Furthermore, the eating of elephant meat is no longer practised in most of Asia and the Asian elephant is less valuable than the African for ivory. This is because female Asian elephants do not have tusks and also a proportion of Asian males are without tusks. Consequently, the direct value of the Asian elephant could be lower than the African especially in areas such as Xishuangbanna. On the other hand, the Asian elephant can be domesticated and is still used in some countries such as Myanmar for logging. However, their domestic use is declining.

The fact that the Asian elephant can be domesticated also makes it a tourist attraction since it can be used for transporting tourists safely, for instance, within national parks. Furthermore, elephant 'schools' such as the one north of Lampang in Thailand draw many visitors. In addition, the non-use value of the Asian elephant is probably very high given the standing of the elephant in Asian history, culture, religion and folklore. Unfortunately, no hard-and-fast estimates of these values are available. Nevertheless, case material from Xishuangbanna throws some additional light on the matter.

### **3. The Status of Animal Pests from Xishuangbanna State Nature Reserve, Especially Elephants and Economic Consequences**

Xishuangbanna State Nature Reserve in Yunnan consists of five separate subreserves and is a source of agricultural pests like many other nature reserves. The main agricultural pest is the Asian elephant *Elephas maximus* which is thought to be responsible for about 90 per cent of the agricultural economic damage caused by pests roaming from the Reserve. Other animal pests include monkeys e.g., Rhesus monkeys *Macaca mulatta*, bears, gaur *Bos gaurus*, spotted or Sambar deer *Cervus unicolor* and wild pigs *Sus scrofa* but on the whole these are not considered to be serious agricultural pests.

On average, it is estimated (October, 1994) that pests straying from Xishuangbanna Nature Reserve cause ¥1 million in agricultural damage and that agricultural damage in the whole of Xishuangbanna Prefecture from wild animals is approximately ¥2 million annually (pers.

comm. Director, Xishuangbanna State Nature Reserve). (In October, 1994 it was approximately the case that ¥8.3 = US\$1.00.) As mentioned above, 90 per cent of the agricultural damage from pests straying from the Reserve is attributed to elephants.

In Xishuangbanna, elephants eat crops such as rice, corn and bananas. Many damage the embankments of paddy fields and break fences. Even within the Reserve they may cause some damage. For example, walking tracks may be damaged and undermined by the movement of elephants and they sometimes push trees across these. This has already started to happen along one of the important newly constructed walking tracks at the San-Ca-He site in the Mengyang Subreserve. Substantial portions of the track are constructed of concrete bricks and are located along a route frequently used by elephants. Especially in the wet season, elephants slide off the track and sometimes travel down the embankment on which it is built, thereby undermining the track. Trees are pushed across the track by elephants so adding to the maintenance costs. This is a source of concern for the management of the subreserve because it has scant funds of its own for maintenance. Considerable care was taken in constructing the track to ensure that tree roots were not damaged by its construction.

In large densities, elephants seriously damage forest vegetation in order to satisfy their food requirements. They also use trees and shrubs as scratching posts and knock them down 'to let off steam' or test their strength. It may be observed however that Asian elephants when disturbing rainforest may normally be performing an important ecological function as noted earlier in relation to the African elephant.

Elephant populations in the subreserves of Xishuangbanna State Nature Reserve are unevenly distributed. The main concentration is in Shangyong and Menglasubreserves in the far south of the Prefecture. The elephant population moves between these subreserves, the first mentioned of which is on the Laotian border. Elephants often cross the Lancang (Mekong) River and so move between Laos and Xishuangbanna Prefecture. The managers of the subreserves report that mainly due to heavy hunting pressure on elephants in Laos, there has been a net migration of elephants to the Chinese side of the border. In general, the population of elephants in the Reserve is increasing, and on average, numbers in the whole Reserve are estimated to be 150-200 head.

There are probably around 50 head of elephants in Mengyang Subreserve but only 3-4 in the smallest subreserve, Menglun, which in fact is a fragmented subreserve. The main

concentrations of elephants are in the Shangyong and Mengla Subreserves where numbers fluctuate due to migrations. On average 150-200 head occur here.

Due to economic development, the elephant population in Mengyang Subreserve has become isolated from the population further to the south. Economic development now impedes migration of elephants to and from Mengyang Subreserve. It has been suggested that land corridors be established between the subreserves to assist the migration of elephants and to ensure genetic mixing of populations. Plans have been drawn up for the creation of such corridors but these are very tentative and in fact may never be established because the cost of land acquisition is likely to be very high. Furthermore, the corridors would add to the pest problem for agriculture from the Reserve. In addition, the corridor proposed at present is dissected by at least one major road and this adds to problems of establishing the corridor.

The Asian elephants in Xishuangbanna are the only remaining wild elephants in China. There are several reasons for the major-decline of populations of wild elephants in China in historic times. These include -past open-access to the species [14, 9, 15, 16] and particularly, the conversion of land from natural vegetation cover to other forms such as agriculture [17, pp. 10-11; 18]. Sukumar [4, pp. 32-38] lists several specific factors that have resulted in the decline of elephant population throughout Asia. These are:

1. exploitation of the habitats of elephants by humans, e.g., competition from humans for plant resources, change in vegetation cover such as the establishment of forest plantations often of monocultures, logging;
2. land and vegetation degradation caused by shortened cycles in shifting agriculture;
3. the spread of permanent agriculture;
4. the construction of hyrdoelectric and irrigation dams which displace elephants and deprive them of valuable food resources located in the valleys;
5. the capture of elephants legally and illegally and
6. the hunting of elephants for ivory, meat and hides, and for pest control purposes.

Most of the above adverse factors have operated in Xishuangbanna in recent times. For example, some of the areas in Xishuangbanna frequented by elephants were converted to

rubber plantations. Xishuangbanna also contains a number of tribal minorities who still practise shifting agriculture. Due to population pressures, cycles of shifting cultivation have been reduced in length so reducing the area of forested land at any one time and the extent to which disturbed forest communities are able to recover after cultivation. This has reduced available food resources for elephants and increased their vulnerability to hunting. Furthermore, the area brought under agricultural cultivation has been extended, sometimes illegally, e.g., previously into the Xishuangbanna State Nature Reserve. While no major dams have been built in Xishuangbanna, a major dam to be located on the Lancang (Mekong) River for the purpose of electricity generation and irrigation has been contemplated for location in the Mengyang Subreserve of Xishuangbanna State Nature Reserve. In the past, the Asian elephants in Xishuangbanna were heavily poached. As a result, a high proportion of the elephants present are without tusks or have very small tusks due to selection.

Economic development in Xishuangbanna can be expected to place increasing pressure on elephant populations outside reserves, even though hunting of these elephants is illegal. From the viewpoint China as a whole, maintaining the existence of the Asian elephant population in China may have a reasonably high value. However, this indirect value has not been measured. Nor has the value of elephants in attracting tourists to Xishuangbanna or to the Reserve been measured. The local tourist industry does use wild elephants for promotional purposes and wooden carved elephants are produced and are on sale in Xishuangbanna. A multi-sided relief of elephants decorates the centrepiece of a main road intersection in Jinghong, the capital of Xishuangbanna Prefecture. On the other hand, the chances of tourists seeing wild elephants in Xishuangbanna are relatively low and the majority of Chinese tourists to Xishuangbanna never venture into the Reserve or look for elephants there.

At San-Ca-He, there is an elephant-viewing treetop lookout which can be reached by about a half an hour's walk from the entrance to the site [19]. It overlooks a favourite watering and bathing area of wild elephants. However, elephants do not always frequent it. To increase the chance of seeing elephants, it is possible to stay the night there in the treetop 'hotel'.

In October 1994, there was one domesticated elephant at the San-Ca-He site. This fed locally in the subreserve and was mainly used by tourists for rides and photographing. It was brought from Myanmar. This is in fact the only elephant that most visitors to this site or the Reserve saw. The possibility of having an extra domestic elephant was discussed with the managers of the subreserve. This would help to compensate visitors for not seeing wild elephants or other

animals. Wild animals are not easily seen in tropical forests such as those in Xishuangbanna State Nature Reserve in contrast to the situation on plains or open woodland in Africa and in parts of North America for example where visibility is high. This reduces the appeal of tropical forests to many ecotourists.

The management of the subreserve felt that the main difficulty in increasing the number of domesticated elephants at San-Ca-He would be that the domesticated elephants would feed locally and damage the vegetation of the subreserve and supplementary feeding might be costly.

The possibility that visitors to the San-Ca-He could be encouraged to buy corn and sugar cane pieces, to feed to the elephants was discussed. This is done for example in Thailand at the elephant training school to the north of Lampang where such activities are popular with visiting tourists. A similar practice occurs at the Lone Pine Koala Sanctuary in Brisbane where visitors can buy pellets to feed kangaroos. However, those managing San-Ca-He said that they had tried a scheme whereby visitors could buy concentrated food to feed to their domesticated elephant but that the Chinese were not inclined to make such purchases and so this approach was discontinued.

Furthermore, domesticated elephants have to be protected from wild elephants. At night the domesticated elephant at San-Ca-He was housed in a building with thick steel pipes as side walls to protect it from wild elephants. Extra costs could be involved in adding to such enclosures.

To have a definite quantitative measure of the total economic value of wild elephants in Xishuangbanna would be useful for management purposes. Unfortunately data is not available to provide this. Nevertheless, a number of relevant observations can be made. The direct use for tourism is low since only a small proportion of visitors to Xishuangbanna actually visit the reserves inhabited by elephants and look for elephants. Furthermore, the chances of seeing elephants in the rainforest are very low. In fact only about ¥30,000 is collected in visitors' fees annually from visitors to Xishuangbanna Nature Reserve. So currently this Reserve generates little direct income. The tourists or consumers' surplus, for further discussion about such measurement see Driml and Common [20], obtained from visitors to it has not been measured and it is impossible at this stage to say to what extent visits are motivated by the possibility of seeing a wild Asian elephant.

On the other hand, the indirect and economic non-use values of the elephant in Xishuangbanna may be high. The Asian elephant probably performs an important role in maintaining botanic diversity in the Reserve and the elephant is a publicised tourist feature in the major towns such as Jinghong where tourists to Xishuangbanna spend much of their time. The local elephant carving industry, involved in production for, the tourist market, probably owes its continuing existence to the presence of elephants in the locality. It seems that some tourists visit an area because of an image-factor and elephants add to the natural image of Xishuangbanna. It might also be observed that there are other species that are rarely seen, such as the tiger, but still visitors come to nature reserves and national parks such as the Sundarbans in India and Bangladesh on the chance that they may see them. They add 'character' to the tourist destination and therefore draw tourists to the neighbourhood.

Using the terminology of Barbier et al., [5] introduced previously, the non-use value of the Asian elephant in Xishuangbanna from the Chinese perspective is likely to be relatively high because it is the only remaining population in China. Even if not all Chinese place an economic value on conserving the Asian elephant in China, and even if the value placed on this by individual Chinese is relatively low, China's population of 1.2 billion can be expected to result in substantial total sum for the continuing existence of the Asian elephant in Xishuangbanna. For example, if 40 million Chinese were willing to pay the equivalent of 1 cent per year to retain the Asian elephant in China, this would amount to \$4 million annually. Option and bequest values would also add to the total economic non-use value of the elephant in Xishuangbanna.

Against the total benefits of the Asian elephant one has to offset its economic damages plus expenditure involved in deterring the elephant from doing such damage plus other costs associated with the management of the elephant. The economic damages involved appear to be annually ¥0.9 million to ¥1.8 million for the whole of Xishuangbanna according to the Director of the Xishuangbanna Nature Reserve. The other costs probably amount to not more than ¥0.2 million annually. Consequently, on indirect evidence, the total net economic value of Asian elephant population in Xishuangbanna is highly positive. Nevertheless, there must be some doubt as to whether the population of elephants in Xishuangbanna are viable in the long-run given the fragmentation of Xishuangbanna State Nature Reserve and the available home areas for elephants. Compare Sukumar, [4], p. 206.

#### **4. Controlling Vertebrate Pests from Protected Areas**

As observed above, protected areas are often the source of agricultural vertebrate pests or important in their survival, as in Xishuangbanna. The animals concerned are often mixed goods - assets from the point of view of the protected area and the general public, but pests from the standpoint of agriculturalists. Because of their mobility, they can also be regarded as transboundary resources [9, pp. 158-168]. Sometimes, it is economic to implement management strategies to control such species taking into account the economic damage which they cause to agriculturalists.

Agricultural damages caused by vertebrate pests straying from protected areas can be controlled in at least three different ways:

1. enclosure of the animals in the nature reserve
2. their exclusion from agricultural land or from agricultural areas likely to be damaged by such animals e.g. by appropriate fencing and
3. by reduction in their populations (possibly selectively) by human action. Each of these options can be costly.

The subreserves of Xishuangbanna State Nature Reserve appear mainly to be unfenced. So its wild animals are not enclosed. Furthermore, to build fences or barriers to enclose elephants effectively in its subreserves would be very difficult and costly. It would also interfere with the movement of elephants between its subreserves and therefore reduce genetic mixing.

As for exclosures, some villagers in Xishuangbanna have erected short lengths of electric fence at points where elephants are likely to enter farmed land and cause damage. These single strand fences are set relatively high on wooden posts and the electrified wire is held by porcelain insulators. Power is supplied by a battery unit recharged by solar energy. These units have been supplied by WWF (The Worldwide Fund for Nature) Europe and are maintained by the Bureau for the Protection of Xishuangbanna State Nature Reserve.

Such a unit is for example located at Zhong Tian Ba village which adjoins Mengyang Subreserve. The fence is several metres in length and is stretched across a slight gully which extends from this subreserve. At the time of inspection (October, 1994), corn (maize) had been grown in this area. With only slight difficulty, an 'intelligent' elephant could have

walked around the fence since it formed a barrier rather than an enclosure for crops or an enclosure for the elephants.

Villagers reported that electric fences are initially a relatively effective deterrent to elephants. However, in time, some elephants learn how to disable electric fences. They pull out the wooden posts holding the electrified wire thereby knocking the fence to the ground and then walk over it. The opinion of the villagers was that the fence was of some value to exclude elephants but was not completely effective.

Zhong Tian Ba had suffered loss of rice to elephants. When elephants begin raiding the rice fields and the electric fence is not fully effective, the villagers stay up at night to guard the fields, camp there and light fires to frighten the elephants away. Nevertheless, most villagers appear to want more electric fencing.

Electric fencing is in fact widely used in many countries as a barrier to prevent movement by elephants [21]. Thouless and Sakwa [21, p. 99] state that “in the past a variety of barriers were constructed to exclude elephants from farming areas, but electrified fences are now considered to be the best solution to the problem”. While electric fences appear to vary in their effectiveness, this appears not to be related closely to their design, construction and voltage, but may depend on the previous experience of elephants with such fences, and the nature of the elephant population involved. Thouless and Sakwa [21] suggest that they should be regarded as signals for ‘no-go’ areas rather than real barriers to elephants. This may require the shooting of rogue elephants which make it a habit to break through electric fences. This would be a more suitable approach than unselectively reducing the population of elephants.

It might be noted that electric fences appear to be more effective for the control of the Asian elephant than the African elephant. Thouless and Sakwa [21, p. 105] indicate that this may be because many Asian elephants are tuskless and African elephants make considerable use of their tusks for breaking electric fences.

As for the strategy of reducing animal populations as a pest control measure, this policy is not favoured in Xishuangbanna State Nature Reserve. There is for example no culling program for elephants as in the Kruger National Park in South Africa. Elephant populations in Xishuangbanna are still considered to be relatively low and the conservation of their population is the main goal.



It should be particularly noted in relation to management of large mammals that reducing the total population of these may be an unnecessary and costly strategy for the control of damage to agricultural crops. Sometimes it is sufficient to remove ‘rogue’ animals or to reduce the male population of the species for control purposes. Sukumar [22, p. 93] points out that “adult male elephants are far more prone than a member of a female-based family herd to raid agricultural crops and kill people”.

Whatever control policies are adopted to manage vertebrate pests protected by nature reserves, these should ideally be devised and implemented with co-operation between managers of the nature reserves and local landholders. The management problem should be approached in an integrated manner. This is not to say that control of ‘pest’ species is always desirable or economic, and this leaves open the question of payment of compensation to agriculturalists suffering damage from wildlife movements from protected areas.

In fact, four broad strategies exist to deal with the protected wildlife pest problem:

1. No control and no compensation to landholders damaged by the wildlife,
2. Control but no compensation,
3. No control but compensation,
4. Control and compensation.

In the case of Xishuangbanna State Nature Reserve there is no control of wildlife populations but some compensation is paid to agriculturists who suffer damages from such wildlife. Let us consider this compensation.

## **5. Compensation Paid to Agriculturalists for Damages Caused by Wildlife from Xishuangbanna State Nature Reserve**

Compensation paid by the Bureau for the Protection of Xishuangbanna State Nature Reserve to villagers for damages caused by animals straying from Xishuangbanna State Nature Reserve amounts to about ¥100,000 per year. This compensation comes from a fund provided annually from government sources, the exact amount being determined each year. However, it seems to be relatively stationary at ¥100,000. The budgeted amount is allocated to villagers in proportion to the amount of pest damage estimated by the Bureau for each claim. This

proportion is found by dividing the total compensation fund by the total agreed damages. Currently this is around 10 per cent of estimated economic damage.

When damage from animal pests from the Reserve occurs in a village, the village must in order to make a claim, report this damage to the management of the relevant local subreserve who send its own assessors to assess the damage. In the past, the damage could be certified by any local government officer but this was found to be unreliable. At the end of the year, all allowed claims are added up and the available compensation funds distributed for all claims in proportion to the total compensation fund available. Most of the compensation is paid for the damage caused by elephants.

Difficulties observed for this compensation scheme are:

1. The proportionate compensation is low,
2. The proportionate compensation for damage is the same whether the farmer loses his whole crop or just a small fraction of it,
3. There is a long delay before any compensation is paid,
4. Transaction costs are involved - the villagers must report and confirm the damage and it must be assessed by subreserve staff.

Proportionate compensation is presumably low because given low incomes in China, little surplus is available to fund income security schemes. In essence, the scheme involves co-insurance but the proportionate burden carried by villagers is very high at 90 per cent. This is not to suggest that it would be desirable to pay 100% compensation even if it were feasible. To do so (or to compensate to a high degree) would increase moral hazards. For example, villagers may take little or no action to prevent marauding animals from destroying their crops.

The question also has been raised of whether proportionate payment of compensation in relation to the value of estimated damages is equitable. For example, a farmer who loses the whole of his crop would end up with 10 per cent of its value after compensation whereas say one who loses 20 per cent would end up with 82 per cent of its value after compensation. If the farmers had the same income and the same amount of cropped land this would seem inequitable. This could in principle be allowed for by paying compensation on a sliding scale

with the proportionate compensation rising in proportion to the percentage of damage sustained by the farmer in relation to his/her income. This, however, still leaves open the question of whether poorer farmers should receive greater proportionate compensation for the same percentage of damage sustained. In relative utility terms, the proportionate loss of the poorer farmers is higher.

It would be of considerable assistance to those affected by pest damage if the period for processing claims and paying compensation was reduced. The possibility of doing this needs to be explored. Care should also be taken to reduce transaction costs to the lowest practical level.

If the protection of animals located in the Reserve becomes more effective and their population increases (this is currently an objective), the extent of agricultural damage caused is likely to increase. Furthermore, as agricultural yields and the intensification of agriculture in Xishuangbanna increases, the extent of pest damage is also liable to increase. This is bound to have implications for future relationships between the Reserve and local farming communities.

## **6. Concluding Comments**

Nearly all nature reserves are a source of pests for neighbouring agricultural properties and this has to be taken into account in establishing and managing nature reserves. The problem of achieving optimal levels of population of species in nature reserves is complicated by many factors. For example, the species may be an agricultural pest but regarded as an asset by non-agricultural members of the community. Furthermore, varying the level of population of a species or reducing its propensity to cause agricultural damage is often only possible at an economic cost. So several economic problems arise in managing populations of wild species. Some of these issues have been illustrated for Xishuangbanna Prefecture, Yunnan. Apart from optimal management questions, economics also has relevance to schemes designed to compensate villagers for damage caused by protected wild animals. Again this has been illustrated for Xishuangbanna Prefecture.

An issue that has not been discussed is who should pay into the pool of funds available for compensation. Economists often argue that beneficiaries should pay. If the general community benefits, then this provides some rationale for the government to contribute to the

compensation fund. Possibly most of China's population sees some value in conserving elephants in Xishuangbanna and in protecting biodiversity there. Hence, it seems not unreasonable for the Chinese government to contribute. Even the international community may benefit, so some contribution from it would also be justified. As yet there is no formal scheme for this contribution. The only international contribution so far has been the voluntary one of WWF in providing facilities for electric fencing to exclude elephants from farming property. If tourists or the tourism industry benefit from the preservation of a pest species as in Xishuangbanna then possibly they should also contribute some funds to the compensation fund.

The 'equitable' solution depends on how one believes rights should be assigned. If it is believed that farmers should have a right to protect themselves against pests and are prevented by some laws from doing this, compensation to farmers seems justified. On the other hand, if it is believed that wild animals have a right to life and ought to be conserved, no compensation might be paid to farmers for damages.

In the latter circumstance, if farmers bear the full cost of agricultural damage, they may still find it worthwhile to set up a cooperative insurance fund. Compare [4] p. 218. If pest damage is not predictable and involves a random element, such a fund could be used for compensation. However, farmers would need to be divided into classes to determine the appropriate insurance premiums. It would also be possible in principle to establish a compensation fund financed partially by the insurance contributions of farmers and by contributions from the government and other parties benefiting from the conservation of the pest species. Ethically such an approach would be based upon the idea that property rights do not belong exclusively to any single party having an economic interest in the populations of a particular species. De facto shared rights in the environment and in natural resources have in fact become commonplace. The solutions to problems involving such joint rights often involve compromise and cannot always be precisely specified in advance. This case provides an example of a limitation to the 'property rights' solution to environmental problems, [advocated for example by Coase, 22] which traditionally involves the allocation of exclusive property rights to a single person or entity.

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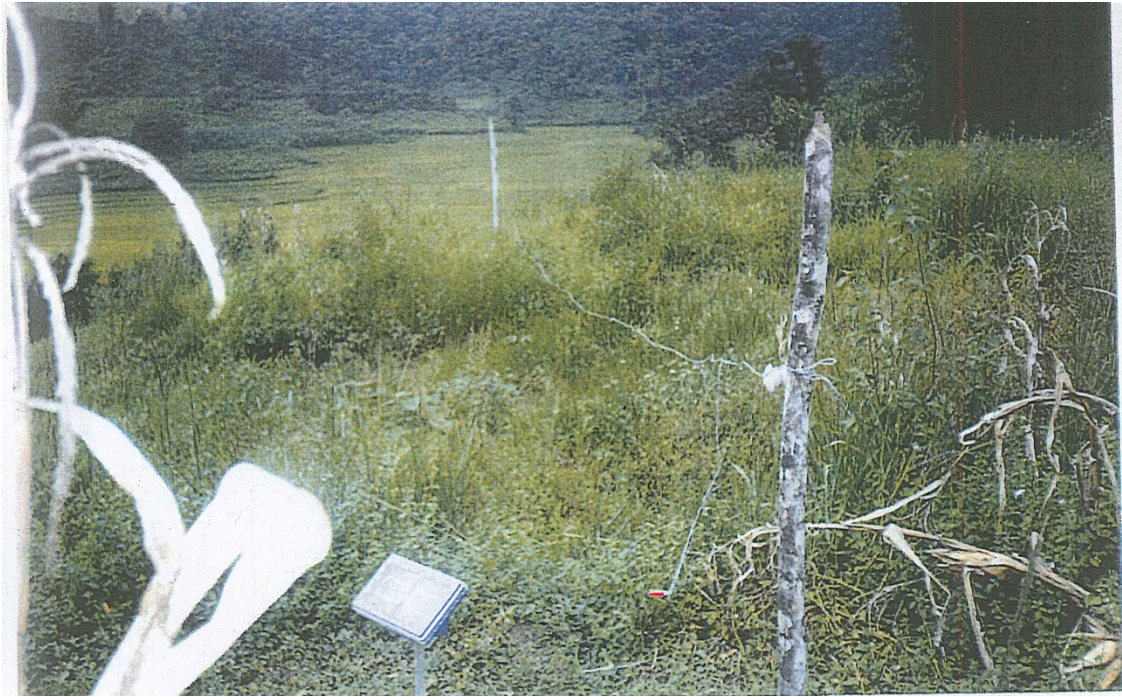
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**Photograph 1:** Carving wooden elephants on the footpath in Jinghong, the capital of Xishuangbanna Prefecture. The carvings are for sale to tourists (Photo: C. Tisdell)



**Photograph 2:** Leaders in the village of Zhong Tian Ba discuss with the authors the problem which they encounter with wildlife from the nearby Mengyang subreserve. (Photo: C. Tisdell)



**Photograph 3:** Single strand electrified fence in an old maize field near Zhong Tian Ba across a path previously used by elephant. The battery is charged by a solar panel which can be seen in the foreground. (Photo: C. Tisdell)



**Photograph 4:** Ripening rice crop in the valley near Zhong Tian Ba with Mengyang subreserve visible in the background. Rice has been eaten by elephants in the past and villagers stay up and light fires to frighten them away when necessary. (Photo: C. Tisdell)





**Photograph 5:** Domestic elephant at San-Ca-He, October 1994 with one of the authors mounted on it. (Photo: C. Tisdell)



**Photograph 6:** Damage at the side of a walking path at San-Ca-He caused by elephants sliding down the embankment. Eventually the path is likely to be undermined. (Photo: C. Tisdell)



**Photograph 7:** Banana trees in Zhong Tian Ba village. Such trees are a favourite food of marauding elephants. (Photo: C. Tisdell)



**Photograph 8:** Treetop hotel at San-Ca-He for viewing elephants. It is a favourite bathing spot of the elephants. Salt is sometimes distributed nearby to entice the elephants to visit the area. (Photo: J.Wen)

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