19 ECONOMIC APPROACHES TO THE VALUE OF TROPICAL RAINFORESTS

*Ian Curtis**

Nature Conservation Trust of New South Wales, SMEC Australia Pty Limited, Townsville, Queensland, Australia; and School of Earth Environmental Sciences, James Cook University, Queensland, Australia
*The author was participant of Cooperative Research Centre for Tropical Ecology and Management

Introduction

The various branches of economics have endeavoured for decades to derive appropriate and effective methods to value the environment, or more particularly the goods and services provided by ecosystems for the public good. These attempts have often been, and still are, the subject of acrimonious debate, but with refinements they have survived and are still used today. The problem has been the public good nature of the environment, and the concept of market failure, where the consumption of these ecosystem goods and services goes uncompensated. In other words, they are non-market or unpriced goods and services. Moreover, the global nature of these externalities has frequently been neglected owing to the main purpose of environmental economic studies being to measure the national welfare (Aronsson & Lofgren 2001).

Fundamental limits on natural capital lead to unsustainable development, and because economic functions are embedded in nature, sustainability requires handing down to future generations local and global ecosystems that largely resemble our own (Goodstein 2002). As ecological economists do not accept that natural and created capital are substitutes, they reject the net national welfare approach to measuring sustainability. Neoclassical economists have resource rents fully reinvested in created capital, which is described as weak sustainability, where strong sustainability is an intact stock of natural capital. If environmental quality and natural resources are not, in general, capable of restoration or substitution, it does not make sense to subtract off the reductions in natural capital from the increase in created capital to arrive at a measure of welfare (Goodstein 2002). The Daly Rule provides for protection of the stock of natural capital that does not have viable, reliable current substitutes (Goodstein 2002), and this goal should be regardless of cost to the current generation. Moreover, the stock of natural capital should be limited to the yield, that is, the flow of services from that capital, now commonly described as ecosystem goods and services (Costanza *et al*. 1997; Cork & Shelton 2000; Curtis 2003, 2004).

Closed canopy wet tropical forests have been high on the agenda for application of these economic valuation procedures owing to their species richness. Vegetation cover has long been regarded as a surrogate for habitat values and ecosystem integrity, with Mooney (1988) developing a metric that related canopy cover to species richness in a ratio of 3 : 2, except for Mediterranean ecosystems where it was 1 : 1.

Table 19.1 The now commonly accepted suite of ecosystem goods and services

Group	*Type*
Stabilization services	Gas regulation (atmospheric composition) Climate regulation (temperature, rainfall) Disturbance regulation (ecosystem resilience) Water regulation (hydrological cycle) Erosion control and soil/sediment retention Biological control (populations, pest/disease control) Refugia (habitats for resident and transient populations)
Regeneration services	Soil formation Nutrient cycling and storage (including carbon sequestration) Assimilation of waste and attenuation, detoxification Purification (clean water, air) Pollination (movement of floral gametes) Biodiversity
Production of goods	Water supply (catchment) Food production (that sustainable portion of GPP) Raw materials (that sustainable portion of GPP, timber, fibre etc.) Genetic resources (medicines, scientific and technological resources)
Life fulfilling services	Recreation opportunities (nature-based tourism) Aesthetic, cultural and spiritual (existence values) Other non-use values (bequest and quasi option values)

Sources: Curtis (2003, 2004), modified after Costanza *et al*. (1997) and Cork and Shelton (2000).

Accordingly, wet tropical forests with a high crown cover projection density are among the highest producers of ecosystem goods and services on the planet. The now commonly accepted suite of ecosystem goods and services is provided in Table 19.1.

Overconsumption of ecosystem goods and services leads to unsustainable resource use, which is akin to the tragedy of the commons (Hardin 1968). More recently the problem has been identified as intertemporal resource misallocation (Folmer *et al*. 2001). Ecological economists, however, take a different view. As indicated by the first law of thermodynamics, all of the energy and matter used by the economic system must come from the environment. Accordingly, ecological economists use material and energy flows to measure the impact of economic activities on the environment (Kaufmann 2001). In order to do so, ecological economists generate empirical models using appropriate quantitative techniques and use these results to generate feasible policies that will succeed where existing policies have been ineffective.

Spatial aspects of resource use can be as important as the temporal dimension (Gerking & List 2001). Ecosystem goods and services provided by tropical rainforests and other landscape types exist at the biosphere/atmosphere interface on a variety of scales – global, regional, bioregional or landscape – and can be assessed down to the individual landholding, whether privately held or in the public domain (Curtis 2003, 2004). While mainstream economics describes some property rights in ecosystem goods and services as incomplete, this can occur in instances where landholders may not be rewarded for ecosystem service provision because they cannot legally or cost-effectively preclude potential downstream consumers. However, the unique nature of the goods and services in question and the benefits enjoyed by the landholder of the natural resource imply a qualified rather than an absolute right, which is reinforced by the power of the owner to limit or severely curtail ecosystem service provision, by, for example, deforestation (Sheehan & Small 2002).

Economic valuation procedures

Mainstream economic valuation procedures are based in the discipline known as microeconomics, which deals with human preferences and choice amidst scarcity. The procedures include methods such as willingness to pay (WTP), an explicit stated preference as to how much an individual is willing to pay for an environmental outcome, which is often then incorporated into the most commonly applied method, the contingent valuation method (CVM), where a contingent market is described to the respondent (Mitchell & Carson 1989; Johansson 1993; Hanley & Spash 1993; Bateman & Turner 1995; Fisher 1996; Judez *et al*. 2000). However, despite the popularity of the CVM, it is possibly the least theoretically rigorous of the economic valuation methods (Allison *et al*. 1996). One reason for its popularity is probably government preference for the democratic choice-making nature of the WTP process. Other methods include: the travel-cost method, where an individuals' cost of accessing a protected area is assessed as a measure of the individuals' revealed and implicit willingness to pay to visit the area; and hedonic pricing, where the value of a view or proximity to, say, a national park can be determined by analysing housing property prices with or without the benefit (Hanley & Spash 1993). The latter method is commonly regarded as the most rigorous of the valuation procedures because it is based on an empirical database of property prices, thus avoiding the vagaries and potential bias of stated preference surveys, and the possibility of, say, multiple destinations in the instance of travel-cost (Allison *et al*. 1996). The choice modelling technique has removed some of the inherent bias in stated preference surveys, but the choice of respondents and bid levels remains contentious.

Notably, none of the neoclassical or environmental economics valuation procedures include an ecological assessment of the integrity of the ecosystem being valued. Surprisingly, this is left up to the respondents in the case of WTP surveys and choice modelling, who most probably have no experience in this field whatsoever, nor of trading in markets for ecosystem services. Travel cost from a common point of origin is the same whether accessing the Great Barrier Reef or the Daintree rainforest, which says nothing about the intrinsic or habitat value of the respective ecosystems. The economic value of recreation is not a proxy for the value of the ecosystems in question, because respondents could hardly be expected to make a conscious choice to allocate money without knowing what ecosystem goods and services are included in their allocation for recreation. In other words, are the respondents to include just direct use values or are respondents supposed also to include indirect use and non-use values, bequest, option, quasi-option and existence values?

The term value is judgement-laden and despite 50 years of development of valuation techniques by the various sub-disciplines of economics, no widely accepted method has appeared to exist that unambiguously identifies the value of a whole ecosystem, or a component of it (Lally 1999). However, this author has recently developed a new approach that has been well received by land and ecological economists, because it builds on the rigour of hedonic pricing. The methodology is based in land valuation procedures that have evolved from English common law, which in Australia have been greatly elaborated and replaced by legislation, most of which was first enacted in the late nineteenth and early twentieth centuries.

This new approach also includes an ecological assessment of the whole suite of ecosystem goods and services as to the extent of their contribution, loosely based on the work of Holdridge (1967), Holdridge *et al*. (1971), Lugo (1988), Mooney (1988) and Brown and Lugo (1982). Lugo (1988: 61) postulated that 'statistically significant relationships suggest that life zone conditions relate to characteristic numbers of tree species, biomass and rate of primary productivity, and capacity to resist and recover from disturbance'. Individual ecosystem goods and services were also weighted in a pecuniary valuation table by using the collective opinions of a group of experts in economics and the natural sciences as to their relative contribution (Curtis 2003, 2004). Criteria were anthropocentric and utilitarian, which were then sensitized to criteria such as threats, risk, uncertainty and precaution, and the resistance and resilience of ecosystems. Bias was eliminated by the use of the Delphi technique, the features of which include iteration and the anonymity of respondents.

Ecosystem goods and services are hosted in the biosphere or the land/atmosphere interface (Figure 19.1), and if property rights were to be assigned, they would be assigned to the proprietor of the estate in fee simple of the land that hosts them. Ecosystem goods and services are thus a production function of land (the *usus fructus per annum*), and can be valued in much the same way as other more traditional products, such as sugar cane or tropical fruit (Roll 1961). Most recently, the NSW Department of Environment and Conservation (DEC) published a paper dealing with biodiversity certification and banking, and proposing historic reforms, stating that it sought 'to correct market failure to recognize important biodiversity values in land prices' (DEC 2005: 3). Clearly, too, as in traditional farm products, the ecological contribution needs to be quantified by ecologists, not economists, and the accounts prepared by an accountant, prior to the landholding being valued by a valuer based on its extended productivity. Economists are not accountants, nor are they valuers. For public land, that is, National Parks, where there are no other products other than ecosystem goods and services, which includes recreation, only the *usus fructus per annum* needs to be capitalized to produce a capital value, or vice versa (Curtis 2006).

Every use of land has an opportunity cost, that being the existing use or other uses to which the land could

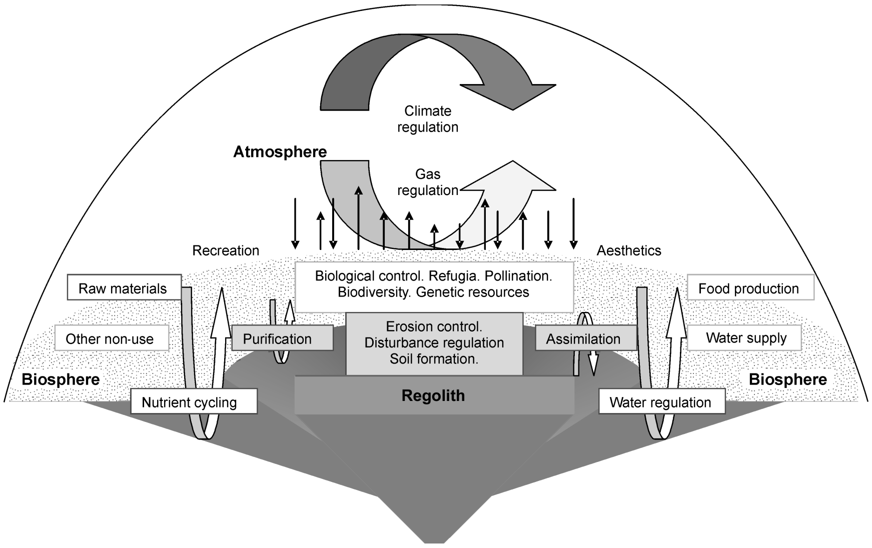

Figure 19.1 Atmosphere; atmosphere land/water interface; biosphere; biosphere/regolith interface; regolith: stratification of ecosystem services.

be put (the use forgone) (Edwards 1987; McNeeley 1988; Frank 1991). The value of a conservation area should be at least as much as the cost of preserving it, or measured by the cost of the forgone opportunities, as the area cannot be developed or redeveloped (Allison *et al*. 1996). McNeeley (1988: 33) described marginal opportunity cost as a 'very useful tool in making decisions about allocation of resources'. Moreover, McNeeley (1988: 33) argued that marginal opportunity cost 'can be used as a means by which those who will lose from having restrictions placed on their use of biological resources can be compensated to recover the value of their lost opportunity'.

Marginal opportunity cost can be expressed in terms of the annual net revenue forgone, in which case it would be capitalized, resulting in a land value in restricted and unrestricted use (McNeeley 1988, 1994). These concepts clearly link the natural production function of land with land valuation procedures. As ecosystem goods and services are the production function of land in its natural state (the *usus fructus per annum*), and as ecosystem goods and services are essential for planetary life support (Ke Chung & Weaver 1994), it could be argued that the provision of ecosystem goods and services is the highest and best use of land. It follows that the value of non-market environmental attributes can be derived indirectly by using prices from a related market that does exist (Allison *et al*. 1996), namely, the property market.

Property rights

The recent real and/or potential commodification of property rights in natural resources such as carbon, water and biota, confers three things:

- management power;
- the ability to receive income or benefits;
- an ability to sell or alienate the interest (Sheehan & Small 2002: 1).

However, the concepts of property rights of a more familiar strain are more concrete than the esoteric, incomplete or partial visions of property rights in natural resources other than land. These new forms of property rights are land property *sui generis*. Permits and licences have in a number of cases been held to be property (*Dovey* 1993; *Western Mining Corporation* 1994; *Newcrest Mining (WA) Ltd* 1997). The recognition of Native Title has also been instructive in identifying other types of property rights and quite different values ascribed to them, albeit they are still all expressions of worth. Clearly, Native Title is synonymous with the concept of usufructuary rights, which have been operational for centuries.

Sheehan and Small (2002: 11) claim that 'economic rights depend on, and are subsidiary to, the capacity of legal rights to permit and allow the holder to enjoy as a benefit … the natural resource in question'. A strong definition of property rights can ameliorate socio-economic and environmental impacts of natural resource allocation. Markets will act to provide the best allocation of property rights in natural resources, provided the rights are clarified and enforced. The crucial test of what defines a property right is fundamental to their widespread acceptance. Case history provides these insights:

- The definition, or notion of, property 'extends to every species of valuable right and interest including real and personal property, incorporeal hereditaments such as rent and services, rights of way, rights of profit or use of land of another, and chooses in action', and 'To acquire any such right is rightly described as an acquisition of property' (Starke 1944).
- 'The word "property" is often used to refer to a something that belongs to another … "property" does not refer to a thing; it is a description of a legal relationship with a thing. It refers to a degree of power that is recognized in law as power permissibly exercised over the thing. The concept of "property" may be elusive. Usually it is treated as a bundle of rights', and 'at common law there could be no "absolute property" but only "qualified property" in fire, light, air, water and wild animals' (*Yanner* v. *Eaton* 1999).

The degree to which any of the three qualities of a property right in a natural resource are conferred depends on the mix of fundamental characteristics of the particular property, and warrants closer investigation, because many variations to property rights emerged only during the past century, including such novel ideas as strata title, where a nexus was created between air space and the Crown guarantee of title residing in land (Sheehan & Small 2002: 23). However, the key determinant in any pursuit of the creation of property rights is need, and the need for market incentives for property rights in biodiversity protection is now well established in the literature, and in reality.

Recent work in the Wet Tropics of Queensland

The total value of ecosystem goods and services provided by public and private land in the Wet Tropics of Queensland World Heritage Area (WHA) was found by this author to be in the range Australian \$188–211 million year^{-1} or \$210–237 ha^{-1} yr^{-1} in 2002 (Curtis 2003, 2004). Biodiversity was ranked most highly, followed by refugia, erosion control and soil/sediment retention, genetic resources, gas regulation and climate regulation. As at 30 June 2005, the value of ecosystem goods and services in the WHA was estimated to have increased by about 94% due to population and development pressures, which while not affecting this land directly, as it is mostly protected by the World Heritage listing, is still significant as a measure of alternative land-use potential and commensurability. However, tropical rainforest on private land in the Wet Tropics bioregion, while less intact than public land, is more at risk and attracts a higher capitalization rate. As at 30 June 2005, ecosystem goods and services provided by tropical rainforest on private land were calculated by this author to be in the range \$373–446 ha^{-1} yr^{-1}.

In a paper for the International Task Force on Global Public Goods, Clemencon (2005) used this author's paper in the journal *Ecological Economics* (Curtis 2004) to demonstrate the methodological complexity in deriving individual values for ecosystem goods and services, and commented that the annual worth derived for the WHA was a dramatic return, considering the estimated cost of managing protected areas in developed countries (US\$10 ha^{-1} yr^{-1}). However, in valuation parlance, the return is the range of values given as a function of the capital value of the WHA. The cost of maintaining the WHA is an expense, and thus represents the difference between the gross and net production, and hence the yield. One does not capitalize the annual expense of maintaining a protected area over the annual value to society of the protected area, one deducts it. Clemencon's (2005) global estimate of the cost of managing protected areas in developed countries (i.e. US\$10 ha^{-1} yr^{-1}) amounts to about US\$8.94 million year^{-1} or about 0.06% of the current annual worth of ecosystem goods and services in the WHA, while James *et al.* (1999) put the cost at US\$10.90 ha^{-1} yr^{-1} for developed countries and US\$2.77 ha^{-1} yr^{-1} for developing nations. Moreover, prior to 1999, the amount spent in managing protected areas in tropical nations was just US\$0.93 ha^{-1} yr^{-1}.

The travel cost method was used by Driml (1996) to estimate consumer surplus generated by Australian tourists to the WHA and also to address criticisms of the method as not providing an absolute measure of welfare by using different ways of estimating travel cost, which led to different but statistically acceptable measures of consumer surplus. The value of recreation was found to be in the range Au\$83–166 million year^{-1}, which translated to about \$100–200 million year^{-1}

in 2002 prices, or \$112–224 ha^{-1} yr^{-1} (Driml 2002). Multipliers were used based on the results of this study to extrapolate the economic value of recreation to the local economy in the region. While the values ascribed by Curtis (2004) and Driml (2002) are not dissimilar (i.e. within the same order of magnitude), they are for different things. This author's work provided estimates for the whole suite of services, while Driml (1996, 2002) estimated only the value of recreation. Clearly, this one direct use, recreation, is not worth as much as all of the others. The travel cost method uses travel cost to access a natural area as a measure of consumer surplus, that is, a surrogate for value. However, this begs the question: the value of what? In the contingency valuation method a hypothetical market is described to respondents to elicit their WTP response to a scenario that may impact on a natural area, but are they being asked to value a specific attribute of the environment that is being impacted or the whole basket of goods and services? Psychologically it is difficult for respondents to separate out the recreational value, for example, and nominate a bid level, when in fact they have absolutely no idea what other attributes there are, what attributes are valuable and what values apply to them. As a result, the imputed price derived from studies of this kind is not just for, say, recreation, but for everything the respondent consciously or subconsciously perceives as being part of the natural environment in question, and as such it must include some indirect use and non-use values and perhaps even some option values and existence values. The same logic can be applied to the travel cost method. The economic values of the whole suite of ecosystem goods and services are constrained within measures that are consistent with all other uses to which land is put and other avenues of investment in the economic system. The values of individual ecosystem services are constrained within this overall basket of goods and services on a landscape or bioregional scale, but in some ecosystems certain goods and services may be worth more than others based on scarcity or limiting factors.

Other work in Australia and overseas

Costanza *et al.*'s (1997) seminal study of the value of ecosystem services in the global biomes has recently been updated and used by Blackwell (2005) to derive values for the coastal regions in Australia including up to 3 kilometres inland. Temperate and boreal forests were again within the same order of magnitude as other studies (Au\$543 ha^{-1} yr^{-1}), but the mean for global forests was Au\$1743 ha^{-1} yr^{-1} and the value of tropical forests a full order of magnitude above all other preceding and later studies (Au\$3609 ha^{-1} yr^{-1}).

Rolfe and Bennett (2002) used the choice modelling technique to assess people's value preferences for conservation of rainforests in Queensland, New South Wales and overseas. A random sample of Brisbane residents was asked to reveal their preferences and to address the issues of location, features and qualities of the choices. It was found to be important to be able to distinguish between different components of value and to prioritize between a set of alternatives. The respondents chose location as possibly the most important attribute to them, and being Brisbane residents the results showed that they were parochial in ranking the choices as Queensland, then Australia, and overseas.

A contingency valuation study was undertaken by Duthy (2002) to determine community support for dedication of the Whian Whian State Forest in north-eastern NSW as a new National Park. Whian Whian is one of the largest remaining sub-tropical rainforests in New South Wales. The two most important uses of the forest were found to be water catchment protection and habitat for endangered species. Respondents placed strongest values on bequest, existence and non-consumptive use values, and weakest on the productive functions of Whian Whian. The mean willingness to pay for the non-consumptive use and non-use values was Au\$18.89 $year^{-1}$ for three years (median \$10). The population from which the sample was drawn was 119 148; thus the value of non-consumptive uses and non-uses was put at \$1.19 million $year^{-1}$ using the median bid, to \$2.25 million $year^{-1}$ using the mean bid, excluding the recreation value ascribed to potential visitors from outside the area. Whian Whian comprises 5567 hectares of State Forest, so these WTP estimates equate to a range of from \$214 to \$404 ha^{-1} yr^{-1} for non-consumptive uses and non-uses. Moreover, Duthy (2002) argued that by transferring recreational values estimated for Dorrigo National Park and Gibraltar National Park, also in northern NSW, these could add another \$264–298 ha^{-1} yr^{-1} to the total for Whian Whian. In respect of this possible benefit transfer to add to the gross hectare values for Whian Whian, this author's same comments apply as to the value of recreation in the WHA of Queensland. The values of recreation elicited for Dorrigo and Gibraltar National Parks must include a component of indirect and non-use values and possibly also some option, bequest and existence values, so to use benefit transfer in such an unqualified way could amount to double counting.

Perhaps the best, but not so recent, example of financing environmental services on both public and private land is the Costa Rican experience (Chomitz *et al*. 1998). Costa Rica's forest cover decreased from more than 50% in 1950 to 29% in 1986, and thence reduced overall by 1.1% per year, with a much lower rate for the areas under World Heritage protection by 1997. Secondary forest, including plantation forest, covers about three-quarters of the deforested area. Economic values were estimated by Kishor and Constantino in 1993 for some use and non-use services at US$162–214 $ha^{-1} yr^{-1}$, the majority ascribed to carbon sequestration (US$120) (Chomitz *et al*. 1998). In 1996, Costa Rica passed a new forestry law that permitted landholders to be compensated for providing some environmental services. The law (no. 7575) explicitly recognized four environmental services of forests: carbon fixation, hydrological services, biodiversity protection and provision of scenic beauty. The implementation rules for the new law were adopted in 1997. A unique set of institutional arrangements was being put in place contemporaneously to enable the creation of markets for the forest's environmental services. Some of these novel arrangements revolved around the joint implementation (JI) and clean development mechanism (CDM) provisions under the Kyoto Protocol. There is no link between the provision of services and financing as the government acts as an intermediary to sell the services, and the funds realized are used to finance the services, including those provided by national parks and other public land. Payments to landholders under the programme currently reimburse them for four types of actions over a 5-year period, after which time they are free to renegotiate or deal direct, but they commit to manage or protect the forest for 20 years, which is recorded on the public land register (Table 19.2).

At the start of the programme earlier incentive programmes already covered 145 000 hectares. In 1997, a further 79 000 hectares were placed under forest protection and 10 000 hectares under forest management, and 6500 hectares were destined for reforestation, for a gross payment to landholders of US$14 million. In 1998, the waiting list or excess demand, was estimated to be of the order of 70 000 hectares.

With the emergence of market-based instruments for environmental outcomes, financial incentives and rewards for environmental stewardship on private land and resource rent as it applies to access to national parks by commercial operators, markets are emerging for land set aside for conservation and other environmental benefits. Clearly for conservation to be a viable alternative land use it must be competitive with other uses to which land could be put, or no one will pay for it. Despite the use of many environmental valuation procedures, including this author's new approach based on opportunity cost, comparison of a range of work and programmes does evidence a surprising synergy in the valuation of ecosystem goods and services provided by rainforests. This synergy could be attributed to the similarity of people's expressed and

Table 19.2 Payment schedule to landholders for conservation contracts in Costa Rica

Activity	*Min. Area (ha)*	*Max. Area (ha)*	*Total payment (US$ ha^{-1} over 5 years)*	*Yr 1*	*Yr 2*	*Yr 3*	*Yr 4*	*Yr 5*
Reforestation	1	any	480	240	96	72	48	24
Natural forest management	2	300	321	161	64	32	32	32
Regeneration	2	300	200	40	40	40	40	40
Protection	2	300	200	40	40	40	40	40

Reforestation by organizations of small producers is limited to a maximum area of 10 ha. Exchange rate approx 250 colones/US$1, March 1998.
Source: modified after Chomitz *et al*. (1998).

Table 19.3 Selected valuation studies or payments made for environmental stewardship of forests on a dollar per hectare basis

Researcher/author	*Subject of the research*	*Lower range Au\$ $h^{-1} yr^{-1}$*	*Upper range Au\$ $h^{-1} yr^{-1}$*
Bennett 1995	Dorrigo National Park, NE NSW Australia (economic value of recreation)		1500
Bennett 1995	Gibraltar Range National Park, NE NSW Australia (economic value of recreation)		46
Blackwell 2005	Boreal and temperate forests (ecosystem services)		543
Blackwell 2005	Global forests (ecosystem services)		1743
Blackwell 2005	Tropical rainforests (ecosystem services)		3609
Castro 1994	Costa Rica Wildlands (all services)	170	357
Chomitz *et al.* 1998*	Costa Rica (various environmental stewardship practices)	40	96
Costanza *et al.* 1997	Global biomes (all services)		1343
Curtis 2004	Wet Tropics Queensland, Australia (all ecosystem goods and services within tenures)	210	236
Curtis 2004	Wet Tropics Queensland, Australia (all ecosystem goods and services across tenures)	149	342
Curtis (this publication)	Wet Tropics Queensland, Australia (ecosystem services, rainforest on private land)	373	446
Davis *et al.*, in Duthy 2002	Gibraltar Range and Dorrigo National Parks, NE NSW Australia (recreation)	264	298
de Groot 1994	Panama's forests (use and non-use values)		835
Driml 2002	Wet Tropics Queensland, Australia (Tourism)	112	224
Duthy 2002	Whian Whian National Park, NE NSW Australia (use and non-use values)	214	404
Flatley & Bennett 1996	Vanuata tropical rainforest on the islands of Erromango and Malakula (conservation)		87
Gillespie 1997	Budderoo National Park, SE NSW Australia (economic value of recreation)		809
Kishor & Constantino in Chomitz *et al.* 1998	Costa Rican forests (use and non-use services)	162	214
Lockwood & Carberry 1998	Southern Riverina, Victoria, Australia (preserve remnants)	38	87
Lockwood & Carberry 1998	NE Victoria, Australia (preserve remnants)	43	98
Pimental in Myers *et al.* 1997	Global rainforests (sustainable use value)		367
Tobias & Mendelson 1991	Monte Verde Cloud Forest Reserve, Costa Rica (domestic recreational value)		20

*Denotes environmental payment scheme.
Studies more than 10 years old have been adjusted to 2002 values.

revealed preferences, and perhaps subliminal awareness of scarcity and risk factors that are demonstrated by higher values being attributed to regions most at risk due to population density and development pressures.

Summary

- The methodologies and examples described in this chapter evidence a range of economic, valuation, ecological and statistical procedures used in order to develop an objective approach to valuing ecosystem goods and services provided by tropical rainforests.
- Property rights in ecosystem goods and services are not incomplete as postulated by mainstream economists, but new forms of unique property rights in natural resources, which are supported by case law in Australia.
- In the most part, estimates of the pecuniary value of the ecological benefits provided by tropical forests internationally fall well within one order of magnitude, but the amount spent on management in developed and developing nations is a full order of magnitude different.
- Tropical forest managers should be proactive in the development of initiatives to develop financial

incentives for the protection of tropical forests on both public and private land, à *la* Costa Rican experience. These may not be limited to resource rents by way of entry fees by commercial operators to protected areas, but extended to include biodiversity credits, water resources, assimilation services, pollination services and soforth on both private and public land, with funding from external organizations that may be affected downstream to institute best practice environmental management of tropical rainforests and upstream catchments.

References

Allison, G., Ball, S., Cheshire, P., Evans, A. & Stabler, M. (1996). *The Value of Conservation? A Literature Review of the Economic and Social Value of the Cultural Built Environment for the Department of National Heritage, and the Royal Institution of Chartered Surveyors*. Royal Institution of Chartered Surveyors, London.

Aronsson, T. & Lofgren, K.-G. (2001). Green accounting and green taxes in the global economy. In *Frontiers of Environmental Economics*, Folmer, H., Landis Gabel, H., Gerking, S. & Rose, A. (eds). Edward Elgar, Cheltenham, UK.

Bateman, I. J. & Turner, R. K. (1995). Valuation of the environment, methods and techniques: The contingent valuation method. In *Sustainable Environmental Economics and Management*, Turner, R. K. (ed.). John Wiley & Sons, London.

Bennett, J. (1995). *Economic Value of Recreational Use: Gibraltar Range and Dorrigo National Parks*. A report prepared for the Environmental Economics Policy Unit, Environmental Policy Division, NSW National Parks and Wildlife Service.

Brown, S. & Lugo, A. E. (1982). The storage and production of organic matter in tropical forests and their role in the global carbon cycle. *Biotropica* **14**: 161–87.

Blackwell, B. (2005). *The Economic Value of Australia's Natural Coastal Assets: A Preliminary Estimate of the Ecoservices of Some of Australia's Natural Coastal Assets*. Coastal CRC, Indooroopilly, Brisbane.

Castro, R. (1994). *The Economics Opportunity Costs of Wildlands Conservation Areas: The Case of Costa Rica*. Department of Economics, Harvard University.

Chomitz, K. M., Brenes, E. & Constantino, L. (1998). *Financing Environmental Services: The Costa Rican Experience and its Implications*. Environmentally and Socially Sustainable Development, Latin America and Caribbean Region, World Bank, Washington, DC.

Clemencon, R. (2005). *Costs and Benefits of Global Environmental Public Goods Provision*. International Task Force on Global Public Goods, University of California, San Diego.

Cork, S. J. & Shelton, D. (2000). The nature and value of Australia's ecosystem services: a framework for sustainable environmental solutions. In *Sustainable Environmental Solutions for Industry and Government*, Proceedings of the 3rd Queensland Environmental Conference, May 2000. Environmental Engineering Society, Queensland Chapter, The Institution of Engineers, Australia, Queensland Division, and the Queensland Chamber of Commerce and Industry, pp. 151–9.

Costanza, R., d'Arge, R., de groot, R. *et al*. (1997). The value of the world's ecosystem services and natural capital. *Nature* **387**: 253–60.

Curtis, I. A. (2003). Valuing ecosystem services in a green economy. PhD Thesis, James Cook University, Cairns Campus.

Curtis, I. A. (2004). Valuing ecosystem services: a new approach using a surrogate market and the combination of a multiple criteria analysis and a Delphi panel to assign weights to the attributes. *Ecological Economics* **50**(3/4): 163–94.

Curtis, I. A. (2006). Valuing the environmental impact of a power line corridor through a State Forest in Queensland: a heuristic exercise in environmental valuation for the property profession. *Australian Property Journal* **39**(2): 87–96.

de Groot, R. S. (1994). Environmental functions and the economic value of natural ecosystems. In *Investing in Natural Capital: The Ecological Economics Approach to Sustainability*, Jansson, A. N., Hammer, M. & Costanza, R. A. (eds). Island Press, Washington, DC, pp. 151–68.

Department of Environment and Conservation NSW (DEC) (2005). *Biodiversity Certification and Banking in Coastal and Growth Areas*. Dept of Environment and Conservation (NSW), Sydney South, July.

Dovey v. *The Minister for Primary Industries* (1993). 119 *ALR* 108.

Driml, S. (1996). Sustainable tourism in protected areas? An ecological economics case study of the Wet Tropics World Heritage Area. PhD thesis, Australian National University, Canberra.

Driml, S. (2002). Travel cost analysis of recreation value in the Wet Tropics World Heritage Area. *Economic Analysis and Policy* **32**(2) special issue: 11–26.

Duthy, S. (2002). Whian Whian – state forest or national park? Community attitudes and economic values. *Economic Analysis and Policy* **32**(2) special issue: 91–111.

Edwards, S. F. (1987). *An Introduction to Coastal Zone Economics: Concepts, Methods and Case Studies*. Taylor & Francis, New York.

Fisher, A. C. (1996). The conceptual underpinnings of the contingent valuation method. In *The Contingent Valuation of Environmental Resources*, Bjornstad, D. J. and Kahn, J. R. (eds). Edward Elgar, Cheltenham, UK.

Flatley, G. W. & Bennett, J. W. (1996). Using contingent valuation to determine Australian tourists' values for forest conservation in Vanuatu. *Economic Analysis and Policy* **26**(2): 111–27.

Folmer, H., Landis Gabel, H., Gerking, S. & Rose, A. (eds) (2001). *Introduction. Frontiers of Environmental Economics*. Edward Elgar, Cheltenham, UK.

Frank, R. H. (1991). *Microeconomics and Behaviour*. McGraw-Hill, New York.

Gerking, S. & List, J. (2001). Spatial economic aspects of the environment and environmental policy. In *Frontiers of Environmental Economics*, Folmer, H., Landis Gabel, H., Gerking, S. & Rose, A. (eds). Edward Elgar, UK.

Gillespie, R. (1997). *Economic Value and Regional Economic Impact of Minnamurra Rainforest Centre, Budderoo National Park*. NSW National Parks and Wildlife Service.

Goodstein, E. S. (2002). *Economics and the Environment*, 3rd edn. John Wiley & Sons, New York.

Hanley, N. & Spash, C. L. (1993). *Cost Benefit Analysis and the Environment*. Edward Elgar, Cheltenham, UK.

Hardin, G. (1968). The tragedy of the commons. *Science* **162**: 1243–8.

Holdridge, L. R. (1967). *Life Zone Ecology*. Tropical Science Centre, San Jose, Costa Rica.

Holdridge, L. R., Grencke, W. C., Hatheway, W. H., Liang, T. & Tosi, J. A. Jr (1971). *Forest Environments in Tropical Life Zones: A Pilot Study*. Pergamon Press, Oxford, UK.

James, A. N., Green, M. J. B. & Paine, J. R. (1999). *Global Review of Protected Area Budgets and Staff*. WCMC, Cambridge UK.

Johansson, P.-O. (1993). *Cost – Benefit Analysis of Environmental Change*. Cambridge University Press, Cambridge, UK.

Judez, L., de Andres, R., Perez Hugalde, C., Urzainqui, E. & Ibanez, M. (2000). Influence of bid and subsample vectors on the welfare measure estimate in dichotomous choice contingent valuation: Evidence from a case study. *Journal of Environmental Management* **60**: 253–65.

Kaufmann, R. (2001). The environment and economic well-being. In *Frontiers of Environmental Economics*, Folmer, H., Landis Gabel, H., Gerking, S. & Rose, A. (eds). Edward Elgar, Cheltenham, UK.

Ke Chung, K. & Weaver, R. D. (1994). Biodiversity and humanity: paradox and challenge. In *Biodiversity and Landscapes: A Paradox of Humanity*, Ke Chung, K. and Weaver, R. D. (eds). Cambridge University Press, Cambridge, UK.

Lally, P. (1999). Identifying non-market public amenity value using a values jury. *Australian Property Journal* February: pp. 436–42.

Lockwood, M. & Carberry, D. (1998). *State Preference Surveys of Remnant Native Vegetation Surveys*. Johnstone Centre Report No. 104. Charles Sturt University, Albury, 24.

Lugo, A. E. (1988). Estimating reductions in the diversity of tropical forest species. In *Biodiversity*, Wilson, E. O. (ed.). National Academy of Sciences Press, Washington, DC.

McNeeley, J. A. (1988). *Economics and Biological Diversity: Developing and Using Economic Incentives to Conserve Biological Resources*. IUCN. Gland, Switzerland.

McNeeley, J. A. (1994). Lessons from the past: forests and biodiversity. *Biodiversity and Conservation* **3**: 3–20.

Mitchell, R. C. & Carson, R. (1989). *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Resources for the Future, Washington, DC.

Mooney, H. A. (1988). Lessons from Mediterranean-climate regions. In *Biodiversity*, Wilson, E. O. (ed.). National Academy of Sciences Press, Washington, DC.

Myers, N. (1997). The world's forests and their ecosystem services. In *Nature's Services: Societal Dependence on Natural Ecosystems*, Daily, G. C. (ed.). Island Press, Washington, DC.

Newcrest Mining (WA) Ltd v. *Commonwealth* (1997). 147 *ALR* 42.

Rolfe, J. & Bennett, J. (2002). Assessing rainforest conservation demands. *Economic Analysis and Policy* **32**(2) special issue: 51–67.

Roll, E. (1961). *A History of Economic Thought*. Faber and Faber, London.

Sheehan, J. & Small, G. (2002). Towards a definition of a property right. Paper presented at the Pacific Rim Real Estate Society (PRRES) Conference, Christchurch, New Zealand,

Starke, J. In *The Minister for the Army* v. *Dalziel* (1944). 68 *CLR* 290 (Dalziel).

Tobias, D. & Mendelsohn, R. (1991). Valuing ecotourism in a tropical rain-forest reserve. *Ambio* **20**(2): 91–3.

Western Mining Corporation v. *Commonwealth* (1994). *121 ALR 661*.

Yanner v. *Eaton* (1999). HCA 53, at 8 per Gleeson CJ, Gaudron Kirby & Hayne JJ.