Table 39. Scenarios developed for Tripa

No	Scenario	Description	Remarks*
1	Business As Usual (BAU)	• Oil palm estates operate according to current HGU and have a right to open remaining forests inside their HGU • Local people can establish agricultural plots outside HGU. Three main local agricultural products are oil palm, cacao and paddy • An off-farm job for local people is to become a labourer in the large oil palm plantations	Conversion of remaining forests inside HGU into oil palm plantations
2	Patch (conservation)	• Oil palm estates operate according to current HGU and agree to conserve remaining forest patches inside their HGU. This includes the 6000 ha forest that was proposed to be conserved following an AMDAL (Analisis Dampak Lingkungan) assessment. • Other situations are the same as described in the BAU scenario	Supporting orangutan survival by conserving remaining forests inside HGU
3	Instantaneous (ecological restoration)	• All oil palm estates agree to stop operation and participate in restoring Tripa area into forest by conserving remaining forests and restoring all oil palm plots inside HGU into forests • Other situations are the same as described in the BAU scenario	Instantaneous restoration of all oil palm plots inside Tripa to forests
4	Gradual (ecological restoration)	• All oil palm estates agree to conserve remaining forests inside HGU and to stop operation in old and no-longer productive oil palm as part of a gradual restoration process of Tripa area into forests • Other situations are the same as described in the BAU scenario	Gradual restoration of all oil palm plots inside Tripa to forests
5	Corridor (ecological restoration)	• Establishment of two corridors linking the remaining forest patch inside Tripa to the KEL for orangutan preservation along with instantaneous restoration of all oil palm plots within the corridor (inside or outside HGUs) to forests • Existing oil palm in the HGU area but not within the corridor remains as oil palm • Other situations are the same as described in the BAU scenario	The conservation value of the 'patch' is probably dependent on ecological connectivity with the main conservation area; corridors use the easiest options: remaining forest along the river and an oil palm concession that is currently already abandoned; other corridor designs can be considered at a later stage

*No change in road and settlement distribution, market price and demand for labour per ha by the oil palm estates during the 30 years

Table 40. Observed aboveground biomass (AGB) and yield of each land use for FALLOW simulations in Tripa

Land cover	AGB (ton/ha)	Yield (ton/ha)
Pioneer forest	10	-*
Young secondary forest	75	-
Old secondary forest	184	-
Primary forest	243	-
Paddy	1	1.2
Cacao pioneer	5	0
Cacao early	19	0.09
Cacao late	29	0.12
Cacao post	66	0.15
Oil palm pioneer	21+	0+
Oil palm early	49	17
Oil palm late	84	25
Oil palm post productive	121	12

*No data; +AGB and yield of oil palm for each stage are estimated with equation given by Dewi et al. (2009)

Table 41. Socio-economic input parameters for the FALLOW simulations in Tripa

Land use	Harvesting product (ton/pd*)	Establish. cost+ (**MRp/ha)	Labour req. for establish+. (pd/ha)	Return to labour (Rp 000/pd)	Return to land (MRp/ha)	Price (MRp/ton)	Non-labour cost (MRp/ha)
Paddy	0.0124	2.065	10	15.43	2.78	3	0.786
Cacao	0.00189	0.366	77	57	5.972	16	0.37, 0.13, 0.50, 1.33#
Oil palm	0.00039	5.106	57	122	88.134	0.93	8.89, 16.1, 11.9, 17.9#

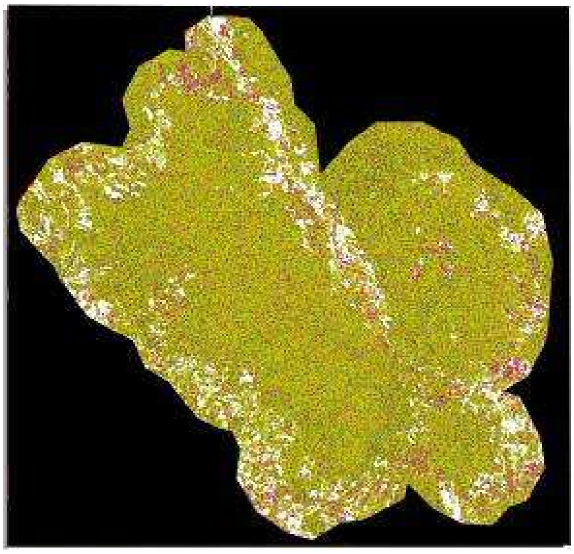
**pd =person day; **MRp=millions of rupiah; + this is the first year establishment cost, not establishment cost until positive cash flow. It excludes labour cost because we assume farmers exert their own lands. Labour requirement here is also for the first year only, not until positive cash flow; #for pioneer, early, late and post production stage respectively.*

6.3 Results and Discussions

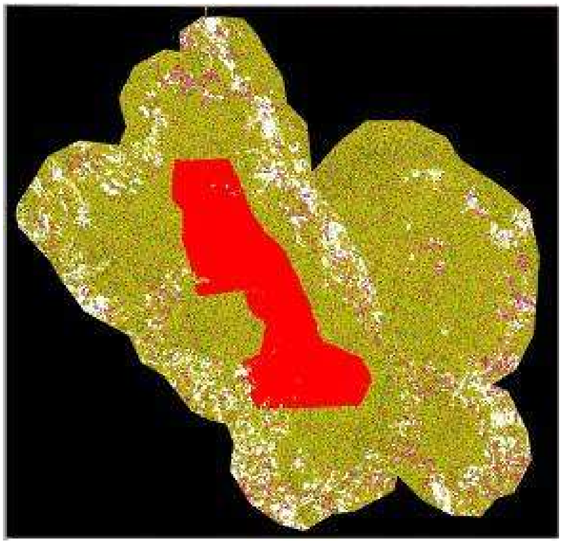
6.3.1 Batang Toru

In the logging concession area, we assumed that forests were logged at young secondary stage or at later stages and this applied to all trees (that is, non-selective logging) inside the forests. This treatment left logged pioneer forest patches inside the HPH area (concession A) or over the habitat area (concession B). In the two 'conservation' scenarios, forests covered the HPH and the whole habitat area.

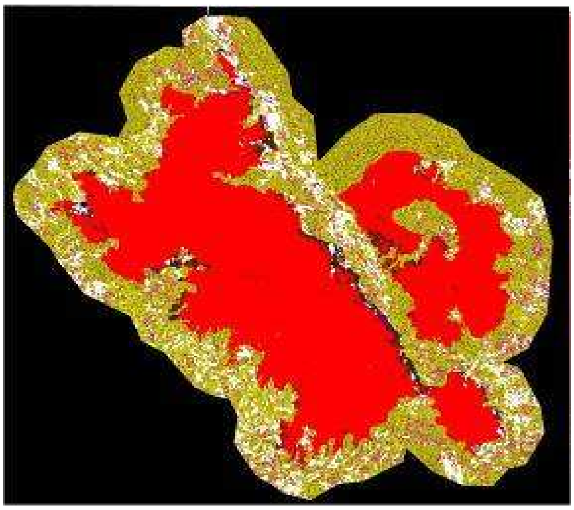
A) BAU



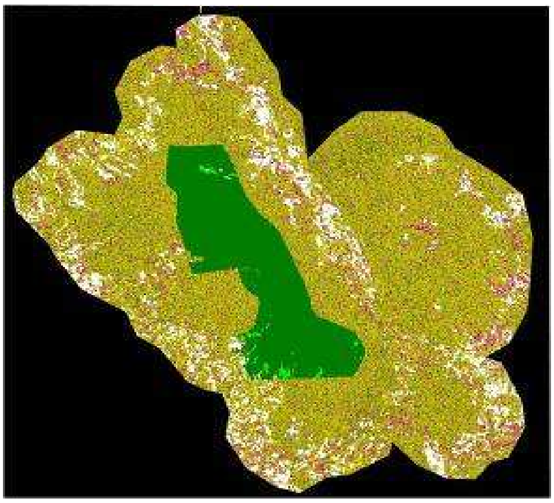
B) Concession A



C) Concession B



D) Conservation A



E) Conservation B

Figure 48. Landscape mosaic in Batang Toru after 30 years: simulation of five scenarios by the FALLOW model

Total area of the simulated landscape was 220 000 ha with a habitat area of 109 220 ha (green area in concession B scenario). Total area of HPH was 29 898 ha (green area in the conservation A scenario).

Abbreviations used in the legend: set=settlement; pfor, ysec, osec, and prim are forests at pioneer, young secondary, old secondary and primary forest respectively; rubpion, rubearly, rublate, and rubpost are rubber plots at pioneer, early, late and post-production stages respectively; OPpion, OPearly, OPlate and OPpost are oil palm plots at pioneer, early, late and post production stage respectively; coffee pio, coffeeear, coffeelate and coffeepost are coffee plots at pioneer, early, late and post-production stages respectively; mixgarpion, mixgardearly, mixgardlate and mixgardpost are mixed gardens at pioneer, early, late and post-production stages respectively.

Unlike the case in Tripa where local farmers preferred to cultivate oil palm, rubber was expected to remain the preferred livelihood option in Batang Toru (Table 2). This was mainly because of low establishment and non-labor costs to open and maintain rubber plots, although it was less profitable compared to oil palm or coffee compare the profits of the crop products. There was not enough capital in the landscape for smallholders to make the transition, even where oil palm was potentially suitable at lower elevations.

Table 42. Total land-use area in the five different scenarios compared to the initial condition in year 2009 as calculated by the FALLOW model in Batang Toru

Land-use type	**Year 2009**	**Scenario**				
		BAU	**Concession A**	**Concession B**	**Conservation A**	**Conservation B**
Inside habitat area (ha)*						
Pioneer forest	151	0	29 151	102 541	0	0
Forests	102 441	1697	1240	0	30 350	102 541
Paddy	30	3129	1417	30	1397	30
Rubber	3452	92 821	68 437	3445	68202	3445
Oil palm	231	3253	2495	231	2705	231
Coffee	81	207	178	81	173	81
Mixed garden	1569	6786	4975	1565	5066	1565
Outside habitat area (ha)*						
Pioneer forest	1165	0	739	0	0	0
Forests	47 016	718	777	625	1497	599
Paddy	5085	3343	2068	198	1841	214
Rubber	27 209	91 954	91 826	94 275	92 025	94 164
Oil palm	3963	4247	4309	4422	4424	4418
Coffee	1761	237	226	125	250	158
Mixed garden	25 732	11 494	12 048	12 348	11 956	12 440

*calculated at the end of simulation

Compared to the year 2009, higher annual income per capita was obtained with forest conversions in the habitat area into smallholder plots as simulated in the BAU (Figure 48.A). Higher incomes relative to the initial condition were also obtained with concession A or conservation A scenarios because only part of the orangutan habitat was conserved while there was no effective constraint on local people from establishing agricultural plots control in the rest of the habitat area. Total conservation in the habitat area, or a massive extension of the logging concession (HPH) to cover all areas inside the habitat area, gave only slightly higher incomes compared to the referenced year. This was perhaps only because of a different composition of land-use types outside the habitat area with a substantial increase of rubber plots. For the simulations, we assumed that local people obtained no economic benefit neither from the extension of HPH area nor extension of conservation areas. We assumed that the HPH does not offer any off-farm jobs to local people as labourers and collection of non-timber forest products was not simulated in the model.

The conversion of the habitat area into smallholder plots resulted in a net negative annual CO_2e sequestration rate (that is, emission) measured over 30 years in the landscape (Figure 49). Surprisingly, the rate is relatively low, owing perhaps to a substantial increase of carbon stock from young smallholder plots into older production stages during the 30-year simulation. Both concession scenarios gave a negative sequestration rate but increases in carbon stock in young smallholder plots outside the habitat area contributed to relative lower emission rates over the 30 years. As expected, higher net sequestration rates were found with the two conservation scenarios, particularly the thorough conservation of the habitat area. The sequestration rate in the forest plots within the habitat area plus that in young smallholder plots outside the habitat area resulted in a high annual sequestration rate in the more extensive conservation scenario.

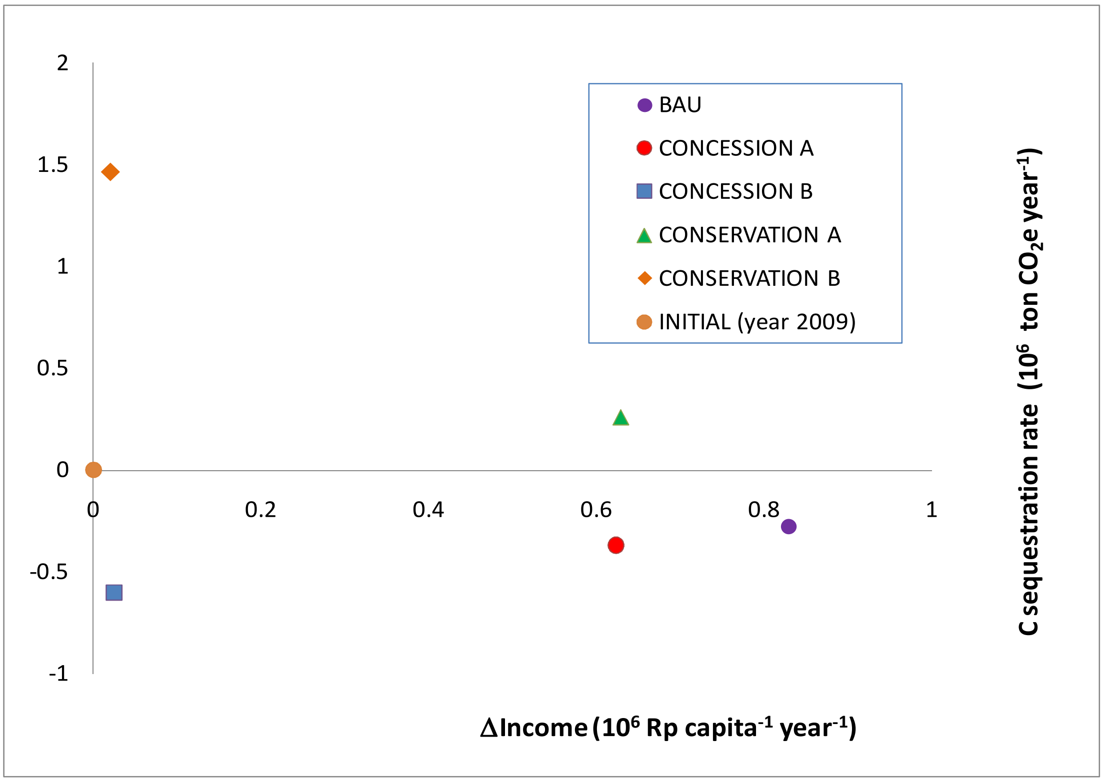


Figure 49. Annual CO_2e sequestration rate and income per capita calculated for each scenario in Batang Toru relative to the carbon stock and annual income in the year 2009 (The measured carbon stock of the year 2009 in the landscape was 11.2 x 10^6 t and the income was 1.1 x 10^6 Rp/capita with a total population of 215 262). FALLOW model calculations

The model predicts that application of any of the five scenarios will result in a higher income compared to that obtained in the year 2009. With a conservation program, either partially or entirely covering the habitat area, local people could cultivate preferred crops such as rubber to create more income. In addition, by avoiding forest conversions into smallholder plots within the habitat area, 0.28 x 10^{-6} tCO_2e would be sequestered per year in a BAU scenario. **Table 43** describes loss in income if a partial or thorough conservation program was applied, by comparing the annual income rate in the conservation scenarios to that in the BAU scenario. Table 44 shows carbon sequestration obtained owing to avoiding deforestation and conserving existing forests either partially or entirely, and the minimum price per tonne of CO_2e that would need to be applied to compensate for economic losses if the conservation programs proceeded.

Table 43. Decrease of income for each scenario

Scenarios	Income (*MRp/capita/yr)	Income (USD/capita/yr)	Decrease in income (MRp/capita/yr)	Decrease in income (USD/capita/yr)	Total decrease in income (**GRp/yr)	Total decrease in income (#M USD/yr)
If do Conservation A	1.73	187.95	-0.19992	-21.7308	-45.3826	-4.93289
If do Conservation B	1.12	121.80	-0.80851	-87.8815	-183.532	-19.9491

*MRp=millions of rupiah **GRp=billions of rupiah #MUSD=millions of US dollars

Table 44. Carbon sequestration of avoiding deforestation and carbon reward of conservation scenarios

Scenarios	Carbon sequestration rate ($MtCO_2e/yr$	Minimum carbon price (USD/tCO_2e)	Carbon reward (10^6 USD/yr)
If do Conservation A	0.54	9.2	4.94
If do Conservation B	1.74	11.5	20.2

6.3.2 Tripa

In all scenarios, local people could use areas outside the HGU for agricultural activities. There were three livelihood options observed as the main local agricultural practices and considered in the simulations: paddy, cacao and oil palm plantations (based on Component A of this report). Owing to its higher economic returns, local people in the model predictions would prefer oil palm rather than the other two products. In the absence of any 'green' programs, this would make Tripa a fully oil-palm-dominated landscape in the BAU scenario (Figure 50).

Table 45 below describes the total area of each land-use type within the landscape for each scenario compared to the initial condition in the year 2009. In the corridor scenario, total areas of paddy and cacao plantation are smaller owing to the establishment, on village lands, of the corridor to connect with the forests of the Gunung Leuser National Park.

Table 45. Predicted area of each land-use type inside and outside HGUs at the end of a 30-year simulation period for each scenario in Tripa, simulated by the FALLOW model

Scenarios	Area of land-use type outside HGUs (ha)*				Area of land-use type inside HGUs (ha)*			
	Forest	Paddy	Cacao	Oil palm	Forest	Paddy	Cacao	Oil palm
BAU	237	667	6435	52 836	0	2547	1811	35 602
Patch	235	728	6402	52 810	17 585	2547	1811	18 017
Instantaneous	245	687	6417	52 826	35 602	2547	1811	0
Gradual	259	700	6384	52 832	35 602	2547	1811	0
Corridor	10 145	693	5881	43 448	19 857	2419	1633	16 059
Year 2009	12 497	11 144	13 048	23 485	17 586	2547	1811	18 017

**measured at the end of the simulation*

In the gradual restoration scenario, we assumed that oil palm plots were allowed to revert to forest at the end of their production cycle (when they reached the post-production stage at 25 years of age). Therefore, all oil palm plots inside HGU had been restored to forests at the end of the 30-year simulation period. Both instantaneous and gradual restoration scenarios successfully restored all areas inside HGU into forest, but forests in the instantaneous scenario reached a higher ecological stage owing to a longer restoration period.

In the last scenario, the northern corridor crossed existing HGUs to link to KEL and the southern one crossed the abandoned HGU (YEL Alue Bili, pers. comm.) located in the eastern part of Tripa. These corridor designs minimised the number of smallholder plots that had to change management. Both corridors, however, crossed settlements (Figure 50.E). We assumed that the affected inhabitants would be compensated and subsequently move to other settlements within the simulation area; the simulations all assumed the same total population in the landscape.

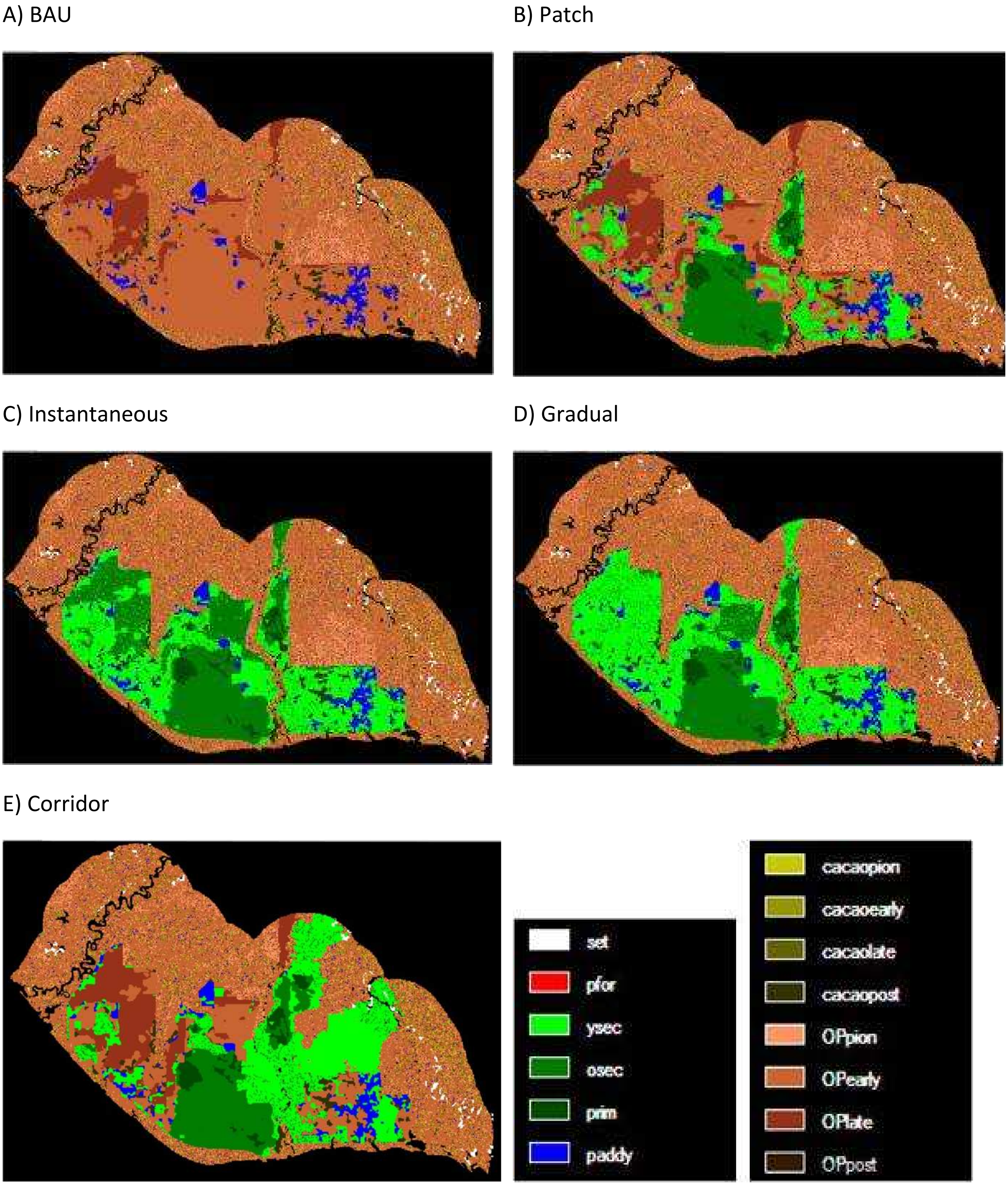


Figure 50. Landscape mosaic in Tripa after 30 years. Simulation of five different scenarios by the FALLOW model: A) Business As Usual (BAU); B) conservation of remaining forest ('patch'); C) instantaneous restoration of all oil palm plantations into forests ('instantaneous'); D) gradual restoration ('gradual'); and E) establishment of two corridors to support orangutan preservation ('corridor'). The total simulated area was 104 000 ha, including 40 000 ha in all HGUs combined. (Abbreviations used in the legend: set=settlement, pfor=pioneer forest, ysec=young secondary forest, osec=old secondary forest, prim=primary forest, pion=pioneer stage, early=early production stage, late=late production stage, post=post-production stage, OP=oil palm.)

All ‘green’ scenarios produced higher carbon stock but less income compared to BAU. The largest differences were produced with the instantaneous conversion scenarios (Figure 50).

Figure 51 describes the trade-off between income and CO_2 sequestration rate in the landscape with different scenarios. The calculated incomes reflect revenues obtained by local people from selling crop products and working as labourers in the oil palm estates, minus non-labour costs divided by total population. The calculated CO_2 sequestration rate is the net CO_2e sequestration (negative emission) for 30 years over the landscape taking into account both above and belowground CO_2e emission when a peat swamp forest is being, or has been, converted to other land-use types, as simulated in the BAU scenario.

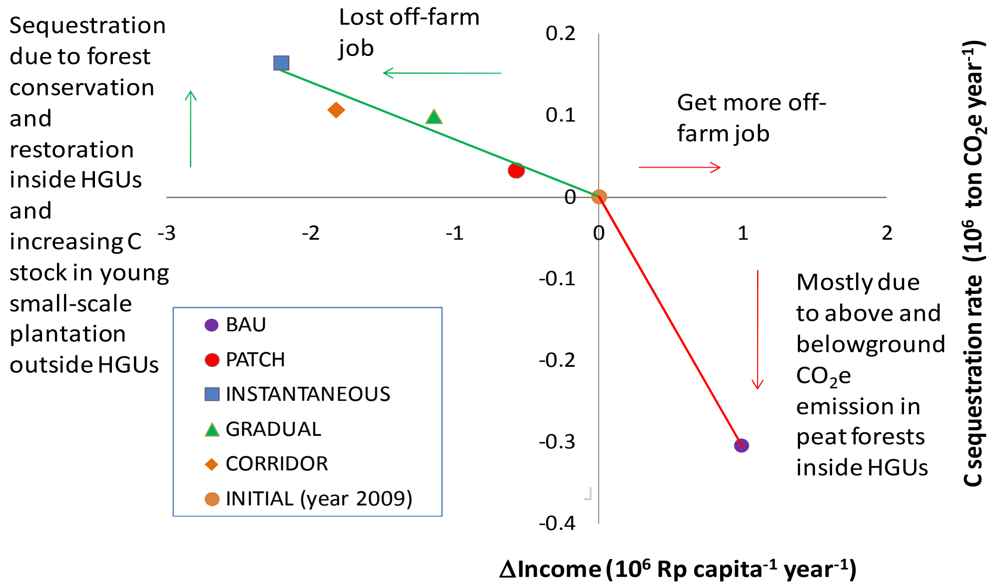


Figure 51. Difference in annual income and annual CO_2e sequestration rate calculated for each simulation scenario for 30-year simulation over the simulated landscape in Tripa relative to the condition measured in year 2009 (i.e. income of Rp 3.5 x 10^6/capita or Rp 6.5 x 10^6/labour with a labour fraction of 0.54 from total population in Tripa) and total aboveground carbon-stock of 5.5 x 10^6 tonne in the landscape). The wage rate as laborer in big-scale oil palm plantations used to calculate income was Rp 1.2 x 10^6/month). Calculated by the FALLOW model

Table 46 describes ‘economic losses’ in the landscape owing to conservation programs in comparison with what could be obtained in the forest conversion scenario (BAU). The highest loss is incurred with the instantaneous scenario owing to a thorough restoration of oil palm plantations inside HGUs. A high decrease in income is also found in the corridor scenario owing to restoration of smallholder plots into forests for orangutan preservation. The total economic losses in the landscape also represent the total ‘compensation’ that should be provided to equal income of the year 2009. If the BAU scenario is used as reference, a further 3 million USD/yr would have to be provided in new income earning opportunities. On top of these costs, the economic value of the existing rights of concessionaires would have to be compensated, while transaction and implementation costs were not covered.

Table 46. Trade-off between CO_2e sequestration rate and local people's income in the landscape with 5 different scenarios in Tripa, calculated by the FALLOW model

Scenarios	CO_2e seq. rate (10^6 tCO_2e/yr)	ΔIncome (10^6 Rp/capita/yr)	ΔIncome (USD* capita/yr)	Total+ change in income (10^9 Rp/yr)	Total change in income across the landscape (10^6 USD/yr)
BAU	-0.31	0.99	107.82	27.72	3.01
Patch	0.03	-0.57	-62.46	-16.09	-1.75
Instantaneous	0.16	-2.20	-239.62	-61.73	-6.71
Gradual	0.10	-1.14	-124.32	-32.02	-3.48
Corridor	0.11	-1.82	-198.33	-51.09	-5.55

**Currency rate Rp 9200=USD 1; +total economic loss in the simulated area (Δincome capita * total population). Positive value in BAU scenario means an increase in income*

The 'patch' conservation refers to the first and second 'D' of REDD+, while the carbon gains in the restoration scenarios refer to the '+'. Compensation might come from carbon reward owing to avoiding deforestation and promoting forest restoration and conservation. Table 47 describes the magnitude of such compensation for each scenario. A lower incentive (that is, a minimum 5.2 USD/tCO_2e) might be sufficient to compensate for the economic losses in the patch scenario. In the more massive conservation and restoration scenario, however, a higher average incentive is needed. In as far as restoration and protection of the area involve labour costs, part of this total compensation could come in such a form. Other elements could be investment in new employment creation activities and direct compensation for those involved in the corridor restoration.

Table 47. Compensation for economic loss owing to conservation programs obtained from reward for carbon sequestration in Tripa. The total carbon sequestration rates include avoiding carbon emission owing to conserving remaining forests inside HGUs. Calculated by the FALLOW model

Scenarios	Total carbon seq. rate (Millions tCO_2e/yr)	Total decrease in income (Millions USD/yr)	Minimum carbon price (USD t/CO_2e)	Carbon reward (Millions USD/yr)
Patch only	0.34	-1.75	5.2	1.75
Instantaneous restoration	0.47	-6.71	14.3	6.71
Gradual restoration	0.40	-3.48	8.7	3.51
Corridor	0.41	-5.55	13.5	5.56

restoration				

Owing to compensation from carbon reward, a 'green development' (that is, resulting in a positive change both in economic and ecological levels) could be achieved. Different conservation programs could be proposed depending on the level that was desired for the environmental prosperity of local people and orangutan. Another 'source' of compensation might come from a reward owing to preserving orangutan. If this occured, it is possible to suggest that local people in Tripa could receive more income by preserving forests.

6.4 Discussion and conclusions

Local government and decision makers need to understand the various components involved in the calculation of trade-offs between economic and ecological aspects of development. Managing the trade-offs involves review of the overall development strategy, as land, labour, capital, knowledge and markets interact in creating economic opportunities, while the fractions of land and their spatial configuration determine the ecological outcomes. The FALLOW model can be used to measure the impact of certain development strategies on the economic and ecological prosperity of local people living in a rural landscape, but model outcomes are sensitive to parameter values and assumptions. The relative ranking of scenarios is likely to be more robust than the absolute values of the results.

In Tripa and Batang Toru, 'conservation' scenarios were designed to allow orangutan to survive. If the income of local people was prioritised, however, the BAU scenario, that allowed expansion of oil palm plantations inside HGU (in the case of Tripa) and expansion of local agriculture into forest conservation areas (in the case of Batang Toru), provided the best option. In the 'green' scenario where ecology was prioritised, a better change in ecological prosperity was usually accompanied by a decrease in economic levels compared to the BAU scenario. This condition was clearly described in the conservation scenarios both in Tripa and Batang Toru. This problem might be overcome, however, if a REDD mechanism, eco-tourism project or similar was applied in the conservation areas, supporting local people's economic sustainability without destroying existing forests.

For Tripa, the range of options was considerable and involved large volumes of emission as well as substantial financial resources. At an effective farmgate carbon price of 5 USD/ tCO_2e, avoided deforestation could be compensated at a price of close to 15 USD/ tCO_2e for the 'conservation' plus 'restoration' scenarios, when seen as a package.

An issue for further debate is whether or not the USD 3 million of potential increase in local income would need to be compensated as well. In Table 38 we see that the difference between BAU and year 2009 was 17 000 ha of oil palm. At 57 person-days/ha/yr and a wage rate of Rp 71 000/day, this oil palm area could generate USD 7.5 million/yr. However, in the absence of oil palm development, the 17 000*57 person-days could be spent in other ways, generating income. Within the parameter value of the model, apparently 4.5 million of the USD 7.5 million could be internally compensated, leaving USD 3 million.

There is, however, a question as to what degree such opportunity would be a legal one. The oil palm concession was, at the time of issuance, in conflict with the presedential decree that peat with a depth greater than 3 m needs to be conserved. More than half the measurements of peat depth showed a depth greater than 3 m for the currently remaining forest patch. One could argue that this ‘opportunity’ for which permits exist is nevertheless illegal. It would also be against current national policies to reduce emissions and to provide a ‘greener’ image to oil palm production by stopping new forest conversion. The political and policy ramifications of this issue go beyond the remit of this report.

7. Orangutan populations, carbon stocks and rural livelihoods under corridor restoration in Tripa[16]

Meine van Noordwijk, Rachmat Mulia, Andree Ekadinata and Sonya Dewi

7.1 Background

The Sumatran orangutan (*Pongo abelii*) is critically endangered, with less than 10 000 individuals surviving in the wild. Several subpopulations still exist outside of protected areas, but in an increasingly fragmented landscape. In line with broader efforts to restore ecological connectivity in landscape mosaics, the potential relevance of restoring connections between subpopulations of Sumatran orangutan is expected to support survival of the species. One of the last chances to do so may be in the Tripa swamp, where a population of over 100 individuals has become separated from the main population in the Gunung Leuser National Park by conversion of peat swamp forest to oil palm plantations. While there may be opportunities to use funding mechanisms linked to REDD+ for a combination of protecting the remaining forest and restoring (ecologically) the surrounding landscape, effectiveness of such efforts on orangutan survival forms a key argument to seek broader investment, beyond the issues of avoided carbon dioxide emissions and net carbon sequestration. The expected functionality of landscape corridors must be weighed against their costs for local livelihoods and/or for outside stakeholders who will have to offset these local costs in order to obtain cooperation at local level.

A recent meta-analysis of ecological corridors (Gilbert-Norton et al., 2009) concluded that such corridors can indeed be effective, especially where they restore natural corridors, for example, along rivers, but effects differ between broad taxonomic and ecological groups. Details of life history, population biology and dispersal, however, matter. A separation olf the imp;acts of additional habitat provided by the corridor and the effects through connectivity cannot generally be made. Most of the literature refers to temperate zone systems and little experience has been documented and analysed for the humid tropics and its rainforests. Basic understanding of the biology of key species can, however, be used to make reasoned inference on the likely effectiveness and to balance aspects of design. We set out to do such an analysis for reconnecting Tripa and Gunung Leuser through corridors that used remaining patches of forest and involved returning part of current oil palm plantations back to secondary forest.

Compared to human beings, the life cycle of orangutan is slow, their natural mortality rate is low, but their potential intergenerational increase in population size is nevertheless very limited owing to long interbirth interval (8–9 years), high age at first reproduction (about 15 years for females) and absence of twins (where these occur only one survived in all cases documented for the wild). Dispersal rates are very low, with most females establishing themselves in or close to their maternal home range. Males roam further, especially as subadults. Current understanding of genetic diversity in orangutan, and between the Sumatran and Bornean species, confirms a strong difference between the matrilineal and patrilineal components of DNA. Based on similarity of

[16] We acknowledge the intellectual input and willingness to share unpublished data from Maria van Noordwijk, Serge Wich and Ian Singleton.

mitochondrial (matrilineal) DNA, four distinct subpopulations (northern Aceh; Leuser west; and also east of the Alas valley; and the Batang Toru population south of Lake Toba) exist. But in terms of patrilineal DNA it is a single large genepool (van Schaik, Pers. Comm. 2010).

Given the differences in male and female dispersal and the sensitivity of orangutan populations to any increase in mortality owing to increased exposure to humans, it is expected that corridors can have both positive and negative impacts on overall population development and a quantitative analysis of corridor functionality is needed. We developed a simple model of metapopulation dynamics that can be applied to local landscape features and the specific biology of a species like the Sumatran orangutan. We provide sensitivity analysis of this model, parametrization on the basis of published and unpublished data on dispersal and then use the model to predict the range of outcomes possible in Tripa depending on details of corridor design and management.

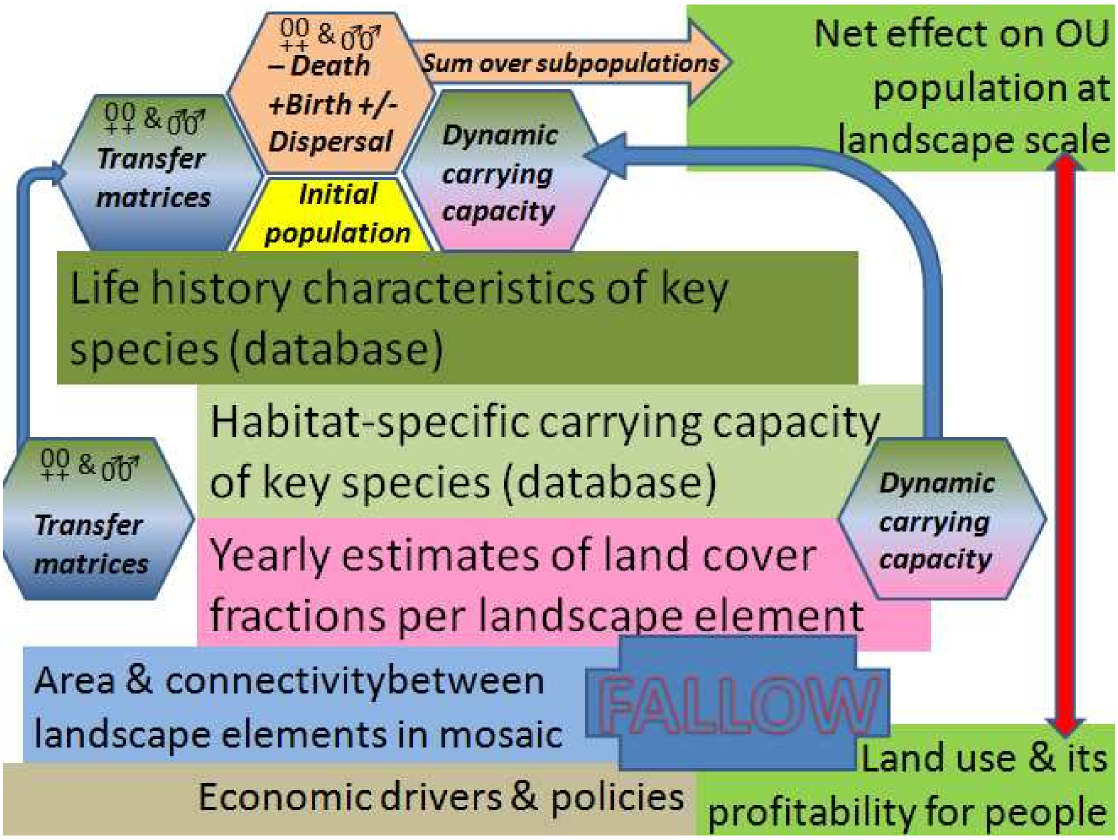


Figure 52. Components of the MetaPop001 model and its application to predict the response of orangutan subpopulations to ecological restoration and corridors between remaining forest and main population

7.2 Method

7.2.1 Construction of MetaPop001 model and its gender-specific model extension

The basis of MetaPop001 is the bookkeeping of a number of subpopulations through their birth rates and mortality, with additional options for partial exchange between subpopulations by dispersal. Dispersal fractions and distances can be differentiated by gender (female or male); mortality can be differentiated between juvenile and adult. The model requires basic life history characteristics and estimates of carrying capacity (maximum population densities that can be supported before additional mortality sets in) for the potential range of habitat types. Mortality is described as having a natural rate with additional mortality that is linked to habitats and/or landscape patches, reflecting, for example, the likelihood of human–orangutan conflict linked to orangutan feeding in agroforests, (illegal) hunting and/or (illegal) capture for wildlife trade. The model is set up in modular form, with options to link the dynamics of habitat type as derived from the FALLOW model to the properties of multiple species, stored in a database of life-history characteristics. The model predicts population dynamics and female/male ratios in the various subpopulations as well as at landscape scale. Parameter requirements include details of the way the landscape elements connect, as well as the initial population size (and female/male ratio) for the different subpopulations.

7.2.2 Application to Tripa–Leuser connectivity options and parameter values

Predictions of habitat fractions per year for each of the landscape elements were derived from applications of the FALLOW model (see preceding chapter).

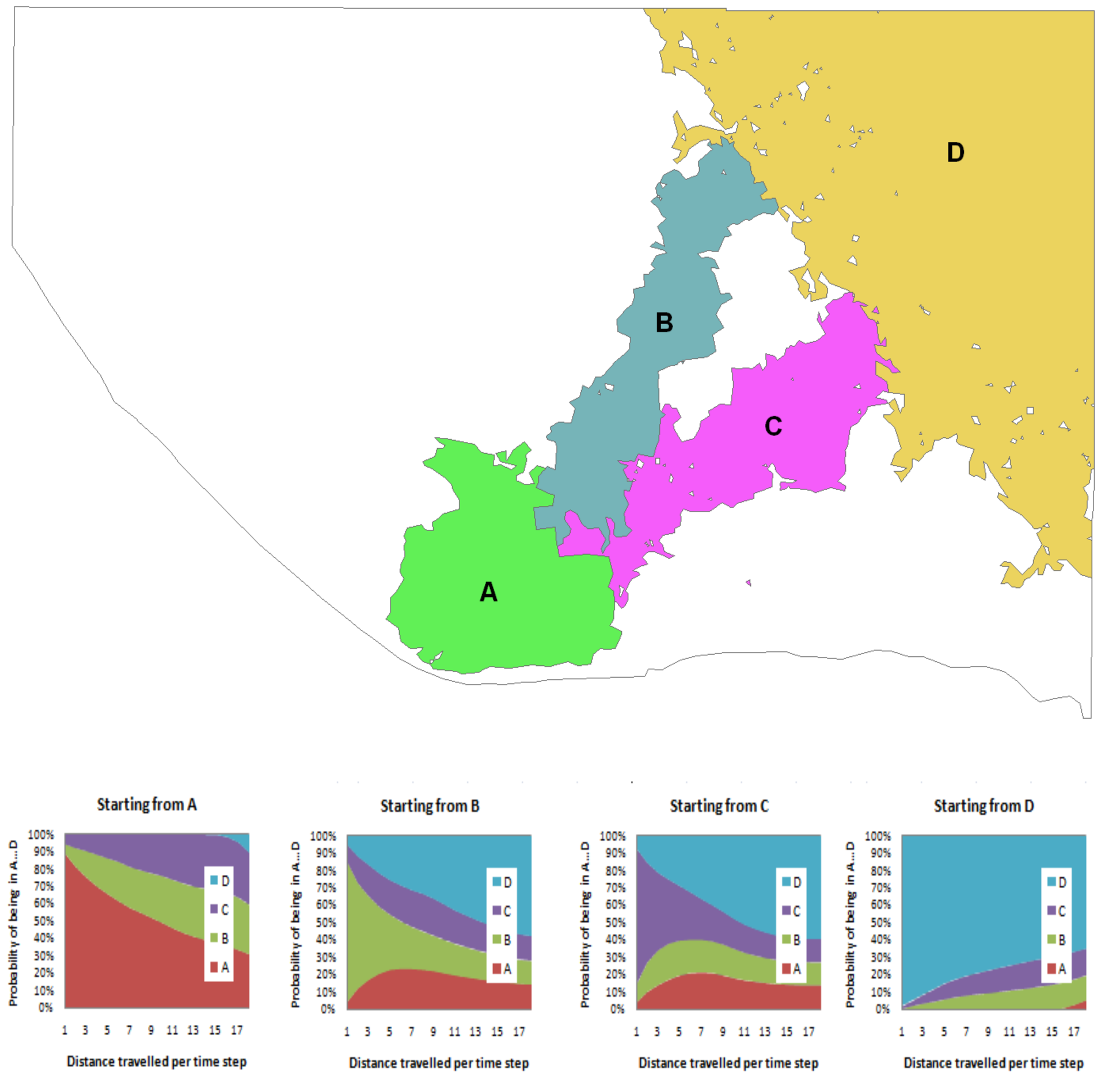


Figure 53. Schematic map of the remaining forest patch (A); the main Leuser population (D); and the two potential corridors (B and C). Spatial analysis provided a relationship between the probability of reaching other landscape components depending on the distance travelled and the starting point

7.2.3 Re-analysis of long-term data on mortality and dispersal

It is very hard to obtain good estimates of mortality for orangutan in their natural habitat. Data from captivity are likely to overestimate mortality. To complement published syntheses on orangutan life-history traits and dispersal characteristics, the leaders of long-term research locations kindly provided a summary of recent data.

A	B	C	D
Forest patch	**Corridor 1**	**Corridor 2**	**KEL = Kawasan Ekosistem Leuser**
Area per habitat (km2)			
82	73	78	650
A connects B?	0.5	B connects C?	0.4
A connects C?	0.5	B connects to D?	0.5
A connects D?	0	C connects to D?	0.5
Pongo abelii		Sumatran Orangutan	
Initial population sizes relative to carrying capacity			
1	0.2	0.1	1
Mortality multiplier			
1.1	1.3	1.5	1

Key output

Subpopulation size				
Forest patch	Corridor 1	Corridor 2	KEL = Kawasan Ekosistem Leuser	
126	16	4	959	1105
At end of simulation				
105	63	47	1007	1222
-21	47	43	48	117
	69			
Female/male ratio				
0.82	0.82	0.82	0.82	
1.28	0.22	0.17	1.02	0.92126

Input parameters: life history

Pongo abelii
Sumatran Orangutan

Female dispersal	Time step (1, 3, 12 months)	Adult male dispersal	Time step (1, 3, 12 months)
1	12	1	3
Age at 1st reproduction (years)	Average interbirth interval (Yr)	Litter size	Fraction female at birth
15.4	8.7	1	0.45
Adult Annual Mortality Rate, %/year	Juvenile mortality multiplier	FemFract Mobile	Female special niche?
2.73	1	0.05	0.1

Derived variables:

Fraction reaching reproductive age	Median age in reproductive stage	Median offspring per female in reproductive stage	Birth rate per female, %/year
0.65	25.00	2.87	7.50
Effective population mortality rate	Net population change, %/year		
2.73	0.64		

	Carrying capacity, km-2 per land cover type	Local name
Primary forest	2.5	f_prim
OldSec forest	1.7	f_osec
YoungSec forest	0.9	f_ysec
Pioneer forest	0.2	f_pion
PostProd. agroforest	0.3	cao_post
LateProd. agroforest	0.3	cao_late
EarlyProd. agroforest	0	cao_early
Pioneer agroforest	0	cao_pion
PostProd. Plantation	0.2	op_post
LateProd. Plantation	0.1	op_late
EarlyProd. plantation	0	op_early
Pioneer plantation	0	op_pion
Open-field crops	0	paddy

Figure 54. Summary of main input and output parameters of the MetaPop001 model applied to Sumatran orangutan in the Tripa-Leuser landscape

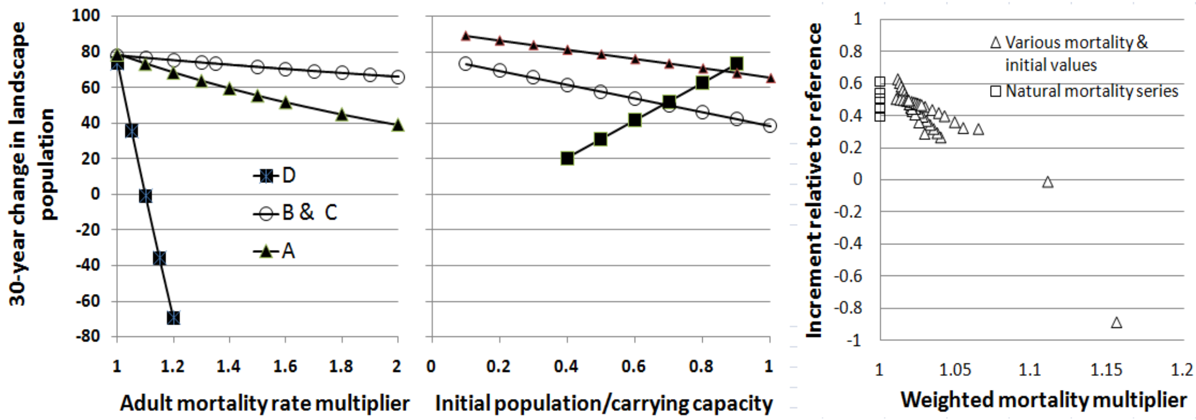


Figure 55. Predicted change in landscape-level population size in response to changes in single parameter values (left panel mortality rates per landscape element, middle panel inital values of population size relative to carrying capacity) and an aggregated rescaling of the model in a weighted mortality rate and an expression of population increment relative to its potential value given the underutilised carrying capacity and potential rates of population increment

7.3 Results

7.3.1 Sensitivity analysis of the model

Testing model sensitvity to parameter change yielded some initial surprises (Figure 55). Increases in mortality multiplier for the different components lead to monotone decreases in the population size after 30 years in comparison to the initial population. Differences in slope of the lines reflect the relative share of the total population in the different components. That was as expected. However, testing the effect of changes on the initial population on the gain that could be made over 30 years showed negatively sloping lines for landscape components A, B and C, but a positive slope for component D, the main reservoir (Figure 55.B). On further analysis, two factors contributed to this phenomenon: 1) the model uses an exponential growth equation below the carrying capacity and then levels off so that starting at lower levels implies slower absolute (but constant relative) growth; 2) shifts in the relative size of the various subpopulations influence the average morality factor for the population as a whole and thus its growth rate (compare Figure 55.A). These two effects can be separated if a 'population-weighted' mortality factor is used as X-axis and a change in population relative to the potential maximum incease as the Y-axis, as in Figure 55.C. Although some variation between the various parameter settings tested remain, the points are now confined to a negatively sloping band. In simple words, this implies that the net effectof corridors on population growth (or decline) is first of all determined by its effect on mortality (are more individuals exposed to increased mortality risk above natural levels) and, secondly, by the opportunities provided through acces to habitats with populations below carrying capacity. Details of connectivity determine the rate of approach of the potential population growth and thus what can be achieved in a 30-year timeframe. The model proved to be very sensitive to parameters describing dispersal rates of male and female individuals and the model default settings were adjusted to reflect the most recent data.

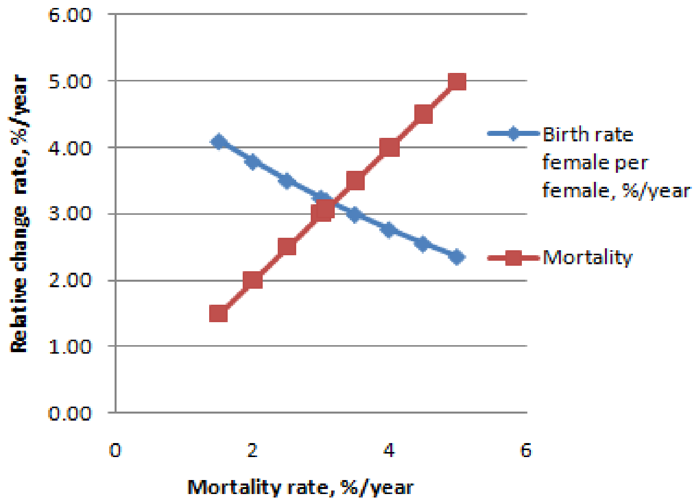


Figure 56. Sensitivity of birth rate and mortality of Sumatran orangutan in relation with the average annual mortality rate; population decline starts when the mortality rate exceeds 3.15%/year

7.3.2 Re-analysis of long-term data on mortality and dispersal

According to data summarised by Wich et al. (2004) for both Sumatran and Bornean orangutan, approximately 25% reach age 50. This implies an annual mortality of 2.73% (calculated as $100(1-0.25^{1/50})\%$). Observations on juvenile mortality of Bornean orangutan in the Tuanan site in Central Kalimantan (Table 48) suggest that aggregated mortality before weaning (age 6–8 years) is around 10% and likely to be less than the 18% expected when a 2.73%/year mortality is applied for 8 years. A 16% increase of the mortality rate above its natural value (i.e. from 2.73 to 3.15 % /year) is sufficient to induce decline of the population (Figure 56).

Table 48. Observations of juvenile mortality at Tuanan Orangutan Research Station (Kalimantan)

Age class	Survival	Comments
0–2	6 out of 6	All known infants born 2003–2008 still alive
2–6	5 out of 6	1 certain death at 4 yr after death of (old) mother
6–9	at least 5 out of 6	1 has not been seen for several months, but might have wandered beyond 50 m of the mother and escapes observation
10 and older	No reliable estimates	Males start to range further from natal range and are hard to find and/or re-identify

Source: Tuanan research station; personal communication Maria van Noordwijk, October 2010

Further observations that support such a low mortality estimate are that of 10 adult females (adult = after giving birth first time at 12–13 years, which is earlier than in Sumatra; weaning in this population happens at 6–7^{+} yr of age, 1–2 years earlier than in Sumatra) only one has died in 7 years of observation, after being displaced from her original home range. Among these 10 known adult females, only one does not have an accompanying offspring under 8 years-old (the exception, an older female, had a c. 10 year-old sometimes with her and has not been seen in two years). At the average annual mortality rate of 2.73%, derived from Wich et al., there would be 82% survival at age 8 years, so we assume that infant mortality is proportional to adult mortality, with a possible increase at subadult stage, for which insufficient data exist. On the basis of these data, for the default model application the juvenile mortality multiplier is kept at 1.0 (that is, juvenile and subadult mortality per year is identical to that for adults, with a likelihood that this overestimate of juvenile mortality compensates for an underestimate of subadult mortality, which is poorly known).

7.3.3 Application to the Tripa case study: Predicted impacts on male and female population size

The predicted population change, even when all life-history characteristics, habitat dynamics and mortality factors were kept the same, depended strongly (more than tenfold) on the effectiveness of the connectivity between landscape elements A...D (Table 42). For the connection between D and A...C this involved crossing a road. The largest increase in population size was predicted for situations where D was well connected to B and C, but the connection to A is weak or absent. This result, surprising as it may be at first, is due to the effective surplus in D, while the subpopulation in A has difficulties in realizing the growth potential of its restored habitat, while individuals that move into B or C are expected to have increased mortality. In the absence of effective connection to D, the link from A to B and C can have negative impacts on the net population size, compared to a fully isolated case. When subpopulation D is a major source of individuals in B and C, connecting to A can be beneficial. Where in fact the connection between B/A and A is easier to realise than than between D and B/C, this result has implication for corridor design.

Table 49. Predicted increment in landscape level population size for the default parameters set but variation in details of the way landscape elements A...D effectively connect (on a 0–1 scale); data were sorted by predicted population increment

A connects B?	A connects C?	A connects D?	B connects C?	B connects to D?	C connects to D?	Increment at landscape scale
1	1	0	1	0	0	14
0.7	0.7	0	1	0	0	17
0.5	0.5	0	1	0	0	20
0.5	0.5	0	0.5	0	0	22
0.5	0.5	0	0	0	0	31
0.5	0	0	1	0	0	33
0.5	0.5	0	0.5	0.1	0.1	45
1	1	1	1	0.2	0.2	59
0	0	0	0	0	0	62
0.5	0.5	0	1	0.2	0.2	64
0.4	0.4	0	1	0.2	0.2	66
0.5	0.5	0	0.5	0.2	0.2	66
0.3	0.3	0	1	0.2	0.2	69
0.2	0.2	0	1	0.2	0.2	73
0.5	0.5	0	0	0.2	0.2	75
0	0	0	1	0.1	0.1	77
0.1	0.1	0	1	0.2	0.2	81
0.1	0	0	1	0.2	0.2	88
0	0	0	1	0.2	0.2	95
0	0	0	1	0.3	0.3	112
0	0	0	1	0.5	0.5	133
0.5	0.5	0	1	1	1	159
0.4	0.4	0	1	1	1	160
0.3	0.3	0	1	1	1	162
0.2	0.2	0	1	1	1	165
0.1	0.1	0	1	1	1	168
0	0	0	1	1	1	174

The model with current parameters predicts that the female/male ratio can increase up to twice its initial value in subpopulation A under conditions that favour male dispersal, while the ratio remains below 0.3 for the corridor areas B and C at the end of the simulation.

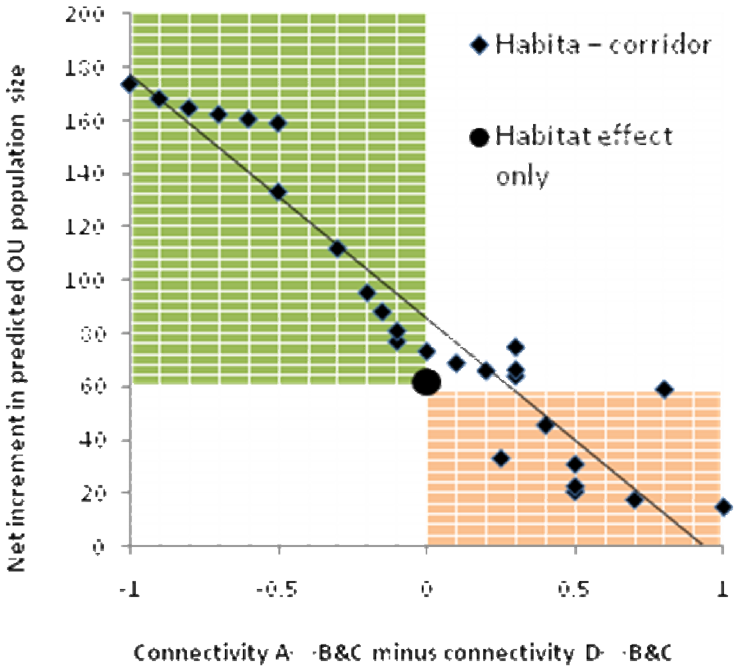


Figure 57. Relationship between the relative connectivity of corridors B and C to the major (D) and minor(A) source areas on the net increment of orangutan populations in the Tripa landscape; the red and green areas indicate net loss and net gain relative to a non-connected scenario that provides correction for the 'habitat increase' effect of the corridor

7.4 Discussion

As has been stated before, mortality is the critical factor for orangutan. With their long interbirth intervals they can hardly compensate for an increased level of immature or young adult mortality. Corridors and ecological connectivity may have a negative effect on total population development, once the increase in habitat as such is accounted for. Connectivity between the main source population and threatened forest patch has to be established with priority to connections to the main source, to avoid draining the threatened forest patch, especially if mortality in the corridor cannot be fully controlled. In the landscape of Tripa this implies that restoration of habitat in the oil palm areas needs to be accompanied by connectivity across the road that separates D and areas B and C.

The predicted differential effect on male and female occupation of the newly available niche space in corridors B and C suggests that effects on gene flow will be more pronounced than direct effects on population dynamics. In the long run the isolated population might run the risk of inbreeding and be dependent on at least a moderate exchange of males with other parts of the landscape, the way orangutan populations have always functioned.

Relative to the broader discussion on ecological connectivity this case study confirms that details of the life history and biology of a species are crucially important in understanding the likelihood of positive or negative responses to enhancing connectivity between specific parts of a landscape. The finding that it matters from which side the bridge is built may have wider implications for current plans in Tripa.

The high sensitivity to predicted orangutan numbers to details of the corridor scenario, demonstrates that at exactly the same carbon stocks and incime, the biodiversity conservation outcomes can be drastically different. Carbon conservation as such is no guarantee that there will be positive biodiversity results, but planning that is based on biodiversity conservation goals will have positive effects for reducing carbon stock emissions. While an effective price of 15 USD/tCO_2e at farmgate level may be relatively high for current carbon market perspectives, the large 'biodiversity co-benefits' justify investment; it may be more appropriate, however, to refer to such an approach as seeking biodiversity outcomes with carbon co-benefits.

8. Options for REDD$^+$ in Batang Toru and Tripa conclusions and recommendations

The six component studies in Batang Toru and Tripa relate human livelihood strategies to their impact on land cover and carbon stocks in the landscape, with consequences for biodiversity in general and specifically affecting the probability of survival of orangutan. Quantitative understanding of the relationships was used to considere to options for the next 30 years and to the feasibility of external support for livelihood strategies that maintain carbon stocks and orangutan in the landscape but still accommodate the human population density that currently exists plus a modest growth rate.

The study of orangutan habitat and human livelihoods in Tripa and Batang Toru started from the contrast of 'segregated' and 'integrated' approaches to achieving the dual goals of conservation and poverty alleviation (that is, economic development). The Batang Toru landscape with its relatively stable forest-agroforest-village-rice-field gradient can serve as model for the 'integrated' approach; the Tripa swamp-forest-or-oil-palm-monoculture represents a 'segregated' case. Are the observations on livelihoods and land-use change in the two landscapes aligned with this contrast? What are the consequences for conservation strategies that try to combine orangutan survival, broader biodiversity conservation and reduction of greenhouse gas emissions, potentially under the REDD umbrella? How can genuine expectations of improvement of local livelihoods be reconciled with ecological priorities? In this final chapter of conclusions and recommendations we return to this broader set of issues.

The forest-to-village gradient in Batang Toru

The findings in the Batang Toru landscape contain few, if any, surprises. Along most of the perimeter of the Batang Toru forest block the current village-to-forest gradient is relatively stable, with rubber and *kemenyan* agroforests as transition zones and rice fields around the village as primary subsistence source complemented by agroforests as sources of income, NTFP, fruits and medicines. The rice fields depend on stable water flows and the villages have an interest not to upset the local hydrology, while there still are opportunities to intensify and change within the agroforest domain.

Currently, however, the *kemenyan* systems have become economically marginal and shifts in production and/or marketing systems will be needed to avoid a destabilisation of the northern part of the Batang Toru forest block. Within the rubber agroforestry systems there are new opportunities to pursue a better price for the product by better local processing and/or obtaining a premium for 'environmentally friendly' production through forms of eco-certification. Current World Agroforestry Centre pilot studies on these in Jambi could be extended to the Batang Toru area. The sugar palm agroforestry at higher elevations may well be at the peak of its potential as an interface between livelihoods and conservation, as efforts to plant and domesticate the tree are, so far, not economically attractive.

The three primary threats to orangutan conservation in this landscape are 'external': the logging concession, the planned gold mining operations and the continued in-migration of people originating from Nias. The latter may well be the most immediate threat, given the expansion of mixed farming along the lower elevations of the Batang Toru block that are the most interesting part of the landscape for orangutan. It is probably also the most difficult to control and deflect, as there is no single government agency that can withdraw permits and stop the process. For the logging and goldmine, substantial income is involved for the local and central governments and offsets of local job opportunities as calculated here will not be sufficient.

The basic picture of Batang Toru as an 'integrated' landscape survived the analysis, helped by dominant commodities in the agroforests that are not on the menu for orangutan. There are some fruit trees that are on both the human and orangutan menu, including durian, but their productivity in peak seasons is enough for the orangutan consumption of fruits to be tolerated. Active hunting of orangutan by population groups who are not restricted to do so by their religion (that is, Christians rather than Muslims) remains an issue that requires attention.

The forest–oil palm dichotomy in Tripa

The findings for Tripa suggest that 'segregated' is the keyword here. With the decline of cacao agroforestry, the landscape moved towards a dichotomy between forest and oil palm. Local perspectives are that conversion to oil palm is changing water quality and affecting the production of *lele* (catfish), decreasing the value of the local economy of the swamp forest and accelerating its further conversion. The swamp forest contains few trees that are providers of NTFP and income sources, unlike swamp forests along Sumatra's east coast, or Kalimantan, where, for example, *Dyera costulata* (*jelutung*) is a source of valued resins and *Alseodaphne*[17] *coriacea* (gemor) bark is collected as a source of mosquito repellent coils. The rapid conversion of the peat swamp forest since the early 1990s was only interrupted during the political instability period when off-road security was a major concern; it picked up rapidly after the Aceh peace agreement, despite the declarations of intent around the Leuser Ecosystem Zone (Kawasan Ekosistem Leuser).

Potentially the most surprising finding of this study was the extent to which smallholder oil palm is now driving land-use change in Tripa. For local livelihoods this is good news, as smallholder oil palm can give good returns to labour once the investment period is bridged and as long as local processing capacity is available. As there are several mills accessible from the area, smallholders have a reasonable bargaining position. From a conservation perspective it is mixed news. Stable oil palm can absorb a fair amount of labour and deflect further expansion into forests and 2 ha of oil palm per household is still available at the current population density. Control over the process by external agents, however, is hard to achieve. A single oil palm concession can be blamed and shamed internationally if they breach (voluntary) agreements to stop conversion of natural forest. A large number of smallholders, however, cannot be easily influenced in their decisions, unless the mills found that their customers care about the source of the fresh fruit bunches that they process into palm oil. With an average projected population density for the area of 29 000 persons and a human population density of 25 persons km^2, up to 70% of the area could be converted to oil palm based on the existing labour pool (assuming 70% of the human population to be economically active and oil palm requiring 60 person-days per hectare per year).

[17] The botanical data for Tripa swamp show an *Alseodaphne* species but it is not clear whether or not this could be used similar to 'gemor'; gemor harvesting in Kalimantan has wiped out the tree in many areas before local domestication of the tree started, so its value as NTFP has been a transient one.

The primary lever on the oil palm economy is the external labour demand. Although the companies try to offer locally competitive wage rates they still rely on seasonal external labour and their historical connection with transmigration that added a labour force to the area. Current expansion is dependent on such labour and on companies who can organise it. A further restructuring of oil palm production to local agents, with oil palm companies focussing on their comparative advantage in the mill and downstream processing rather than primary production, may achieve local-livelihoods-plus-conservation goals if it removes the demand for an external labour supply. The main company with an 'agreement in principle' for oil palm establishment in the best remaining forest block in Tripa has declared a moratorium on its plans for forest conversion, which aligns with the rules of the Roundtable on Sustainable Palm Oil and the intentions of the Government of Indonesia. The company realises that there is international attention on the area and that their actions are scrutinised. If they withdrew from their concessions, however, without clarity on the future of the area, a vacuum might appear in which local actors might see opportunities for direct gain. The unresolved tenurial claims and contest in the area will need to be resolved as part of a comprehensive conservation plan. From the perspective of orangutan conservation, the interrupted corridor between the remaining orangutan habitat in the swamp and the Gunung Leuser National Park is probably the biggest concern.

In both Batang Toru and Tripa there are threats to orangutan habitat that simultaneously lead to CO_2 emissions. Efforts to reduce emissions can, under certain conditions, coincide with efforts to conserve orangutan. Five key questions remain.

A) Can efforts to reduce emissions and conserve orangutan qualify under international REDD+ rules and current perspectives on its implementation in Indonesia?

B) Will any effort to reduce emissions in these landscapes directly provide biodiversity benefits and specifically conserve orangutan ?

C) Will investment in CO_2 emission reduction in this landscape be feasible on the basis of carbon finance alone or will conservation benefits require additional investment?

D) How can these results be used for local negotiations and discussions on alternative ('high carbon stock' or 'green') development pathways?

E) How uncertain are current results and what can and should be done to reduce uncertainty?

REDD+ eligibility issues

Can the REDD+ framework offer new opportunities for Batang Toru and/or Tripa? The irony is that Tripa, despite its high carbon-loss potential in the peat soils and high biodiversity value for orangutan and other biota, has not so far been considered to be a priority, as it is already defined as legally 'deforested'. It is outside the legally defined forest area and classified as APL (Area Penggunaan Lain = Other Use Area) and thus also outside the purview of the Ministry of Forestry as the primary government agency involved in REDD+. Existing public policy commitments to support conservation in the Leuser Ecosystem have not had tangible impacts on the ground and a strong case can be made for 'de facto additionality' of new efforts to reduce emissions, even though on paper the area already is protected.

For Batang Toru, the REDD options may be slightly better, despite lower emission reduction potential, although classification of part of the forest as 'watershed protection forest' also forms a challenge to any 'additionality' claim for any REDD project at subnational scale. In this landscape extrapolation of the recent levels of emissions provides a less negative baseline and thus less emission reduction can be claimed if the landscape is fully conserved.

To understand these eligibility issues better, a comparison is needed of international and Indonesian perspectives on, and definitions of, 'forest'. The internationally agreed definition of 'forest' has four components: canopy cover, tree height, minimum area and expected recovery from an 'unstocked' condition. Based on the UNFCCC forest definition, forest can include 'areas normally forming part of the forest area which are temporarily unstocked and are expected to revert to forest'. In Indonesian forestry law, 'forest' is defined as an ecosystem with multiple functions (Law no. 41 of 1999) but the concept of 'forest without trees' is possible as well. Ultimately, 'forest area' in both international and Indonesian definitions is an institutional designation that does not depend on the presence of trees. This categorisation can help explain why official statistics of deforestation show much smaller areas than remote-sensing data on loss of tree cover (van Noordwijk and Minang, 2009). Equally, however, non-forest can contain trees and recent data for Indonesia (Ekadinata et al., 2010) suggest that emissions from change in woody vegetation outside institutional forest are equal to those inside the institutional forest area. The way the REDD+ debate has so far been interpreted as necessarily focused on the 'forest area' is not mandated by international rules, but based on Indonesia's interpretation of these rules. In a comprehensive approach to land-based emissions that do not depend on an institutional forest definition, the emission reduction feasible in Tripa can match international rules for REDD+ and the 'forest plus peat' interpretation that has been used for the Letter of Intent between Norway and Indonesia.

In Batang Toru, farmers have developed mixed gardens and agroforest systems, which can be counted as 'forest' according to the current internationaly agreed definition. Again, by international standards all emission reduction options discussed here can be eligible, even though they involve land outside the 'forest area' (Kawasan Hutan). The institutional translation of REDD+ in Indonesia and the way agencies outside of 'forestry' are to be involved is currently under discussion and both Tripa and Batang Toru can provide interesting case studies for a broader landscape approach.

Biodiversity and orangutan, other ecosystem services and emission reduction

Forest has various functions and different people look at forest in different ways. Especially in Batang Toru, villagers depend on, and appreciate, the forest in their landscape as a source of sugar palm, rattan and other harvestable products as well as regular water flow into their rice paddies.

In much of this study we took aboveground carbon-stock as a proxy for for other services. Figure 18 and Figure 21 indicate that such an approach is acceptable only as a first approximation in the case of tree diversity. Chapter 7 showed that even with the same landscape-level carbon-stock the outcomes for orangutan conservation can vary considerably depending on the spatial organisation of the carbon stocks in the landscape, even apart from the potential influence of hunting and human–orangutan conflict that depend on landscape organisation rather than its carbon stock. It is not the forest in itself or its carbon stock that provide watershed functions (Verbist et al., 2010; van Dijk et al., 2009). Watershed functions such as buffering of riverflow are primarily related to the litter layer covering the soil and stimulating presence of 'soil engineers' that create macroporosity of the soil (Hairiah et al., 2006) and/or old tree root channels derived from natural or human-induced turnover of woody vegetation (van Noordwijk et al., 1991). The two landscapes differ in the type of important watershed functions.

In Batang Toru, the protection of steep slopes from landslides and erosion probably depends on woody vegetation (natural forest or agroforest) on the slopes. At lower elevation, riparian vegetation and wetlands provide temporary water storage and buffer flooding risks, but this happens outside of the study area as such. In Tripa, the peat domes still interact with the river delta and provide habitat for fish, but without people downstream are not important for flood control. The integrity of coastal vegetation is generally linked to reduced risk from sea-level rise and tsunamis, but the empricial evidence is sketchy at best (Cochard et al., 2008; Juan Laso Bayas, pers. comm., 2010). Further site-specific effort will probably be needed to tease apart other ecosystem services for the two areas. For the current discussion it is important to note that they will generally be positively associated with carbon stocks across land uses, even though the association is not a very tight one.

Investment levels required

In both Batang Toru and Tripa the study identified opportunities for land-use change that may increase local income but decrease carbon stocks and cause net CO_2 emissions. To the degree that such land-use change is legally permitted and/or de facto tolerated, economic incentives will be needed to change the course of action. This study provides indicative values of the potential cost-effectiveness of such measures.

Opportunity costs were calculated in three different ways: in a direct comparison between land-use systems; in the landscape-scale time-dependent opportunity-cost curves (both in chapter 5); and based on change in rural income per unit CO_2 emissions (chapter 6). The latter may be of more direct relevance in discussions with local stakeholders of the type and level of emission reduction that may be feasible through what type of measures, with negotiated levels of 'compensation' (an essentially negative concept) or positive investment in a green future. With total cost levels at 5–15 USD/t CO_2e, depending on the type of interventions, we can conclude that REDD+(+) scenarios could be feasible but require a commitment to top-up the purely efficiency-based carbon market prices. The likelihood of contributing to survival of the Sumatran orangutan (especially in the more costly corridor options for Tripa) may provide sufficient reason on the 'voluntary market', but requires that biodiversity and emission reduction are seen as equally important (rather than one as 'co-benefit' of the other).

According to our analysis, a major constraint faced by smallholders who may be attracted by the possible returns of oil palm systems is the lack of capital for investment, price uncertainty and low intensity of management and specific knowhow on the crop. For cacao, many farmers are constrained by lack of technical guidance with management, with pest control a major issue. Increased availability of investment capital and knowhow may increase attractiveness of the crop, while it could also be part of a 'guided intensification' process that allows forest conservation and emission reduction. The main issue ('Pandora's Box', as discussed in Tomich et al. 1998, 2001), is whether or not the landscape will continue to attract external labour and migrants. Technical support for diversifying agroforests with valuable tree species, as piloted in Batang Toru (Martini et al. 2008), may support local motivation for conservation, but needs to be evaluated in realistic economic terms.

The way the incentives reach the local economy can still be open to discussion: our opportunity-cost analysis only provides a target for a bottomline. Higher prices for agricultural products derived from environmentally friendly management may be feasible in the rubber agroforests of Batang Toru. In Tripa, alternative employment may have to be created. Past policies (since early 2000) of the local government to promote smallholder oil palm for local households may have increased the number of households in the area; further growth may not be compatible with a high carbon-stock development pathway. However, if policies induce people to move elsewhere then emission displacement rather than emission reduction may be the consequence. The target should be to find population-neutral development alternatives.

A key result of this study is the indication of a partial 'internal offset' of lost income opportunities from avoided further oil palm expansion (from USD 7.5 million to USD 3 million per year as discussed in Chapter 6). Such offsets are indicative of (and dependent on the correct representation of) the cross-sectoral links between activities in the model. The results so far show that beyond opportunity costs, the issue of 'in-landscape' employment opportunities is key to any success in conservation. Specific investment plans may need to be checked in the scenario model for interactions with land-use choices, as part of a broader evaluation and as input into local policy debate.

Next steps in negotiation and discussion of high carbon-stock development pathways

There is an emerging consensus in the REDD+ arena that any measures taken should be based on 'Free and Prior Informed Consent' (FPIC). The ideas and scenarios presented in this report are intended as input into local discussions and not as 'project designs' as such.

A sensitive issue with such negotiations is who should be involved. The local communities will definitely have to be, as well as the well-established migrants such as the Nias people in Batang Toru or transmigrants in Tripa. What about seasonal or temporary labour working on the oil palm plantations or the people who might want to migrate into the areas? The potential differences in perceptions and interests may be substantial, while external stakeholders such as conservation groups or oil palm/logging companies have an agenda that does not necessarily match with the local one.

We expect that further discussions at local level will lead to refinement of the scenarios explored here and we hope that the tool can be presented in sufficiently transparent fashion to allow such to happen.

Uncertainty that needs to be addressed

Results presented here depend on assumptions and methods and both need to be critically examined. Results of the FALLOW model are expressed as inflation-corrected currencies that ignore temporal variability of (farmgate) prices. The relationship between 'independent smallholders' and the mills needs to be better understood (Sheil et al., 2009).

Our data on calculation of carbon stock and carbon emission at landscape level is subject to uncertainty and errors. Data on peat thickness in Tripa is very limited, so that image interpretation on peat depth is subject to error. Besides this, the subsidence rate in relation to land use has not been quantified for the peat swamp forest of Tripa; data from Aceh Barat confirmed the order of magnitude of the assumed values, but uncertainty remains. Owing to difficulties in obtaining agreement with the concession holders, the core forest area was not visited in the fieldwork stage; its carbon-stock value may be higher than reflected in current data (which were collected in areas closer to human settlement).

Use of the peat swamp by local people, once averaged over the 20 000-plus people in the area, is not of major importance, but there is a small fraction of the population for which this matters a lot, and their perspective needs to be better understood. The livelihood survey (Chapter 2) indicated that *lele* (catfish) used to be a dominant non-timber forest product (NTFP) from Tripa, but that farmers no longer catch a high quantity of *lele*. The income generated from fishing is lessening, owing to the decreasing quality of river water. Fishers complained of leaching of fertilizer from the HGU that contaminated the river. In Batang Toru, collecting rattan, *kemenyan* and sugar palm from the forest would contribute to livelihoods. All NTFP should be included in the calculations of the FALLOW model to give better options of income sources if forest is conserved as an orangutan habitat, since people could generate income from NTFP. Probably these options are still highly relevant for specific groups of the population, but they disappear in the background at the overall economy of the landscape, as represented in the FALLOW scenarios. For a more detailed stakeholder analysis, such results need to be further checked.

Ecosystem services provided by the forests that this study examined were quantified only as carbon stock and tree diversity. Other than these, water is also measureable and has economic value, such as for energy (hydro-electricity) and drinking (both in in Batang Toru); these services have not yet been evaluated. Quantification of such values, however, is double-edged in the context of investment in emission reduction: it clearly increases the social/societal desirability of efforts that will (also) reduce emissions, but it also identifies more local stakeholders of hydro-electricity and drinking water as co-responsible for the investment, and it undermines the argument for 'additionality' of specific emission reduction. Such issues are critical in a 'market-based' approach for commoditised environmental services that need to be carved out from multifunctional landscapes (see CES paradigm as discussed by van Noordwijk and Leimona, 2010); it matters less in a program where public funds are used to offset opportunity costs (COS paradigm) and even less in a Co-investment in Stewardship (CIS) paradigm. As long as society can be assured that other benefits are positive, detailed quantification and valuation may not be necessary for the policy decisions that are to be made.

An earlier study in Batang Toru with the Rapid Land Tenure Assessment (RaTA) tool by Sirait (2007) clarified that there were multiple perceptions of land rights, with a rather complex history of interactions between local communities and the government that dates back to the pre-Independence era. Some indications of multiple and contested land claims were described in the livelihood study for Tripa, but further exploration of these issues is desirable.

The corridor study in Chapter 7 brought out the relevance, from an orangutan conservation perspective of establishing connectivity with the main orangutan populations in the Gunung Leuser National Park. This will have to involve more detailed studies in the area outside HGUs. If oil palm land swaps are to be part of the solution, further analysis is needed of the areas to which oil palm could be moved and how this would interact with the rest of the landscape

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Annex 1. Major Land-Cover Types in Batang Toru

Undisturbed forest

Disturbed forest

Rubber agroforest

Cofeee agroforest

Mixed gardens

Plantation/estate

Oil palm plantation

Crops

Shrubs and herbs

Cleared land

Rural settlement

Water body

Annex 2. Major Land-Cover Types in Tripa

Undisturbed forest
(swamp forest)

Disturbed forest

Agroforest/vegetation mosaics

Oil palm


Crops


Shrubs and grass


Rural Settlement


Cleared Land

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

PanEco

UNEP

The World Agroforestry Centre (ICRAF), in collaboration with PanEco and Yayasan Ekosistem Lestari (YEL), conducted a rapid assessment of ecosystem services and human livelihood options provided by the remaining habitat of the Sumatran orangutan outside the Gunung Leuser National Park. We used a rapid analysis of carbon stock assessment (RaCSA) method to assess the carbon stock (above- and belowground) at plot level and calculated land cover for carbon stock at landscape level. We calculated the net present value of important crop and tree commodities in Tripa and Batang Toru and analysed the costs and benefits of each commodity. To find solutions for better management at the two study sites, applications of the FALLOW model were developed, which allowed comparison of several possible scenarios. An attempt was made to translate such scenarios into opportunities for human livelihoods, orangutan population size and carbon emissions and stocks.