Development of a Lao-specific Equation for the Estimation of Biomass of 'Regenerating Vegetation' and Determination of the Threshold Years for its Regeneration into Forest

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Contents

Acronyms

Acronym	Name
AGB	Above Ground Biomass
BGB	Blow Ground Biomass
CCR	Crown Cover Rate
DAFO	District Agriculture and Forestry Office
DBH	Diameter at Breast Height
DOF	Department of Forestry
FIPD	Forest Inventory and Planning Division
MD	Mixed Deciduous Forest
NUoL	National University of Laos
PAFO	Provincial Agriculture and Forestry Office
REDD+	Reducing Emissions from Deforestation and Forest Degradation and the role of conservation of forests and enhancement of forest carbon stock
RV	Regenerating Vegetation
SOP	Standard Operation Procedure
UAV	Unmanned Aerial Vehicle

1. Executive Summary

In Lao PDR, each year around 100-150 thousand hectares of forest areas are affected by shifting cultivation. The area is cultivated for a short period, often one year, and then left to regenerate (fallow) as "Regenerating Vegetation (RV)". Such areas covered around 25% of the total area of Lao PDR in 2015. The ability to quantify tree biomass in this landscape is limited by the availability of reliable estimation models. Furthermore, distinguishing between RV and forest[1] through remote sensing is difficult. The survey, therefore, aimed to develop an equation for predicting the biomass for RV based on the number of years since abandoned cropping; and also to clarify the threshold year of abandoned RV to regrow to forest.

Survey clusters were selected by using annual vegetation loss dataset of Hansen *et al*[2], to detect the year of loss on forest loss plots, then ground truthed and measured the crown cover to determine whether it had reached the forest status or not. For each survey plot, the year of forest loss was further verified by interviewing the villagers. A total of 120 survey plots (40 survey clusters with three survey plots each) were surveyed in five provinces, to survey the lands with 1st year to 8th year after abandonment. In each plot, DBH (≥ 5 cm) for all trees was recorded, and other types of vegetation were sampled.

At the same time, Unmanned Aerial Vehicles (UAV) was used to take an aerial photograph of the plot in order to identify the crown cover rate (CCR). The CCR was used for identifying the threshold year of abandoned RV to regrow into forest.

As a result of the survey, an equation which represents the relationship between the number of years since abandoned cropping and the amount of above-ground biomass (AGB) was developed (AGB= AGB = 1.7573e0.4107Y). Furthermore, the results of the survey showed that the number of years for RV to reach the forest threshold was on average 7 years.

[1] Under the national definition: minimum DBH of 10cm, Minimum crown density of 20%, minimum area of 0.5ha. By this definition, RVs are considered as temporarily un-stocked forest.
[2] Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from: http://earthenginepartners.appspot.com/science-2013-global-forest.

2. Introduction

2.1 Background

In the upland of Lao PDR, shifting cultivation is a major cause of disturbance in forests. Each year around 100-150 thousand ha of forest areas are affected by slash and burn agriculture. The area is cultivated for a short period, often one year and then left to regenerate as "Regenerating Vegetation (RV)". Such areas covered around 25% of the total land area in 2015.

Lao PDR has a national forest definition as shown in Table 1 below. While RV usually does not fall under the national forest definition, it is regarded as forest, as they are "…vegetation that currently fall below, but are expected to exceed, the threshold of forest land category." (IPCC, 2003), and also as RV often occurs on land administratively assigned by the Government as 'forestland'.

Table 1: Forest definition in Lao PDR

Minimum Threshold of Forest Definition		
DBH	Crown Cover Rate	Minimum Area
10 cm	20%	0.5ha

Figure 1 gives an overview of the extent of the RV area in Lao PDR.

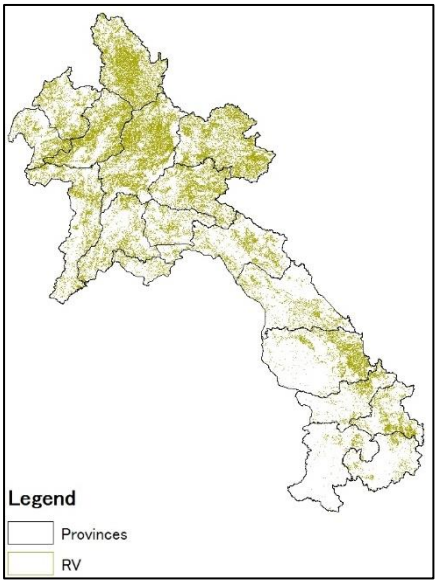


Figure 1: RV area in Lao PDR (2015)

To implement Reducing Emissions from Deforestation and Forest Degradation and the role of conservation of forests and enhancement of forest carbon stocks (REDD+), data on the estimated volume of carbon in each land cover type is needed. The estimation of carbon stock of RV, however, has a higher degree of uncertainty due to the high diversity of different vegetation species (including bamboo), topographic factors, and human factors associated with the land.

In northern Lao PDR, a model was developed, which established the relationship between the age of fallow and the average carbon stocks per age of fallow (Kiyono, *et.al.* 2007). However, this survey was conducted only in Luang Prabang province of northern Lao, thus, not suitable to represent the entire country.

Furthermore, distinguishing the RV class from 'forest' classes (i.e. those forest type classes that fall under the national definition of forests, namely Mixed Deciduous: MD class) through remote sensing poses a challenge[3]. To address this challenge, auxiliary data such as the number of years after abandonment (i.e. years under fallow) would be useful.

2.2 Objectives

This survey was conducted with following two objectives:

1. To collect data on biomass and the years after abandonment in order to develop a model for estimation of biomass for RV; and
2. To determine the threshold age of abandoned years between RV and forest.

[3] Among the stages of shifting cultivation, RV and Mixed Deciduous Forest (MD) are often continuous phases of regeneration, and old RV and young MD have similar color tone and texture on satellite imagery, thus, distinguishing the two poses technical challenges. This is in part addressed through analysis using multi-temporal remote sensing imagery.

3. Survey preparation

3.1 Survey sites

For the estimation of carbon stock of the trees, non-woody vegetation and bamboo, sampling should take place across the subject land under RV. As RV are mainly found in northern Laos, the survey sites were selected as follows: three provinces in the Northern region, one province in the Central region and one province in the Southern region.

The survey was designed to distribute sample plots with a range of years after abandonment. An assumption was made, based on expert judgement, that the number of years after abandonment it takes to regenerate to forest (i.e. MD) was around 6 years. Based on this assumption, in each survey site, a total of eight clusters were distributed, one cluster each for the 1st year to 8th year after abandonment. Table 2 and Figure 2 show the number of clusters and their locations.

Survey cluster locations were selected from the annual vegetation loss dataset of Hansen *et al.*[4] to determine the year of loss, then ground truthed and measured the crown cover to determine whether it had reached the forest status or not, as per the national forest definition. For each survey plot, the year of forest loss was further verified by interviewing local villagers. Only the plots confirmed as fitting the RV definition were measured.

Table 2: Number of clusters in each region

Region	Province	Years after cropping	Number of Cluster	Subtotal
North	Bokeo	1,2,3,4,5,6,7,8	1 x 8	8
North	Xayabouly	1,2,3,4,5,6,7,8	1 x 8	8
North	Xiengkhouang	1,2,3,4,5,6,7,8	1 x 8	8
Central	Bolikhamxay	1,2,3,4,5,6,7,8	1 x 8	8
South	Sekong	1,2,3,4,5,6,7,8	1 x 8	8
			Total	**40**

[4] Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from: http://earthenginepartners.appspot.com/science-2013-global-forest.

Figure 2: Cluster location

3.2 Obtaining permission for the survey equipment

UAV[5] was used for this survey to take aerial photos to measure the crown cover rate (CCR) of each surveyed plots. The survey team (Forest Inventory and Planning Division (FIPD) of Department of Forestry (DOF), prepared a request letter, which included information related to the purpose of the survey, survey sites (province) and survey method, and submitted to the Ministry of Defense and Ministry of Aviation to obtain permission[6]. The staff from Ministry of Defense accompanied the entire survey.

3.3 Pre-survey test and trainings

Before starting the full survey, a pre-survey was conducted in Thai Heua district of Vientiane province to test the methods and criteria for survey site selection, plot setting and operation of UAV. At the same time, trainings for the survey teams were implemented, then further supplemented trainings were also provided immediately before the survey in December 2016.

[5] For the specification of the UAV used - "Phantom 3"-, see: http://www.dji.com/phantom-3-standard/info#specs)

[6] It should be noted that using UAVs in Lao PDR seem to require formal and sometimes lengthy process. For this case, it took approximately four weeks to obtain the permission.

4. Field survey method

The biomass of RV can be estimated through two field survey components; tree measurement and sample collection of other vegetation. Tree biomass can be estimated from tree measurement and by applying allometric equation of trees, and other biomass can be estimated by using a wet-to-dry weight ratio of the samples collected. The survey was designed to collect these two data sets.

The result of the Crown Cover Rate (CCR) is utilized for identifying the threshold year of abandoned RV lands to regenerate to 'forest'.

The detailed procedures of the field survey was summarized in the "Standard Operating Procedures: Regenerating Vegetation Survey". The equipment used for the survey is shown on Attachment 8.3.

4.1 Establishment of sampling cluster and plots

Establish survey clusters and plots

A GPS was used to navigate the survey team to the predetermined survey location. The center point of the first plot was located in each survey cluster so that three plots can be set in a single RV sample area (Figure 3). Three square plots were located in each cluster. If the sampling area was not large enough for making a range of three plots, a cluster could have only two plots, or three plots in different arrangements from Figures 3, but with at least 30m between the plots.

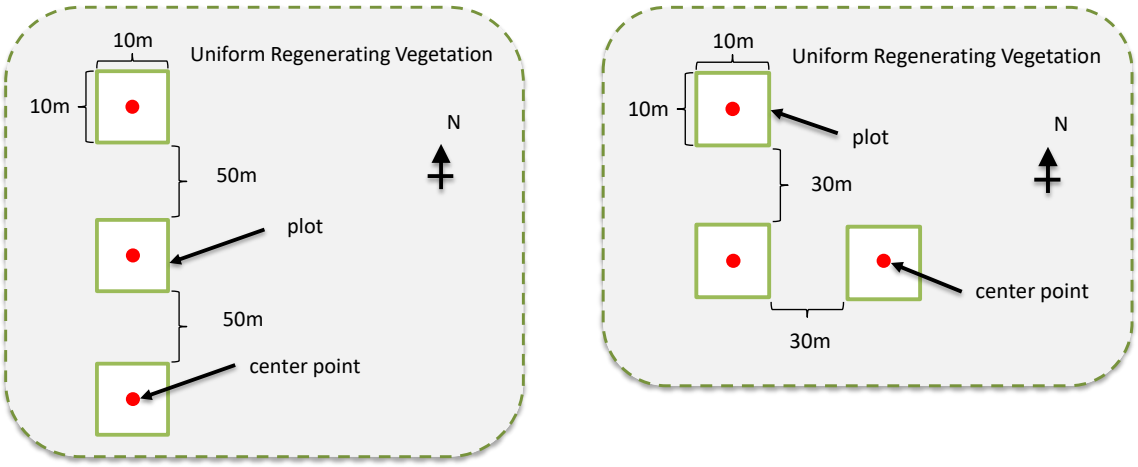


Figure 3: Clusters with three square plots

Establish sub-plots

Within each plot, sub-plots were established to sample all vegetation except trees with DBH ≥ 5 cm with the following procedure and as shown in Figure 4:

1) Starting at a corner of the plot, a sub-plot is located with its corner at the location of 1m x 1m inside of the plot (as in Figure 4);
2) The size of a sub-plot is dependent on average height of vegetation. If the height is lower than 1 m, the size of sub-plot should be 1m x 1m. If the height is more than 1m, the size of sub-plot should be 2m x 2m.
3) Repeat this three more times, starting from the other corners of the plot.

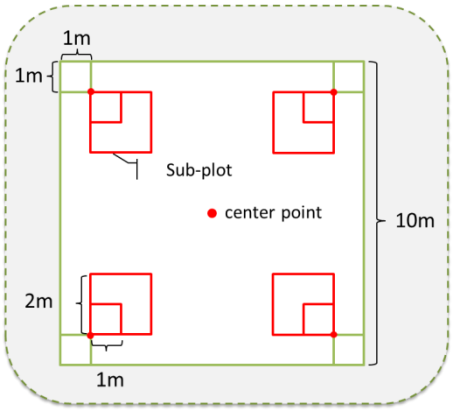


Figure 4: A plot with four square sub-plots.

4.2 Field measurement

Measurement of Trees

For each plot, the following were recorded: trees with DBH ≥ 5 cm, the position of measured trees on the data sheets for CCR analysis and the name of the tree species.

Sample collection

For each sub-plot:

a. All above ground vegetation including trees with DBH < 5cm, saplings, standing dead trees, and non-tree-vegetation and bamboo inside were cut at the base.
b. All harvested vegetation were placed on plastic sheeting and weighed.
c. A representative sub-sample of vegetation was selected, including trees, non-tree-vegetation including bamboo, and cut into small pieces.
d. The sub-sample (up to 500g) was weighed and recorded.

e. Later, the sub-sample were oven dried to a constant weight at 100°C, weighed, and the ratio of the dry weight of fresh weight was calculated.

Crown Cover Rate survey

For each plot:

a. Four poles at each corner of each plot were set, all of which must be exposed from the tree canopy.
b. UAV was used.
c. Pictures were taken at different elevations (20 m, 25 m, and 30 m) at the center of the plot.
d. The direction of the plot was recorded in the pictures.

4.3 Analysis method

Equation for estimating biomass

Tree above-ground biomass (DBH≥ 5 cm) was estimated by applying the following Lao specific allometric equation for MD forests, and for other biomass by using a wet-to-dry weight ratio of sub-samples.

AGB=0.407*DBH^2.069

On the other hand, biomass of other vegetation (DBH<5cm) were estimated by using a dry-wet ratio. Approximately four (4) samples were collected in the field for each plot in order to obtain the dry-wet ratio for estimating whole dry weight of vegetation. Thus, more than 480 samples were dried in the oven. As it was difficult to find ovens with sufficient capacity to dry such large amounts of samples, the samples were dried in a number of steps. First, using the oven at a laboratory of the National University of Laos (NUoL) the samples were dried at 80 °C. Next, one sample from each plot was selected in order to be dried in the oven in temperatures higher than 100°C. The 80-100°C ratio was used for estimating the absolute dry mass of biomass in each plot.

After the above processes were taken, the total biomass of each plot was summed. The average biomass of each cluster was obtained as the average of the three plots within the cluster. Then, an equation for estimating biomass was developed by using the number of abandoned years since cropping as a parameter (see Section 6.1).

Crown Cover Rate (CCR)

Trees with DBH ≥10 cm were identified by referring to the data sheet. The crown for each tree was digitized on the GIS software and the area percentage of CCR in the plot was

calculated. Average CCR of each cluster was estimated and plotted on the graph in order to identify the threshold year between RV and 'forest'.

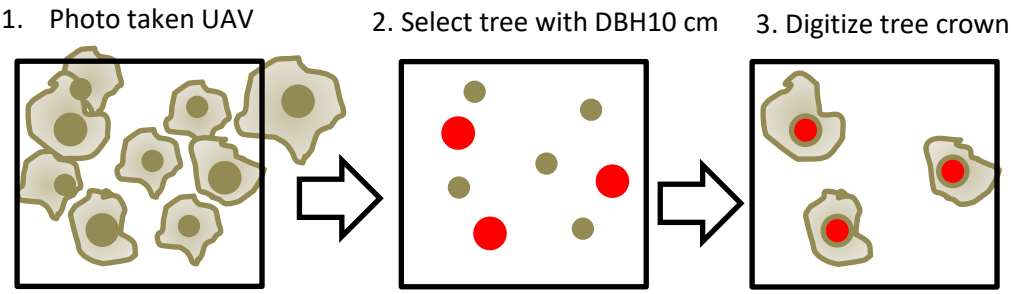


Figure 5: Analysis process for CCR survey

5. Implementation of the Field Survey

5.1 Implementation structure (team organization)

The field survey team was composed of the following members.

Table 3: Survey team composition

Institution	Number of staff
FIPD (Forest Inventory and Planning Division)	2
Driver	2
PAFO (Provincial Agriculture and Forest Office)	1
DAFO (District Agriculture and Forest Office)	1
Villager	1
Drone expert	1
Ministry of defense	1

5.2 Schedule

The survey was implemented in a total of 31 days, not including traveling and coordinating days. Details of the schedule are shown in the following table.

Table 4: Schedule

Province	Schedule
Xayabouly	27-Nov-2016 to 7-Dec-2016 (11 days)
Bokeo	9-Dec-2016 to 13-Dec-2016 (5 days)
Xiengkhouang	17-Dec-2016 to 22-Dec-2016 (5 days)
Sekong	24-Dec-2016 to 29-Dec-2016 (5 days)
Bolikhamxay	7-Jan-2017 to 12-Jan-2017 (5 days)

6. Results

6.1 Equations for estimation of above-ground biomass

Figure 6 shows the relationship between the number of years since abandoned cropping and the amount of carbon, applying the carbon fraction of = 0.49 given in the IPCC Guideline, 2006.

$$AGB = 1.7573e^{0.4107Y}$$

Y represents the number of years abandoned since cropping. This equation can be used for RV areas that have been fallow for 1-7 years.

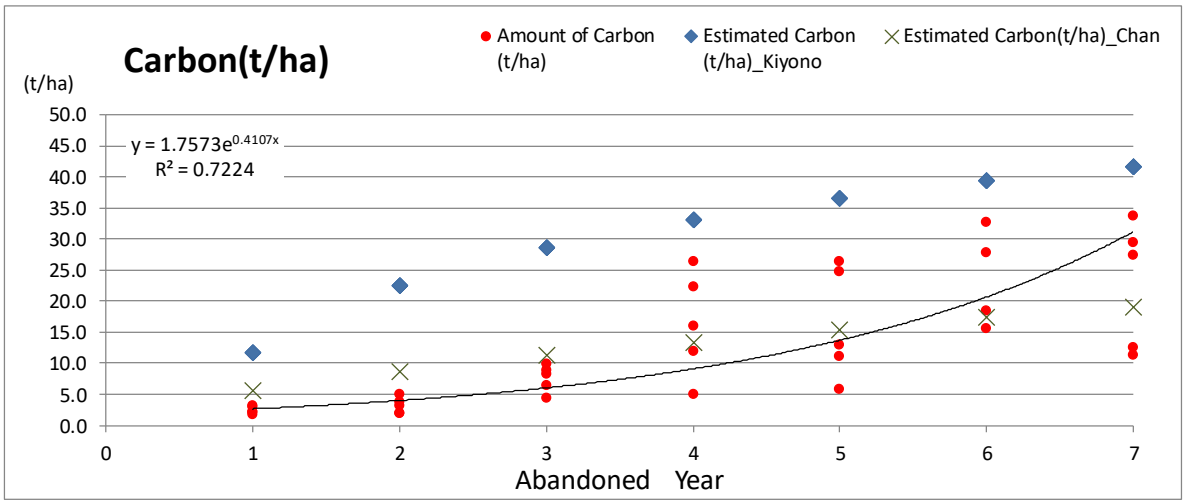


Figure 6: Relationship between the number of years since abandoned cropping and the amount of carbon stock.

"●" shows the carbon stock measured in this survey

"◆" shows the estimated carbon stock from the equation developed by Kiyono, *et al* (2007);

"X" shows the estimated carbon stock from the equation developed by Chan, *et al* (2013).

The equation by Kiyono, *et al* (2007) shown below, was developed from the carbon stock of pachymorph bamboo communities in slash and burn agriculture fallow, in Northern Lao PDR

$$C\ b+d+l = 15.378[\ln(Y)] + 11.815 \qquad (n = 6,\ R2 = 0.9327,\ p = 0.0017)$$

Where;

C b+d+l is the sum of C stock of the living biomass, deadwood and litter (MG C /ha/year),

Y is the number of years since the last slash-and-burn cropping (years)

Equation by Chan, *et al* (2013), shown below, was developed from the carbon stock of swidden cultivation fallow in mixed deciduous forest of the Bago Mountains, Myanmar, and by applying the carbon fraction of "0.49" (given in the IPCC Guideline 2006)

$$Ln(y) = 2.439+0.629Ln(x) \quad (R2=0.721, P<0.001)$$

Where;

Y is the sum of aboveground biomass (MG/ha),

X is the number of years after abandoning cropping (years)

The variation of carbon stock was found to be not insignificant, especially in the lands over 4 years since abandoned. In the RV lands, vegetation growth often face several barriers. For example, in the early period of abandonment, if bamboo dominates the area, tree growth may be inhibited. Disturbance by humans (e.g. fuelwood collection) may also affect the growth of trees. These circumstances support the relatively large degree of variation in carbon stock across the surveyed samples.

The equation developed by Kiyono, *et al* (2007) includes BGB, Deadwood and Litter, therefore, biomass accumulation appears to have been higher compared to the case by Chan, *et al* (2013). Both models are developed based on logarithmic approximation, since the target years after abandonment of these studies is more than 25 years. Thus, at the earlier stages, biomass growth is steep, but after a certain period, the biomass values converge.

As the survey covered up to seven years after abandonment, the biomass volume shows increase throughout. Therefore, the exponential approximation is adopted for the equation.

In this survey, variations in the area of RV were not considered when distributing the survey clusters for each year after abandonment. The average carbon stock of RV lands measured and calculated through this survey is 13.6 t/ha and the standard deviation is 11.1.

6.2 Crown Cover Rate

Table 5 shows the average CCR of each cluster. Figure 7 shows the average CCR of each cluster and the resulting approximate curve, with the red line showing 20% CCR. According to this figure, at the sites where the DBH and the minimum area satisfy the forest definition, CCR reaches 20 % after 7.4 years on average. Thus, the threshold year of abandoned RV to regrow to "forest" is concluded as 7 years.

Table 5: Average Crown Cover Rate in each cluster

Bokeo			Xayabouly			Xiengkhouang			Bolikhamxay			Xekong		
Cluster	Year	%	Cluster	Year	%	Cluster	Year	%	Cluster	Year	%	Cluster	Year	%
Bk1	1	0.0	Xa1	1	0.0	Xi1	1	0.0	Bl1	1	0.0	Xe1	1	0.0
Bk2	2	0.0	Xa2	2	0.0	Xi2	2	0.0	Bl2	2	0.0	Xe2	2	0.0
Bk3	3	0.0	Xa3	3	0.0	Xi3	3	0.0	Bl3	3	0.0	Xe3	3	0.0
Bk4	4	5.0	Xa4	4	1.3	Xi4	4	0.0	Bl4	4	3.6	Xe4	4	0.0
Bk5	5	10.8	Xa5	5	0.0	Xi5	5	3.9	Bl5	5	12.6	Xe5	5	1.0
Bk6	6	14.8	Xa6	6	15.2	Xi6	6	7.4	Bl6	6	3.5	Xe6	6	15.0
Bk7	7	31.9	Xa7	7	10.0	Xi7	7	18.0	Bl7	7	34.8	Xe7	7	16.7
Bk8	8	40.4	Xa8	8	5.2	Xi8	8	10.9	Bl8	8	49.4	Xe8	8	4.3

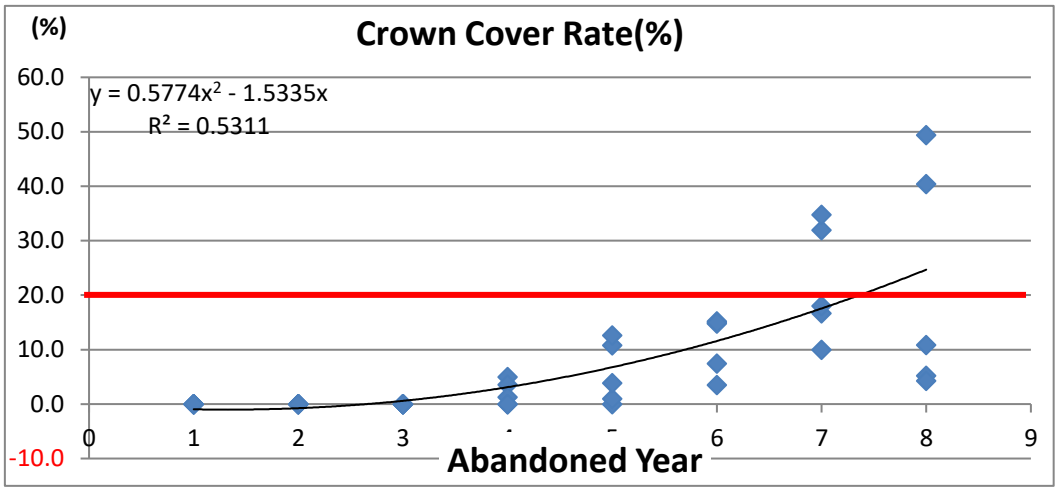


Figure 7: Crown Cover Rate in each cluster

Similar to the analysis of the carbon stock (Section 6.1), the variation of CCR was found not insignificant, and this is again supported by the circumstances of RV lands that face disturbances, such as dominance of bamboo, human interactions, etc.

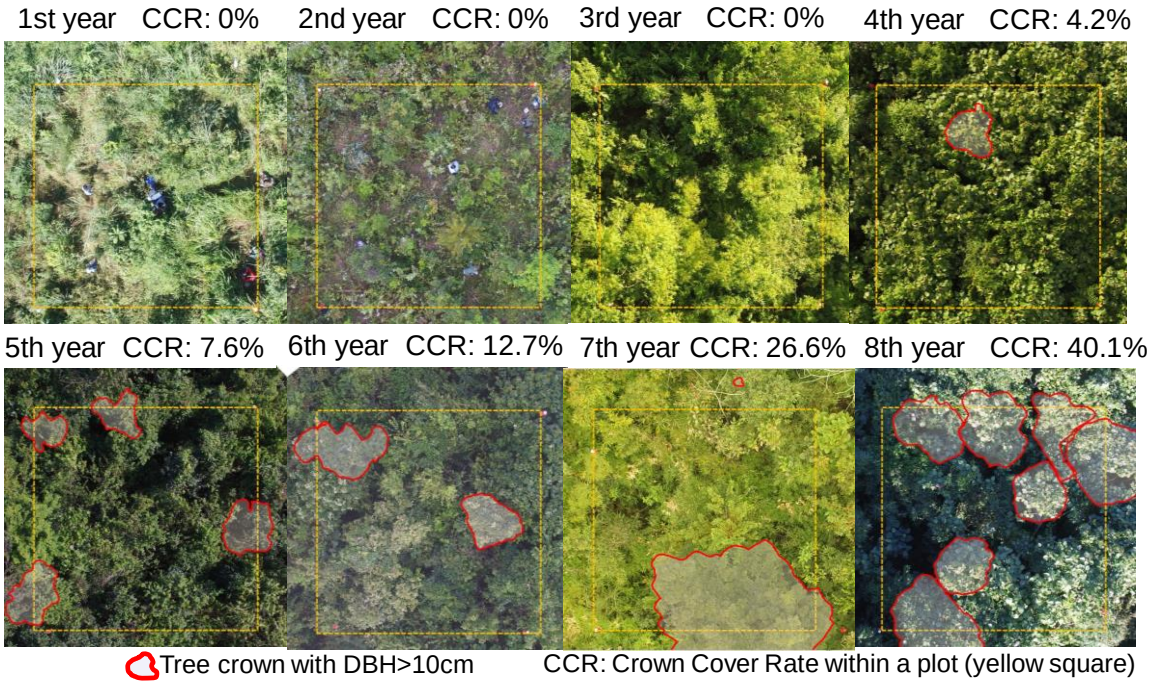


Figure 8 : Example of CCR in each year

7. References

- Kiyono *et al.* (2007): Predicting chronosequential changes in carbon stocks of pachymorph bamboo communities in slash-and-burn agricultural fallow, northern Lao People's Democratic Republic
- JICA (2016): Standard Operation Procedure: Regenerating Vegetation Survey (developed for the survey).
- Nyein Chan *et al.* (2013): Establishment of allometric models and estimation of biomass recovery of swidden cultivation fallows in mixed deciduous forests of the Bago Mountains, Myanmar

8. Attachment

8.1 Result of biomass survey

	Cluster ID	Age	Province	District	Date	Biomass (t/ha)	Carbon (t/ha)
1	BK1	1	Bokeo	Meung	2016/12/11	3.5	1.7
2	BK2	2	Bokeo	Meung	2016/12/9	8.0	3.9
3	BK3	3	Bokeo	Meung	2016/12/11	8.3	4.1
4	BK4	4	Bokeo	Meung	2016/12/12	35.6	17.4
5	BK5	5	Bokeo	Meung	2016/12/12	38.9	19.1
6	BK6	6	Bokeo	Meung	2016/12/12	49.7	24.4
7	BK7	7	Bokeo	Meung	2016/12/11	65.5	32.1
8	BK8	8	Bokeo	Meung	2016/12/10	-	-
9	XA1	1	Xayabouli	Ngeun	2016/12/1	6.4	3.2
10	XA2	2	Xayabouli	Thongmyxai	2016/12/6	3.8	1.9
11	XA3	3	Xayabouli	Ngeun	2016/12/2	13.9	6.8
12	XA4	4	Xayabouli	Thongmyxai	2016/12/6	44.5	21.8
13	XA5	5	Xayabouli	Thongmyxai	2016/12/7	16.2	7.9
14	XA6	6	Xayabouli	Ngeun	2016/11/30	66.9	32.8
15	XA7	7	Xayabouli	Thongmyxai	2016/12/6	18.7	9.1
16	XA8	8	Xayabouli	Thongmyxai	2016/12/6	-	-
17	XI1	1	Xiengkhuang	Khoune	2016/12/12	6.1	3.0
18	XI2	2	Xiengkhuang	Khoune	2016/12/17	6.3	3.1
19	XI3	3	Xiengkhuang	Khoune	2016/12/18	14.3	7.0
20	XI4	4	Xiengkhuang	Khoune	2016/12/22	8.4	4.1
21	XI5	5	Xiengkhuang	Khoune	2016/12/22	9.9	4.9
22	XI6	6	Xiengkhuang	Khoune	2016/12/17	23.9	11.7
23	XI7	7	Xiengkhuang	Khoune	2016/12/19	17.6	8.6
24	XI8	8	Xiengkhuang	Khoune	2016/12/20	-	-
25	XE1	1	Xekong	Lamarm	2016/12/28	4.4	2.1
26	XE2	2	Xekong	Lamarm	2016/12/24	7.2	3.5
27	XE3	3	Xekong	Lamarm	2016/12/25	13.1	6.4
28	XE4	4	Xekong	Lamarm	2016/12/28	18.0	8.8
29	XE5	5	Xekong	Lamarm	2016/12/29	18.5	9.0
30	XE6	6	Xekong	Lamarm	2016/12/25	42.6	20.9
31	XE7	7	Xekong	Lamarm	2016/12/24	46.3	22.7
32	XE8	8	Xekong	Lamarm	2016/12/26	-	-
33	BL1	1	Bolikhamxay	Viengthong	2017/1/9	4.4	2.2
34	BL2	2	Bolikhamxay	Viengthong	2017/1/7	3.9	1.9
35	BL3	3	Bolikhamxay	Viengthong	2017/1/11	13.4	6.6
36	BL4	4	Bolikhamxay	Viengthong	2017/1/8	22.2	10.9
37	BL5	5	Bolikhamxay	Viengthong	2017/1/7	40.3	19.7
38	BL6	6	Bolikhamxay	Viengthong	2017/1/12	24.5	12.0
39	BL7	7	Bolikhamxay	Viengthong	2017/1/9	51.2	25.1
40	BL8	8	Bolikhamxay	Viengthong	2017/1/8	-	-

8.2 Activity photos

MD-RV Team member (Sekong Province)

UAV operation training (Xayabouly Province)

Discussion for site selection (Bokeo Province)

Plot and pole setting (Xiengkhouang Province)

Measuring DBH (Bolikhamxay province)

Sample bag preparation (Xayabouly Province)

8.3 Equipment list

Field Equipment:
Chainsaw
Handsaws
Machetes
DBH tape
Tree corer
50 kg scale
1~2 kg scale
Durable, but thin plastic sheeting ~2 m x 2 m
Durable plastic tarp (2 m x 2 m)
Cloth sample bags for sub-samples
Flagging tape
Chalk
Marker (to label bags and samples)
10 m of rope, 1 - 2 cm thick (to tie up scale and to weigh branches)
'Calibration weights' (see below)
< 50 m measure tape

Pole (>10 m)
Drone (Phantom 3 or higher spec one)
Extra drones, if necessary
Extra batteries for drones (At least 6 flights)

Laboratory Equipment:
Drying oven
Laboratory scale

8.4 Field note

RV DESTRUCTIVE SAMPLING DATA SHEET

Cluster _____ Location: _____ Date: _____
Team Leader: _____ GPS: _____ Time start: _____
Lat: _____ Time end: _____
Long: _____ Photo ID (overview): _____

Preparation
Weight of plastic sheet A: _____ g
Weight of plastic sheet B: _____ g
Weight of plastic sheet C: _____ g

Calibrating 50 kg scale:
Object weight: _____ g
Name of object: _____ g

Calibrating 1kg scale:
Object weight: _____ g
Name of object: _____ g

Calibrating 500 g scale:
Object weight: _____ g
Name of object: _____ g

Note:

1. Tree Measurement

Measure DBH and species of trees(DBH ≥ 5cm)

Plot 1
Photo ID Overview: _____
Photo ID North: _____
Photo ID East: _____
Photo ID South: _____
Photo ID West: _____
GPS coordination
Lat: _____
Long:

Tree ID	DBH (cm)	Species
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Plot 2
Photo ID Overview: _____
Photo ID North: _____
Photo ID East: _____
Photo ID South: _____
Photo ID West: _____
GPS coordination
Lat: _____
Long:

Tree ID	DBH (cm)	Species
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Plot 3
Photo ID Overview: _____
Photo ID North: _____
Photo ID East: _____
Photo ID South: _____
Photo ID West: _____
GPS coordination
Lat: _____
Long:

Tree ID	DBH (cm)	Species
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

2. Vegetation Cutting
All vegetation including tree < 5 cm DBH, grass and bamboo shall be cut

Plot 1

Weigh all the harvested vegetation in each sub-plot

Sub-plot 1
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 2
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 3
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 4
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

weigh bags and sample + bag

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

Plot 2

Weigh all the harvested vegetation in each sub-plot

Sub-plot 1
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 2
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 3
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 4
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

weigh bags and sample + bag

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

Plot 3

Weigh all the harvested vegetation in each sub-plot

Sub-plot 1
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 2
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 3
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Sub-plot 4
Size: _____ m x _____ m

	Weight of vegetation (kg)	Sheet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

weigh bags and sample + bag

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

bags (g)	sample + bags (g)

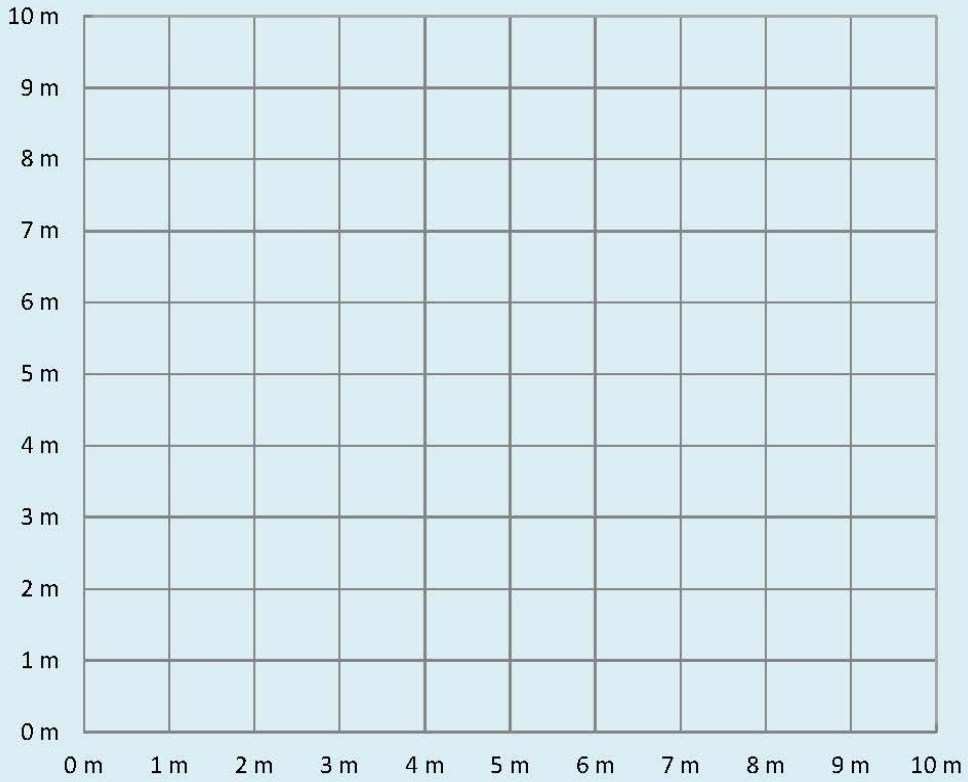
bags (g)	sample + bags (g)

3. Treecover rate
Plot 1
make points as trees with DBH ≥ 10 cm and write "Tree ID" beside the points.

Photo ID (from drone)

_____

*make points of large trees outside of the plots

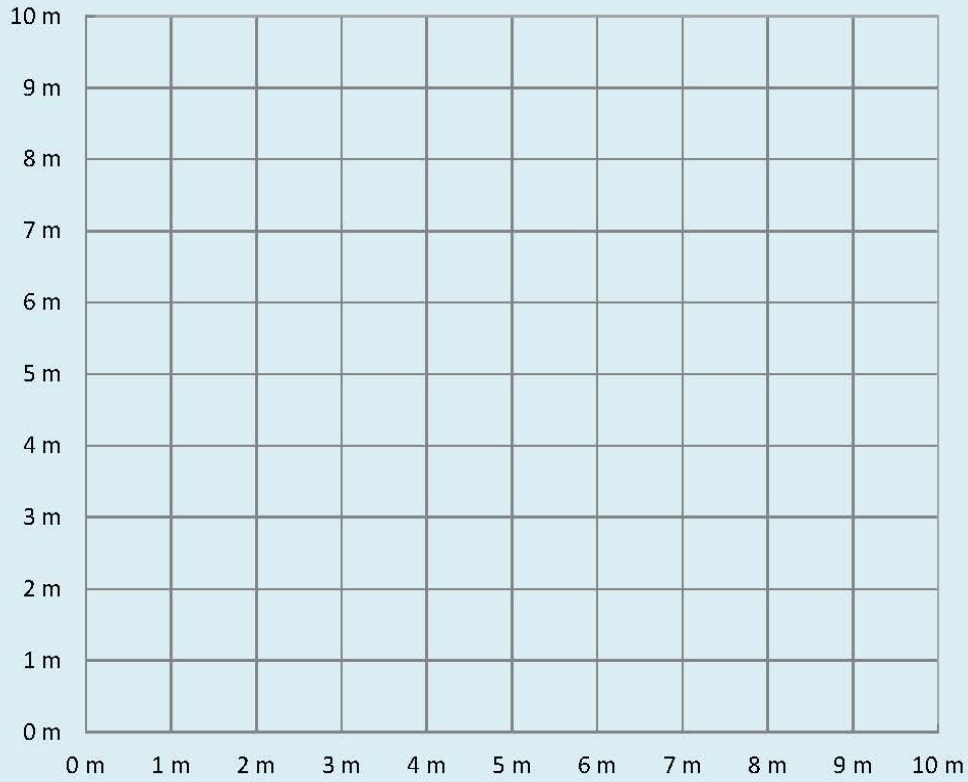


Plot 2
make points as trees with DBH ≥ 10 cm and write "Tree ID" beside the points.

Photo ID (from drone)

_____

*make points of large trees outside of the plots

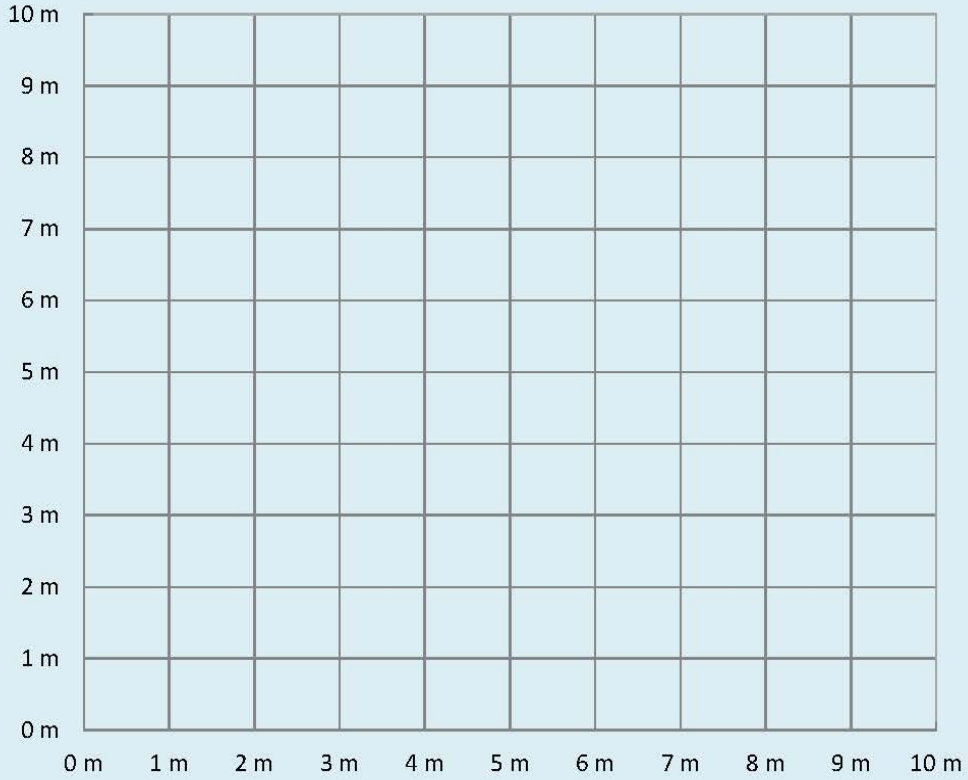


Plot 3
make points as trees with DBH ≥ 10 cm and write "Tree ID" beside the points.

Photo ID (from drone)

_____

*make points of large trees outside of the plots



3. Treecover rate
Plot 1
make points as trees with DBH ≥ 10 cm and write "Tree ID" beside the points.

Photo ID (from drone)

*make points of large trees outside of the plots