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

Working Paper No. 16

Protected Areas, Agricultural Pests and Economic Damage: A Study of Elephants and other Pests from Xishuangbanna State Nature Reserve

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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: A Study of Elephants and Other Pests From Xishuangbanna State Nature Reserve

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, *Elaphas 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 seems to be much less than the economic d mage caused by elephants and other species protected by it. So the economic value of protecting these species must depend on other factors or future economic prospects.

Methods of controlling pests from the Reserve are discussed as also 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. The appendix introduces a simple model for optimally controlling the population of a species (variously regarded as a pest and as an asset) from an economic viewpoint.

Protected Areas, Agricultural Pests and Economic Damage: A Study of Elephants and Other Pests From Xishuangbanna State Nature Reserve

1. Introduction

It is popular at the present time to emphasize the benefits of protected areas and the conservation of species. While this is reasonable, sight should not be lost of the fact that protected areas can be a source of negative spillovers to nearby farmers. They may for example increase fire risks to nearby farms or be a source of agricultural pests such as 'weeds' and animal agricultural pests e.g. such as elephants and wild pigs. 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. This appears to be the case in Xishuangbanna Prefecture.

Many animal species (and some other species) have opposing attributes because from the point of some individuals they are assets but from the point of view of others they are pests. It is even possible that the same individual sees 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. The traditional economic approach to determining the optimal level of the population of a species is to maximize its net benefit (its value as an asset less its economic damage as a pest) as function of its population taking account of the cost of varying the level of its population. Thus if a species is on balance a pest, at its current level of population it is optimal to reduce its population to the level where the marginal cost of the value of reduction in its population equals the marginal reduction in economic damage caused by the species less any loss in value experienced by those who favour an increased population of the species. This is illustrated and discussed in the appendix to this paper.

At the 'socially optimal' level of control of the population of a pest, farmers will usually still experience damage from it. Furthermore, the level of control of the population of the species, if some individuals regard the species as an asset, will be less than if the species is just considered to be a pest. This raises the question of whether farmers should be paid compensation for the damages caused by protected species. This is considered below.

2. Pests from the Xishuangbanna State Nature Reserve

Xishuangbanna State Nature Reserve in Yunnan, which consists of five sub-reserves, 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, bears, gaur, spotted or Sambar deer and the wild pigs but on the whole these are not considered to be serious agricultural pests.

Elephants eat crops such as rice, com and bananas. Many damage the embankments of paddy and break fences. Even within the Reserve they may cause some damage. For example, walking tracks may be damaged by the movement of elephants and they sometimes push trees across these. This for example has already started to happen along one of the important newly constructed walking tracks at the San-Ca-He site in the Mengyang Sub-reserve. Substantial portions of the track are constructed of concrete bricks and it is 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 so undermining the track. Trees are already being pushed across the track by elephants. This will all add to maintenance costs. This is a source of concern·for the management of the sub-reserve 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. Currently, there is one domesticated elephant at the San-Ca-Re site. This feeds locally in the sub-reserve and is 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 see. The possibility of having an extra domestic elephant was discussed with the managers of the sub-reserve. 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. This reduces the appeal of tropical forests· to many ecotourists.

The management of the sub-reserve 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 sub-reserve 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 is 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.

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

Elephant populations in these Reserves are fairly unevenly distributed. The main concentration is in Shangyong and Mengla Sub-reserves in the south of the Prefecture. The elephant population moves between these sub-reserves, 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 sub-reserves report that mainly due to heavy hunting pressure on elephants in Laos, there has recently 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.

It is estimated that there are probably around 50 head of elephants in Mengyang Sub-reserve but only 3-4 in the smallest sub-reserve, Menglun, which is in fact a fragmented sub-reserve. The main concentrations are in Shangyong and Mengla Sub-reserves where numbers fluctuate due to migrations. On average 150-200 head occur here.

It appears that due to economic development the elephant population in Mengyang Sub-reserve has become isolated from the population further to the south. Economic development now impedes migration of elephants to and from Mengyang Sub-reserve. A suggestion has been put forward that land corridors be established between the sub-reserves 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 Asian elephants in China, and in the past were heavily poached. As a result many of these elephants are without tusks or have very small tusks due to·selection. From the point of view of 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. However, the chances of tourists seeing wild elephants 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. 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'.

Total net revenue from ecotourism received by the management of the Xishuangbanna Nature Reserve is much less than ¥1 million annually, the damage caused by pests. It seems to be not more than ¥30,000. Of course additional factors would have to be taken into account in assessing the tourist value of animals such as elephants in the Reserve. Nevertheless, it seems probable that the tourist value currently is much less than ¥1 million annually. Hence, the animals in the Reserve, especially the elephants, appear to result currently in a net economic loss. However to the tourism benefit one would have to add existence, option value and so on to estimate the economic value of the wild animals of the Reserve and subtract the cost of damages caused to obtain the net economic value·of the animals concerned.

3. Controlling Pests and Paying Compensation for Damages Caused

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 by human action.

Each of these options can be costly.

The sub-reserves 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 sub-reserves would be very difficult and costly. It would also interfere with the movement of elephants between its sub-reserves and 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 farn1ed 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) 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 Sub-reserve. The fence is several metres in length and is stretched across a slight gully which extends from this sub-reserve. 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 exclosure for the elephants.

Villagers reported that the electric fence was initially a relatively effective deterrent to elephants. However, in time, some elephants learn how to disable the electric fence. They pull·out the wooden posts holding the electrified wire thereby knocking the fence to the ground and walk over it. The opinion of the villagers was that the fence was of some value to exclude elephants but 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 in these and light fires to frighten the elephants away. Nevertheless, most villagers appear to want more electric fencing.

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.

Some compensation is paid to villagers for damages caused by animals straying from Xishuangbanna State Nature Reserve. On average, .about ¥100,000 is paid by the Bureau for the Protection of Xishuangbanna State Nature Reserve to villagers as compensation for damages caused by animals straying from the Reserve. This compensation fund is 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 amount of pest damages 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 sub-reserve which then sends 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 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 sub-reserve 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 damaged by pests if the period for processing claims and paying compensation could be 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 size of the pest damages sustained is also liable to increase and so have implications for future relationships between the Reserve and local farming communities.

4. 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 sees some value in conserving elephants in Xishuangbanna and in protecting biodiversity there. Hence, it seems not unreasonable for the government to contribute. Even the international community may benefit, so some contribution from it would also be justified. As yet there is, however, 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, benefits for the preservation of a pest species as in Xishuangbanna then possibly it 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 seems justified. On the other hand, if it is believed that wild animals have a right to life and that there is an ·obligation to· conservationists to protect these animals, 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. 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 absolutely 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 shared 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 which involves the allocation of exclusive property rights to a single person or entity.

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APPENDIX

A Simple Model of Optimal Control of a Pest that is also an Asset

C. Tisdell

The optimal control of populations of species is extremely complicated. However, some simple modelling is instructive even if it only dispels misunderstandings about the question.

Suppose that the population of a pest species is stable at some level P and that its control only involves reducing its population. Let the reduction in its population relative to P be indicated by R where R P. Reducing the population of a species and holding it constant at the new population level will involve a cost which might be represented by the function

$$C = C(R) \tag{1}$$

This function is likely to increase at an increasing rate i.e. $C'(x) > 0$ and $C''(x)$ ·> 0 is likely.

As far as the benefit (disbenefit) of control is concerned, if the species is a pest then considering it only as a pest, the benefit will be equal to the reduction in (the value of) economic damages resulting from the reduced population of the species. Let this be represented by the function

$$F = F(R). \tag{2}$$

This is likely to increase with R but at a decreasing rate. If the species is only considered to be a pest, the optimal level of reduction in the population of the species will .be that for which $C'(R) = F'(R)$, that is a reduction for which the marginal cost equals the marginal reduction in the (value of) economic damages.

However, for some humans, the population of the spe.cies may be an asset so a reduction in its population is a disbenefit experienced by this group. Let

$$L = L(R) \tag{3}$$

represent the net disbenefit experienced by this group as a result of reducing the population of the species.

It follows if the Kaldor-Hicks criterion is adopted, that the economically optimal level of reduction in the pest population is that which maximises

$$V = F(R) - L(R) - C(R). \tag{4}$$

Hence, the necessary condition for optimality is that

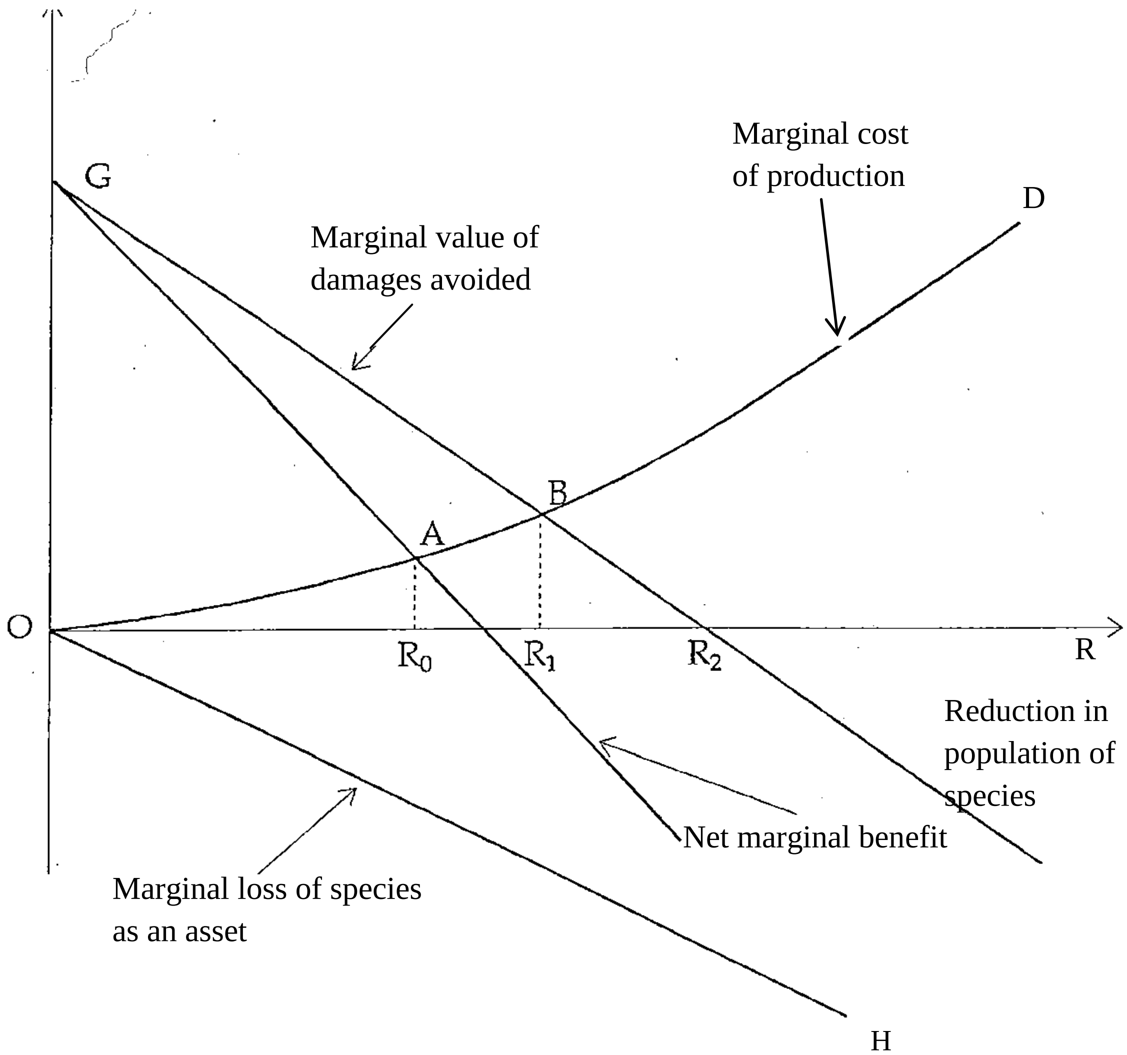
$$F'(R) = L'(R) + C'(R). \tag{5}$$

The population of the species should be reduced up to the point where the marginal cost of achieving the reduction equals marginal benefit from reducing the species as a pest plus the marginal loss in its value as an asset. If R_o represents the optimal level of reduction in the population of a species, its optimal adjusted population will be $\overline{P} - R_o$.

Some minor observations can be made. First, it is often not economically optimal to eliminate a species as a pest because of cost considerations even if elimination is technically possible. Secondly, if the species is regarded by some as an asset, a smaller reduction than otherwise in its population is optimal. In some circumstances, it is even possible that no reduction in the population of the species is optimal because of its high value as an asset.

Figure 1 can be used to illustrate the above. In Figure 1, curve OABD represents the marginal cost of reducing the population of the species and holding it at its reduced levels. Line GB represents the marginal value of damages avoided as a result of reducing the population of the species whereas line OH represents the marginal loss of the species as an asset. The marginal net benefit of reducing the population of the species is therefore represented by line GA. Hence, in this case the optimal level of reduction in the level the species is R_o, that level for which the marginal net benefit of the reduction equals its marginal cost. As can be seen the optimal" reduction is smaller than when the species is solely regarded as a pest. In that case the optimal reduction would be R_1.

Figure 1   Determining the economically optimal level of population of a species



It is possible to have situations in which no reduction in the population of the species is justified because for example the species causes little damage and the marginal loss from its reduction when it. is considered as an asset is very large.

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