Cambodia's cut

An ITTO fellowship helped estimate a sustainable yield from logged-over forests in Cambodia

By Dana Kao[1], Nobuya Mizoue[2] and Shigejiro Yoshida[2]

Dr Dana Kao (Cambodia) received an ITTO fellowship in 2008 to undertake a Doctoral Program in Forest Management at the Department of Forest and Forest Products Sciences, Faculty of Agriculture, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, Japan. This article is based on his doctoral research.

Stand of foresters: One of the inventory teams. *Photo: D. Kao*

Tropical forests host a large majority of the earth's biodiversity, representing an invaluable asset both globally and for local communities (see Top *et al.* 2009). Forests are also important for their role in the carbon and water cycles (Clark *et al.* 2001), and well-managed forests can be an ecotourism attraction.

One of the tasks of foresters is to ensure that the extraction of forest products such as timber does not exceed the sustainable capacity of the forest ecosystem, thus ensuring that forests are able to perform their many functions. To assess the sustainability of commercial timber harvesting, estimates are needed of forest increment—that is, the rate at which the forest grows. However, reliable data on commercial tree growth are very limited in the natural tropical forests of Southeast Asia.

In 1998 over 7 million hectares of Cambodia's forests were available for harvesting in forest concessions. In 2001 the government suspended all logging activities in concessions and this ban remains mostly in place, although illegal logging is thought to be widespread (ITTO 2011). Should legal logging resume it is important to know growth and yield characteristics so that a sustainable harvest can be calculated and imposed. Little is known, however, about the growth dynamics of Cambodian forests. Therefore, we carried out a study to estimate forest increment of logged and unlogged tropical evergreen forests in northern Cambodia.

Study site and method

The study area is located at longitude 104°58'E to 105°82'E and latitude 13°48'N to 14°89'N within a forest concession in Preah Vihear province (Figure 1), with various (logged and unlogged) forest formations covering a total area of 103 058 hectares. In 20 sample plots in logged (1998) and unlogged forests, the diameter at 1.3 m (dbh) and height of each live tree (commercial, non-commercial and non-timber forest product—NTFP) were measured, first in March 2001 and then in October 2008. Immature trees and NTFPs with dbh 10–29 cm were measured in subplots (20×20 m), while mature trees with dbh greater than 30 cm were measured in the main plots (40×60 m).

All measured trees were classified by diameter and tree density, volume and basal area were estimated. The average tree volumes of dipterocarps and non-dipterocarps were estimated based on equations reported in Forest Authority (2004). The periodic annual increment (PAI) was estimated by comparing the densities, volumes and basal areas of logged and unlogged sites in 2001 and 2008.

The structural change in the first three years after logging was estimated by comparing analogous unlogged evergreen forest (UNFE) with the 2001 measurement of evergreen forest that was logged in 1998 (LGFE). The change over ten years was estimated by comparing the 2008 measurements of the UNFE and the LGFE. The annual change in structure was estimated by comparing measurements in 2001 and 2008.

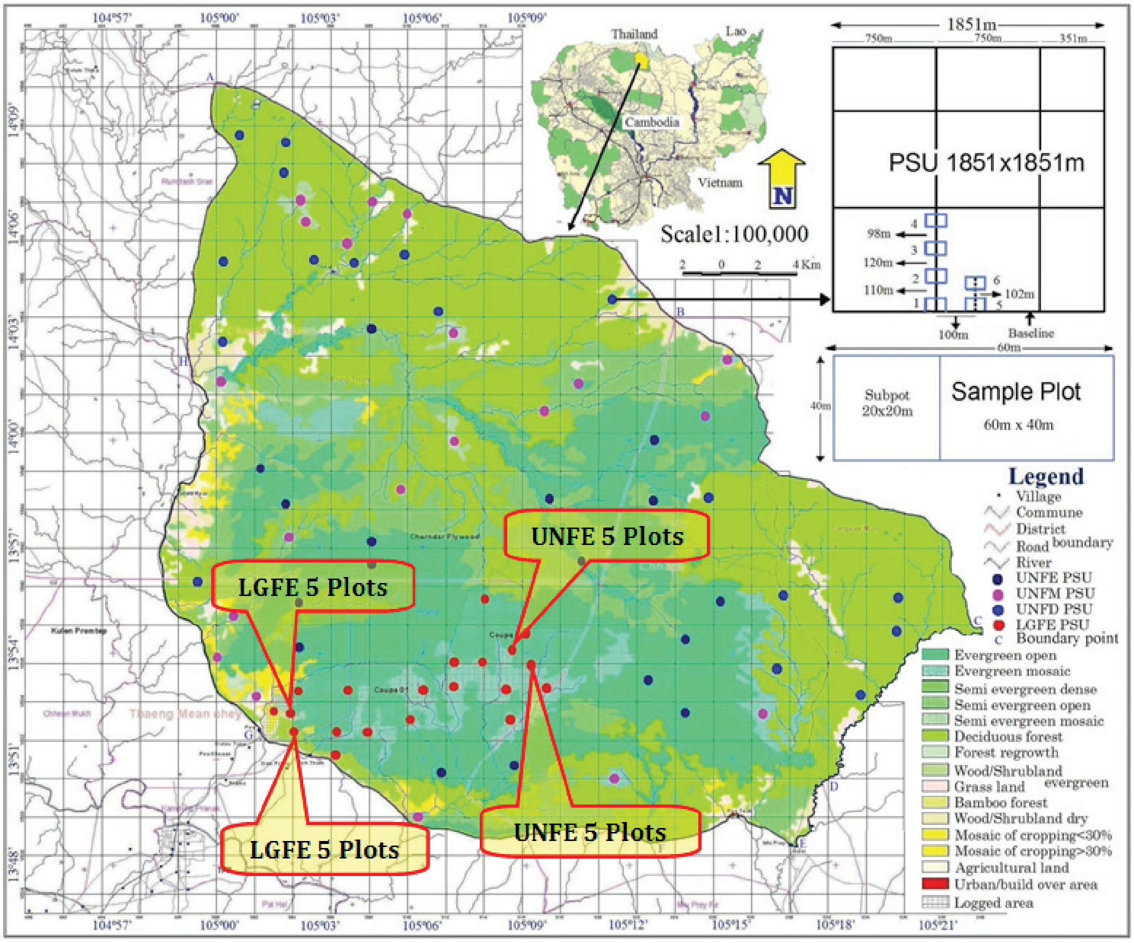
The PAI was assumed to constitute net growth because the remaining live trees and newly recruited trees were considered as live trees in the second measurement. Vanclay (1994) defined yield as $V_n = V_2 - V_1 + V_c$, where V_2 and V_1 are the live stand volume at measurements 2 and 1, respectively, and V_c is the cut volume. Vanclay (1994) defined

1 *Forest Management Office, Department of Forest and Forestry Community Management, Forestry Administration of Cambodia kaodana@gmail.com*

2 *Department of Forest and Forest Products Sciences, Faculty of Agriculture, Kyushu University, Japan*

Logged and unlogged

Figure 1 Plot locations



Note: UNFE = unlogged evergreen forest and LGFE = logged evergreen forest.

the net growth of initial volume as $V_{ni} = V_n - V_i$, where V_i is the ingrowth volume. This study considers only $V_2 - V_1$ of each forest type.

Results

In 2008 the density, volume and basal area (for trees with dbh ≥ 10 cm) of the LGFE were 431.7 trees/ha, 202.6 m^3/ha and 26.0 m^2/ha, respectively; those of the UNFE were 483.3 trees/ha, 199.7 m^3/ha and 22.2 m^2/ha (Table 1). The average annual recruitment of trees with dbh ≥ 10 cm in the LGFE (5.7%) was higher than that in the UNFE (3.3%), due to the open canopy created by harvesting (Table 2).

For trees with dbh ≥ 50 cm the PAI of commercial tree volume was 1.1 m^3/ha in the LGFE and 0.2 m^3/ha in the UNFE, while the PAI of basal area was 0.6 m^2/ha and 0.2 m^2/ha, respectively (Table 2). About 2.4% of trees with dbh ≥ 10 cm were assessed as dead in the LGFE in 2008, compared with 5.5% in the UNFE (Table 1). The annual growth rate of tree density (all stems with dbh ≥ 10cm) was higher in the LGFE (5.7%) than in the UNFE (3.3%), as was the annual volume increment (3.5% compared with 1.6%) (Table 2).

Conclusion

In 1998, the harvest of the LGFE site involved the removal of 3.0 trees/ha (dbh ≥ 50 cm), which resulted in a yield of 22.2 m^3/ha by volume and 1.6 m^2/ha by basal area (Kao and Iida 2006). The volume and basal area increments for trees with dbh ≥ 50 cm can be used to set the sustainable yield (although logging damage, planned silvicultural treatments and the forest's capacity to provide ecosystem services such as those related to biodiversity, carbon, water and aesthetic values should also be taken into account).

The *ITTO criteria and indicators for the sustainable management of natural tropical forests* (ITTO 2005) state that forest resource assessments carried out periodically are vital for ensuring the sustainable production of forest goods and services for society; this includes determining the sustainable yield. In the study area, the total volume increment of trees with dbh ≥ 50 cm 25 years after logging is estimated at about 27 m^3/ha (i.e. 1.1 m^3/ha x 25), which is greater than the previously harvested volume. Therefore, harvesting on a 25-year cutting cycle should be possible in the LGFE. Since the initial logging was in 1998, the next harvest could take place in 2023. However, we recommend

Showing their classes

Table 1 Forest parameters, 2001 and 2008, by dbh class and logged and unlogged

dbh class (cm)	2008						2001					
	LGFE			UNFE			LGFE			UNFE		
	De	Vol	BA	De	Vol	BA	De	Vol	BA	De	Vol	BA
[dbh < 0.5 cm; height >1 m]	9440	NA	NA	7960	NA	NA	5100	NA	NA	3900	NA	NA
0.5–9	810	115.8	3.3	900.0	146.1	3.5	691.7	NA	NA	712.5	NA	NA
10–19	230	47.6	3.6	327.5	77.0	4.8	143.8	35.6	2.1	250.0	62.7	4.2
20–29	120	50.2	5.4	87.5	28.4	3.3	62.5	29.3	2.8	62.5	23.9	2.8
30–39	37.1	18.8	2.6	25.4	13.7	2.0	22.9	18.2	2.0	17.2	11.3	1.5
40–49	12.9	12.8	2.0	13.3	13.1	1.9	2.8	3.5	0.4	10.9	11.7	1.7
>50	31.7	73.1	12.4	29.6	67.4	10.1	16.7	64.7	7.7	22.9	65.9	8.8
Total (dbh≥10 cm)	431.7	202.6	26.0	483.3	199.7	22.2	248.6	151.4	15.1	363.5	175.6	18.9
Grand total	10682	318.4	29.2	9343.3	345.8	25.7	6040.3	151.4	15.1	4976.0	175.6	18.9
[Total dead]	40.4			54.6								
[Total dead dbh≥10 cm]	10.4			24.6								

Note: LGFE = logged evergreen forest, UNFE = unlogged evergreen forest, dbh = diameter at breast height (1.3 m); De = density (trees/ha); Vol = tree volume (m^3/ha); BA = basal area (m^2/ha); NA = data not available; TD ≥ 10 cm = total number of trees with dbh > 10 cm.

Growing back

Table 2 Periodic annual increment, by diameter class, logged and unlogged

	Annual growth						Annual growth (% of dbh≥10 cm)					
	LGFE			UNFE			LGFE			UNFE		
dbh class (cm)	De	Vol	BA	De	Vol	BA	De	Vol	BA	De	Vol	BA
[dbh < 0.5 cm; height >1 m]	578.7	NA	NA	541.3	NA	NA						
0.5–9	15.8	NA	NA	25.0	NA	NA						
10–19	11.5	1.6	0.2	10.3	1.9	0.1	2.7	0.8	0.8	2.1	1.0	0.4
20–29	7.7	2.8	0.3	3.3	0.6	0.1	1.8	1.4	1.3	0.7	0.3	0.3
30–39	1.9	0.1	0.1	1.1	0.3	0.1	0.4	0.0	0.3	0.2	0.2	0.3
40–49	1.3	1.2	0.2	0.3	0.2	0.0	0.3	0.6	0.8	0.1	0.1	0.1
>50	2.0	1.1	0.6	0.9	0.2	0.2	0.5	0.6	2.4	0.2	0.1	0.8
Total (dbh≥10 cm)	24.4	6.8	1.5	16.0	3.2	0.4	5.7	3.4	5.6	3.3	1.6	2.0

See Table 1 for abbreviations.

that damage caused by logging should be studied in detail before putting this conclusion into effect, as should the effects of logging at this intensity on other forest values. Long-term monitoring of yield, growth and regeneration is especially important to ensure that harvest levels and the mix of forest products are sustainable.

Acknowledgements

The authors thank H.E. Sokhun Ty, former Director General of the Cambodian Forestry Administration, for his approval to enter the forests for setting up and measuring the permanent sample plots; local authorities and indigenous people who willingly contributed to the project through a consultation process and gave the authors their trust; reviewers, who gave valuable comments and suggestions on the draft manuscript; and ITTO, which provided crucial support through the ITTO Fellowship Program.

References

Clark, D., Brown, S., Kicklighter, D., Chamber, J., Thomlinson, J. and Ni, J. 2001. Measuring net primary production in forest: concepts and field method. *Ecological Applications* 11: 356–370.

Forestry Administration 2004. Development of growth and yield studies and establishment of permanent sample plots. Project credit No. 3365-KH. Forestry Administration, Phnom Penh, Cambodia.

ITTO 2005. *Revised ITTO criteria and indicators for the sustainable management of tropical forests including reporting format.* ITTO Policy Development Series No 15. ITTO, Yokohama, Japan.

ITTO 2011. *Status of tropical forest management 2011.* ITTO Technical Series 38. ITTO, Yokohama, Japan.

Top, N., Mizoue, N., Ito, S., Kai, S., Nakao, T. and Ty, S. 2009. Effects of population density on forest structure and species richness and diversity of trees in Kampong Thom Province, Cambodia. *Biodiversity Conservation* 18: 717–738.