

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

Working Paper No. 70

**Socioeconomic Causes of Loss of Animal Genetic
Diversity:
Analysis and Assessment**

by

Clem Tisdell

May 2002



THE UNIVERSITY OF QUEENSLAND

ISSN 1327-8231
**WORKING PAPERS ON
ECONOMICS, ECOLOGY AND THE ENVIRONMENT**

Working Paper No. 70

**Socioeconomic Causes of Loss of Animal Genetic Diversity:
Analysis and Assessment**

by

Clem Tisdell*

June 2002

© All rights reserved

* Professor of Economics, The University of Queensland, Brisbane 4072 Australia.
Email: c.tisdell@economics.uq.edu.au

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.

For more information write to Professor Clem Tisdell, School of Economics, University of Queensland, Brisbane 4072, Australia. Email c.tisdell@economics.uq.edu.au

SOCIOECONOMIC CAUSES OF LOSS OF ANIMAL GENETIC DIVERSITY: ANALYSIS AND ASSESSMENT

Abstract

The number of breeds of domesticated animals, especially livestock, have declined rapidly. The proximate causes and processes involved in loss of breeds are outlined. Also the path-dependent effect and Swanson's dominance-effect are discussed in relation to lock-in of breed selection. While these effects help to explain genetic erosion, they need to be supplemented to provide further explanation of biodiversity loss. In the respect, it is shown that the extension of markets and economic globalisation have contributed significantly to the loss of breeds. In addition, the decoupling of animal husbandry from surrounding natural environmental conditions, particularly industrialised intensive animal husbandry, is further eroding the stock of genetic resources. Recent trends in animal husbandry raise serious sustainability issues, apart from animal welfare concerns.

Keywords: biodiversity loss, breed selection, economic globalisation, intensive agriculture, market extension, path dependence.

JEL Classification: Q200

SOCIOECONOMIC CAUSES OF LOSS OF ANIMAL GENETIC DIVERSITY: ANALYSIS AND ASSESSMENT

Introduction

This article focuses on the socioeconomic factors and processes that have contributed to the loss of genetic diversity of domesticated animals, particularly livestock. These are animals that primarily have, or used to have, direct use value for humankind and contrast with much wildlife possessing mainly non-use values. Nevertheless, it is possible for some breeds of livestock, especially if rare or endangered, such as Scottish Highland cattle, to have significant non-use values as well. Furthermore, grazing by livestock can create favoured cultural landscapes (a type of favourable economic externality) and help maintain global biodiversity. This is well recognised in Europe. For example, the landscapes of the Yorkshire Moors in England and the Luneberg Heath in Germany owe their character to sheep grazing. So in some European localities, agricultural practices creating cultural landscapes are subsidised. This helps protect some rare breeds and even some breeds themselves are directly subsidised. Furthermore, in some countries, rare breeds are also being conserved in protected areas (The World Conservation Monitoring Centre, 1992, p.397).

Nonetheless, despite the fact that most domestic animals and their products are classified, in economic terms, as private goods, many breeds have been lost in the last 100 years or so (Alderson, 1994; Scherf, 2000). The World Conservation Monitoring Centre (1992, p.397) reports

“Pursuit of higher production targets, the commercial success of particular breed promoters, and, in developed countries, changes in consumer preferences have led to livestock development activities becoming concentrated in few breeds and breed groups. The corollary of this is that more breeds are declining in importance, many have been lost and the survival of many others is in considerable doubt. Concern for rare breeds has been most marked in northern temperate countries with a history of specialised livestock production, but it is becoming increasingly evident that declining breeds in less developed countries also represent genetic resources of great significance”.

There is considerable uncertainty about the magnitude of the loss in biodiversity of domestic animals but no doubt that loss is considerable. According to the website for the Civil Society Organisations and Participation Programme of the UNDP, “Half of all Europe’s domesticated animals have become extinct in [the 20th] century. A third of all remaining livestock species in both Europe and North America are endangered” (UNDP/CSOPP, undated, p.2). The NGO, Genetic Resources Action International (undated, p.2), reports “Livestock breeds are disappearing at an annual rate of five percent, or six breeds per month. In Europe, half of all breeds of domestic animals existing in 1900 are gone, with 43 percent of those remaining endangered”.

In some respects, these figures could exaggerate the loss. FAO (undated, pp.44-45) suggests that some lists of extinct or endangered animal species include non-indigenous species and breeds that have never left the research station, e.g. the FAO Worldwatch List (Scherf, 1996). These are not species involved in co-evolution. This FAO document (p.44) points out: “The breeds most relevant to biodiversity concerns are those that have co-evolved with a particular environment and farming system and represent an accumulation of both genetic stock and management strategies in relation to a particular environment. These have usually taken a long time to evolve and have characters, such as humidity resistance, that cannot be easily developed”. On the other hand, there appear to be or to have been breeds in developing countries that have not been identified and which could have already been lost.

Despite this, according to data collected by the World Conservation Monitoring Centre (1992) there were 3,237 extant livestock breeds in 1992 and 617 breeds had become extinct since 1892. This suggests that almost one in six breeds became extinct in this time period. In addition, another 474 breeds were considered to be rare and endangered. This suggests that within a period of 100 years about 28 percent of livestock breeds either became extinct or rare or endangered. Therefore, the magnitude of the loss is considerable, even on the basis of conservative efforts.

To a large extent this loss appears to have been accelerated by the extension of market systems and associated processes of globalisation. These processes together with the nature of technologies associated with particular breeds have encouraged global

concentration of economic activity on fewer breeds. Furthermore, the changing structures of societies, such as increased urbanisation in developing countries may favour breeds and associated technologies found initially to be of economic value by higher income countries. Development of the livestock industry in developing countries may be 'biased' in favour of breeds and technologies from higher income countries because of their 'prime-mover' advantage and the presence of the breed-technology 'lock-in' effect (Swanson, 1994, 1995a, 1995b).

In this article the proximate causes of breed losses and the processes involved are outlined and the relevance of Swanson's theory (Swanson,1994) of species extinction is considered. Then follows a discussion of how the extension of markets and economic globalisation accelerates the loss of breeds and encourages the tendency to concentrate on a few breeds. Finally, the growing practice of decoupling the husbandry of animals from their natural environment is examined. This is partly a market-driven phenomenon mostly involving industrial-type livestock production. It further adds to genetic erosion and raises serious sustainability issues.

A Review of Proximate Causes of Breed Losses and the Processes Involved

Breed replacement or substantial replacement of extant breeds can occur as a result of straight replacement by other existing ones considered to be superior from an economic point of view, by the formation of synthetic breeds that eventually replace existing breeds, and by stabilised cross-breeding (World Conservation Monitoring Centre, 1992, p.395). The latter, however, requires pure breeds of parent stock to be maintained and so, unless genetic introgression occurs in the breeding stock, is not a force for breed loss *per se*. However, it is possible that the crosses have superior quality and this results in some breeds being entirely replaced by the crosses.

Apart from breed substitution, economic change can result in the elimination of livestock in some regions in favour of other forms of agriculture such as the growing of crops. In such cases, breeds specific to a region undergoing land-use changes may disappear.

Hammond and Leitch (1995) identify the factors listed in Table 1 as sources of the erosion of livestock biodiversity. Some of these sources have an economic basis e.g.

specialisation, some are technologically based (but this change may be ultimately driven by economic considerations) and others depend on political and natural events.

Table 1 Causes of Erosion of Livestock Biodiversity

Factor	Description
Development interventions	Preference given to high-input, high output breeds developed for benign environments. Commercial interest in donor countries promote use of relatively temperate-adapted breeds and create unrealistic expectations in developing countries
Specialisation	Emphasis on a single productive trait, e.g. dairying, leading to exclusion of multi-purpose animals
Genetic Introgression	Crossbreeding and accidental introgression leading to loss of indigenous breeds
Technology	Machinery replaces work animals
Biotechnology	Cryopreservation equipment is as yet inadequate to store germplasm of threatened breeds.
Political instability	Can eliminate local breeds owned by vulnerable population
Natural disaster	Floods, drought and epizootics preferentially affect remote or isolated human and livestock populations

Note: Adapted from Hammond and Leith (1996) by FAO (no date)

Table 1 does not sufficiently specify the economic and market factors that accelerate erosion of biodiversity. The following economic factors can be important in biodiversity loss.

- (1) As discussed later, the extension of markets via economic globalisation encourages regional economic specialisation. This may result in particular types of livestock production becoming relatively uneconomic in a particular region with loss of breeds peculiar to that region. However, according to the implications of neoclassical international economic theory, this adds to global economic efficiency, at least in the short term.
- (2) With economic globalisation, it has become less costly to transfer breeds across international boundaries and this increases the possibilities for breed substitution.
- (3) Factor 2 enables the Swanson dominance-effect (discussed in the next section) to operate more easily. The Swanson dominance-effect suggests that breeds

selected in more developed countries will tend to replace those in less developed countries.

- (4) The law of specialisation by comparative advantage suggests that specialised breeds will tend to replace multi-purpose breeds as markets expand and market transaction costs fall.
- (5) Changing tastes and demands can hasten breed erosion. Consumer preference for leaner meat is resulting in the demise of breeds of pigs that have a fatter meat.
- (6) Changes in the availability and price of imports e.g. food for livestock can change the economics of keeping different breeds.
- (7) The scope for altering environments in which livestock are held can change the economics of selecting different breeds. To a large extent, livestock in developed countries has been decoupled from dependence on its surrounding natural environment. Much livestock in developed countries (and increasingly so in developing countries) is maintained in an artificial environmental capsule protected from the natural environment in intensive-farming systems. Local environments are either controlled or stabilised (e.g. by use of fertilizer) and/or inputs, and even livestock food, may not be produced locally due to forces making market extension possible. This makes for greater uniformity of livestock environments and therefore, contributes to reduced diversity of livestock breeds.

Thus, the scope for economic forces to contribute to breed losses is very wide. Economic impacts are closely associated with the strengthening of the forces of globalisation and market extension. Furthermore, the pattern of breed losses may be influenced by the Swanson dominance-effect.

The Swanson Dominance-Effect and Breed Loss

Swanson (1994) identified two important factors contributing to biodiversity loss generally. The first was the loss of natural habitat due its conversion to human-use, mainly for agriculture. Tisdell (1999, Ch.4) suggests that in addition to this, man-made activities have increased the uniformity of extant environments and that this has contributed, amongst other things, to reduced diversity of species.

A further influence is the selective approach of humankind to conserving and husbanding species, such as livestock, resulting in path dependence. As Swanson (1994, pp.99-100) states:

“..... the entire roster of species is not being considered for use on any given parcel of land. It is more likely that the choice is only for a handful of ‘commercialised’ crops and livestock. The roster of species used to appropriate photosynthetic products for humans has converged to this very small select group of plants and animals”.

Swanson (1994, pp.101-106) argues that path dependence (a situation where initial conditions heavily influence the subsequent development path), as had been observed in relation to the development and survival of new technologies (David, 1985), is important in the survival of species. If this is so then, by analogy, it should also be important in relation to the survival of domesticated animal breeds.

Swanson (1994) argues that learning, investment and experience in developing the use of a species tends to be species-specific. It cannot be easily shifted to other species but it may be shifted to other geographical regions. A similar situation may exist for breeds of livestock.

Swanson (1995a, 1995b) further elaborates on his hypothesis that choices of the species developed depend on the prime-moving regions and determine the choices made and paths taken by many subsequent societies. Specifically Swanson (1995a, 1995b) argues that “the degree of conversion witnessed in developing societies is predetermined by the conversion decision made by the first-developing societies. These societies selected a set of locally available natural assets around which to develop, but many subsequent asset selections have taken their shape in response to those initial decisions. Now societies that are ‘catching up’ attempt to leapfrog intermediate stages of development made by previous developers in their own territories. In this way, development is biased toward the conversion of natural environments to the same set of assets across the globe. This is diversity decline as a result of the uniformity of the development process across heterogeneous states”.

Presumably, by analogy, the Swanson path-dependence hypothesis would also extend to the selection of different animal breeds. As economic development occurs, one might

expect to witness increasing global dominance of breeds selected in higher income countries and the displacement of breeds specific to less developed countries.

Swanson (1994) largely attributes these lock-in effects of choice of utilised species to non-rivalry in the use of knowledge and dynamic externalities of the type mentioned by Romer (1987, 1990a, 1990b), but in fact foreshadowed earlier by Myrdal (1956). In line with Romer's view, Swanson suggests that this leads to a non-convexity in development. Increasing returns (in contrast to decreasing returns) by specialising in the production and development of particular products provides an example of a non-convexity. Alternatively, this phenomenon could also be envisaged as involving a form of hysteresis, that is reduced plasticity or flexibility, and thus reduced adaptability in the relevant system. Furthermore, lock-in can conceivably arise in the absence of knowledge externalities. The latter could happen where, for instance, a monopolist obtains effective property-rights to new breeds or varieties of crops.

Because the initial selection of breeds or species for development tends to be partial or locally determined and is to a large extent uncoordinated, breeds or species may be selected for development that fail to maximise economic returns from a global or a long-term perspective. This is basically a result of decision-making being myopic and evolutionary. The array of breeds developed, although having some economic advantages, may not constitute the economically optimal choice. But lock-in occurs and breeds fail to survive which would have been superior from an economic viewpoint if developed in time.

This can be illustrated by Figure 1. Two breeds I and II are assumed to be available initially and a 'decision' is to be made to develop one or the other. If no breed development takes place, the flow of the net economic value of Breed I might be as indicated by line CD and that breed II as indicated by line AB. If Breed II is developed rather than Breed I, the flow of net economic value from it might be as indicated by line EFG. On the other hand, if Breed I is developed, the flow might be as represented by line HJK.

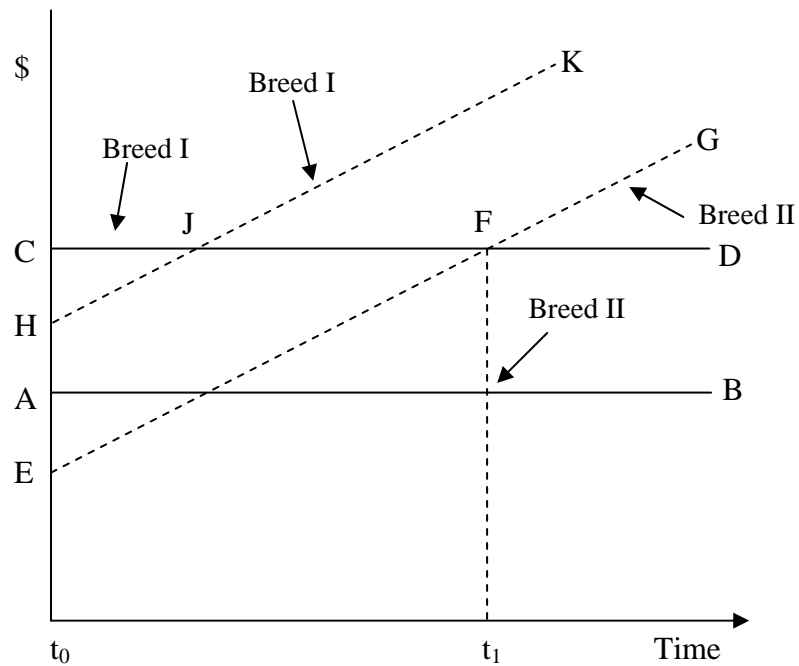


Figure 1 Illustration of the Swanson lock-in effect when applied to choice of breeds.

It can be seen from Figure 1 that if Breed II is developed and Breed I is neglected that eventually the flow of economic benefits from Breed II overtake those from Breed I. The opportunity cost of developing Breed I increases given the development of Breed II and the sunk costs of investment in this. Consequently, as time passes, it becomes increasingly clear that the development of Breed I is no longer economical. Its inherent superior genetic position is eroded as time passes by its relative neglect.

In the case illustrated in Figure 1, the initially inferior breed is shown to always remain inferior for the same level of investment in its development as the initially superior breed. In practice, this may not be so. The potential for what appears initially to be the inferior breed to respond to development may be greater than for the breed initially appearing superior in terms of its net economic value. Nevertheless, lock-in can occur no matter which of the breeds is selected for development.

Systems involving path-dependence can be extremely complex, particularly if coupled with the presence of radical uncertainty. They certainly add force to Clark's observation that "predicting the future is a risky business at best, particularly where human activities are involved" (Clark, 1995, p.143).

In his work, Swanson (1994, 1955a, 1995b) stresses that initial choices of species and associated technological development are the prime influences on biodiversity loss. While these processes and mechanisms are important, his approach does not provide sufficient emphasis on the role of market extension, and associated economic globalisation, as a contributor to the extent of biodiversity loss..

Market Extension and Economic Globalisation as a Source of Biodiversity Loss

The widening of markets can help to magnify the types of initial persistent genetic biases identified by Swanson and at the same time act as a prime mover of such biases. Therefore, circular causation is present. Market extension often creates new avenues for extinction of breeds and species by eliminating protective economic niches (cf. Tisdell and Seidl, 2001) and unleashing other competitive forces. While on balance the widening of markets can be expected to reduce the number of surviving breeds, occasionally some breeds are saved from extinction by this process because of their special qualities that appeal to niche buyers. Market extension can increase the pool of such buyers. The Schabish Hall pig has been suggested as such a case. In fact, the patterns of breed and species elimination arising from the extension of markets can be quite varied and complex. Here it is only possible to identify some of these patterns.

The spread of the market system favours selfish competitive forces and individual survival often depends on the economic entities participating in economic rivalry. These forces also favour the adoption of least-cost technology (Svizzero and Tisdell, 2001). Thus when the market system is introduced to a region using a regional-specific breed inferior in productivity compared to an exotic breed, if introduced to the locality, the exotic breed will replace the regional breed. Therefore, the regional breed will become extinct.

This is illustrated by the simple supply and demand curve analysis shown in Figure 2. Once the local region gets linked to wider markets, the demand for its livestock produce might be as represented by the curve marked DD. The local breed of livestock has the supply curve for this produce of S_1S_1 . But because of enhanced global links, the local region can obtain an exotic breed (new technology) for which the supply curve of the region's livestock produce is as shown by S_2S_2 . The exotic breed can produce

livestock output at lower cost. Consequently, competition will result in it replacing the local breed. The local breed is driven to extinction by economic change. It matters not at all in this context whether the replacement breed has been made superior by the Swanson bias-type process.

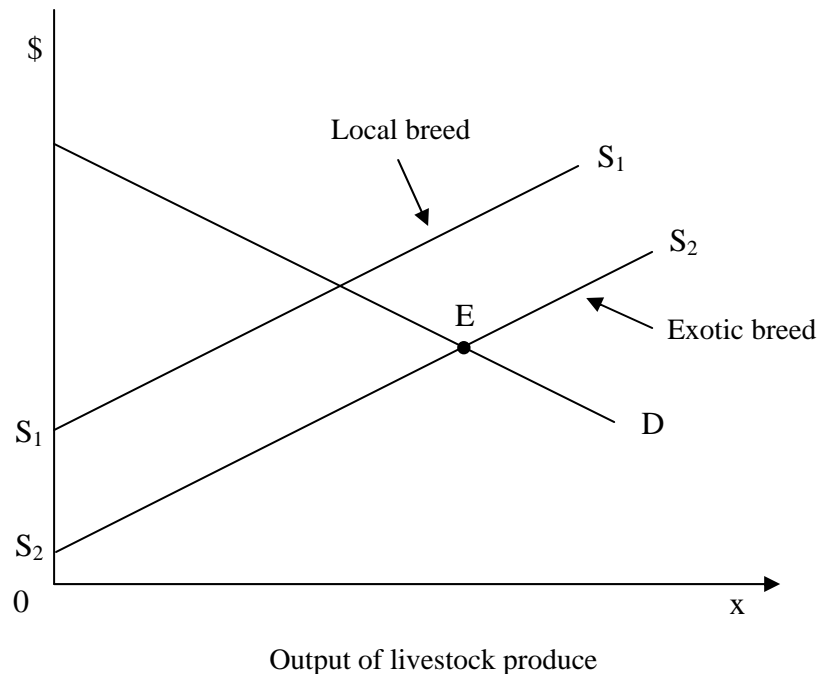


Figure 2 Market systems and global genetic opportunities result in this case in extinction of the local breed.

Economic globalisation, the process of extending markets, as extolled by Adam Smith and seen by David Ricardo as a powerful force for reducing economic scarcity, encourages regional and international specialisation in production. However, at the same time, it is a powerful force for loss of genetic diversity. Two different types of illustration follow.

In the case shown in Figure 3, as a result of the extension of markets or economic globalisation, it becomes cheaper in a region to import livestock produce rather than supply it locally. The cost curve for supplying the produce locally might be as shown by S_1S_1 whereas the supply curve of the produce from outside the region is as indicated by S_2S_2 . In a market system, the latter will usually be much more elastic than the former supply curve and maybe perfectly elastic given that the global market is broad and a local market is narrow. Thus if DD represents the demand for livestock produce

in the region, all livestock produce will be imported. If there is an endemic livestock breed, it will disappear.

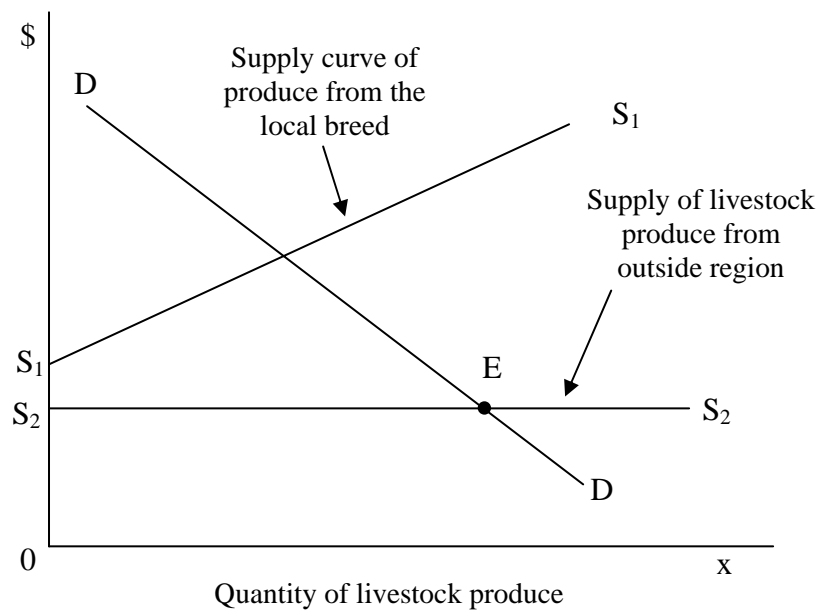


Figure 3 A case in which a local livestock breed is rendered extinct by import of livestock produce.

Figure 4 illustrates the matter in a more holistic way. Assume that individuals in a region are identical and have the same resources, preferences and production opportunities. Any one individual is representative of all. In Figure 4, the line ABC may represent the production possibilities available to an individual and the indifference curves marked I_1I_1 and I_2I_2 represent individual preferences. In the absence of trade, a mixed production system corresponding to the combination of crop and livestock production at B is ideal. But with the opening up of interregional trade, individuals in this region can engage in exchange, and exchange opportunities represented by the line CEF become available. This indicates that this region has a comparative advantage in crop production. It specialises therefore in crop production and livestock production ceases. Hence, with market development individuals can move to equilibrium, E, and be 'better off'. However, if there is a specialised local breed, it becomes extinct.

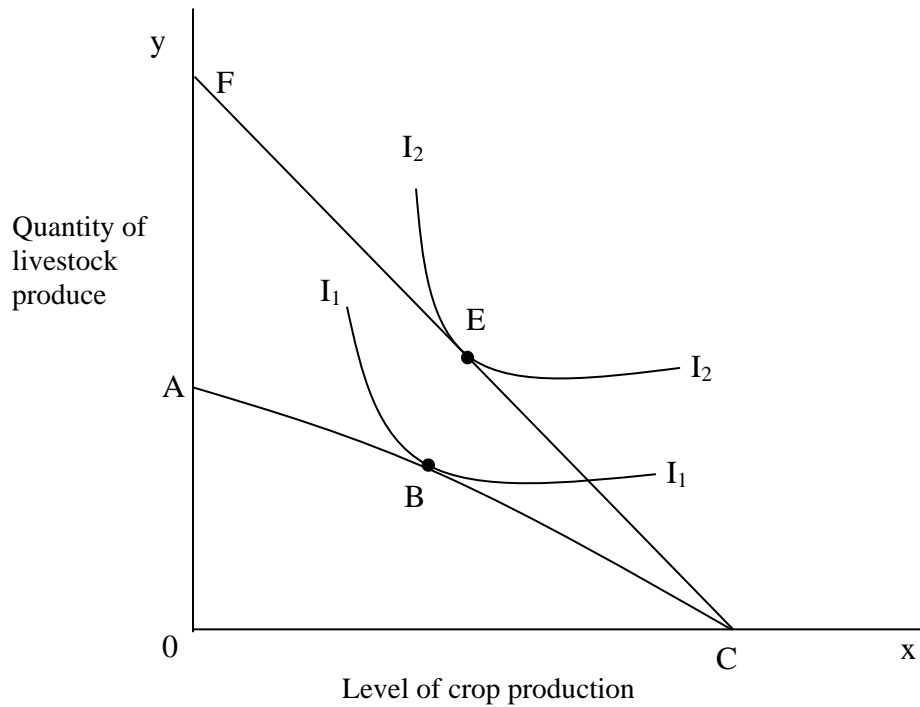


Figure 4 Another case of breed elimination as result of market extension.

FAO (no date) provides a relevant example. It states: “In many areas in Southern Nigeria, rising prices of tree-crops such as cocoa and palm-oil have caused the communities to dispense with their traditional dwarf cattle and goats to concentrate on these profitable crops” (FAO, no date, p.45). These local breeds are in danger of disappearing. This FAO report continues with the following relevant statement: “This is a perfectly rational medium-term strategy on their part. But it would be short-sighted of the national government to lose the genetic resource these livestock represent because of a temporary pattern in world trade”. It is argued that this loss will reduce economic flexibility in an uncertain world and options should rationally be kept open at the national level by, at least, conserving a portion of this genetic resource.

It has been observed that with the extension of markets and economic development, there is a general switch from multi-purpose breeds to specialised breeds. This switch may occur for several reasons. One may be the path dependence of development and differentiation of technology ancillary to the different types of specialised produce of special breeds. The technology and knowledge of husbandry needed for efficient milk production from cattle now differs to a considerable extent from that required for

efficient beef production. Thus the Swanson-technology driving factor can eliminate multi-purpose breeds.

A second reason may have to do with market development. In a non-exchange subsistence economy, keeping multi-purpose breeds to meet human needs in a balanced way is likely to be an advantage. Market exchange may be absent in such economies because of the social system or because high market-transaction costs make markets uneconomical. But once markets become an economical possibility, pre-existing constraints to specialisation are removed.

This case can be illustrated by Figure 5. Assume that three breeds of cattle A, B and C are available in a local region, and that initially it is a non-exchange economy. For simplicity, assume that all in the region have the same resources and preferences. Their preferences are only for milk and beef. The indifference curves I_1I_1 and I_2I_2 in Figure 5 represent these individual preferences. The production possibility if Breed A only is used, is represented for each resource-holder by point A in Figure 5. Similarly, the production possibilities for herds consisting only of breeds B or C are represented by points B and C respectively.

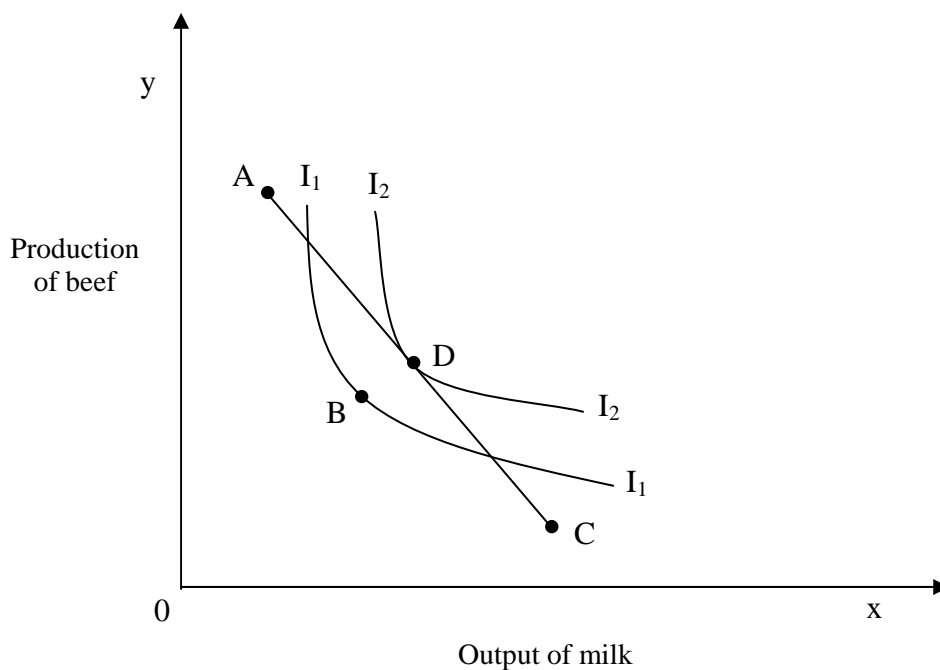


Figure 5 A case in which the creation of markets eliminates multi-purpose breeds

In the absence of exchange and assuming that mixed herds are not genetically or economically viable (that is, a divisibility problem exists), farmers will maximise their welfare by keeping only the multi-purpose Breed, B. A choice of A or C would place them on a lower indifference curve than I_1I_1 . But if exchange became possible with zero (or minor) market transaction costs farmers can gain by specialising in milk or meat production, that is, by having a herd either consisting entirely of breed A or breed C. For example, if the exchange line is ADC, they can reach point D on the indifference curve I_2I_2 . Consequently, the multi-purpose Breed, B, is eliminated. In fact, in many cases the specialisation goes so far that none of the by-product of one breed is marketed by a farmer. For example, beef producers in specialised conditions do not also supply milk to markets.

In many developing countries, farming is actually of a semi-subsistence type rather than pure subsistence or entirely non-exchange in nature. In such cases, there are many additional ways by which local breeds disappear as market systems expand. For example, in Asia, breeds of livestock have traditionally been kept for multiple purposes. Cattle and buffalo, for example, provide fertilizer, draught power and at the end of their working life may be sold for meat to obtain cash. In addition, they provide a store of value. But with the extension of market systems, the value of one or more of these functions may be reduced. For example, market extension makes chemical fertilizer available as a substitute for animal manure, the availability of motorised vehicles, stationary motors, and electricity reduces the demand for animal draught power, and increased competition from other meat supplies may reduce the 'retirement' price of an animal. All these circumstances also reduce the utility of an animal as a store of value. Furthermore, the extension of the cash economy and banking provides an alternative and in many respects, more convenient means to store value. Thus, because of changing economic circumstances fostered by market extension, it may no longer be economical for a farmer to keep a local breed. In addition, the increasing possibility of off-farm work in some developing countries may accelerate the loss of traditional local breeds used mainly for subsistence purposes or as a store of value. In such cases, purchased goods tend to substitute for home-produced ones by those having cash income thereby reducing interest in keeping livestock for domestic use. Also, money increasingly becomes an alternative store of value for those earning cash income. As off-farm work expands, farm families have less time to care for livestock

requiring considerable labour and attention, for example, herding of cattle and sheep and collection of fodder for livestock. Such economic changes can have important consequences for the survival of local breeds.

Decoupling of Breeds and Animal Husbandry from Local Natural Environments

Modern agricultural technologies tend to decouple agriculture from the surrounding natural environment. This they do partly by the creation of man-made environments for domestic animals such as the provision of artificial housing, regulated water and food supplies for livestock managed under industrial-type farming. But even in the case of less intensive modern agriculture, livestock is much protected as a rule from its surrounding natural environment e.g. via vaccinations and veterinary care, improved pastures. Furthermore, for intensively managed livestock in particular, it is possible that none of the livestock food used comes from the local environment. For instance, there may be a heavy reliance on imported grains and food additives. The environmental decoupling phenomenon is most pronounced for poultry and pigs kept in intensive conditions but can also be important for dairy cattle and beef lot cattle.

This form of animal husbandry seems to have been initially developed in higher income countries. It favours breeds that are highly productive under such conditions can be expected to result in strong lock-in (path-dependence of the type identified by Swanson). Therefore, a breed with very little environmental tolerance, say Breed I, is likely to be favoured in comparison to a breed with a high degree of environmental tolerance, say Breed II. In Figure 6, for example, curve ABC may represent production from species I in relation to a range of environmental conditions and the corresponding curve for Breed II might be as indicated by curve DEF. Such curves reflect the biological law of tolerance (Tisdell, 1983). If it is economic by human manipulation to hold environmental conditions at or in the neighbourhood of x_1 , Breed I will be favoured and Breed II may disappear. Thus, a high-yielding risky situation is chosen. Nevertheless, if for some reason, farmers cannot sustain ideal or near ideal environmental conditions for Breed I, production from it collapses. In contrast, Breed II is more tolerant and robust (cf. Tisdell, 1999, pp.38, 46-47).

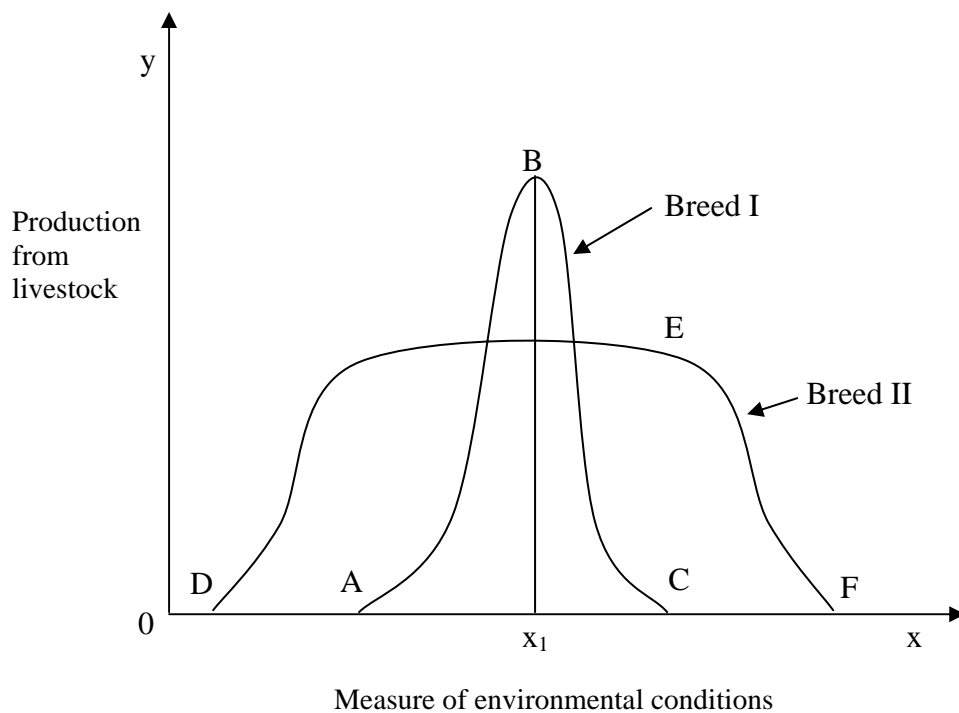


Figure 6 Modern livestock husbandry may favour breeds that are highly productive but show a low degree of environmental tolerance.

From a long-term point of view, it is possible that concentration on high-yielding environmentally-sensitive breeds will create a serious problem for the sustainability of livestock production. There is the problem already mentioned. In addition, it is possible that farmers will lose their ability at some time to manipulate natural environmental conditions. If all environmentally tolerant breeds are lost in the interim, the level of livestock production could collapse.

The decoupled environmental nature of modern animal husbandry has another consequence. It may tend to further widen market competition. It increasingly enables much livestock production to become footloose. Such production is no longer tied necessarily to local environmental conditions and to local food supplies for animals. This footloose tendency is happening increasingly in the broiler industry. To the extent that this raises market competition, it is liable to add to the demise of breeds not ideal for intensive husbandry. It accelerates genetic erosion.

Nevertheless, given growing opposition in many higher income countries to industrial animal husbandry, and increasing demand for products from animals kept under more

natural conditions, e.g. increased demand for free-range eggs, this could reverse past trends in livestock husbandry in more developed countries. However, many of the breeds best suited for natural conditions may already have been lost or be in danger of being lost. Furthermore, the tendency towards concentration of breeds may not be negated, especially given that modern supermarketing of food products puts a high premium on products conforming to regular set standards (cf. Young, 2001). Breeds able to deliver standardised products are favoured in such marketing systems.

Concluding Remarks

The question of what breeds of domesticated animals should be saved from extinction has not been addressed in this article because this is a large, complex and important topic in itself beyond the bounds of this essay. However, the World Conservation Monitoring Centre (1992. p.404) states that “a breed can be conserved (a stock maintained which continues to represent the foundation stock without too much genetic drift or inbreeding) for surprisingly small cost compared with possible economic benefits”. Furthermore, Smith (1984) demonstrates that the net economic benefits of conserving livestock breeds can be very great. Consequently, two conditions of Ciriacy-Wantrup (1968) in favour of maintaining ‘safe’ minimum populations of many livestock breeds appear to be satisfied, namely little cost and potentially high gains from such a strategy (see also Seidl and Tisdell, 2001). Nevertheless, it is unlikely to be economical to conserve all breeds even if Ciriacy-Wantrup’s criterion is used, and difficult human selection choices cannot be avoided. Furthermore, given current social mechanisms, including market systems, human selection is unlikely to result in an optimal social choice of breeds to be conserved, if the utility of humankind alone is considered (cf. Perrings et al., 1995).

The extension of market systems has been shown to be a powerful force for biodiversity loss, especially for the loss of breeds. This is not to deny that market systems may result in the development of new breeds better suited for marketing. However, this outcome may merely add to the erosion of existing breeds. The overall result of the extension of markets and economic globalisation appears to be to reduce the number of extant breeds and to reduce biodiversity generally. Worldwide this loss is continuing as market systems penetrate developing countries more deeply. This article argues that the Swanson lock-in or path dependence effect identified by him in relation

to species selection is also important in relation to the conservation of breeds of domesticated animals. In fact, it may be even more important at this level than at the species-selection level.

Swanson (1995a, p.4) claims that choices of species for use in developing countries (and we can include here breeds of domesticated animals) are heavily influenced by the choices in more developed countries. However, although the Swanson effects contribute to lock-in of choices, they are not pertinent to initial choices. While export of breeds from developed to developing countries appears to be the major route for transfer of breeds, there have also been some two-way flows. Consider, for example, the development of Brahmin cattle, Brangus cattle and so on in the United States and Australia.

It has also been noted that much development of animal husbandry in recent decades has resulted in its being decoupled from local natural environmental conditions. As a consequence, processes of co-evolution have largely been circumvented. This brings with it new environmental dangers and social problems (Tisdell, 2000). Apart from concerns for animal welfare (and in some cases human health) raised by industrialised animal husbandry systems, they may constitute a time-bomb for the collapse of livestock production. One cannot safely ignore the sustainability consequences of such methods of economic production. Whether or not consumer backlash against such methods will change such trends and result in more varied breeds being conserved is unclear. Observe also that hobbyists and enthusiasts in Western countries play a role in conserving rare and endangered breeds, but their role may be marginal. This is probably also true of the conservation of such breeds in protected areas. Nevertheless, these 'aberrations' in self-seeking economic market systems make some positive contribution to the conservation of breeds, and could, therefore, have social merit. Additionally, subsidies for preserving cultural landscapes by encouraging low intensity of land use, such as in some regions of the EU, also play a positive role as do direct subsidies for conserving specific breeds of endangered livestock. As pointed out by a reviewer, the MEKA-program in the State of Baden-Württemberg, Germany, is EU co-financed and includes specific subsidies for five endangered breeds of domestic livestock. But these measures are relatively recent in origin and do not appear to have

counter parts in developing countries. The global trend of declining domestic animal diversity has not yet been halted.

Acknowledgements

I wish to thank the editors of this special issue of *Ecological Economics* for helpful feedback on my first draft of this article and also anonymous reviewers of this journal for their comments, as well as Alistair Robson for research assistance. The usual *caveat* applies.

References

- Alderson, L., 1994. Rare Breeds. Laurence King, London.
- Ciriacy-Wantrup, S. V., 1968. Resource Conservation: Economics and Policies, 3rd ed. Division of Agricultural Science, University of California, Berkeley, CA.
- Clark, C. W., 1995. Scale and feedback mechanism in market economics. In: T. M. Swanson (Editors), *The Economics and Ecology of Biodiversity Decline: The Forces Driving Global Change*. Cambridge University Press, Cambridge, 143-148.
- David, P. A., 1985. Cleo and the economics of QWERTY. *American Economic Review*, 75: 332-337.
- FAO, no date. Extensive pastoral livestock systems: issues and options for the future. <http://www.fao-kyokai.or.jp/edocuments/docement2.html>
- Genetic Resources Action International. no date. Biodiversity threat: the steamroller of modern monoculture and factory farming in sweeping away our crop and domestic livestock diversity, putting future food production at risk. <http://www.grain.org/publications/destruction-documents-meltdown.cfm>. Accessed 27/09/01.
- Hammond, K. and Leitch, H. W., 1995. Towards better management of animal genetic resources. *World Animal Review*, Nos.84/85: 48-53.
- Myrdal, G., 1956. *On International Economy: Problems and Prospects*. Routledge and Kegan Paul, London.
- Perrings, C., Mäler, K.-G., Folke, C., Holling, C. S. and Jansson, B.-O., 1995. Introduction: framing the problem of biodiversity loss. In: C. Perrings, K.-G. Mäler, C. Folke, C. S. Holling and B.-O. Jansson (Editors) *Biodiversity Loss: Economic and Ecological Issues*. Cambridge University Press, Cambridge, 1-17.

- Romer, P., 1987. Growth based on increasing returns due to specialisation. *American Economic Review*, 77: 56-62.
- Romer, P., 1990a. Endogenous technological change. *Journal of Political Economy*, 98: 245-273.
- Romer, P., 1990b. Are nonconvexities important for understanding growth? *American Economic Review*, 80(2): 97-103.
- Scherf, B., 1996. *World Watch List for Domestic Animal Diversity, Edition 2*. FAO, Rome.
- Scherf, B., 2000. *World Watch List for Domestic Animal Diversity, Edition 3*. FAO, Rome.
- Seidl, I. and Tisdell, C. A., 2001. Neglected features of the safe minimum standard: socio-economic and institutional dimensions. *Review of Social Economy*, 59: 417-442.
- Smith, C., 1984. Economic benefits of conserving animal genetic resources. *Animal Genetic Resource Information*, 3: 10-14.
- Swizzero, S. and Tisdell, C., 2001. Concepts of competition in theory and practice. *Revista Internazionale de Scienze Economiche e Commerciali*, 47: 143-162.
- Swanson, T. M., 1994. *The International Regulation of Extinction*. New York University Press, New York.
- Swanson, T. M., 1995a. Why does biodiversity decline? The analysis of forces for global change. In: T. M. Swanson (Editor) *The Economics and Ecology of Biodiversity Decline: The Forces Driving Global Change*. Cambridge University Press, Cambridge, UK.
- Swanson, T. M., 1995b. Uniformity in development and the decline of biological diversity. In: T. M. Swanson (Editor) *The Economics and Ecology of Biodiversity Decline: The Forces Driving Global Change*. Cambridge University Press, Cambridge, UK.
- Tisdell, C. A., 1983. The biological law of tolerance average biomass and production in a variable uncontrolled environment. *International Journal of Ecology and Environmental Science*, 9(2): 99-109.
- Tisdell, C. A., 1990. Economics and the debate about the preservation of species, crop varieties and genetic diversity. *Ecological Economics*, 12: 77-90.
- Tisdell, C. A., 1999. *Biodiversity, Conservation and Sustainable Development*. Edward Elgar, Cheltenham, UK.

- Tisdell, C. A., 2000. Coevolution, agricultural practices and sustainability: some major social and ecological issues. *International Journal of Agricultural Resources, Governance and Ecology*, 1: 6-16.
- Tisdell, C. and Seidl, I., 2001. Niches and economic Competition: implications for economic efficiency, growth and diversity. *Economic theory, applications and issues*, Working Paper No.8. School of Economics, The University of Queensland, Brisbane. Revised version forthcoming in *Structural Change and Economic Dynamics*.
- UNDP/CSOPP Documents, no date. *Conserving Indigenous Knowledge*.
[Http://www.undp.org/csopp/CSO/NewFiles/dociknowledge2.html](http://www.undp.org/csopp/CSO/NewFiles/dociknowledge2.html). Accessed 27/09/01.
- World Conservation Monitoring Centre, 1992. *Global Biodiversity: Status of the Earth's Living Resources*. Chapman and Hall, London.
- Young, J. A., 2001. Communicating with cod and others – some perspectives on promotion for expanding markets for fish. *Aquaculture Economics and Management*, 5: 241-251.

PREVIOUS WORKING PAPERS IN THE SERIES

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

1. Governance, Property Rights and Sustainable Resource Use: Analysis with Indian Ocean Rim Examples by Clem Tisdell and Kartik Roy, November 1996.
2. Protection of the Environment in Transitional Economies: Strategies and Practices by Clem Tisdell, November 1996.
3. Good Governance in Sustainable Development: The Impact of Institutions by K.C.Roy and C.A.Tisdell, November 1996.
4. Sustainability Issues and Socio-Economic Change in the Jingpo Communities of China: Governance, Culture and Land Rights by Ren Zhuge and Clem Tisdell, November 1996.
5. Sustainable Development and Environmental Conservation: Major Regional Issues with Asian Illustrations by Clem Tisdell, November 1996.
6. Integrated Regional Environmental Studies: The Role of Environmental Economics by Clem Tisdell, December 1996.
7. Poverty and Its Alleviation in Yunnan Province China: Sources, Policies and Solutions by Ren Zhuge and Clem Tisdell, December 1996.
8. Deforestation and Capital Accumulation: Lessons from the Upper Kerinci Region, Indonesia by Dradjad H. Wibowo, Clement a. Tisdell and R. Neil Byron, January 1997.
9. Sectoral Change, Urbanisation and South Asia's Environment in Global Context by Clem Tisdell, April 1997.
10. China's Environmental Problems with Particular Attention to its Energy Supply and Air Quality by Clem Tisdell, April 1997.
11. Weak and Strong Conditions for Sustainable Development: Clarification of concepts and their Policy Application by Clem Tisdell, April 1997.
12. Economic Policy Instruments and Environmental Sustainability: A Second Look at Marketable or Tradeable Pollution or Environmental-Use Permits by Clem Tisdell, April 1997.
13. Agricultural Sustainability in Marginal Areas: Principles, Policies and Examples form Asia by Clem Tisdell, April 1997.
14. Impact on the Poor of Changing Rural Environments and Technologies: Evidence from India and Bangladesh by Clem Tisdell, May 1997.
15. Tourism Economics and its Application to Regional Development by Clem Tisdell, May 1997.
16. Brunei's Quest for Sustainable Development: Diversification and Other Strategies by Clem Tisdell, August 1997.
17. A Review of Reports on Optimal Australian Dugong Populations and Proposed Action/Conservation Plans: An Economic Perspective by Clem Tisdell, October 1997.
18. Compensation for the taking of Resources Interests: Practices in Relations to the Wet Tropics and Fraser Island, General Principles and their Relevance to the Extension of Dugong Protected Areas by Clem Tisdell, October 1997.
19. Deforestation Mechanisms: A Survey by D.H. Wibowo and R.N. Byron, November 1997.
20. Ecotourism: Aspects of its Sustainability and Compatibility by Clem Tisdell, November 1997.

21. A Report Prepared for the Queensland Commercial Fisherman's Organisation by Gavin Ramsay, Clem Tisdell and Steve Harrison (Dept of Economics); David Pullar and Samantha Sun (Dept of Geographical Sciences and Planning) in conjunction with Ian Tibbetts (The School of Marine Science), January 1998.
22. Co-Evolutions in Asia, Markets and Globalization by Clem Tisdell, January 1998.
23. Asia's Livestock Industries: Changes and Environmental Consequences by Clem Tisdell, January 1998.
24. Socio-Economics of Pearl Culture: Industry Changes and Comparisons Focussing on Australia and French Polynesia by Clem Tisdell and Bernard Poirine, August 1998.
25. Asia's (Especially China's) Livestock Industries: Changes and Environmental Consequences by Clem Tisdell, August 1998.
26. Ecotourism: Aspects of its Sustainability and Compatibility with Conservation, Social and Other Objectives, September 1998.
27. Wider Dimensions of Tourism Economics: A Review of Impact Analyses, International Aspects, Development Issues, Sustainability and Environmental Aspects of Tourism, October 1998.
28. Basic Economics of Tourism: An Overview, November 1998.
29. Protecting the Environment in Transitional Situations, November 1998.
30. Australian Environmental Issues: An Overview by Clem Tisdell, December 1998.
31. Trends and Developments in India's Livestock Industries by Clem Tisdell and Jyothi Gali, February 1999.
32. Sea Turtles as a Non-Consumptive Tourism Resource in Australia by Clevo Wilson and Clem Tisdell, August 1999.
33. Transitional Economics and Economics Globalization: Social and Environmental Consequences by Clem Tisdell, August 1999.
34. Co-evolution, Agricultural Practices and Sustainability: Some Major Social and Ecological Issues by Clem Tisdell, August, 1999.
35. Technology Transfer from Publicly Funded Research for improved Water Management: Analysis and Australian Examples by Clem Tisdell, August 1999.
36. Safety and Socio-Economic Issues Raised by Modern Biotechnology by Dayuan Xue and Clem Tisdell, August 1999.
37. Valuing Ecological Functions of Biodiversity in Changbaishan Mountain Biosphere Reserve in Northeast China by Dayuan Xue and Clem Tisdell, March 2000.
38. Neglected Features of the Safe Minimum Standard: Socio-economics and Institutional Dimension by Irmi Seidl and Clem Tisdell, March 2000.
39. Free Trade, Globalisation, the Environment and Sustainability: Major Issues and the Position of WTO by Clem Tisdell, March 2000.
40. Globalisation and the WTO: Attitudes Expressed by Pressure Groups and by Less Developed Countries by Clem Tisdell, May 2000.
41. Sustainability: The Economic Bottom Line by Clem Tisdell, May 2000.
42. Trade and Environment: Evidence from China's Manufacturing Sector by Joseph C. H. Chai, June 2000.
43. Trends and Development in India's Livestock Industry by Clem Tisdell and Jyothi Gali, August 2000.
44. Tourism and Conservation of Sea Turtles by Clem Tisdell and Clevo Wilson, August 2000.

45. Developing Ecotourism for the Survival of Sea Turtles by Clem Tisdell and Clevo Wilson, August 2000.
46. Globalisation, WTO and Sustainable Development by Clem Tisdell, August 2000.
47. Environmental Impact of China's Accession to WTO in the Manufacturing Sector by Joseph Chai, August 2000.
48. Effects of Cartagena Biosafety Protocol on Trade in GMOs, WTO Implications, and Consequences for China (English version) by Dayuan Xue and Clem Tisdell, August 2000.
49. Effects of Cartagena Biosafety Protocol on Trade in GMOs, WTO Implications, and Consequences for China (Chinese version) by Dayuan Xue and Clem Tisdell, August 2000.
50. The Winnipeg Principles, WTO and Sustainable Development: Proposed Policies for Reconciling Trade and the Environment by Clem Tisdell, September 2000.
51. Resources Management within Nature Reserves in China by Dayuan Xue, October 2000.
52. Economics, Educational and Conservation Benefits of Sea Turtle Based Ecotourism: A Study Focused on Mon Repos by Clem Tisdell and Clevo Wilson, October 2000.
53. Why Farmers Continue to use Pesticides despite Environmental, Health and Sustainability Costs by Clevo Wilson and Clem Tisdell, November 2000.
54. Wildlife-based Tourism and Increased Tourist Support for Nature Conservation Financially and Otherwise: Evidence from Sea Turtle Ecotourism at Mon Repos by Clem Tisdell and Clevo Wilson, November 2000.
55. A Study of the Impact of Ecotourism on Environmental Education and Conservation: The Case of Turtle Watching at an Australian Site by Clem Tisdell and Clevo Wilson, December 2000.
56. Environmental Regulations of Land-use and Public Compensation: Principles with Swiss and Australian Examples by Irmi Seidl, Clem Tisdell and Steve Harrison.
57. Analysis of Property Values, Local Government Finances and Reservation of Land for National Parks and Similar Purposes by Clem Tisdell and Leonie Pearson, March 2001.
58. Alternative Specifications and Extensions of the Economic Threshold Concept and the Control of Livestock Pests by Rex Davis and Clem Tisdell, May 2001.
59. Conserving Asian Elephants: Economic Issues Illustrated by Sri Lankan Concerns by Ranjith Bandara and Clem Tisdell, June 2001.
60. World Heritage Listing of Australian Natural Sites: Tourism Stimulus and its Economic Value by Clem Tisdell and Clevo Wilson, September 2001.
61. Aquaculture, Environmental Spillovers and Sustainable Development: Links and Policy Choices by Clem Tisdell, October 2001.
62. Competition, Evolution and Optimisation: Comparisons of Models in Economics and Ecology by Clem Tisdell, October 2001.
63. Aquaculture Economics and Marketing: An Overview by Clem Tisdell, October 2001.
64. Conservation and Economic Benefits of Wildlife-Based Marine tourism: Sea Turtles and Whales as Case Studies by Clevo Wilson and Clem Tisdell, February 2002.

65. Asian Elephants as Agricultural Pests: Damages, Economics of Control and Compensation in Sri Lanka by Ranjith Bandara and Clem Tisdell, February 2002.
66. Rural and Urban Attitudes to the Conservation of Asian Elephants in Sri Lanka: Empirical Evidence by Ranjith Bandara and Clem Tisdell, May 2002.
67. Willingness to Pay for Conservation of the Asian Elephant in Sri Lanka: A Contingent Valuation Study by Ranjith Bandara and Clem Tisdell, May 2002.
68. Bioeconomic Analysis of Aquaculture's Impact on Wild Stocks and Biodiversity by Clem Tisdell, May 2002.
69. Will Bangladesh's Economic Growth Solve its Environmental Problems? by Clem Tisdell, May 2002.