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Valuing the Economic Loss of or Modification of the Ecosystem Services provided by the Forest

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Benefit transfer procedures, along with an opportunity cost valuation, is used to assess the economic loss to the landholders of a large scale unauthorised logging operation in the Middle Fly region of the Western Province of Papua New Guinea. Loss of or modification of the ecosystem services provided by the forest were estimated to be in the vicinity of 56 million PNG Kina per annum, or a net present value of in excess of 500 million PNG Kina depending on choice of discount rate. The matter is currently before the National Court of Papua New Guinea for a ruling to determine the quantum of compensation due to the customary landowners.

Unauthorised logging was carried out by the contractors of a road to connect Aiambak and Kiunga in the Middle Fly region, Western Province, Papua New Guinea. The environmental plan that was accepted and presumably agreed to, provided for selective logging along the road perimeter up to one kilometre either side of the road, in order to pay for the road.

The activities took place between about 1994 and 2004. Contrary to the proposal and agreement, the contractor principal companies constructed a very much inferior road, which is unusable, and which is the source of many ongoing

environmental problems. After ten years of construction and logging, the road did not even reach its destination (Kiunga). During the process, the contractor principal companies extracted a large timber resource, pushing roads and logging tracks into the pristine lowland forest for up to 20kms off the main track. Apparently no attempt was made to comply with the PNG Code of Practice for (even) Logging Roads, and no attempt was made to comply with PNG Environmental Practice. As a result the customary landowners are left with severe environmental problems, and an unusable road. The ecosystem services of the formerly intact and untouched forest have been severely modified or reduced.

The customary landholders lead a truly subsistence lifestyle, and as such this invasion and wanton destruction of their livelihood resources has a far greater impact on them than for other more developed societies.

The economic value of the loss of/or modification of forest ecosystem services has been estimated to be in the vicinity of (PNG)K56,000,000 per year.

BACKGROUND

The author was engaged after having perused the reports prepared by Dr D R Melick (2003) and Tom Diwai Vigus (2008), by the Centre for Environmental Law and Community Rights (CELCOR) in Papua New Guinea, and as a result of the relevant directions made by the National Court of Papua New Guinea. CELCOR are advised and assisted by the Environmental Defenders Office of NSW (EDO), Australia.

The first defendant, Paiso Limited, is a landowner group ostensibly representing the customary landowners of the Middle Fly, Western Province. Paiso Limited applied for and was granted a Timber Authority TA; 024 on the 18th April 1994. The second defendant, Concord Pacific Limited, was engaged to conduct the timber harvesting as recompense for the construction of a road connecting Aiambak with Kiunga, as outlined in the Environmental Plan. The Environmental Plan prepared by Paiso Limited provided for a 40 metre wide road surface including shoulders, and selective logging of the land along the perimeter of the road. The area where logging was permitted extended 1000 metres each side of the road, for the full 246 kilometres distance (adjusted to 195km according to Mellick 2003). Selective logging ahead of the road construction was permitted to aid financing construction of the road; however it was assumed that such logging would be within the agreed corridor.

Such arrangements in Papua New Guinea, and other developing nations, do not always proceed in accordance with the expectations of the landowners. AusAid has found that in Papua New Guinea; "once the representatives of the incorporated land group have signed

the Forest Management Agreement, the National Forest Service has very little more to do with the incorporated land groups. No assistance is provided to the groups to learn how to involve themselves in business opportunities offered by the timber industry and the Forestry Act prevents landowners from negotiating directly with logging companies. The National Forest Service says it lacks the funds to help land groups with their financial management and business opportunities." As a result, "most logging companies have not become involved in the social and economic welfare of the people on whose land they are cutting down trees" (Power, T. AusAid. Undated), moreover, AusAid reference a 2001 World Bank review of 32 proposed logging projects which found that over 90 per cent of landowners were not aware of the implications of belonging to an incorporated land group. Even fewer landowners were aware of the possible economic opportunities provided by their incorporation into a land group, or the responsibilities of the group's leaders" (Power, T. AusAid. Undated)

Land in Papua New Guinea is currently 97% held as Customary Land in a mostly Patrilineal system, where there is no formal land titles and/or registration (Anderson, T. University of Sydney, 2006). As such, formal valuations of land are only able to be undertaken in the City and Town areas, where land has been alienated, a market exists, and there is a record of sales that have taken place. Sale price evidence is a mainstay of the principles of the valuation of land (Curtis 2004).

The landowners in the Middle Fly lead a truly subsistence lifestyle and rely completely on the natural resources provided by their land and waterways. Any loss of these natural resources has far and broad-reaching consequences, involving far more than money. Loss of possession includes "the natural resources and customs such as livelihood practices for which they may claim rights or ownership" (Snyder et al., 2003). Loss of possession also refers to broad but interrelated categories of loss, namely:

- Loss of possession; ie. "which implies a value which is alienable or more or less amenable to economic compensation;" and,
- Loss of kinship or belonging, "which involves an intimate bond or sense of place, which is inalienable."

Research has shown that full regeneration of a tropical lowland forest can take up to about 80 years (Brown and Lugo 1990), depending on the level of disturbance, during which time invasive and opportunistic species can establish and invade cleared areas and forest edges. Vigus (2008) cites a number of authorities who assert a longer period up to 300 years for full recovery to resemble a primary rainforest in biomass and species diversity. Over time it is the lack of direct light due to the regenerating forest that contributes to the demise of the opportunists, and the forest returns to its former state as a secondary rainforest.

> "up to 300 years for full recovery to resemble a primary rainforest in biomass and species diversity…

The Environmental Plan clearly states that by far the majority of logging activity was to take place away from villages and traditional resource harvesting areas where 'sense of place' is more pronounced. Reports prepared post logging by Dr D R Mellick (2003) and Tom Diwai Vigus (2008) appear to confirm this, as do research by the University of Papua New Guinea, and this author's observations of satellite images.

If this is established beyond a reasonable level of doubt, Category 1 above would apply, and the economic cost of the environmental damage would theoretically be able to be calculated. It is in the jurisdiction of the Courts to determine how this damage is to be compensated.

As the author of this report has not had the opportunity to inspect the environmental damage first hand, the reports by Dr D R Melick and Tom Diwai Vigus are relied on as portraying a reasonable and accurate description of the environmental impact. These reports are filed with the National Court of Papua New Guinea, Waigani.

THE ENVIRONMENTAL IMPACT AND LOSS OF ECOSYSTEM GOODS AND SERVICES DUE TO THE ROAD CONSTRUCTION AND LOGGING ACTIVITIES

Unauthorised logging activities far in excess of the agreed one kilometre each side of the road have caused significant environmental damage, including the direct impacts of tree and canopy loss and collateral tree damage and sapling loss due to tree-fall; a change in the nutrient balance; collateral vegetation damage and soil compaction on logging tracks by the use of heavy machinery; and, indirect environmental impacts by way of the potential for erosion, particularly on the new and steeper logging tracks, leading to increased sediment loads to the creeks and rivers downstream; potential for weed invasion in canopy gaps; promotion of pioneer species and the suppression of 'oskars'.

The agreed envelope to encompass both the road and the area to be logged, as described in the Environmental Plan, was to be about 50,000 hectares. However, research by the Remote Sensing Centre at the University of Papua New Guinea using satellite imagery, reveals a logging and road construction footprint closer to 200,000 hectares. Maps based on

satellite imagery were provided to Tom Vigas along with GPS points, which were included in his report (2008).

'Environmental impact' for the purposes of this paper is defined as 'the loss of or reduction or modification of ecosystem goods and services provided by the land impacted by logging, collateral damage and edge effects'. It does not include the value of timber removed.

Edge effects can encompass both human induced and other biophysical effects, including microclimate variables across the ecotone. Wider corridors or larger gaps are shown to have a more significant impact than narrow corridors or smaller gaps due to depth of penetration of the various effects into the forest. The effects are more pronounced in closed canopy environments closer to the edge, ie. rainforest, however they still exist and extend further into an open forest environment than a closed forest environment. Photosynthetically active radiation (PAR) reaching the forest floor has a significant relationship with distance from clearing, leading to possible emergence of alien species at the edge.

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Soil surface temperatures both on the surface and at 10cm depth are highest at the edge and extend inwards depending on the orientation of the corridor and season (declination of the sun). Air temperatures and vapour pressure deficits have more pronounced gradients for open canopy forests than closed canopy forests, which has implications for regeneration. Overall, linear clearing impacts on microclimate decrease with distance from the edge. Wide clearings or gaps without canopy retention allow greater invasion of weeds, and result in greater penetration of disturbance indicator species (Goosem and Turton 2000).

The reports of Dr D R Mellick (2003) and Tom Diwai Vigas (2008) provide firsthand accounts of the environmental and landscape damage due to the road construction corridor and logging activities.

Mellick (2008) asserts that the road construction project fails in its primary intent of delivering a permanent dry weather road connecting Aiambak and Kiunga. Poor road design and construction techniques, and failing to comply with the PNG Logging Code of Practice for even a 'logging road', let alone a road that will provide a reasonable level of service to these remote communities, has been shown to be incontrovertible evidence of a carefully contrived 'scam' to defraud the landowners in the Middle Fly and the Lake Murray Resource Owners Association (LMROA) region, of a valuable natural resource.

Both Dr D R Mellick (2003) and Tom Diwai Vigas (2008) refer to the very many, up to 49, major secondary roads and numerous tertiary roads and skid tracks leading off the main road, that were used to access timber resources. Only 8 of these roads can be accounted for to access villages. Dr Mellick recorded 232 direct violations of the PNG Logging Code of Practice with the highest level of incidental losses (collateral damage) recorded in the literature. Undersized logs were commonplace and reject logs were burnt or buried. Other large areas of forest were burnt out due to negligence in maintaining burning refuse piles. Many contraventions of the PNG Environment Act 2000 were also recorded. Tom Diwai Vigus records many interviews with the people of the region, and demonstrates in many ways the connectedness the clans have with

their customary lands. The value of the timber removed and shipped was in excess of 137 million PNG Kina, although Vigus estimates a total loss of the timber resource due to wastage of 157 million PNG Kina

However, the most cogent issue addressed in this paper, is that the impact area is some four times the area proposed under the Environment Plan, and four times the impact area presumably agreed on by the parties.

APPROACH

Murray, J. (1954, 1967), asserts that the task of a valuer is to use as many approaches as are possible under a particular set of circumstances to weigh all the evidence and determine a value that can be supported in a court of law.

The property market does not exist on customary land in Papua New Guinea, however there are markets for produce, which can elicit potential earnings on land by a family group. This can be both seen as an opportunity cost method of valuation, which when combined with land for housing and gardens, and other benefits from the forests, such as 'subsistence' value from customary land such as access to materials for medicines, fuels, fences, weapons, tools, canoes, textiles, string bags, cords, musical instruments, artworks, articles of personal adornment, ritual and magic (the equivalent value of these resources is difficult to calculate), can provide vital insight into the landowner's perceptions of value. Evidence also exists for rental values of land given over for resource extraction, or for example, the growing of Oil Palm Plantations. If these truly represented a 'market' price for land and resource leases in Papua New Guinea, they could be capitalised to arrive at a capital value. However, Anderson (2006) clearly states that the quantum of resource rents paid is very low (10 to 20 PNG Kina $ha^{-1}yr^{-1}$), and greatly undervalues land in Papua New Guinea.

Anderson's work on opportunity cost in 2006 established a base-line income level of 13,500 PNG Kina per family group of 7 (mother and father and five piccaninnies), although some families can and do earn up to 18,000 Kina by adding in external employment. The estimates were based upon what the equivalent food, housing and other essentials would have cost if they were living in a town area, such as Madang. It does not include materials for medicines, fuels, fences, weapons, tools, canoes, textiles, string bags, cords, musical instruments, artworks, articles of personal adornment, ritual and magic, etc. This is useful data when attempting to assess equitable recompense for loss of opportunity or resources. It becomes more valuable when the population of the regions is known.

> "The Oxford Dictionary defines Usufruct as: 1.Law. "The right of temporary possession…

The PNG Electoral Commission put the population of the Middle Fly, Western province to be 55,853 in 2005. Moreover, the National Population Census put the population of the Lake Murray Land Owners Group region to be 9,796 in 2002.

The ancient Roman and Scots' legal and economic principle of usufruct is applicable in any valuation of natural resources, including ecosystem goods and services. The Oxford Dictionary defines Usufruct as: 1.Law. "The right of temporary possession, use, or enjoyment of the advantages of property belonging to another (or in common), so far as may be had without causing damage or prejudice to this. Usufruct is the power of disposal of the use and fruits, saving the substance of the thing". This definition is easily understood when it is considered that land (real property or real estate) has long since been regarded as different from personal property.

Thomas Jefferson's letter to James Madison on September 6, 1789, explains that the legal concept of usufruct can be traced back at least as far as ancient Roman law and has changed little over the centuries. In Jefferson's time, as now, "usufruct" referred to "the right to make all the use and profit of a thing that can be made without injuring the substance of the thing itself. It was a term used to describe the rights and responsibilities of tenants, trustees, or other parties temporarily entrusted with the use of an asset -- usually land." (Constitutional Law Foundation, USA).

Sir William Petty (1623-1687), Valuer General for Ireland, believed that capitalization of all of the profit and benefit produced by land held in the public domain was a logical economic step to take to determine capital value, or vice versa (Roll 1961). However, Petty was uncertain as to how to determine the rate of return from land other than using the surplus from production as rent, but came up with an ingenious solution. Petty determined that the usufructuary rights to land of three generations of humans would be a reasonable estimate, and as three life expectancies in England in the 17th Century were 120 years, he computed the value of land at twenty one year's purchase of its annual rent, or in money-capital terms, a capitalisation rate of 4.76% (Roll 1961). The productivity method of valuation therefore enables a valuer to determine the capital value of a property from the passing rent (or subsistence income – usus fructus per annum), or vice versa, the economic rent from the capital value, using market capitalisation rates.

In order to arrive at a benchmark for a range of values of ecosystem goods and services formerly provided by the forest, benefit transfer methodology is used. This methodology has broad application world-wide, as ecosystem valuation has proliferated during the last decade. The studies selected include many of forest ecosystems, and often in developing nations. A statistical analysis of a selection of studies within a range of values, including similar vegetation types, may provide an insight into the appropriate range of values to be awarded for compensation. In order to 'ground-truth' the results, they are compared to Anderson's (2006) study on opportunity cost in PNG and the population statistics in the LMROA and the Middle Fly region.

THE VALUE OF ECOSYSTEM GOODS AND SERVICES PRIOR AND POST UNAUTHORISED LOGGING ON THE SUBJECT PROPERTY

'Environmental impact' for the purposes of this report is defined as 'the loss of or reduction or modification of ecosystem goods and services provided by the land impacted by logging, collateral damage and edge effects'. The spatial extent of the environmental impact of the unauthorised logging has been estimated at 150,000 hectares, including direct impact, collateral damage due to tree-fall and movement of heavy machinery, gaps created due to tree-fall, logging tracks and staging areas, edge effects and flow on effects. Moreover, considering the real threats of weed invasion, the risk of severe erosion without immediate remediation of the poorly engineered logging tracks, and the uncertainty of downstream effects such as high sediment loads to rivers and streams, this is considered a conservative estimate.

Prior to the road construction and logging enterprise, the approximate route of the road was considered to be in as

natural a state as any lowland tropical rainforest, which has only been subject to subsistence resource extraction by hand, and perhaps hand tools. Mechanised tools were possibly limited to those that could be carried by hand, for example, chainsaws. Timber extraction would have been small scale, and limited to timber for housing and canoes. No timber had been cut for export. Ecosystem goods and services could be argued to have been 100% intact, considering the low use levels of the people of the Middle Fly. Moreover, the road route was well removed from their traditional high use areas around Lake Murray.

The unauthorised logging adjacent to and extending outwards from the agreed corridor clearly has had an environmental

> "Post road construction and logging they have been diminished by up to 80% where impact is greatest…

impact, all the more particularly owing to its pristine condition. Gas regulation (atmospheric composition) and climate regulation are diminished, disturbance is exacerbated, erosion is increased, genetic resources and biological control are diminished. Potential flow-on effects include increased sediment loads to the streams and rivers, suppression of climax species (oskars) in favour of pioneer species, and weed invasion. Opportunistic and invasive species will capitalise on the hot and dry conditions prevalent in tree fall gaps and alongside the road and skid tracks well into the forest. These species are of particular concern along the margins of intact forest. None of these species will penetrate into the intact forest due to high moisture levels and lack of heat and light.

The value of the forest ecosystem goods and services would have been close to the maximum possible prior to road construction and logging. Post road construction and logging they have been diminished by up to 80% where impact is greatest, logging tracks, staging areas, clear fell areas, down to 40% where the impacts are collateral, tree fall damage to other vegetation, including 'topping' etc. Every tree removed would have damaged surrounding vegetation, and depending on the size of the tree being felled, this could amount to up to one half of a hectare per tree fall.

METHODOLOGY

Examination of a selection of 22 case studies between 1994 and 2004, involving both valuation of ecosystem services and payment for ecosystem services in both developed and developing nations has revealed a range of both lower and upper values (Table 1).

Applying the now preferred practice of 'Benefit Transfer', where no other stated or revealed preferences can be elicited, and no surrogate market such as land values exists, will help to determine a range of values for the loss of ecosystem goods and services due to the unauthorised logging outside the agreed corridor.

'Benefit Transfer' uses economic data captured at one place and time to provide inferences about the eco-value at another place and time. The database of past studies represents an empirical stock of data knowledge, which is invaluable if properly applied. Benefit transfers can only be as accurate as the initial benefit estimates; however, a portion of measurement error can be passed through unless care is taken.

The 22 case studies used have been deemed to be appropriate considering the limited timeframe. The data set has been charted on a log scale, and after reviewing the descriptive statistics of the data set, it was decided to remove the outliers (lowest and highest orders of magnitude). These case studies are all valuations of forests, and in some cases claim to value specific aspects of them, insofar as their contribution to human well-being. They also utilise a variety of the accepted methods, which also tends to limit the biases of any one particular method.

Eleven of the 22 case studies give both an upper and a lower value range for the ecosystem services provided by the forest valued. Both the mean and median values were calculated for the total combination of upper and lower values, then the lower values alone and the higher values alone.

Anderson's (2006) work on opportunity cost valuations in Papua New Guinea resulted in an average annual sustainable income per family group of seven, of 13,500 Kina, up to a high of 16,000 Kina for those that specialised on growing a few specialty items for markets. By far the majority of the people only cultivate small areas, of say one or two hectares. Reliable information such as this can be used as a comparison with other non-market valuation methods, and it is used in this paper.

RESULTS

The areal impact on the forest occasioned by logging activities outside the agreed envelope of about 50,000 hectares, amounted to 150,000 hectares. The forest was an untouched, pristine, lowland rainforest. Reduction and or modification of the forest ecosystem services is estimated to be 80% on logging roads, skid tracks and staging areas, and 40% elsewhere, including collateral damage from tree fall, edge effects, and flow on effects. Without commissioning a physical survey of the damage site, it is not possible to provide an exact calculation; however, it could be assumed that the area damaged by

Table 1: A selection of case studies from both developed and developing nations for analysis (Curtis 2008).

Researcher/Author	Subject of the Research	AUD $ha-1yr-1	AUD $ha-1yr-1
		Lower range	Upper range
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 2008	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

Notes *1. *Denotes environmental payment scheme*
2. Studies more than ten years old have been adjusted to 2002 values

gaining access to individual or stands of trees to be logged was at least equal to the impact area of the actual tree felling, collateral damage and edge effects. Accordingly, the loss of or modification of the forests services is estimated to be 60% of the entire 150,000 hectare footprint

Descriptive statistics of the data-set to be used for 'Benefits Transfer' show the following characteristics (Table 2).

Table 2: Descriptive statistics of the data set.

Item	Mean (AUD$/ha/yr)	Median (AUD$/ha/yr)
Lower Range Values	161	162
Upper Range Values	250	267
All Values	251	212

As the data-set is highly skewed, the appropriate measure of central tendency is the 'median'. In order to incorporate the lower values (which were too few to be reliable alone), we have adopted the median for 'All Values' (AUD$212 ha-1yr-1), and the median for 'Upper Range Values' (AUD$267 ha-1yr-1), as the extent of the value of the reduction or modification of the forest ecosystem services.

The above individual values per hectare were computed in terms of the areal damage footprint (reduction in ecosystem services), not the logging footprint, resulting in the following data table (Table 3).

Table 3: Using the adopted 'all values' and 'upper' values for a final range of values of the damage in PNG Kina.

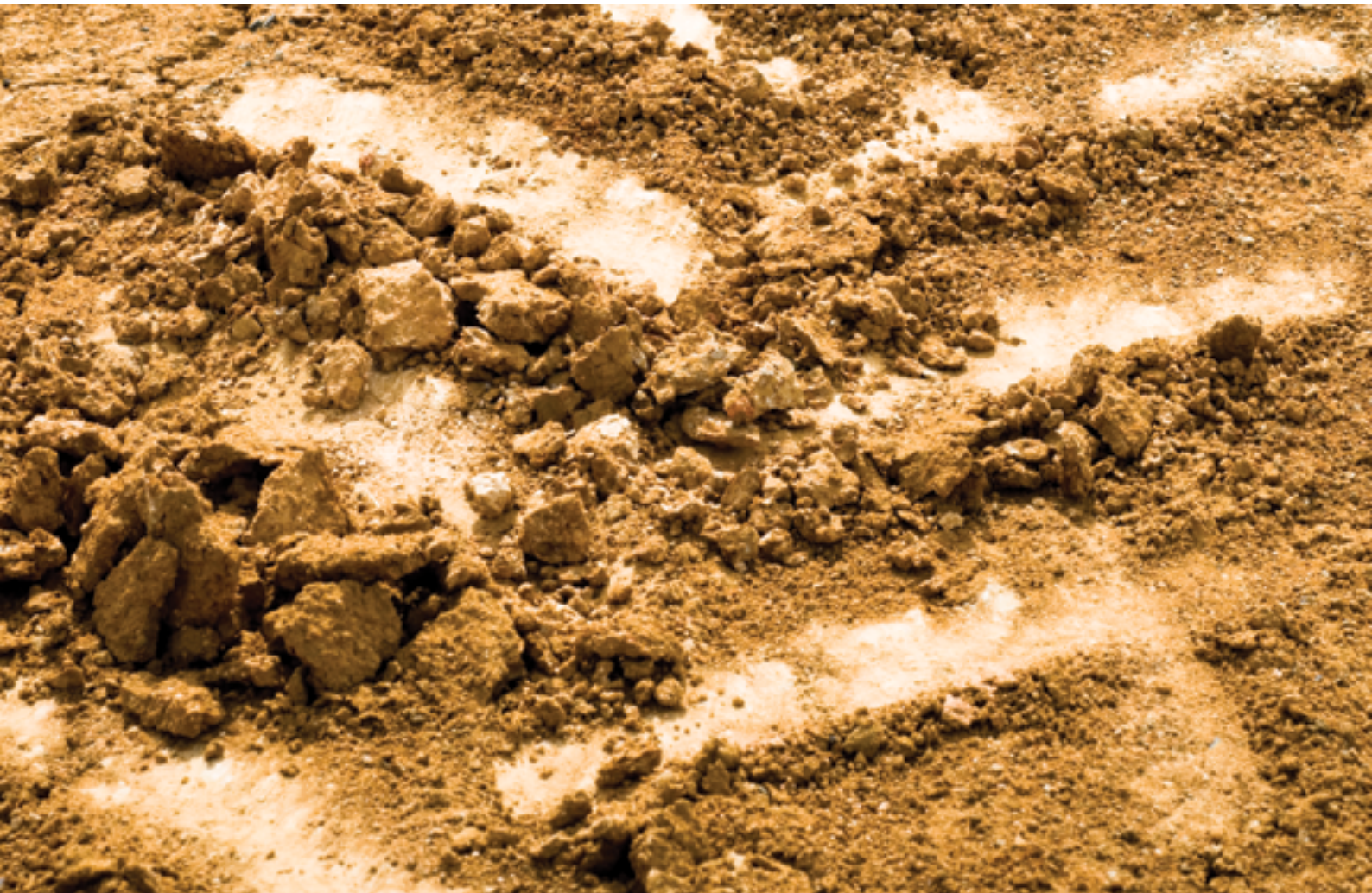
Range	Hectares	AUD$/yr	PNG Kina/yr
Lower	90000 (60% loss)	19,080,000	50,562,000
Upper	90000 (60% loss)	24,030,000	63,679,500

Using Anderson's (2006) estimate of the opportunity cost of customary land, and the National Population Census data for the people of the Middle Fly and the Lake Murray Land Owners Group, the estimated total gross income and potential value of the real property utilising a capitalisation rate of 5%, for the regions is given in Table 4.

Table 4: Opportunity cost valuation of Customary Land in the Middle Fly and Lake Murray.

Item	Lake Murray ROA region (PNG Kina)	The Middle Fly (PNG Kina)
Gross Subsistence Income	18,892,286	107,716,500
Gross Real Property Value	377,895,714	2,154,330,000

Comparing the median upper and lower values of damage (say K56 million/ha/yr), to the above capital values for the land resource, results in a yield cost of 52% in the Lake Murray region, and 2.6% for the whole of the Middle Fly. Clearly the loss of forest services and environmental damage is evident farther afield than the LMROA region, and extends for the full 195 kilometres through the Middle Fly region. Accordingly, the impact on the subsistence net primary production yield of 2.6% for the Middle Fly would appear to be a market yield for subsistence primary production, and thus it would support both the results of the Benefit Transfer procedures (including the data set selected) and Anderson's study on Opportunity Cost.



LIMITATIONS OF THIS STUDY

The limitations of this study are explained in the section headed 'methodology'. However, it is also fair to say that if any methodology is at all useful, it should produce a result within at least an order of magnitude of any other study utilising an alternate methodology.

It is claimed that Benefit Transfer is a methodology that is, and never will be, as accurate as a primary valuation study. This may well be so, however, the 'benefit' of benefit transfer, is that by using a reasonable sample and diversity of studies, with all their biases and errors, statistical and otherwise, gross error across the sample is reduced dramatically.

Moreover, the special issue of the Elsevier Journal, Ecological Economics, in 2006, includes a paper by Ready & Navrud, who claim that errors in benefit transfer can be in the range 25 to 40%, both within and across countries.

However, correlation with Anderson's 2006 work on Opportunity Cost Valuation lends a measure of comfort to the results, which exhibit a range of values of 25%.

It is always possible to carry out a primary valuation study, given a reasonable time frame, however there will be a strong element of bias in any willingness to pay survey based on the socio economic status of the sample participants.

CONCLUSION

In the considered opinion of this author, the loss of, or modification of ecosystem services in the Middle Fly, Western Province, Papua New Guinea, owing to the illegal logging activities associated with the construction of the Aiambak to Kiunga Road, are in the range: Fifty million, five hundred and sixty two thousand Kina per annum, to sixty three million six hundred and seventy nine thousand five hundred Kina per annum (K50,562,000 to K63,679,500 per annum).

A lump sum compensation can be determined by converting the above figures to a net present value (NPV) by using appropriate discount rates. Depending on the discount rate and the term applied, this figure could be considerably higher than **K500 million**. To put this in perspective, the logging companies extracted or destroyed K157 million worth of trees (logs), but did many hundreds of million kina worth of damage in the doing.

To further break down the values, the value range ascribed in this study to the loss of or modification of ecosystems services is K212 to K267 per hectare. Yet the value of timber removed was over K1000 per hectare. Timber is only ONE of the twenty ecosystem services provided by forests.

Clearly, under the above scenario, either timber is overvalued as a resource with respect to the life-supporting benefits obtained from a natural system left intact, or ecosystem services, as a whole, are severely undervalued.

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