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Priority Areas for Conservation Planning in Dong Na Tard Provincial Protected Area, Lao People's Democratic Republic (Lao PDR)

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Abstract

Priority areas for conservation planning (core, and transition areas) in Dong Na Tard Provincial Protected Area, Savannakhet Province, Lao People's Democratic Republic (Lao PDR) were identified using data on total conservation values of plant species and anthropogenic threats. Weighted score method was used to determine the core and transition areas. Two core areas had an area of 3,303 ha and 1,664 ha respectively while the transition area comprised of 1,303 ha. The core areas for conservation should be institutionalized through a policy to ensure conservation of plant diversity and sustain ecosystem services for the people and society.

Keywords: Total conservation values; Anthropogenic threats; Core area; Transition area

1. Introduction

Interaction of the local people with plant diversity is a major concern in Dong Na Tard Provincial Protected Area (PPA). If unchecked, overexploitation of plant resources can be very damaging to species diversity and the environment. Therefore, it is urgent to protect the habitat (Larsen *et al*., 2012) by establishing priority areas in the park (Brooks, 2010).

Setting core and transition areas is a widely-used approach to achieve desired conservation outcomes in protected areas because they are important measurements for conservation planning (Regan *et al*., 2007) as the efficient targets for benefitting human well-being through the services of those ecosystem provisions (Turner *et al*., 2012; Larsen *et al*., 2012). The core areas should each have a definite boundary, and the transition area as a whole is usually not strictly delineated (Li *et al*., 1999).

However, the establishments of core and transition areas require available information on total conservation values and anthropogenic threats of plant species (Li *et al*., 1999; Upadhaya *et al*., 2013; Gerber *et al*., 2014). To date, this information is not available at Dong Na Tard PPA. This study aimed to identify the priority areas. Specifically it aimed to: (i) determine the total conservation values and anthropogenic threats of plant species; and (ii) identify the priority areas (core, and transition areas)

for conservation planning and sustainable utilization of plant diversity.

2. Materials and Methods

2.1 Study area

Dong Na Tard PPA is located in Savannakhet Province, Lao PDR covering a total area of 6,385 ha (Figs. 1 and 2). It lies between 16º 35' 20" and 16º 40' 40" N latitude and between 104º 50' 00" and 104º 57' 10" E longitude. It is influenced by the North-East and South-West monsoons causing highly uneven rainfall. The annual average temperature is 27.2 C°, while the relative humidity is 74%, and rainfall is 1,445 mm (Chanthavong and Buot, 2017).

2.2 Determining the total conservation value and anthropogenic threat of plant species

The total conservation status of plant species was determined by a number of species occurred per zone and its conservation value (Butchart *et al.* 2004) as follows:

$$T_{t_i} = \sum_{c} W_c \cdot N_{c(t_i)}$$

Where T_{ti} is total conservation values of plant species; N_c is the number of species occupied per zone at a given time ti; W_c is conservation value of a species; and c is forest zone.

The conservation value (*Wc*) was classified based on globally (IUCN-2008) and nationally (MAF-2012) threatened plant assessment, perception of plant users, and values of relative frequency (RF) of each species using importance scale by Likert's (1932) such as scale 1 (very low importance), scale 2 (low importance), scale 3 (moderate importance), scale 4 (high importance), and scale 5 (very high importance) as follows:

(1) Critically Endangered (CR) = 5; Endangered (EN) = 4; and Vulnerable (VU) = 3; Near Threatened (NT) = 2; and Least Concern (LC) = 1. IUCN (2008).

(2) Prohibition (PR) = 5; Special (SP) = 4; Management I (MA I) = 3; Management II (MA II) = 2; and Management III (MA III) = 1. MAF (2012).

(3) Perception of plant users: Very High Importance (frequent harvesting is always disturbed) = 5; High Importance = 4; Moderate Importance = 3, Low Importance = 2; and Very Low Importance (least harvesting) = 1.

(4) Relative Frequency (RF): Very Low Frequency (0 – 20%) = 5; Low Frequency (21 – 40%) = 4; Moderate Frequency (41 – 60%) = 3; High Frequency (61 – 80%) = 2; and Very High Frequency (81 – 100%) = 1.

Finally, the values were classified into conservation status of plant species of Dong Na Tard PPA: CR - 17-20; EN – 13-16; VU – 9-12; NT – 5-8; and LC – 1-4.

The anthropogenic threats (*ATs*) was merged with influential factors affecting plant

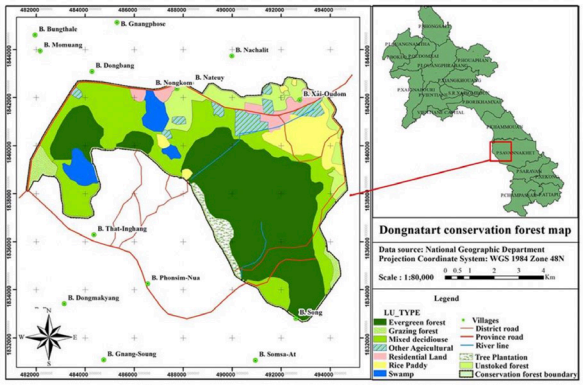

Figure 1. Map of Dong Na Tard Provincial Protected Area. Villages located in and around the park are marked with green dots.

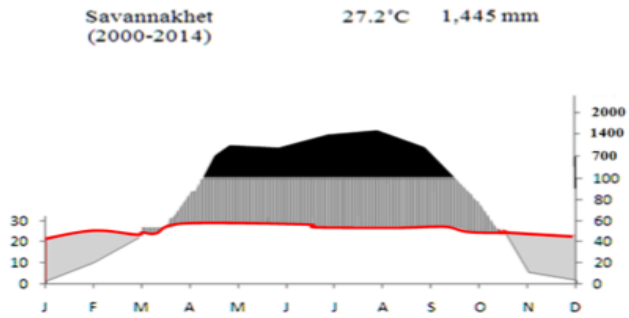

Figure 2. Climograph of precipitation and temperature in Dong Na Tard Provincial Protected Area.

diversity in each forest zone including distance (DI) from National Road No. 9 to a dense forest and human impacts (HI) on specific sites as follows:

$$ATs = DI + HI$$

Where: *DI* is an average distance (Km) of plots occupied in each forest zone; and *HI* is an average percent (%) of disturbed plots occurred in each forest zone. The anthropogenic threats were then calculated by using weighted score method.

2.3 Determining core and transition areas

The total conservation values (T_{ti}) and anthropogenic threats (*ATs*) were used as important parameters to determine the core and transition areas (*CTAs*). The methods used were adapted and modified from Myers (1988); Upadhaya *et al.* (2013); and Gerber *et al.* (2014) as follows:

$$CTAs = T_{ti} - Ats$$

The results of T_{ti} and *ATs* were then used to identify the core and transition areas. The higher *CTAs* values can be the core areas for conservation, while the lower *CTAs* values can be transition areas or areas of cooperation.

3. Results and Discussion

3.1 Total conservation values of plant species

There were six (VI) forest zones in Dong Na Tard PPA (Chanthavong and Buot, 2017). *Afzelia xylocarpa* (Kurz) Craib had the highest total conservation value in Zone I with 80 and Zone III with 96. *Diospyros malabarica* (Desr.) Kostel had the highest values in Zone II with 56. Similarly, *Anisoptera costata* Korth, *Dipterocarpus* spp Roxburgh ex G, and *Tectona grandis* Linn had the highest total conservation values with 51, 44, and 56 in Zone IV, Zone V, and Zone VI, respectively (Table 1). The highest total conservation values of species were found in Zone I and Zone III with 781 and 1,162 respectively, while the lowest values with 438 and 400 were found in Zone II and Zone VI, respectively (Table 1). These total conservation values were important for identifying core and transition areas.

In setting up core and transition areas, information on the distribution of species in the area are required (Table 1) as stated by Upadhaya *et al.* (2013). Both total conservation value (T_{ti}) and anthropogenic threats (*ATs*) are important factors for conservation planning (Gerber *et al.*, 2014). The higher the T_{ti} would be considered as the core areas (Myers 1990; 1998; Upadhaya *et al.* 2013) because conservation of biodiversity is one out of three functions launched by United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2004 to carry out the complementary activities of biodiversity conservation. Thus, forest zones I and III which had the highest T_{ti} would be the core areas, while forest zones II and VI which had the lowest T_{ti} would be the transition areas (Table 1).

Upadhaya *et al.* (2013) identified priority areas for conservation in Northeast India based on the IUCN Red List with several categories such as Extinct (EX), Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least concern (LC), Data deficient (DD) and Not evaluated (NE) and endemic species. On the other hand, Gerber

Table 1. Total conservation values (T_{ti}) of plant species in six forest zones of Dong Na Tard PPA.

Families/Species	Zones					
	I	II	III	IV	V	VI
Anacardiaceae						
Spondias pinnata (Koening & L.F.)	39	0	39	0	0	0
Ancistrocladaceae						
Ancistrocladus tectorius (Lour.) Merr	18	0	18	0	0	0
Apocynaceae						
Alstonia rostrata Fisher	0	0	24	0	0	0
Wrightia arborea (Dennstedt) Mabberley	9	9	0	18	27	0
Arecaceae						
Cocos nucifera L.	0	20	0	20	0	0
Wallichia gracilis Beccari	0	0	0	9	18	9
Bignoniaceae						
Fernandoa adenophylla Wall ex. G. Don	0	9	0	0	0	18
Oroxylum indicum (L.) Ventenat.	9	0	9	9	0	0
Bombacaceae						
Bombax albidum Gagnepain	13	0	39	26	0	0
Combretaceae						
Terminalia catappa L.	0	18	0	18	0	9
Terminalia corticosa Pirre ex Lanessan	14	0	56	0	0	0
Cucurbitaceae						
Lagenaria siceraria	8	0	8	0	0	0
Dipterocapaceae						
Anisoptera costata Korth	17	0	34	51	17	17
Dipterocarpus obtusifolius Teijsm.	34	0	17	0	17	17
Dipterocarpus spp Roxburgh ex G	55	22	55	44	44	22
Hopea odorata Roxb	17	0	0	17	17	0
Hopea recopei Pierre	0	32	0	16	0	0
Shorea obtusa Wall. ex Blume	14	0	28	0	0	0
Vatica odorata (Griff.) Symington	14	0	14	14	0	14
Ebenaceae						
Diospyros filipendula Pirre ex Lecomte	4	8	4	0	0	0
Diospyros malabarica (Desr.) Kostel	42	56	28	0	0	0
Diospyros mollis Griffith	30	0	30	30	30	30
Elaeocarpaceae						
Elaeocarpus stipularis Blume	0	9	0	0	9	9

Remark: Total conservation value (T_{ti}) is conservation value (W_c) of a species multiplied by the number of a species (N_c) occupied per zone.

Table 1. Total conservation values (T_{ti}) of plant species in six forest zones of Dong Na Tard PPA (Continued)

Families/Species	Zones					
	I	II	III	IV	V	VI
Euphorbiaceae						
Aporosa villosa (Lindl.) Baillon	18	0	18	9	0	0
Baccaurea ramiflora Gagnepain	0	14	7	14	0	28
Bridelia stipularis (L.) Blume	0	0	9	0	0	0
Croton joufra Roxburgh	0	0	20	10	10	0
Fabaceae						
Afzelia xylocarpa (Kurz) Craib	80	32	96	0	0	0
Bauhinia malabarica Roxburgh	0	9	0	0	0	0
Dalbergia cochinchinensis Pierre	0	0	0	0	0	18
Dialium cochinchinense Pierre	10	0	30	0	10	0
Dialium indum L.	21	0	35	14	14	7
Peltophorum dasyrachis Kurz	33	33	44	22	0	22
Pterocarpus macrocarpus Kurz	42	0	56	28	42	0
Sindora siamensis Teysm. ex Miquel	0	0	0	0	14	0
Xylia xylocarpa (Roxb.) Taub	28	0	84	0	0	0
Flacourtiaceae						
Hydnocarpus anthelmintica Pierre	9	0	18	0	0	0
Hypericaceae						
Cratoxylum formosum (Jack) Dyer	14	0	21	14	7	0
Irvingiaceae						
Irvingia harmandiana Oliv. Ex A. Benn	40	0	48	16	24	8
Lythraceae						
Lagerstroemia balansae Koehne	0	0	0	0	14	42
Lagerstroemia spp	36	48	96	0	12	0
Meliaceae						
Melia azedarach L.	0	0	0	13	13	0
Sandoricum koetjape (Burm.f.) Merrill	24	0	0	0	0	0
Moraceae						
Artocarpus spp	0	35	0	0	0	28
Ficus drupacea Thunberg	15	0	30	0	0	0
Ficus septica Burn.f. var. septic	0	15	0	0	0	0
Streblus asper Lour	0	0	12	0	0	0
Streblus ilicifolius (Kurz.) Corn	0	0	8	0	0	0
Myrsinaceae						
Ardisia evonymifolia Pitard	9	0	9	0	0	0

Remark: Total conservation value (T_{ti}) is conservation value (W_c) of a species multiplied by the number of a species (N_c) occupied per zone.

Table 1. Total conservation values (T_{ti}) of plant species in six forest zones of Dong Na Tard PPA (Continued)

Families/Species	Zones					
	I	II	III	IV	V	VI
Myrtaceae						
Eucalyptus spp	0	0	0	0	0	9
*Syzygium cinereum (*Kurz) Chant. & Parn	16	0	40	0	0	0
Syzygium zeylanicum (L.) DC.	0	0	0	28	14	0
Syzygium gratum (Wight) S.N. Mitra	0	0	0	14	42	0
Syzygium tinctorium (Gagn.) Merr. ex Pierre	0	0	9	9	9	0
Pinaceae						
Keteleeria evelyniana Master	0	0	0	0	15	0
Rhamnaceae						
Ziziphus cambodiana Pierre	21	28	7	21	7	7
Rosaceae						
Pyrus pashia Buch. Ham. Ex D. Don	0	0	0	9	0	0
Rubus multibracteus Lev. & Vaniot	0	0	8	0	0	0
Rubiaceae						
Prismatomeris tetandra (Roxburgh) K. Schum	0	0	0	0	9	0
Sapindaceae						
Lepisanthes rubiginosa (Roxburgh) Leenh	9	9	18	9	18	0
Solanaceae						
Solanum torvum Swartz	0	0	0	0	9	18
Sterculiaceae						
Heritiera javanica (Blume) Kosterm	9	0	9	0	0	0
Sterculia spp	0	14	0	0	0	0
Stilaginaceae						
Antidesma bunius Sprengel	0	0	9	0	0	0
Symplocaceae						
Symplocos racemosa Roxburgh	0	0	8	8	16	0
Tiliaceae						
Peltace	10	0	10	0	0	0
Verbenaceae						
Tectona grandis Linn	0	0	0	0	0	56
Vitex pinnata L.	0	0	0	0	0	12
Zingiberaceae						
Curcuma alisamatifolia Gagnepain	0	9	0	0	0	0
Alpinia spp.	0	9	0	0	0	0
Total conservation values	781	438	1162	510	478	400

Remark: Total conservation value (T_{ti}) is conservation value (W_c) of a species multiplied by the number of a species (N_c) occupied per zone.

et al. (2014) applied information on T_{ti} and *ATs* in identifying priority areas in the Gulf of California, Mexico.

Due to the current rate of human disturbance and habitat loss, some of the threatened plant species may have had altered distribution and are now vulnerable to extinction. The effective conservation of such species should be by enriching and planting, especially the threatened/endangered species through community forestry program which is widely practiced in many parts of Lao PDR and in Thailand.

3.2 Core and transition areas

Aside from the T_{ti}, considering the core and transition areas for conservation required identification of the anthropogenic threats (*ATs*) which included distance (*DI*) from the National Road No. 9 to dense forests and human impacts (*HI*) on the forest zones (Table 2). The *DI* disturbs plant diversity in terms of resource utilization because local people can easily harvest such resources near their residential areas (Buot and Osumi, 2011). The shorter the *DI*, the higher the disturbances are. Thus, the average shortest distance which was in forest Zone VI (0.65 km) resulted the highest weighted score (WS = 6). Forest Zones I and III with an average farthest distance of 4.15 and 4.21 km, respectively, had the lowest weighted score (*WS* = 1 and 2). On the other hand, the highest percent of human impacts (26.34%) was found in forest Zone V, whereas forest Zone I had the lowest percent (7.68%). Further, the total conservation value of a species was lowest at10.61% (*WS* = 1) in Zone VI and highest at 30.83% (*WS* = 6) in Zone III (Table 2).

A thematic map showing the locations and total areas of the core and transition areas were produced. From this, Zones I and III covered a total area of 3,303 ha at latitude (lat.) 16˚35'8" to 16˚39'14 N and longitude (long.) 104˚50'33" to 104˚54'26"E, while Zones IV and V, covered a total area of 1,644 ha at lat. 16˚36'11" to 16˚39'43"N and long. 104˚50'01" to 104˚56'31" E. Finally, Zones II and VI covered a total area of 1,303 ha at lat. 16˚38'21" to 16˚39'27" N and long. 104˚52'30" to 104˚56'31" (Fig. 3).

Zone I and Zone III had the highest T_{ti} (Table 2). This means that these areas should be considered as the core area (I) for conservation (Fig. 3) in order to protect the diverse landscape and its biodiversity from human disturbances (Shrestha *et al*. 2010; Ambal *et al*. 2012; Polak *et al*. 2015). Zone IV and Zone V (Table 2; Fig. 3) had moderate T_{ti} and should be considered as the core area (II) for conservation because its secondary forests are still young and need to be protected from anthropogenic threats. Finally, Zones II and VI (Table 2; Fig. 3), where low T_{ti} and moderate *ATs* exist, should be the transition zone because of the diverse land-use types found in these areas that also include residential areas (Nong Kolm and Na That villages), rice fields and agricultural areas where the local people may be allowed to use woods and forest products according to their respective village management plan, forestry law, and regulations. It can be seen that the current conservation management in Dong Na Tard PPA is inadequate for plant diversity protection. The plant diversity was disturbed because of unclearly defined boundaries and roles of core and transition areas. It is, therefore, suggested that the core areas should be established in biologically important sites and to strictly prohibit human activities (Rotich, 2012). However, the transition areas should be established in areas with low biological values. In these sites, the local people can use natural resources based on their respective village's development plans and at the same time, they can enrich and plant tree species for long-time uses.

4. Conclusion

The forest Zone I and Zone III were the first to be identified as core area in Dong Na Tard PPA, followed by Zone IV and Zone V; Zone II and Zone VI were identified as second core area and transition area/area of cooperation. Each core and transition area has a unique role in conserving plant diversity and in supporting the benefits to local people. To ensure prevention of encroachment on the first and the second core areas, the buffer zone

Table 2. . Total conservation values of plant species (T_{ti}) and anthropogenic threats (*ATs*) for considering core and transition areas for conservation planning in Dong Na Tard Provincial Protected Area.

Parameters	Zone I			Zone II			Zone III			Zone IV			Zone V			Zone VI		
	Value*	(%)	WS	Value*	(%)	WS	Value*	(%)	WS	Value*	(%)	WS	Value*	(%)	WS	Value*	(%)	WS
T_{ti}	781	20.7	5	438	11.6	2	1162	30.8	6	510	13.5	4	478	12.7	3	400	10.61	1
DI (km)	4.15	29	2	2.14	15	3	4.21	30	1	1.35	10	5	1.68	12	4	0.65	5	6
HI (%)	12.5	7.68	1	28.6	17.6	4	18.2	11.2	2	37.5	23.1	5	42.9	26.3	6	23.1	14.09	3
(Types)**																		

* The total conservation value of plant species was determined by a number of species occurred per zone and its conservation value.
** Logging, collecting, burning and hunting wild animals in unsustainable manner.
Legends: T_{ti} is the total conservation value of plant species; *ATs*- anthropogenic threats (*DI* and *HI*): *DI*- distance from road to dense forest; *HI*- human disturbance; (%) - percent; *WS* – Weighted score.

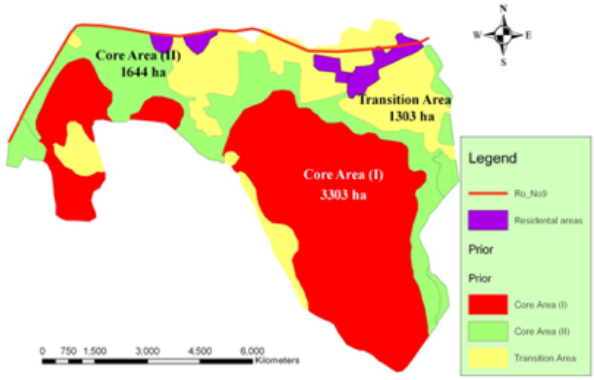

Figure 3. Core and transition areas in Dong Na Tard Provincial Protected Area

widths should be further designed depending on the importance of influential factors affected in the priority areas.

Although the result of this study had identified priority areas for conservation planning and sustainable utilization of plant diversity, it is only a theoretical design. There are still some places that need to be improved in practical operation by involving relevant stakeholders to participate in the process. This approach will help complete the goals of conservation planning in reducing the negative impacts on plant diversity and in increasing the well-being of local people living inside and adjacent to Dong Na Tard PPA.

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