ISSN 1327-8231

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

Working Paper No. 168

The Survival of a Forest-Dependent Species and the Economics of Intensity of Logging: A Note

by

Clem Tisdell

August 2010

THE UNIVERSITY OF QUEENSLAND

ISSN 1327-8231
WORKING PAPERS ON

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

Working Paper No. 168

The Survival of a Forest-Dependent Species and the Economics of the Intensity of Logging: A Note[1]

by

Clem Tisdell[2]

August, 2010

---

1 This note was written in response to an issue raised by Hemanath Swarna Nantha in studying the opportunity cost of conserving the orangutans.

2 School of Economics, The University of Queensland, St. Lucia Campus, Brisbane QLD 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 Emeritus Professor Clem Tisdell, School of Economics, University of Queensland, St. Lucia Campus, Brisbane 4072, Australia.

The Survival of a Forest-Dependent Species and the Economics of the Intensity of Logging: A Note

ABSTRACT

Analyses the economics of alternative land-use allocations for a forested area that ensure a targeted viable population of a forest-dependent species, such as the orangutan. The alternative of setting aside a sufficient fully protected portion of the forested area allowing the rest to be used for intensive forestry (or another intensive land use) in which the focal species is unable to survive is compared with that of fully protecting none of the forested area but allowing a sufficient portion of it to be lightly logged to ensure the survival of the targeted population of the focal species with the remainder of the land area (if any) being available for intensive use. The conditions for determining the least cost option (the one that minimizes profit forgone) are identified. It is not possible to say *a priori* which land use is the least cost option. The matter should not be prejudged as some conservationists tend to do.

Keywords: biodiversity conservation, conservation of forest-dependent species, forestry, heavy versus light logging, intensive versus extensive land use and conservation, logging and conservation, opportunity cost and species conservation, orangutan conservation.

JEL Codes: Q23, Q51, Q57

The Survival of a Forest-Dependent Species and the Economics of the Intensity of Logging: A Note

1. Introduction

Some wildlife species are dependent on the presence of forests for their survival but can survive (albeit often at lower densities) when light logging occurs. The orangutan is one such species. Some conservationists have argued that low-intensity forestry may provide an economic and politically acceptable means of ensuring the survival of such species. Sometimes, light logging is seen as an alternative strategy to one of completely protecting an area in order to conserve the population of a forest-dependent species. However, the problem does not appear to have been analysed systematically. The purpose of this article is to introduce a simple model in order to help resolve the economic issues involved in choosing between the alternative strategies for utilizing a forested area of (1) fully protecting a portion of it of sufficient size to conserve exactly the targeted number, K, of a forest-dependent species and allowing the remainder of the forested area to be used for intensive logging or (2) allowing this protected area plus a part of the non-protected area to be lightly logged so as to conserve the targeted number (K) of the focal species with any remainder being available for intensive logging. In the second case, no portion of the forested area is fully protected – all of it is utilized either for light or heavy logging.

First, the nature of the problem is outlined and then a solution to it is specified. After this, the general consequences of the solution are explored and discussed.

2. The Problem

The density of the population of some wildlife species depends on the intensity of logging and so too does the profitability of logging. A problem arises in specifying the relationships involved precisely because the process of logging can be diverse and has multiple attributes or characteristics. For simplicity, however, let us suppose that its intensity can be represented by a variable x which falls in the range $0 < x < 1$ where zero means that logging is absent and 1 implies it is at its maximum intensity.

Suppose that λ represents the density per km^2 of the focal forest dependent species (for example, orangutans). Then the long-term density of this species as a function of the intensity of logging might be like that shown by relationship ABCD in Figure 1. The long-term density of the species declines as logging intensity approaches x_1 and then falls to zero. However, it is conceivable that for some forest species, this density at first rises and then falls because they benefit from some forest disturbance. Also for some species a precipitous decline at a threshold like that of x_1 in Figure 1 may not occur – the decline may be more gradual.

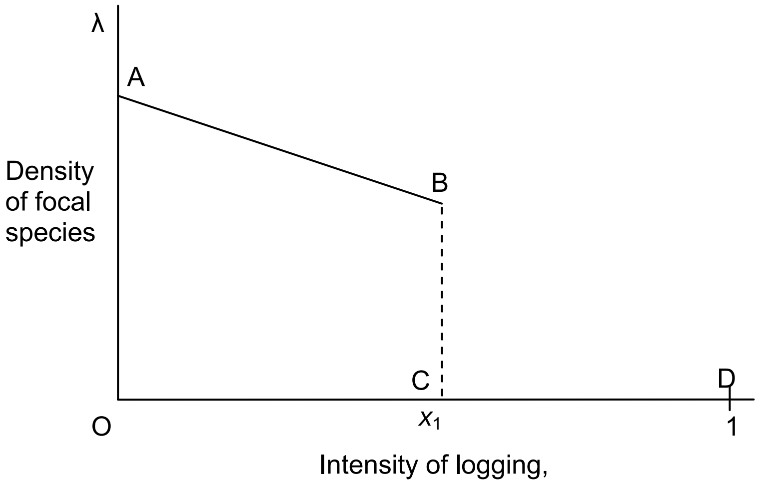

Figure 1: A hypothetical relationship between the density of a focal forest-dependent species and the intensity of logging in its abode

The profit per km^2 from logging also depends on the intensity of logging. It is usually higher for conventional (higher intensities of logging) than for low intensity logging. One possible relationship between the profitability of logging and its intensity is shown in Figure 2 by curve DEFG. In this case, logging at an intensity of less than x_0 is unprofitable. Profit is positive for intensities of logging greater than x_0 and rises as the intensity of logging increases.

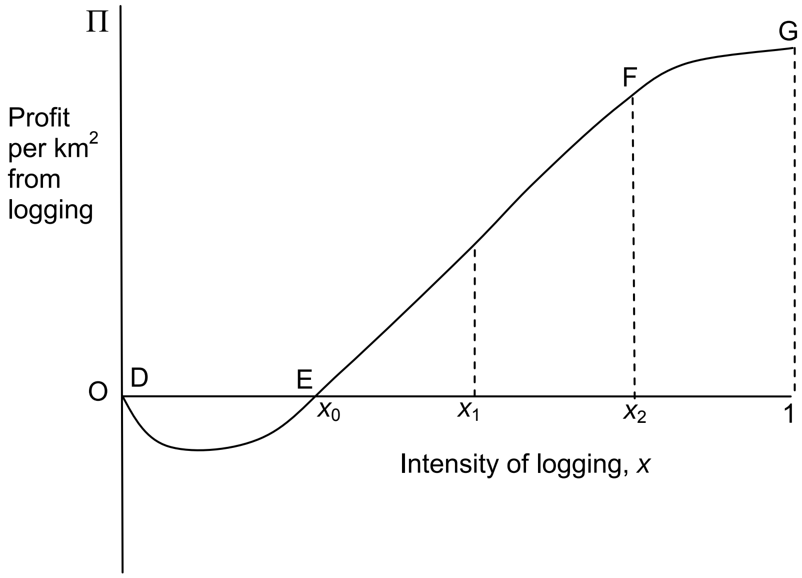

Figure 2: A possible relationship between the profitability per km^2 from logging and its intensity

In Figure 1, x_1 is the maximum intensity of logging compatible with the long-term survival of the focal species. However, in reality, this threshold is likely to be uncertain. Therefore, to be on the safe side if the survival of the species is at stake, it may be wise to opt for a lower intensity of logging than this.

It is not practical to consider **all** possible intensities of logging and the economic cost of conserving the focal species. Therefore, consider two discrete alternative strategies for the allocation of a forested area for forestry and the conservation of the focal species of a size of H km^2. These are:

(1) Completely protecting a portion of the area H km^2 of the forested area so as to conserve just K of the focal species and allow the remaining portion to be used for high intensity logging.

(2) Not completely protecting any part of the forested area and allowing light logging in a portion of it sufficient to conserve a population K of the focal species and permitting heavy logging in the remainder. The level of light logging and heavy logging are assumed to be pre-specified, and the allowed level of heavy logging is assumed to be the same as in Option 1.

Given the two alternative strategies, which is the most profitable alternative?

3. The Solution

In order to visualize the solution, consider Figure 3. The total available forested area for allocation is equal to the area of the rectangle marked A plus that marked B and is shown in the top portion of Figure 3. The area is assumed to be uniform in the quality of its forest and in the density of the focal species it can carry. Option 1 is illustrated by the top large rectangle and Option 2 by the lower one. In case 1, the area of the rectangle identified by A is fully protected so as to conserve K of the focal species and the remainder is used for heavy logging (or it could be used for plantations or other forms of agriculture). In case 2, the protected area is made available for light logging and an area indicated by the rectangle identified by C is withdrawn from heavy logging and used for light logging so as to ensure that the area lightly logged conserves K of the focal species. The rectangular shapes of the forested land area and its uses are assumed for ease of exposition. The solution can be generalized to accord with other land patterns.

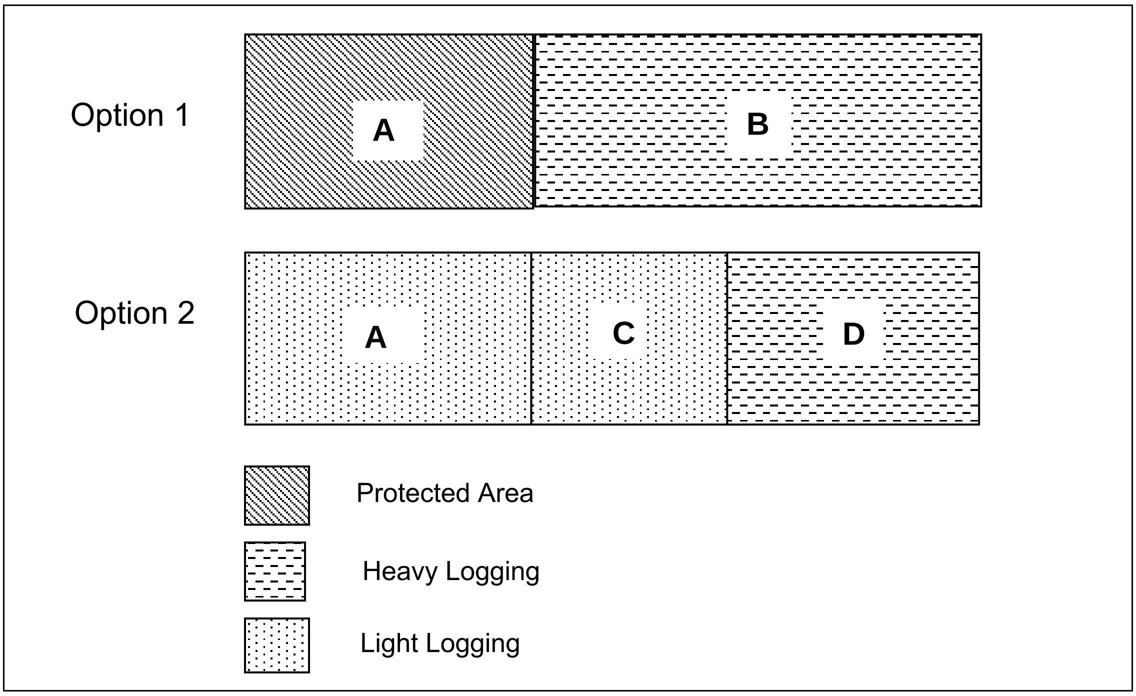

Figure 3 An illustration of the alternatives of (1) a combination of a protected area plus a heavily logged area and (2) a lightly logged area plus a heavily logged area (no protected area) as ways of conserving a targeted level of the population of a forest-dependent focal species

The change in total profit from forestry when Option 2 rather than Option 1 is adopted equals the increase in profit from being able to log area A less the reduction in profit from area C as a result of altering its use from heavy to light logging. If the former amount exceeds the latter amount, profit from forestry rises as a result of the changed strategy for conserving the focal species. On the other hand, if the latter amount exceeds the former amount, profit from forestry falls as a result of the change in strategy.

In order to analyse the matter further, consider a mathematical analysis of the issue. Let K represent the target population of the focal wildlife species, and let λ be its density per km^2 on protected land and $\theta\lambda$ be that on lightly logged land where $0 < \theta < 1$. The species is assumed to disappear in the long-term on heavily logged land. In this case, if Option 1 is adopted, the required size of protected area A in Figure 3 is K/λ km^2. If Option 2 is adopted and light logging occurs, the area needed to conserve K of the species (marked A plus C) is $K/\theta\lambda$ km^2. [It is assumed here that this $K/\theta\lambda$ km^2, is not greater than H km^2. If it is, light logging is not an option compatible with the survival of the targeted level, K, of the focal species.] Therefore, the area marked C equals ($K/\theta\lambda - K\lambda$) km^2.

Suppose that the profit from heavy logging is Π per km^2 and that from light logging it is εΠ where $0 < \varepsilon < 1$. The total change in returns from logging when Option 2 is adopted rather than Option 1 can be expressed as:

$$\Delta R = \frac{K}{\lambda}\varepsilon\Pi - \left(\frac{K}{\theta\lambda} - \frac{K}{\lambda}\right)(\Pi - \varepsilon\Pi) \qquad (1)$$

$$= \frac{K}{\lambda}\varepsilon\Pi - \left(\frac{K}{\theta\lambda} - \frac{K}{\lambda}\right)(1-\varepsilon)\Pi \qquad (2)$$

The first term on the right hand side of this equation is the increased profit from being able to lightly log the previously protected area and the second term is the reduction in profit from having to forgo heavy logging in an area corresponding to area C in Figure 3.

Other things being held constant, it is observed that the likelihood that ΔR is negative (that is that light logging is less financially rewarding than the alternative) increases as ε becomes smaller, that is the greater is the reduction in profit per km^2 from light logging compared to that from heavy logging. Secondly, other things held constant, the smaller is θ (that is, the larger the reduction in the density of the focal species when light logging occurs compared to no logging) the more likely is the light logging strategy to give lower returns from logging than Option 1. This is because the co-efficient $\left(\frac{K}{\theta K} - \frac{K}{\lambda}\right)$ increases as θ becomes smaller.

4. Discussion and Conclusions

The above analysis identifies conditions under which it is the economically optimal to follow a fully protected land policy for a portion of forested land compared to a light logging type of policy to ensure the survival of a focal forest-dependent wildlife species. Only a few parameters need to be estimated to complete the analysis. This is a practical advantage.

Note that it cannot be decided *a priori* whether a protected area policy combined with heavy logging or a light logging type of policy is the most profitable land use policy from the point of view of loggers. This can be illustrated by the following simple examples. If both θ and ε equal 0.5, Expression (2) reduces to zero. In this case, light logging results in both a halving density of the focal species per km^2 and a halving of profit per km^2 compared to heavy logging. In Figure 3, it implies that the area marked by C equals the area identified by A.

Now consider the example in which, $\varepsilon > 0.5$, (that is the profit per km^2 from light logging in less than half that from heavy logging,) and $\theta = 0.5$ (the density of the focal species is halved compared to that in the absence of logging). The light logging option raises returns from logging compared to Option 1 in this case, other things being unchanged. If $\varepsilon < 0.5$ and $\theta = 0.5$, then the opposite result follows.

Consider now variations in θ when ε is set at 0.5. If the $\theta > 0.5$, the density of the focal species falls by less than a half when light logging occurs compared to no logging, and the returns from Option 2 exceed those from Option 1. On the other hand, if $\theta < 0.5$, the returns from Option 2 are less than those for Option 1.

In general, the lower is the reduction in the density of a focal species under conditions of light logging compared to its density when no logging occurs, and the smaller is the reduction in profit from logging per km^2 when light rather than heavy logging is practised, the greater is the likelihood that the light logging option (Option 2) gives greater total returns from forestry than the protected area option (Option 1). This is on the assumption that a given targeted level of the focal species is to be conserved. The opposite relationship also holds.

Therefore, whether Option 1 or Option 2 maximizes returns from forestry depends on the circumstances identified. The model presented here is relevant in the context of conserving a single species, such as the orangutan, at minimum economic cost in terms of profit forgone. Therefore, the analysis should not be construed as a reason for failing to aside protected areas, especially if the aim is to conserve whole ecosystems. Furthermore, there might also be circumstances in which it is socially defensible to support the light logging option even when it is not the least cost one in forms of profit forgone. The light logging option may, for example, ensure greater employment spread over a wider geographical area than setting aside a full protected area and allowing intensive land use outside of it. This may also result in its greater political acceptability in some jurisdictions as a land use option.

PREVIOUS WORKING PAPERS IN THE SERIES
ECONOMICS, ECOLOGY AND ENVIRONMENT

For a list of working papers 1-100 in this series, visit the following website: http://www.uq.edu.au/economics/PDF/staff/Clem_Tisdell_WorkingPapers.pdf or see lists in papers 101 on.

101. Knowledge and Willingness to Pay for the Conservation of Wildlife Species: Experimental Results Evaluating Australian Tropical Species, by Clem Tisdell and Clevo Wilson, May 2004.
102. Antarctic Tourists, Wildlife and the Environment: Attractions and Reactions to Antarctica, by Clem Tisdell, May 2004.
103. Birds in an Australian Rainforest: Their Attraction for Visitors and Visitors' Ecological Impacts, by Clem Tisdell and Clevo Wilson, May 2004.
104. Nature-Based Tourism and the Valuation of its Environmental Resources: Economic and Other Aspects by Clem Tisdell, May 2004.
105. Glow Worms as a Tourist Attraction in Springbrook National Park: Visitor Attitudes and Economic Issues, by Clem Tisdell, Clevo Wilson and David Merritt, July 2004.
106. Australian Tropical Reptile Species: Ecological Status, Public Valuation and Attitudes to their Conservation and Commercial Use, by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, August 2004.
107. Information and Wildlife Valuation: Experiments and Policy, by Clem Tisdell and Clevo Wilson, August 2004.
108. What are the Economic Prospects of Developing Aquaculture in Queensland to Supply the Low Price White Fillet Market? Lessons from the US Channel Catfish Industry, by Thorbjorn Lyster and Clem Tisdell, October 2004.
109. Comparative Public Support for Conserving Reptile Species is High: Australian Evidence and its Implications, by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, October 2004.
110. Dependence of public support for survival of wildlife species on their likeability by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, October 2004.
111. Dynamic Processes in Contingent Valuation: A Case Study Involving the Mahogany Glider by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, November 2004.
112. Economics, Wildlife Tourism and Conservation: Three Case Studies by Clem Tisdell and Clevo Wilson, November 2004.
113. What Role Does Knowledge of Wildlife Play in Providing Support for Species' Conservation by Clevo Wilson and Clem Tisdell, December 2004.
114. Public Support for Sustainable Commercial Harvesting of Wildlife: An Australian Case Study by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, December 2004.
115. Endangerment and Likeability of Wildlife Species: How Important are they for Proposed Payments for Conservation by Clem Tisdell, Hemanath Swarna Nantha and Clevo Wilson, December 2004.
116. How Knowledge Affects Payment to Conserve and Endangered Bird by Clevo Wilson and Clem Tisdell, February 2005.
117. Public Choice of Species for the Ark: Phylogenetic Similarity and Preferred Wildlife Species for Survival by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, March 2005.
118. Economic Incentives for Global Conservation of Wildlife: New International Policy Directions by Clem Tisdell, March 2005.
119. Resource Entitlements of Indigenous Minorities, Their Poverty and Conservation of Nature: Status of Australian Aborigines, Comparisons with India's Tribals, Theory and Changing Policies Globally by Clem Tisdell, March 2005.
120. Elephants and Polity in Ancient India as Exemplified by Kautilya's *Arthasastra* (Science of Polity) by Clem Tisdell, March 2005.
121. Sustainable Agriculture by Clem Tisdell, April 2005.
122. Dynamic Processes in the Contingent Valuation of an Endangered Mammal Species by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, April 2005.
123. Knowledge about a Species' Conservation Status and Funding for its Preservation: Analysis by Clem Tisdell, June 2005.
124. Public Valuation of and Attitudes towards the Conservation and Use of the Hawksbill Turtle: An Australian Case Study by Clem Tisdell, Hemanath Swarna Nantha and Clevo Wilson, June 2005.

125. Comparison of Funding and Demand for the Conservation of the Charismatic Koala with those for the Critically Endangered Wombat *Lasiorhinus krefftii* by Clem Tisdell and Hemanath Swarna Nantha, June 2005.
126. Management, Conservation and Farming of Saltwater Crocodiles: An Australian Case Study of Sustainable Commercial Use by Clem Tisdell and Hemanath Swarna Nantha, August 2005.
127. Public Attitudes to the Use of Wildlife by Aboriginal Australians: Marketing of Wildlife and its Conservation by Clem Tisdell and Hemanath Swarna Nantha, August 2005.
128. Linking Policies for Biodiversity Conservation with Advances in Behavioral Economics by Clem Tisdell, August 2005.
129. Knowledge about a Species' Conservation Status and Funding for its Preservation: Analysis by Clem Tisdell, August 2005.
130. A Report on the Management of Saltwater Crocodiles (*Crocodylus porosus*) in the Northern Territory: Results of a Survey of Pastoralists by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, September 2005.
131. Crocodile Farms and Management of Saltwater Crocodiles in Northern Territory: Results of a Survey of NT Crocodile Farmers Plus Analysis of Secondary Information by Clem Tisdell, September 2005.
132. The Environment and the Selection of Aquaculture Species and Systems: An Economic Analysis by Clem Tisdell, October 2005.
133. The History and Value of the Elephant in Sri Lankan Society by Ranjith Bandara and Clem Tisdell, November 2005.
134. Economics of Controlling Livestock Diseases: Basic Theory by Clem Tisdell, November 2006.
135. Poverty, Political Failure and the Use of Open Access Resources in Developing Countries by Clem Tisdell, November 2006.
136. Global Property Rights in Genetic Resources: An Economic Assessment by Clem Tisdell, November 2006.
137. Notes on the Economics of Fish Biodiversity: Linkages between Aquaculture and Fisheries by Clem Tisdell, November 2006.
138. Conservation of the Proboscis Monkey and the Orangutan in Borneo: Comparative Issues and Economic Considerations by Clem Tisdell and Hemanath Swarna Nantha, March 2007.
139. Economic Change and Environmental Issues: Policy Reforms and Concerns in Australian Agriculture, by Clem Tisdell, April 2007.
140. Institutional Economics and the Behaviour of Conservation Organizations: Implications for Biodiversity Conservation by Clem Tisdell, March 2007
141. Poverty, Policy Reforms for Resource-use and Economic Efficiency: Neglected Issues by Clem Tisdell, May 2007.
142. The State of the Environment and the Availability of Natural Resources by Clem Tisdell, May 2007.
143. Economics of Pearl Oyster Culture by Clem Tisdell and Bernard Poirine, July 2007.
144. The Economic Importance of Wildlife Conservation on the Otago Peninsula – 20 Years on by Clem Tisdell, November, 2007.
145. Valuing the Otago Peninsula: The Economic Benefits of Conservation by Clem Tisdell, November 2007.
146. Policy Choices about Agricultural Externalities and Sustainability: Diverse Approaches, Options and Issues by Clem Tisdell, November, 2007.
147. Global Warming and the Future of Pacific Island Countries by Clem Tisdell, November 2007.
148. Complex Policy Choices about Agricultural Externalities: Efficiency, Equity and Acceptability by Clem Tisdell, June 2008.
149. Wildlife Conservation and the Value of New Zealand's Otago Peninsula: Economic Impacts and Other Considerations by Clem Tisdell, June 2008.
150. Global Property Rights in Genetic Resources: Do They Involve Sound Economics? Will They Conserve Nature and Biodiversity? By Clem Tisdell, August 2008.
151. Supply-side Policies to Conserve Biodiversity and Save the Orangutan from Oil Palm Expansion: An Economic Assessment. By Clem Tisdell and Hemanath Swarna Nantha, September, 2008.
152. The Orangutan-Oil Palm Conflict: Economic Constraints and Opportunities for Conservation by Hemanath Swarna Nantha and Clem Tisdell, October 2008.
153. Economics, Ecology and the Development and Use of GMOs: General Considerations and Biosafety Issues by Clem Tisdell, October 2008.

154. Agricultural Sustainability and the Introduction of Genetically Modified Organisms (GMOs) by Clem Tisdell, February, 2009.
155. Notes on Biodiversity Conservation, The Rate of Interest and Discounting by Clem Tisdell, April, 2009.
156. Is Posner's Principle of Justice an Adequate Basis for Environmental Law? by Clem Tisdell, June 2009.
157. The Sustainability of Cotton Production in China and Australia: Comparative Economic and Environmental Issues By Xufu Zhao and Clem Tisdell, June 2009.
158. The Precautionary Principle Revisited: Its Interpretations and their Conservation Consequences by Clem Tisdell, September, 2009.
159. The Production of Biofuels: Welfare and Environmental Consequence for Asia by Clem Tisdell, September, 2009.
160. Environmental Governance, Globalisation and Economic Performance by Clem Tisdell, November 2009.
161. Managing Forests for Sustainable Economic Development: Optimal Use and Conservation of Forests by Clem Tisdell, February 2010.
162. Comparative Costs and Conservation Policies for the Survival of the Orangutan and Other Species: Includes an Example by Clem Tisdell and Hemanath Swarna Nantha, May 2010.
163. Notes on the Economics of Control of Wildlife Pests by Clem Tisdell, May 2010
164. Are tourists rational? Destination decisions and other results from a survey of visitors to a North Queensland natural site – Jourama Falls by Clem Tisdell, June 2010.
165. Conservation Value by Clem Tisdell, June 2010.
166. The Influence of Public Attitudes on Policies for Conserving Reptiles by Clem Tisdell, July 2010.
167. Core Issues in the Economics of Biodiversity Conservation by Clem Tisdell, July 2010.