ISSN 1327-8231

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

Working Paper No. 177

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September 2011

THE UNIVERSITY OF QUEENSLAND

ISSN 1327-8231
WORKING PAPERS ON
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[1] This is a revised and edited version of Working Paper No 161 in this series and has prepared for a contribution to a publication being prepared by the Bengal Economics Association in honour of Professor Raj Kumar Sen

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WORKING PAPERS IN THE SERIES, *Economics, Ecology and the Environment* are published by the School of Economics, University of Queensland, 4072, Australia, as follow up to the Australian Centre for International Agricultural Research Project 40 of which Professor Clem Tisdell was the Project Leader. Views expressed in these working papers are those of their authors and not necessarily of any of the organisations associated with the Project. They should not be reproduced in whole or in part without the written permission of the Project Leader. It is planned to publish contributions to this series over the next few years.

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* was sponsored by the Australian Centre for International Agricultural Research (ACIAR), GPO Box 1571, Canberra, ACT, 2601, Australia.

The research for ACIAR project 40 has led in part, to the research being carried out in this current series.

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Economics of Controlling Vertebrate Wildlife: The Pest-Asset Dichotomy and Environmental Conflict

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ABSTRACT

Some wildlife species are agricultural pests (or otherwise a problem) but their populations are often valued by other than agriculturalists or by those not adversely affected by them directly. For non-farmers, the population levels of such wildlife are frequently pure public goods. This is one source of market failure in the economically optimal social control of an (agricultural) pest of this type. Secondly, if the species is geographically mobile, externalities occur between farmers (or other individuals) in the control of the species, and individuals ignore these spillovers in controlling pest species. Simple analysis is used to show that depending on the relative strength of these opposing types of market failure, farmers (or others) may excessively reduce or insufficiently decrease the population of a wildlife species from a social economic point of view based on the application of the potential Paretian improvement criterion. After providing some background on general methods of wildlife control and their effectiveness, the economic optimality of this control is assessed using simple models. The limitations of this modelling are then discussed paying particular attention to 'newly emerging' diseases in wildlife that in some cases impact humans, for example, *Henipavirus* carried by flying foxes.

Keywords: agriculture, market failure, pest control, pure public goods, West Bengal, wildlife, zoonoses.

Economics of Controlling Vertebrate Wildlife: The Pest-Asset Dichotomy and Environmental Conflict

1. Introduction

Vertebrates species (including many wildlife species such as elephants, crocodiles and flying foxes) cause considerable agricultural damage and pose direct and indirect threats to human beings and their livestock. Some vertebrates attack and kill human beings and their livestock and act as vectors for transmitting contagious diseases to them. Their socially optimal control is, however, complicated by the fact that some members of society value the existence of such species and are opposed to actions that might drastically reduce their populations. Many non-agriculturalists and those not directly damaged by wildlife species regard these species as assets or pure public goods (Tisdell, 1979). This is a source of social conflict that needs to be addressed in most countries. The potential Paretian improvement criterion (also called the Kaldor-Hicks criterion) has been widely applied by economists to suggest a socially optimal solution to such conflicts. The consequences of applying it to the control of wildlife pests will be considered here and its limitations will be discussed.

A second issue of economic importance is that many agricultural pests are very mobile and move between farms. Consequently, if an individual farmer destroys pests on his/her property, nearby farmers may benefit. In other words, other farmers obtain a favourable externality from the efforts of an individual farmer to control mobile pest. This favourable externality will not be taken into account by an individual farmer in his/her decision making. Consequently, from the point of view of agriculturalists as a whole, there can be an undersupply of control of the pest. This externality gives rise to free-riding by individual agriculturalists.

Thus, two types of market failure can arise in pest control in agriculture. These are (1) a failure by agriculturalists when undertaking pest control to take account of the value to non-agriculturalists of wildlife pestering farmers and (2) failure by individual farmers to take account of the benefit to other farmers when controlling pests on their individual properties. It is shown in this paper that given these different types of market failures, farmers may excessively reduce or insufficiently decrease the population of a species from a social point of view, depending on the circumstances. This is so if the Kaldo-Hicks criterion is applied to determine what is socially optimal. However, the adequacy of that principle is questionable even though in recent times, the eminent jurist/economist, Posner (1981, 1985, 1987) has supported its application as a basis for justice. The principle is discussed at some length in Tisdell (2009, Ch. 4)

This article is developed as follows: First some general methods of controlling vertebrate pests are outlined and commented on briefly. Then the theory of the undersupply of pest control by individual farmers relative to its optimal supply for farmers collectively is outlined. Subsequently, this theory is modified to take account of the demands of non-agriculturalists, and the results of the overall analysis are discussed before concluding.

2. General Methods for Controlling Wildlife Pests and Some of their Consequences

Many different (general) methods exist for controlling wildlife pests and they vary in their effectiveness, economic consequences and implications for the population of the species involved. Consider some of these methods.

Enclosures

By erecting barriers (fences, trenches and so on), it may in principle be possible to enclose wildlife pests in areas, such as national parks. For example, trenches or electric fences may be used in an effort to enclose elephants in protected areas. Such methods are, however, costly and often are not completely effective. For example, elephants often break electric fences. Furthermore, some species (for example, flying foxes, some felines) cannot be contained in this way. Furthermore, many protected areas are too small to maintain a minimum viable population of the species concerned. In such cases, these species may be reliant on the use of land, including farmland near protected areas to sustain their population at a minimum viable level. This may well be the case for many elephant populations in India and in Sri Lanka (Bandara and Tisdell, 2004). The question then arises of whether agriculturalists should be compensated by non-agriculturalists for the damage caused by these animals assuming that non-agriculturalists demand the continuing survival of their populations?

Exclusion

Another strategy for possible vertebrate pest control is to erect barriers (such as electric fences) to exclude these pests from agricultural prey or crops which attract them. However, this can also be costly even if it is workable. In many cases, it will be too costly to be economic and many poor farmers have insufficient capital to invest in such controls.

Removal and relocation of wild animals

Sometimes, wildlife officers will remove 'rogue' animals from farming areas and relocate them in protected areas. This is sometimes done in Sri Lanka with elephants for example. While this may ease the immediate problem for farmers, other animals may migrate and replace those taken away. Sometimes, the removed animals even return. It is unlikely to be a long-term solution.

Scaring away of animal pests

In some cases, farmers adopt techniques to scare away animal pests. For example, farmers in some locations light fires, explode crackers and make noise to scare raiding elephants away from their crops such as rice. However, these methods are not entirely effective because the animals may become accustomed to these tactics. Furthermore the problem may be transferred to less vigilant farmers.

Culling of troublesome wildlife in protected areas

Another potential control method is to cull populations of troublesome species in national parks. This is done in the case of African elephants and cape buffalo in Kruger National Park. One of the main reasons in this case, however, is that in the absence of culling the population of these species is predicted to expand beyond the carrying capacity of the park. In such cases, the elephant population, in particular, could cause permanent damage to the park. The culling, however, also provides income for the management of the park because the meat and other products from these animals are marketed.

However, culling may not prevent all species from causing agricultural damage to nearby farms and if culling occurs on a large scale it could reduce the populations of species valued by other than agriculturalists to levels that threaten their survival.

Furthermore, some members of society may be ethically opposed to the killing of animals, especially mammals.

Habitat alteration

Another possible means of controlling unwelcome wildlife is by habitat modification. However, doing this in protected areas undermines their purpose. On farmland, crops can be grown that are less palatable to wildlife pests or their type of livestock may be altered so it is less subject to predation. However, there is an unseen cost, namely the loss in profit from not being able to adopt the use of the land which would be more profitable if wildlife pests were not present.

Killing of agricultural pests by farmers

Farmers may legally (or illegally) kill wildlife pests on their property. This, however, will not be very effective as a control if those killed are quickly replaced by animals form neighbouring properties or if the rate of increase in the population of the pest species is rapid when the level of its total population is reduced. These effects differ with the types of wildlife species involved.

Compensating those damaged by wildlife

Instead of trying to control wildlife which causes economic damage an alternative is to compensate those who suffer damages. This can, however, be costly and problems of moral hazard arise – some farmers, for example, may claim damages well beyond the losses incurred by them. In practice, however, where such compensation schemes exist, payments to those damaged are usually insufficient to compensate farmers for the damage caused. Furthermore, scope exists for corruption and inequality in distributing compensation.

Another problem is that there is usually no compensation paid for being subject to possibility of unpredictable damage being caused by wildlife. This possibility creates anxiety for those who may suffer damages and has an economic cost. Furthermore, it is doubtful if adequate economic compensation can be given for some damages, such as death.

Given this background let us consider some of the theoretical issues involved in the socially optimal control of wildlife pests by considering initially the benefits to agriculturalists and then also taking into account the interests of other members of society. The discussions will be limited to the killing of wildlife on farms.

3. Decisions by Individual Farmers to Kill Wildlife Pests on their Property and Collective Benefits to Farmers

In deciding on whether to kill pests on their property, it is assumed that individual farmers will compare the economic gains from this action with the cost to them of killing the pest. In Figure 1, for example, line ABC might represent the marginal benefit to a farmer of killing a pest on his/her property and line OBD might be the associated marginal benefit to the farmer. In the case shown, the farmer maximises his/her own net gain by killing K_1 of the pest population on his/her property. It does not pay the farmer to kill all of the pest animals that are on his/her property.

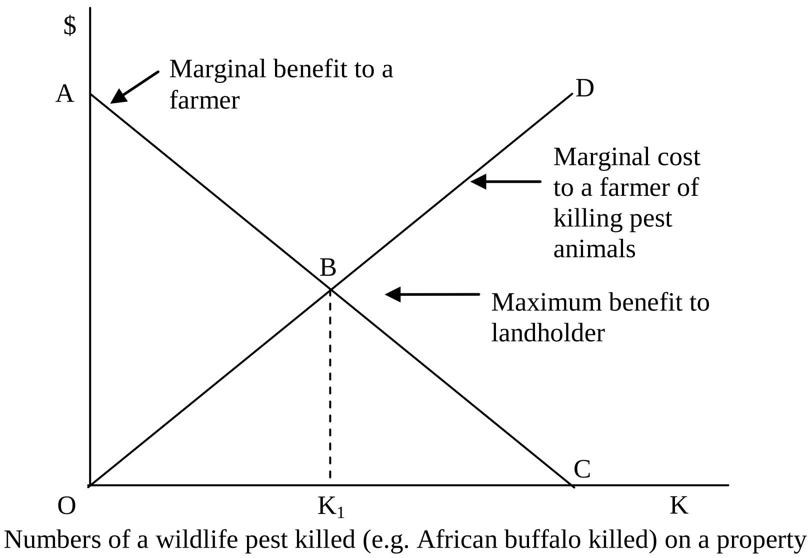

Figure 1: An illustration of the most economic kill of a pest by a farmer on his property. Only the farmer's net benefits are considered.

Note that the mobility of the pest population and the natural rate of population replacement will affect the level of kill that is optimal from the farmer's point of view. The more rapid is the replacement of killed animals by those from other properties, the lower is line ABC. Therefore, the less economic is control. In general, the greater the geographical mobility of animals, the less economic is control from an **individual** farmer's point of view (Tisdell, 1982, pp. 367-372). Also this is so the faster the population increases after its numbers are reduced (Tisdell, 1982, pp. 372-374).

Nevertheless, the pest control strategy that is economically optimal from an individual farmer's point of view is not necessarily optimal from the point of view of farmers collectively. For example, individual farmers are likely to exert insufficient control of a pest from the **collective** viewpoint of farmers if the pest is mobile. When the pest is mobile, other farmers obtain a favourable externality from its control by an individual farmer. However an individual farmer will not take this into account in his/her decision to control the pest population on his property. There is, therefore, insufficient control from the collective point of view of farmers. This can be illustrated by Figure 2.

In Figure 2, line ABC is the private marginal gain to an individual farmer of reducing the population of the pest found on his property and line EFG represents the marginal collective benefits (benefit to all farmers only) of doing this. The difference between these two lines represents the external (spillover) benefits to other farmers of the individual farmer killing the pest population on his property. The marginal cost to the farmer of killing the pest is represented by line OD. Given the situation shown in Figure 2, the individual farmer will only kill K_1 of the pest found on his/her property whereas it is optimal from the viewpoint of all farmers to kill K_2.

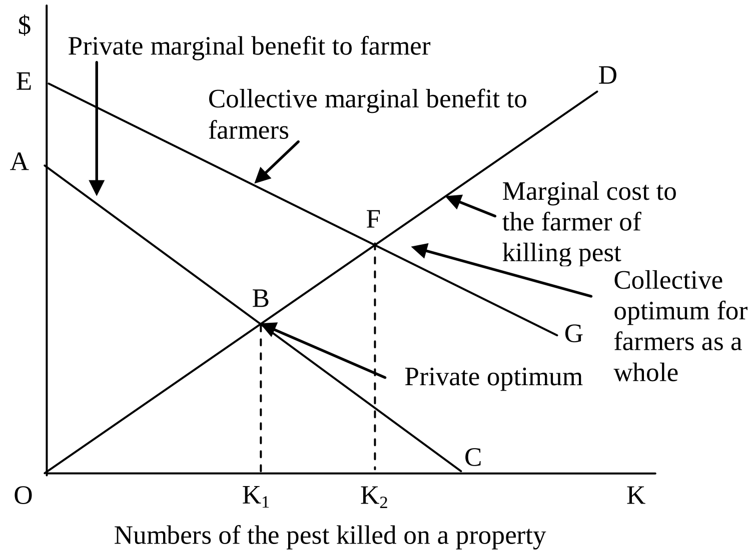

Figure 2: Figure to show that because of external benefits to other farmers, individual farmers may, when the collective benefits of all farmers are considered, under control a pest on their property (if the pest is mobile)

A complex interdependence problem arises when pests are mobile. The amount by which a farmer finds it profitable to control a pest varies with the amount of control that other farmers exert. Therefore, modelling this problem is complex! However, it is not completely hopeless. For example, matrices of the type used in game theory can be used to capture the possible relationship (see Davis, et al., 2002 for examples of these applications).

4. The Socially Optimal Reduction in the Population of a Wildlife Pest

Many wildlife species cause damage to farmers but are also valued by non-farmers. For some non-farmers, the level of the population of the wildlife species may be a **pure public good**. What is the socially optimal level of control of an agricultural wildlife pest in this case? Figure 3 can be used to consider this issue. In this figure, X represents the level of population of the wildlife species and the Y-axis indicates monetary values, for example in dollars. Relationship ACD represents the extra value placed by non-farmers on the level of population of the focal species (for instance, the African buffalo) and line OE specifies the extra losses incurred by farmers collectively as the level of population of the species increases. Non-farmers do not place any extra value on populations of the focal species in excess of X_3.

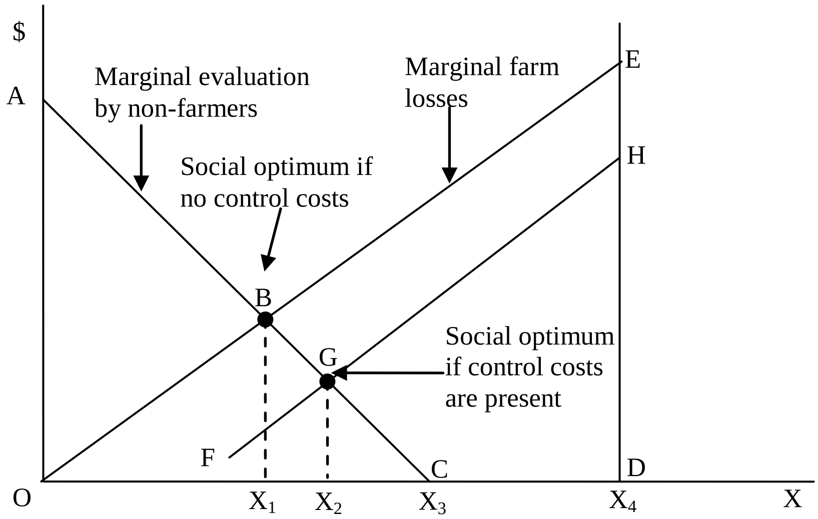

Figure 3: An illustration of the socially optimal control of a focal wildlife species which is an agricultural pest for farmers but which is valued by non-farmers.

Suppose that the focal species has a population of X_4. Although farmers would like to see the population of the pest reduced to zero, it would only be socially optimal to reduce it to at most X_1. A reduction to X_1 would be optimal in the unlikely event that the level of the population of the species can be reduced at zero cost. X_1 corresponds to point B, the point at which the marginal value of the species to non-farmers just equals the marginal loss that their population causes to farmers. If the marginal cost of killing members of the species or otherwise reducing its population is positive, it is socially optimal to reduce its population by less than $X_4 – X_1$. Furthermore, the larger the marginal cost of reducing the population of a species, the smaller is the socially optimal reduction in the level of its population.

For example, suppose for simplicity that the marginal cost of reducing the population of the focal species is a constant equivalent to EH as indicated in Figure 3. Then line FH represents the net marginal benefits to the farm sector from reducing the population level of the species when movements from right to left in X are considered.

In this case, the socially optimal level of the population of X corresponds to point G and reduction in the level of population of the species from X_4 to X_2 is socially optimal.

Note that the above model assumes that farmers place no intrinsic value on the continuing existence of wildlife that pester them. In practice, this is often not the case and is a source of psychological conflict for some farmers who may also have moral or ethical objections to some forms of control of wildlife pests. For example, Bandara and Tisdell (2003) found that farmers surveyed in Sri Lanka were supportive of the continuing existence of elephants despite agricultural damages caused by them. The existence of such attributes may result in farmers executing less control of elephant populations than otherwise. Consequently, they may act on the basis of marginal loss curves that are somewhat lower than those shown in Figure 3. Some of the complexities involved in conserving the Asian elephant are discussed by Tisdell and Bandara (2004).

5. Discussion

Further discussion of the modelling

Note that if the population of the focal species is less than X_3, (see Figure 3) non-farmers will be opposed to any policies that reduce its population and therefore, will be in conflict with farmers. Furthermore, because of the externality issues mentioned above farmers may, by their individual actions, reduce the population of the focal species by too little or by too much from a social point of view. Opposing forces come into play. The failure of farmers to take into account the preferences of non-farmers tends to lead to a socially excessive level of reduction in the population of the species by farmers. On the other hand, when the species is mobile between farms, this reduces the economic incentive of individual farmers to reduce its population. The final outcome depends on the relative strength of these forces. If the mobility of the species is low, if the costs to individual farmers of reducing populations on their properties are low and if the losses caused by the species are high, this is likely to result in an excessive economic reduction in the population of the species at the hands of farmers. On the other hand, if the species is highly mobile, less than a socially optimal level of control of its level of population is likely to be undertaken by farmers.

It is clear that depending on the circumstances, farmers can excessively or inadequately reduce the population of wildlife species which are agricultural pests. As specified above, several types of market failure occur. These failures tend to operate in opposite directions. On the one hand, failure of farmers to take into account the marginal value that non-farmers place on the population of a focal species encourages farmers to reduce its population by a socially excessive amount if it is an agricultural pest. On the other hand, the externalities that arise when the agricultural pest is mobile reduce the incentive of individual farmers to control its population. The net effect on the population of the species depends on the relative strength of those counteracting forces.

Note that in the above discussion, killed wildlife has been assumed to have no market value. If it does, this will reduce the net cost of killing it and in Figure 3 this will shift the line FGH upwards. If in fact, it is profitable to harvest it, line FG will rise above line OE and therefore, it may become socially optimal to reduce the population of the wildlife species by more than $X_4 – X_1$.

The limited value of the social optimality criterion used above

The above discussion of social optimality is based on the potential Paretian improvement criterion. Although Posner (1985) claims that it is just to apply this criterion because it results in increased aggregate wealth, the criterion ignores the distributional consequences of public policies. It is, therefore, difficult to accept Posner's view that application of this criterion is just. Furthermore, the application of this criterion is unlikely to settle social conflict and to be politically acceptable. Therefore, policies based on this criterion (and many similar economic criterion) are unlikely to be implemented. Therefore, Hagedorn (1993) has suggested that economic criterion should take greater account of what is institutionally and politically practical. Otherwise they become irrelevant for policy purposes.

Emerging zoonoses – flying foxes and Henipavirus

Zoonoses are a disease that can be spread from animals to humans. It is believed that 'new' zoonoses are emerging because of increasing overlap between some wildlife species, humans and their domestic livestock. Two strains of *Henipavirus* 'emerged' during the 1990s namely the Hendra virus and the Nipah virus, both of which are carried by flying foxes (fruit bats). The Hendra virus is fatal to horses and can be transmitted by infected horses to humans (Anon, 2011). There is no know cure for the disease in horses and in humans and it is often fatal (Anon, 2011). However, a vaccine is being developed in Australia for protection of horses from the disease and this should indirectly help protect humans. There is a fear that the virus may ‘jump’ species and that person-to-person transmission might occur in the future.

The Nipah virus, which belongs to the same genus as the Hendra virus, emerged in Malaysia in 1999 causing large pig losses and human fatalities (FAO, No date). No cure for the infection is available and it is often fatal to human beings in whom person-to-person transmission is possible (World Health Organization, 2009). Furthermore, the occurrence of the disease in humans does not require an intermediate host, although intermediate hosts (such as pigs) can transmit the virus to humans. It is believed that humans are infected by the virus by consuming fruit, such as mangoes, that have been partially eaten by flying foxes. Infected bats carry the virus in their saliva. Since the occurrence of infections by this virus in Malaysia, human fatalities caused by it have been recorded in Bangladesh and in West Bengal (Anon, 2011). Contaminated fruit appears to be the main form of transmission of this virus to human beings, and fruit consumption can also be an important pathway for its occurrence in pigs. Additional information about this virus is available from Queensland Government (2011) and CIDRAP (2011).

Determining the most economic strategies for concentrating emerging diseases (such as that caused by *Henipavirus*) is very challenging because many different options exist and reducing populations of wildlife carriers of such viruses is not always an economic nor a socially acceptable option. More attention needs to be given to systematic development of economic research in this area. Furthermore, new diseases that have surfaced in some species of wildlife, such as the Tasmanian Devil (Tisdell, 2010), but which do not as yet infect humans or their domestic animals also need to be assessed from an economic point of view, given that both use and particularly non-use values of these species may be lost due to spread of the disease. At the same time, however, it must be kept in mind that economic considerations are just one input into social decisions about what action should be taken to counteract such developments; a point emphasized by Pigou (1932).

6. Concluding Observations

The simple theory outlined above and illustrated by diagrams helps to explain why in some jurisdictions landholders are legally obliged to reduce wildlife agricultural pests on their properties and to refrain from doing this in other cases. The former seems likely when little or no value is placed on the wildlife species by non-farmers, as is the case of some feral animals (for example, feral pigs) and the species is very mobile (Tisdell, 1982). The latter seems more likely in cases where non-farmers value the wildlife species significantly and it is relatively immobile.

Despite the above mentioned insights obtained from economic modelling of the control of wildlife having positive and negative attributes (from a human perspective) further development of economic analysis is needed to take account of distributional and political economy considerations in the management and conservation of wildlife. This is underlined by the emergence of 'new' diseases of wildlife that can be transmitted to humans and domestic livestock. How to most economically respond to their emergence is difficult to determine because of uncertainty about their nature and the future progression of the causal agents, such as viruses which can evolve very rapidly.

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