Technical Report on Building Species Conservation Landscapes for Central Laos (Mainly around Nam Kading National Protected Area, Bolikhamxay)

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Summary

The Landscape Species Approach (LSA) is a series of steps and tools designed to plan for conservation across large human impacted landscapes. As a key step modeling of species habitats and threats occurs. It is about implementing a concept of "Conservation Without Borders" for important landscape species, it is a tool for site-based conservation that takes into account balancing needs between animals and human.

Wildlife populations in Lao PDR are directly affected by many human activities. A Conservation landscape is an approach that can be used to visually convey the impact of these activities on habitat of landscape species as well as their abundance. This technique involves participatory process as a number of workshops were organized in order to inform all the stakeholders about the idea related to conservation landscape and how each step was carried out. The participatory process has brought some benefits into proceeding with this project in terms of gaining trust from related parties and getting some useful information and data for our analysis.

The defined landscape boundary covers provinces in the central Laos. There are 7 selected landscape species; elephant; tiger; serow; wild pig; gibbon; great hornbill; and Pa Khueng (cat fish). Creating conservation landscape involves creating biological landscape for each species and threat landscapes. Different criteria were defined and applied in order to build a particular species biological landscape. Based on human behavior threat layers were created including hunting, logging, human-animal conflict near agricultural fields, and human-tiger conflict near ranches.

Combining biological and threat landscapes to produce conservation landscape can be done using 2 methods. A conservation landscape can be represented with qualitative scale of high, medium and low. However, abundance value of landscape species can also be calculated based on habitat carrying-capacity, using quantitative method of combining biological and threat landscapes. Biological landscapes for 6 species were created except the fish due to the consequences of the ongoing dam construction project in the Nam Kading. Conservation landscapes for all 6 species were built using Qualitative method but, Quantitative method was applied only for gibbon and tiger, so far.

Data sets from the Vietnamese side were not incorporated into the analysis of threat landscapes as they were not available at the time. As such, accuracy of threat incident near Lao-Vietnam border is limited.

Additional benefits were achieved in the process of this modeling as part of the larger Landscape Species Approach. The stakeholder engagement in workshops facilitated discussion and focused stakeholders on targeted outcomes for the landscape. The maps produced provided a valuable visual aid to target conservation actions. Although, the modeling was resource intensive and time consuming in its initial stages and sometimes less understood by other stakeholders involved in the process overall the modeling has been highly valuable to the overall plan for conservation in the Nam Kading Landscape and the methods have gained considerable support within partner agencies for other sites in Laos as a methods of strategic planning at a landscape scale.

This report lays out details about steps taken in the analysis of our landscape as part of the LSA.

1. Introduction

1.1. Background and Objectives

Wildlife hunting and use is considered to be crucial for rural livelihoods in Lao PDR. Meanwhile, wildlife populations are seriously affected by over harvesting for both subsistence and trade and habitat destruction (Johnson *et al.*, 2003). Thus, there is a requirement to develop an effective conservation plan that can manage wildlife for sustainable use and conserve endangered species.

Effective conservation planning takes into account a number of aspects including biological, social and economic aspects in order to define management strategies that not only favor conservation of biodiversity, but also allows people to make a living (Sanderson and Redford, 2002). Living landscape approach is an approach that can provide tools to support decision making in identifying effective management plans. It provides bases for conservation planning based on species requirements in terms of their suitable habitats (Sanderson and Redford, 2002).

Living landscape project is part of the Integrated Ecosystem and Wildlife Management Project (IEWMP) in Bolikhamxay Province. Building a species conservation landscape (Figure 1) is the main part of this project. It is a model/landscape that demonstrates the intercept areas of human use of the landscape (i.e. potential threats to animal populations) and animal potential habitats. This information can then be used as a base for refining conceptual model and developing interventions for the new management plan for national protected areas (NPA), especially Nam Kading National Protected Area (Bryja, 2006b).

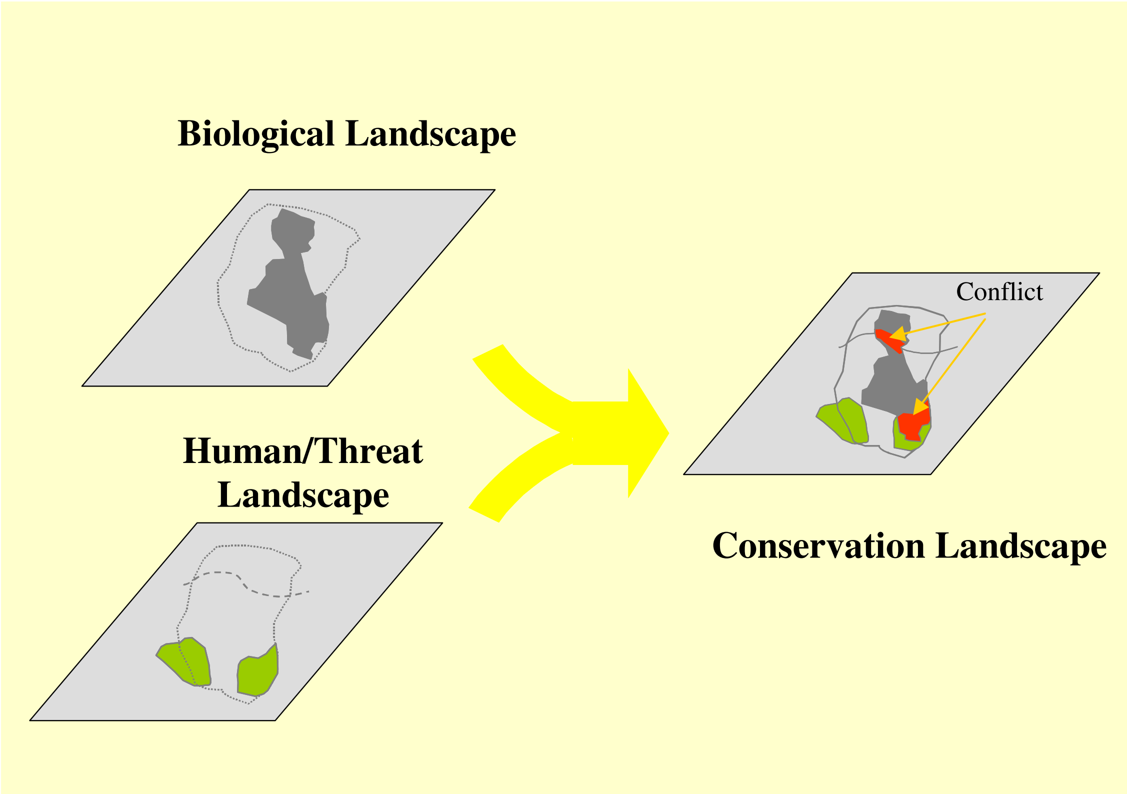


Figure 1: *Conceptual overlay of the biological and human landscape*

This project has three main objectives:

- To create biological landscapes that indicate where the best habitats are for selected landscape species.
- To create potential threat or human landscape that represent the areas where the significant human caused threats occur; and the severity of the threats to the species.
- To combine biological and threat landscapes in order to create conservation landscapes for the selected individual species.

1.2. Study Site

This project has analysis boundary/extent (Figure 2) that covers a few provinces in the central Laos which are part of Luangprabang, part of Xiengkhuang, part of Vientiane Province, part of Vientiane Capital, part of Khammuan, Bolikhamxay, and Xaysomboun Special Region. The boundary of the landscape was determined by using the 10km buffer around the Tiger Conservation Landscape (TCL) and NPA's near TCL. The TCL was created for Mainland Southeast Asia and Sumatra by cooperation between WCS international, WWF, Smithsonian, and NFWF-STF.

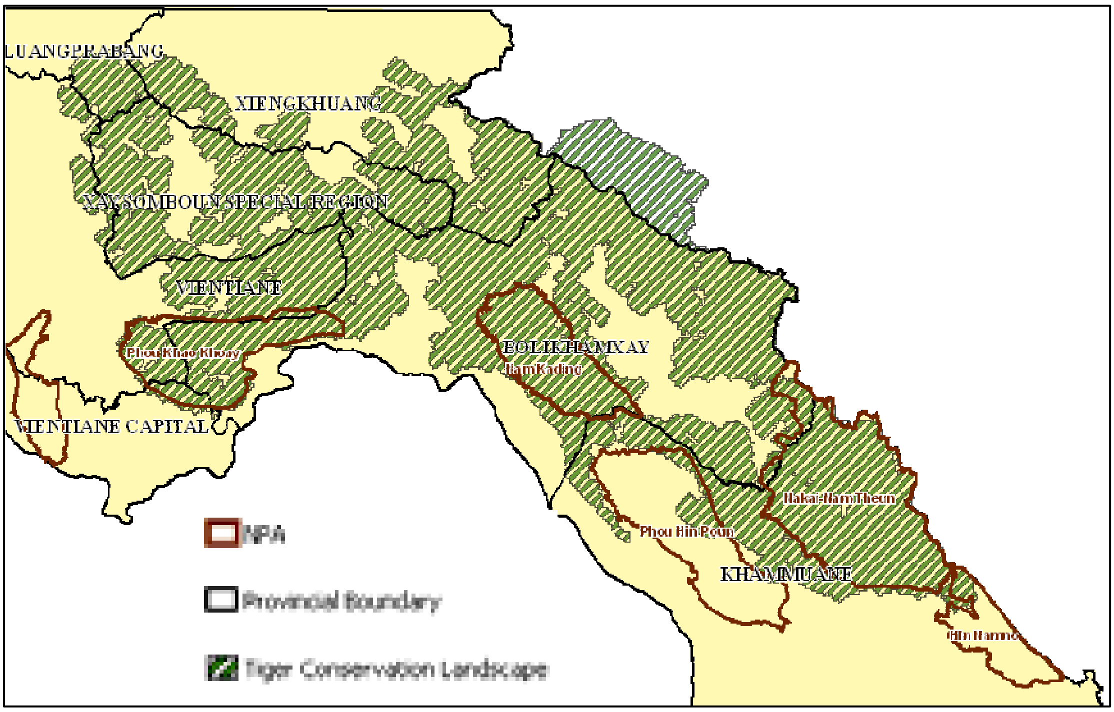


Figure 2: *Landscape boundary*

2. Primary Datasets

Many datasets were required for the analysis process. The main datasets that were used a lot are land cover, road, river and DEM. A list of primary datasets, their description and data source can be found in Table 1 below. The land cover dataset was refined and given new values for the purpose of the analysis (Table 2). For example, the single Upper Dry Evergreen habitat in the original dataset was given a new value (10 = Dry Evergreen) and was refined using DEM to be two values that included 11 = Upper Dry Evergreen (elevation >800m) and 12 = Lower Dry Evergreen (elevation ≤800m).

Table 1: Summary of the primary datasets used for the modeling process

ID	Type	Description	Data Source
1	Landscape Boundary	Determined using TCL and national protected areas clipped to the boundary of Laos and converted to a grid layer.	WCS international, Forest Inventory and Planning Division, National Geographic Department
2	Land Covers	Clipped the original NGD and MRC land cover data with the landscape boundary, converted to grid, recoded with the new codes and updated with data obtained from district officers. (Refer to Table 2 for new land cover new codes and description)	Mekong River Commission, National Geographic Department
3	PA Boundary	Converted to grid and assigned null value to 0.	Forest Inventory and Planning Division (FIPD)
4	Population /Village	Clipped to the boundary	National Statistic Centre
5	Production Forest	Clipped to the boundary, converted to grid and assigned null value to 0	Forest Inventory and Planning Division
6	River	Extracted all the Intermittent rivers, girded and recoded major river and small river with value 1 and 2, respectively.	National Geographic Department
7	Road	Updated using ASTER images. Extracted all the major roads and some footpaths from the original NGD road data, and added a new unpaved road within Nam Kading NPA.	National Geographic Department
8	Agriculture	Extracted all the agriculture areas from land cover coverage	National Geographic Department
9	Karst	Extracted all the karst areas from land cover coverage	National Geographic Department
10	DEM	50 meters Digital Elevation Model, clipped to the landscape boundary.	Mekong River Commission

Table 2: Code and Description of Land Cover Types Used from National Geographic Department (NGD).

Original NGD data	NGD data with new value		DEM REFINED	NGD data after DEM refining	
Type	NEW VALUE	Type		Refined value	Type
Bamboo	14	Bamboo		14	Bamboo
Barren Land and Rock	17	Rock		17	Rock
Coniferous Forest	9	Coniferous Forest		9	Coniferous Forest
Dry Dipterocarp	13	Dry Dipterocarp		13	Dry Dipterocarp
Forest Plantation	19	Forest Plantation		19	Forest Plantation
Gallery Forest	15	Riparian		15	Riparian
Grassland	7	Grassland		7	Grassland
Mixed Broad-Leaved and Coniferous	8	Mixed Broad-Leaved		8	Mixed Broad-Leaved
Natural Regeneration	3	Regeneration Forest		3	Regeneration Forest
Other Agriculture Land	2	Agriculture		2	Agriculture
Other Land	2	Agriculture		2	Agriculture
Ray	2	Agriculture		2	Agriculture
Rice Paddy	2	Agriculture		2	Agriculture
Savannah	5	Savannah		5	Savannah
Scrub	6	Scrub		6	Scrub
Swamp	16	Swamp		16	Swamp
Unstocked Forest	4	Secondary Forest		4	Secondary Forest
Upper Dry Evergreen	10	Dry Evergreen			
			<=800	11	Lower Dry Evergreen
			>800	12	Upper Dry Evergreen
Upper Mixed Decidious	20	Mixed Deciduous			
			<=800	21	Lower Mixed Deciduous
			>800	22	Upper Mixed Deciduous
Urban or Built up Area	1	Urban		1	Urban
Water Bodies	18	Water		18	Water

3. Procedures

3.1. Species Selection

Landscape species were selected using Landscape Species Selection Software Version 2.1. Five criteria were used in the process of defining the key species out of the candidate species, which are their area requirement, ecological importance, social economic significance, susceptibility to human use of wild landscape, and use of a variety of habitat types (Anon, 2006a).

Eleven taxa experts were asked to provide some information regarding candidate species (Table 3) and the data from these experts contributed to making selection decision. Landscape species selection meeting was held in Bolikhamxay in March 2006. District officers and village experts were invited to participate in the process. Details about how this process was carried out can be found in the Landscape Species Selection for the Nam Kading Landscape report (Johnson *et al.*, 2006).

Table 3: The list of candidate species

No.	Common Name	Scientific Name
1	Great Hornbill	*Buceros bicornis*
2	Wreathed Hornbill	*Rhyticeros undulatus*
3	Lesser Fish Eagle	*Ichthyophaga humilis*
4	River Lapwing	*Vanellus duvaucelii*
5	Big-Headed Turtle	*Platysternon megacephalum*
6	Water Monitor	*Varanus salvator*
7	Oriental Small-Clawed Otter	*Aonyx cinerea*
8	Big Otter	*Lutra lutra*
9	Bear Macaque	*Macaca arctoides*
10	Francois's Langur	*Semnopithecus francoisi*
11	White-Cheeked Crested Gibbon	*Nomascus leucogenys*
12	Bear	*bear sp*
13	Clouded Leopard	*Neofelis nebulosa*
14	Tiger	*Panthera tigris*
15	Asian Elephant	*Elephas maximus*
16	Sambar	*Cervus unicolor*
17	Gaur	*Bos gaurus*
18	Wild Pig	*Sus scrofa*
19	Serow	*Naemorthedus sumatraensis*
20	Pakhe	*Bagarius bagarius*
21	Pakheung	*Hemilbagrus wyckoides*

3.2. Building Biological Landscapes

Building species biological landscapes is a process of identifying areas where particular species exist according to the conditions of the area in terms of vegetation types and habitat limitations. Biological landscapes are maps of habitat quality that correspond to abundances of species animals, which high habitat quality indicates high abundances and vice versa (Anon, 2006b).

This section will provide some information on process and criteria used for creating/building biological landscapes. This type of landscapes was built for the final 6 selected landscape species. The selected species are elephant, tiger, serow, wild pig, white-cheeked crested gibbon, and great hornbill. The biological landscape of each species was built using different criteria depending on their characteristics and habitat requirements.

3.2.1. Elephant

Elephants utilize a large area for their habitat. Their movement is governed by both food and the spatial distribution and temporal availability of water. Elephants prefer grassland (open habitats), deciduous forests with tall grasses, and evergreen forest (Sukumar, 1992). However, slope can be a limited factor for their movement within a certain landscape and their habitat suitability.

Elephant biological landscape (habitat suitability) (Map1) can be defined by a number of factors:

- Vegetation type;
- Distance to water;
- Habitat patch size; and
- Slope.

Vegetation Type:
Scores from 0 to 100 are assigned to each vegetation type (Table 4) to identify most suitable areas for elephant habitat in terms of forest cover within the boundary of our studied landscape.

Table 4: Elephant habitat suitability scores for each vegetation type

ID	Vegetation Type	Score
1	Urban	0
2	Agriculture (current)	70
3	Regeneration Forest	100
4	Secondary Forest	100
5	Savannah	100
6	Scrub	100
7	Grassland	100
8	Mixed Broad-Leaved	90
9	Coniferous Forest	50
11	Lower Dry Evergreen	80
12	Upper Dry Evergreen	80
13	Dry Dipterocarp	50
14	Bamboo	100
15	Riparian	100
16	Swamp	100
17	Rock	0
18	Water	100
19	Forest Plantation	10
21	Lower Mixed Deciduous	90
22	Upper Mixed Deciduous	90
100	Transitional Agriculture	100
200	Plantation Forest	10

The big water bodies including dam reservoirs and Mekong River occurring in the landscape were then removed by assigning to value 0 as a habitat suitability level for the elephants.

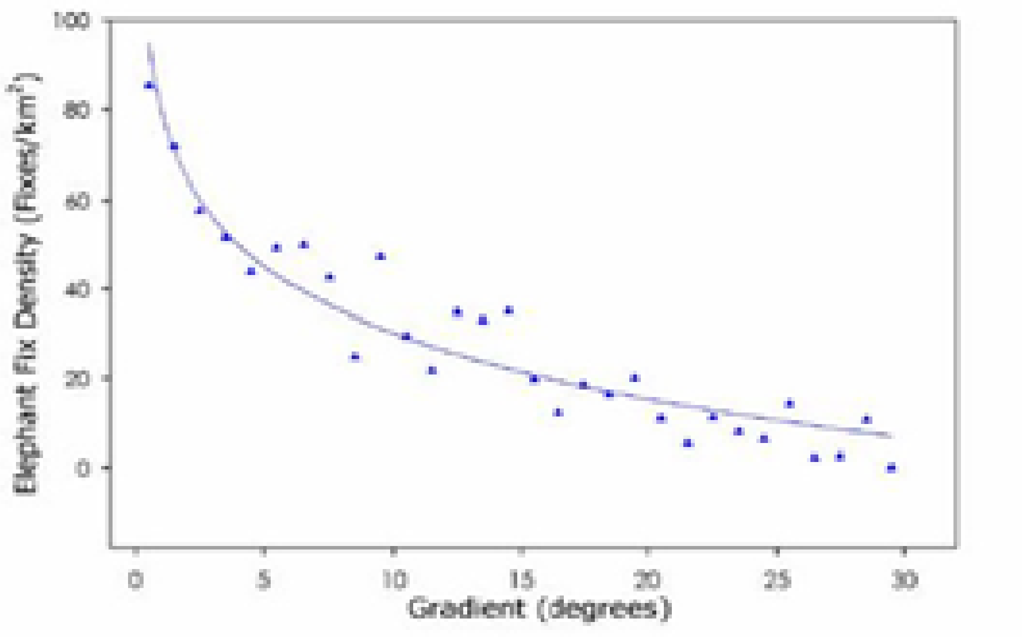
Distance to Water:
According to the distribution of the rivers and their tributaries within the landscape, the distance to water turned out to be not a limiting factor. After calculating the distance to all water sources, the result showed that all the water sources are within 15km range which is within the distance that an elephant can travel in one day (Sukumar, 1992). Therefore, this factor was not considered in the analysis process.

Slope:

We divided the slope factor into 7 classes according to the easiness of traveling across the landscape of elephants. The higher the slope, the less elephant density it became. Therefore, we assigned suitability score to each slope class:

0 – 2	=100
3 – 5	= 80
6 – 10	= 60
11 – 15	= 30
16 – 20	= 20
21 – 30	= 10
30 >	= 0

The slope classes were determined by referring to the graph (Figure 3) below:



(Wall *et al.*, 2006)

Figure 3: *Decreasing elephant fix density with increasing hillslope. R2 = 0.90 (for details of method see supplemental methods: slope and elevation)*

Habitat Patch Size:

In this process, we looked at identifying habitat patches (combining slope and vegetation cover factors) with an area smaller than home range (100 km2) and surrounded by 'impassable' patches unsuitable for dispersal (slope and/or agricultural fields/urban/rocks, none of those ever to be changed), which should be removed from the suitable quality class.

According to a minimum home range of a group of elephants, the optimal habitat patch size should be contiguous and larger than 100 km^2 to support the herd of elephants (Sukumar, 1992). All areas that have patch size less than $100km^2$ and discontinuous were eliminated or were assigned value zero. Value 1 was then assigned to the all the suitable areas equal or larger than 100 km^2

In order to calculate minimum habitat patch size (formula ***2***), we combined the slope factor and the reclassified vegetation type using formula ***1***. Slope factor is treated as a limiting factor and it is assumed based on the above calculations that elephants can't cross slopes higher than 30 degrees. Once we combined vegetation and slope layers we collapsed the output grid (assigned value 1 to all the habitat area and 0 to non-habitats), and generated group regions. In ArcView, there is a function in Spatial Analyst called Region Group, which groups each cell of a Grid into a connected region and assigns a unique number to each region (ESRI, 2002). We selected the option that using the "Four orthogonal neighbors" method to generate group region for the elephants, as we were not too strict in setting the criteria for other factors. However, the option of "Eight nearest neighbors" method could be applied to increase the connectivity factor among patches if necessary.

Combining slope and vegetation cover factors:
Raster Calculator:

(1) **Vegslopepreference = [Slope] * [Vegetation] / 100**

Calculate Minimum Patch Size and assign the value 1 to the patch larger than 100 km2 and then 0 to any smaller patch

Raster Calculator:

(2) **Minimum Patch = Con (((([RegionGroup].Link) = 1) & (([RegionGroup].Count) < 10000)), 0, 1)**

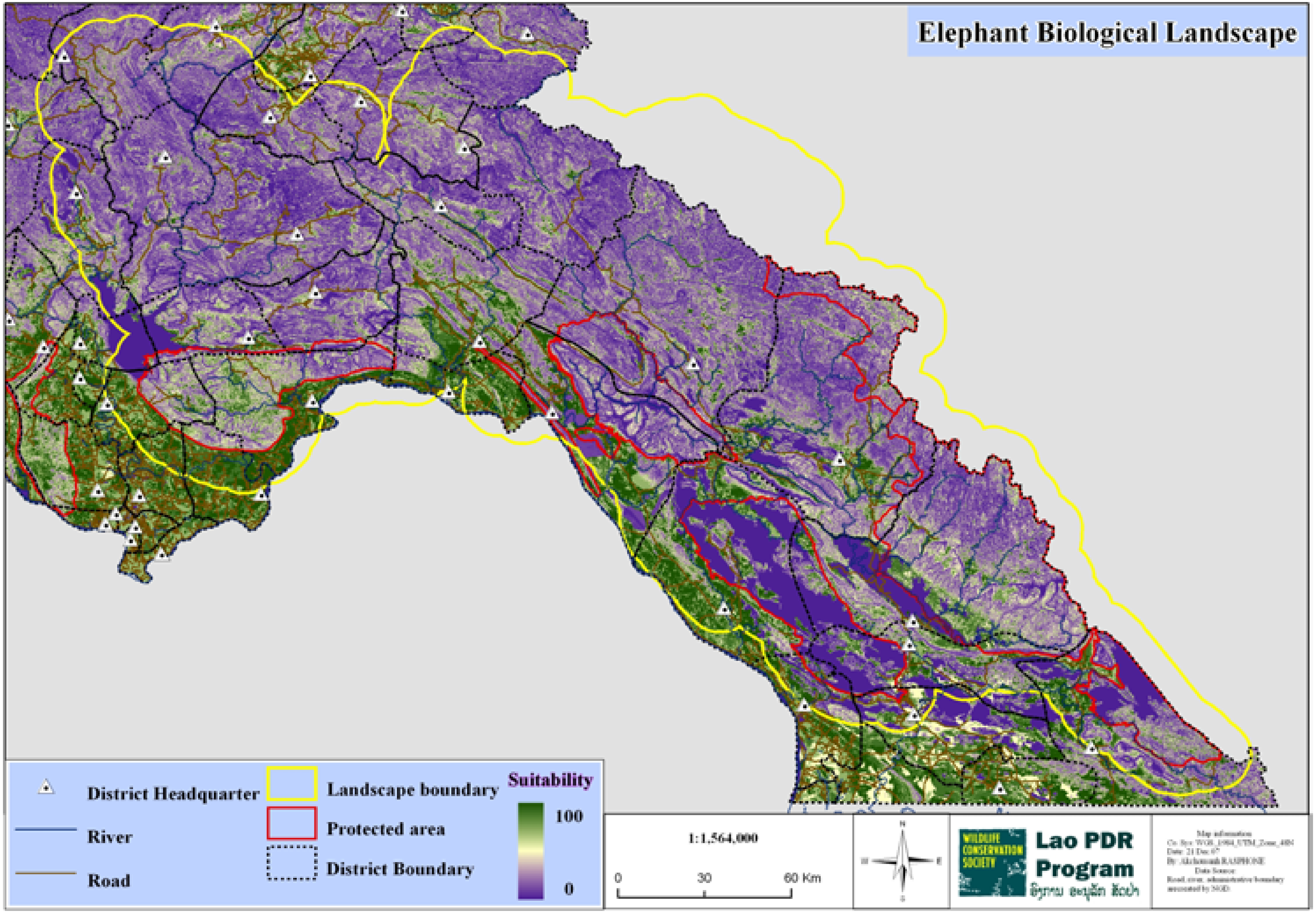
The Biological Landscape:

To produce the final biological landscape for the elephants (formula ***3***), we used again the combined slope and vegetation layer and the result layer of the reclassified into 0 and 1 minimum patch file obtained in the above calculations

Raster Calculator:

(3)

[Minimum Patch] * [Vegslopepreference]/100



Map 1: Biological landscape of elephants

3.2.2. Tiger

Beside tiger habitat preference, the occurrence of tiger preys is an important part to account in building a tiger biological landscape. Hence, we also looked at factors contributing to tiger prey density in this analysis. All the factors/criteria involved in building this landscape are explained as below.

Tiger Habitat Preference:
Vegetation cover was reclassified by assigning suitability score (0 to 100) to each forest and land cover types which are preferred tiger habitat (Table 5). It is certainly linked to the prey density as this is difficult to separate from the habitat usage, but we tried to code/score habitats more as the tiger preference overall regardless of where preys are.

Tiger Prey Density:
The habitat type or vegetation classes were reclassified according to the prey density (Table 5) and then modified by slope and proximity to water. We assumed that prey densities are higher on flat areas and closer to water bodies.
Slope – this layer was reclassified according to level of prey density in relation to slope factor:

0 - 20 → 100
20 - 30 → 80
30 - 40 → 60
40 - 50 → 40
> 60 → 20

- **Distance to water** – we first generated distance to rivers layer (**RiverDist**) with Spatial Analyst/Distance/Straight line function. In our analysis distance to water is a linear decrease of habitat quality (formula ***4***). This was calculated based on wild pig movement dispersal. Calculating this has involved the use of Linear Function (Y = SLOPE * Distance + INTERCEPT). The criteria we set for defining suitable habitat based on distance to water being: at 15217m (as it is a maximum distance value for this layer) or below. At 15217 m will be considered 0 and up to 2000 m will be considered as 100.

(4)
Dist.Water = Int (Con ([RiverDist.] <= 2000, 100, con ([RiverDist.] > 2000, (Slope * [RiverDist] + Intercept), 0)))

Table 5: Tiger habitat preference and prey density scores used in reclassification

ID	Type	Habitat Preference	Prey Density
1	Urban	0	0
2	Agriculture (Current)	10	80
3	Regeneration Forest	70	80
4	Secondary Forest	70	80
5	Savannah	70	80
6	Scrub	70	60
7	Grassland	100	100
8	Mixed Broad-Leaved	90	70
9	Coniferous Forest	70	60
11	Lower Dry Evergreen	90	70

12	Upper Dry Evergreen	90	70
13	Dry Dipterocarp	90	70
14	Bamboo	70	80
15	Riparian	100	100
16	Swamp	100	50
17	Rock	30	20
18	Water	0	0
19	Forest Plantation	10	10
21	Lower Mixed Deciduous	90	70
22	Upper Mixed Deciduous	90	70
100	Transitional Agriculture	70	80
200	Plantation Forest	10	10

- **Tiger Prey Density** –This is the process of modifying the prey density layer after the vegetation reclassification by including slope factor and distance to water(see formula ***5***).

(5)

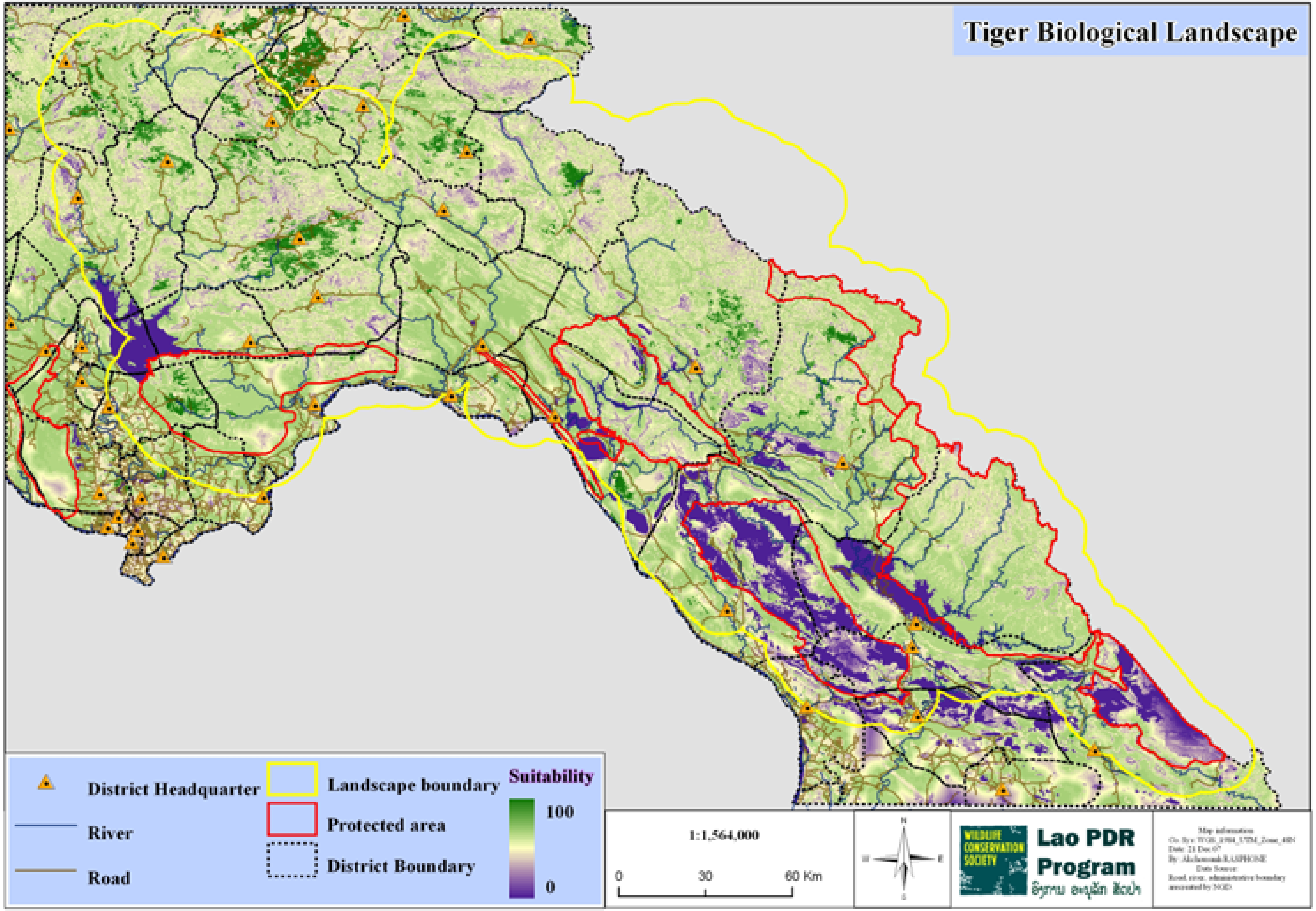
Tig.Prey.Dens = ([Prey. Vegetation] * [Dist.Water] * [Slope]) / 10000

Tiger Biological Landscape:

The final tiger biological landscape (Map 2) can now be created by putting together the prey density and habitat preference landscapes (formula ***6***). Weighting system is used in this process by assign weight of 3 to prey density and weight 1 to habitat preference. This is because we assumed that tiger preys are higher dominant factor of tiger habitat.

(6)

([Hab.Prefer.] + (3 * [Tig.Prey.Dens])) / 4



Map 2: Biological landscape of tigers

3.2.3. Serow

Serows prefer the steep slope rocky areas that covered by the thick bush at elevation lower than 2700m (Shackleton, 1997). They shelter in deep bush or scrub during the day and go out to feed in more open areas in late evening (Lovari and Locati, 1994). They eat almost any vegetation but prefer grass, tender leaves and shoots (Lekagul and Mcneely, 1988).

Three criteria were used to define their biological landscape (See formula ***8***) including:

- **Land Cover/Vegetation Type –** The same scoring system was used to reclassify the vegetation classes (Table 6) that are considered to be preferable by this type of species.

Table 6: Serow habitat suitability scores for each vegetation type

ID	Type	Score
1	Urban	0
2	Agriculture (Current)	10
3	Regeneration Forest	50
4	Secondary Forest	50
5	Savannah	10
6	Scrub	50
7	Grassland	10
8	Mixed Broad-Leaved	50
9	Coniferous Forest	10
11	Lower Dry Evergreen	90
12	Upper Dry Evergreen	90
13	Dry Dipterocarp	10
14	Bamboo	5
15	Riparian	10
16	Swamp	0
17	Rock	100
18	Water	0
19	Forest Plantation	10
21	Lower Mixed Deciduous	70
22	Upper Mixed Deciduous	70
100	Transitional Agriculture	50
200	Plantation Forest	10

- **Slope** – The slope coverage was reclassified into three new classes as being the most suitable slope for their habitat:

  0 - 10 - value of 50
  11 - 15 - value of 80
  16 – 77 or above - value of 100

- **Distance to Slope** - The criteria we set for defining suitable habitat based on distance to steep areas are:
  At 500m or below → suitability level is 100;
  At value 750m → suitability is 50; and
  At 1km or above → suitability is 0.

With Spatial Analyst/Distance/Straight line function, we generated distance layer for the slope (**SlopeDist**). Linear function was then applied in the calculation (formula *7*).

(7)

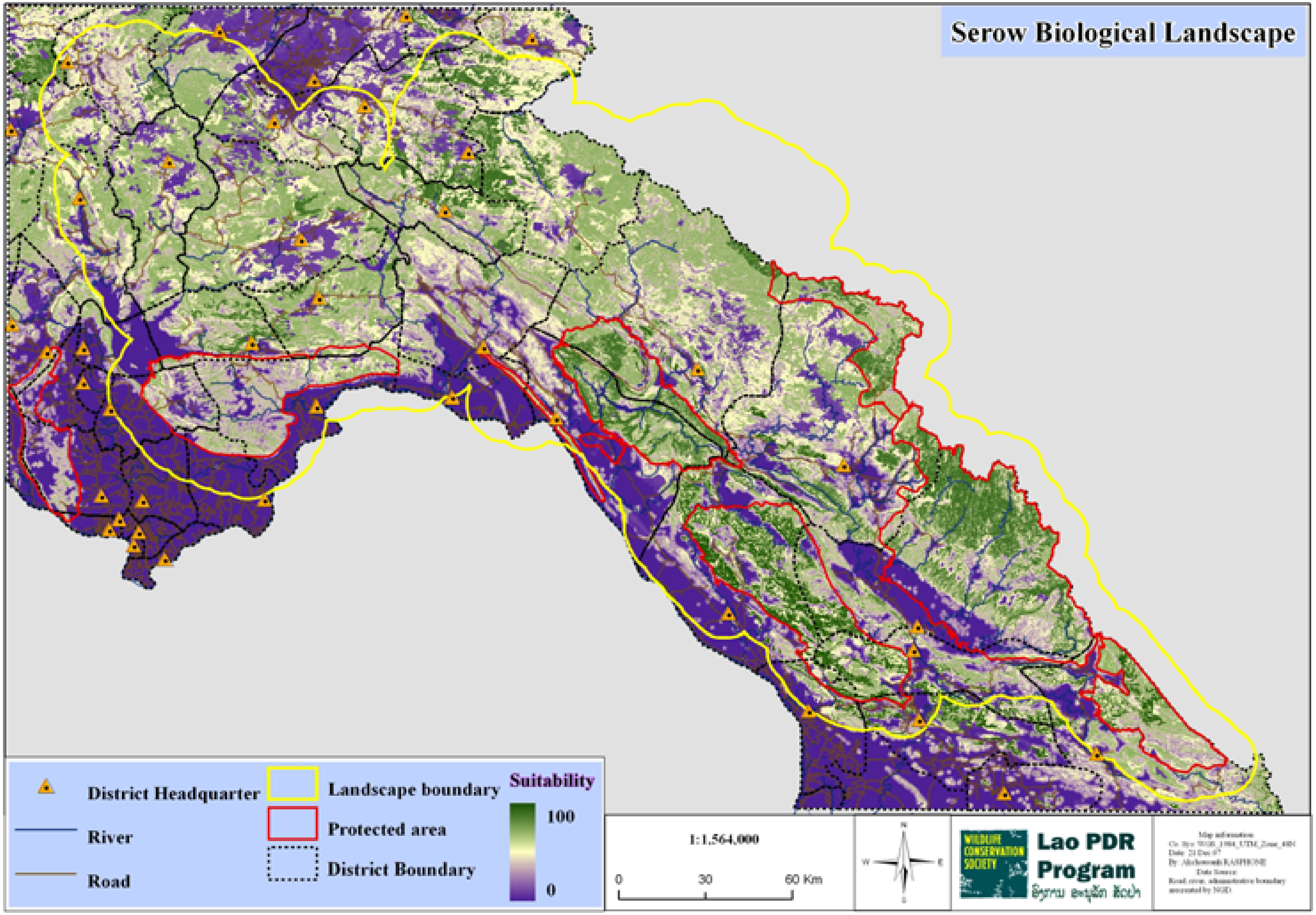
Dist.Slope = Int (Con ([SlopeDist] <= 500, 100, con ([SlopeDist] > 500 & [SlopeDist] <= 1000, (Slope * [SlopeDist] + Intercept), 0)))

Serow Biological Landscape:

Complete biological landscape of Serows can be viewed in Map 3.

(8)

[Land_Cover_Reclass.] * [Slope_Reclass] * [Dist.Slope] / 10000



Map 3: Biological landscape of serows

3.2.4. Wild Pig

Habitat preference of wild pig is mainly the areas that have proximity to water sources. They are usually found within 4km distance to the water and slope of the areas less than 45% (Nowak, 1991). They eat wide range of food including fungi, roots, snakes, rats. Carrion, bulbs, tubers, shoots, and many kinds of fruit and vegetables including cultivated crops (Lekagul and Mcneely, 1988).

According to characteristics of this species, the criteria for building their biological landscape (Map 4) are based on three aspects which are vegetation type, distance to rivers, and habitat slope. These three factors can be combined using formula ***11***.

- **Land Cover/Vegetation Type –** the scores given to each habitat vegetation type are ranked from 0 to 100 based on their preferences (See Table 7).

Table 7: Wild Pig habitat suitability scores for each vegetation type

ID	Type	Score
1	Urban	0
2	Agriculture (Current)	90
3	Regeneration Forest	100
4	Secondary Forest	80
5	Savannah	30
6	Scrub	30
7	Grassland	30
8	Mixed Broad-Leaved	90
9	Coniferous Forest	90
11	Lower Dry Evergreen	90
12	Upper Dry Evergreen	90
13	Dry Dipterocarp	90
14	Bamboo	90
15	Riparian	100
16	Swamp	100
17	Rock	0
18	Water	0
19	Forest Plantation	10
21	Lower Mixed Deciduous	90
22	Upper Mixed Deciduous	90
100	Transitional Agriculture	100
200	Plantation Forest	10

- **Distance to Water** - Good habitat for wild pig should lines within 4 km distance from the rivers or water bodies. Calculating this has involved the use of **Linear Function** (See formula ***9***). Criteria we set for defining suitable habitat based on distance to water being:

  at 2km or below → suitability level is 100
  at value 3km → suitability level is 50
  at 4km or above → suitability level is 0.

  Like others, we generated distance layer (**RiverDist**) from the river layer, before applying linear function.

  (9)

Dist_to_Water = Int (Con ([RiverDist] <= 2000, 100, con ([RiverDist] > 2000 & [RiverDist] <= 4000, (Slope * [RiverDist] + Intercept), 0)))

- **Slope –** slope was reclassified into two classes (formula ***10***). Slope greater than 45 % are considered as no-go area (assigned value = 0).

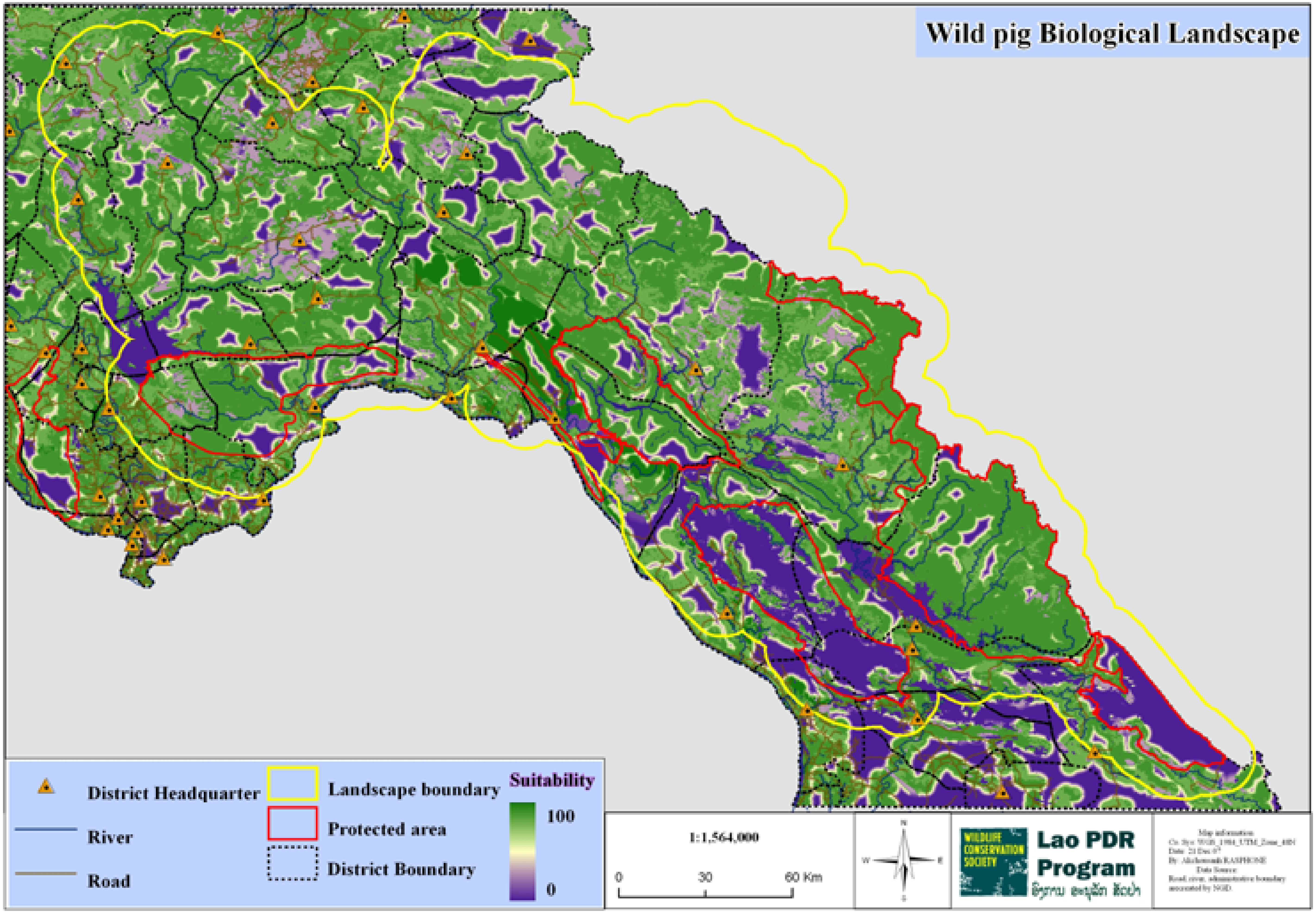
(10)

Slope Pref. = con ([sl_nk_int] <= 45, 100, 0)

Wild Pig Biological Landscape

(11)

[Veg.Pref.] * [Dist_to_Water] * [Slope Pref.] / 10000



Map 4: Biological landscape of wild pigs

3.2.5. Gibbon

White-cheeked crested gibbons prefer habitats with high density of tree cover, while patch viability is important, as they have very limited dispersal capabilities and rarely cross open spaces. They eat mostly ripe fruits, leaves, and a small amount of invertebrates. They move and feed mainly in the upper and middle levels of the canopy and almost never come down to the ground. Families often feed together in the trees (Anon, 2001; M.ASQUITH, 2001; KA, 2005). However, elevation might be a limiting factor for food availability.

Criteria used for creating biological landscape (Map 5) of the gibbons were defined based on vegetation type, elevation, and habitat patch size and can be combined using formula ***15***.

- **Vegetation Type -** Gibbons require relatively high density of tree cover to obtain fruits and avoid open areas. Their home range and dispersal capabilities are very limited and they do not cross area further than 50 – 100 meters (Arlyne Johnson, personal communication, June 5, 2006). They may have to compensate for the lower quality habitat (lower cover density) with larger home ranges. Therefore, we assigned scores to each vegetation type as shown in Table 8. Areas where there are major roads and rivers were considered as non habitat area.

  Due to the fact that gibbons do not like to cross opened space, we incorporated habitat fragmentation factor caused by rivers and roads. Separate river (main river value = 1, see formula ***12***) and road (major road value = 1, see formula ***13***) layer were used to modify the vegetation layer by turning all areas of road and rivers to an unsuitable habitat (Value 0).

  (12)

  VegRiver = Con ([Rivers] == 1, 0, [Vegetation])

  (13)

  Veg. Pref = Con ([Majoroads_0] == 1, 0, [VegRiver])

- **Elevation** - gibbons were mostly found in the elevation between 0 and 2000 m (Smuts *et al.*, 1987). It is hard to say if they can get higher as the vegetation and availability of fruits might be limited above this elevation. We reclassified elevation grid into two classes. Gibbons prefer habitat below 2000m altitude. In the absence of data above 2000m, we provisionally classified that as no habitat.

- **Habitat Patch Size**
  To determine habitat patch size for gibbons, in the Veg.Pref layer, the areas that have suitability score of greater than 70 are collapsed by assigning value of 1, and 0 for others. Group region analysis was then done for the collapsed grid in ArcView to get a new grid (**RegionGroup**). We reclassified the group region grid based on viability levels of gibbon population for each particular patch size (See formula ***14***).

(14)

Hab. Patch Size =

Con ([RegionGroup].link eq 1 & ([RegionGroup].count >= 31 & [RegionGroup].count <= 90), 10, [RegionGroup].link eq 1 & ([RegionGroup].count >= 91 & [RegionGroup].count <= 180), 50, [RegionGroup].link eq 1 & ([RegionGroup].count >= 181 & [RegionGroup].count <= 1800), 80, [RegionGroup].link eq 1 & ([RegionGroup].count >= 1801 & [RegionGroup].count <= 3750), 90, [RegionGroup].link eq 1 & [RegionGroup].count > 3750, 100, 0)

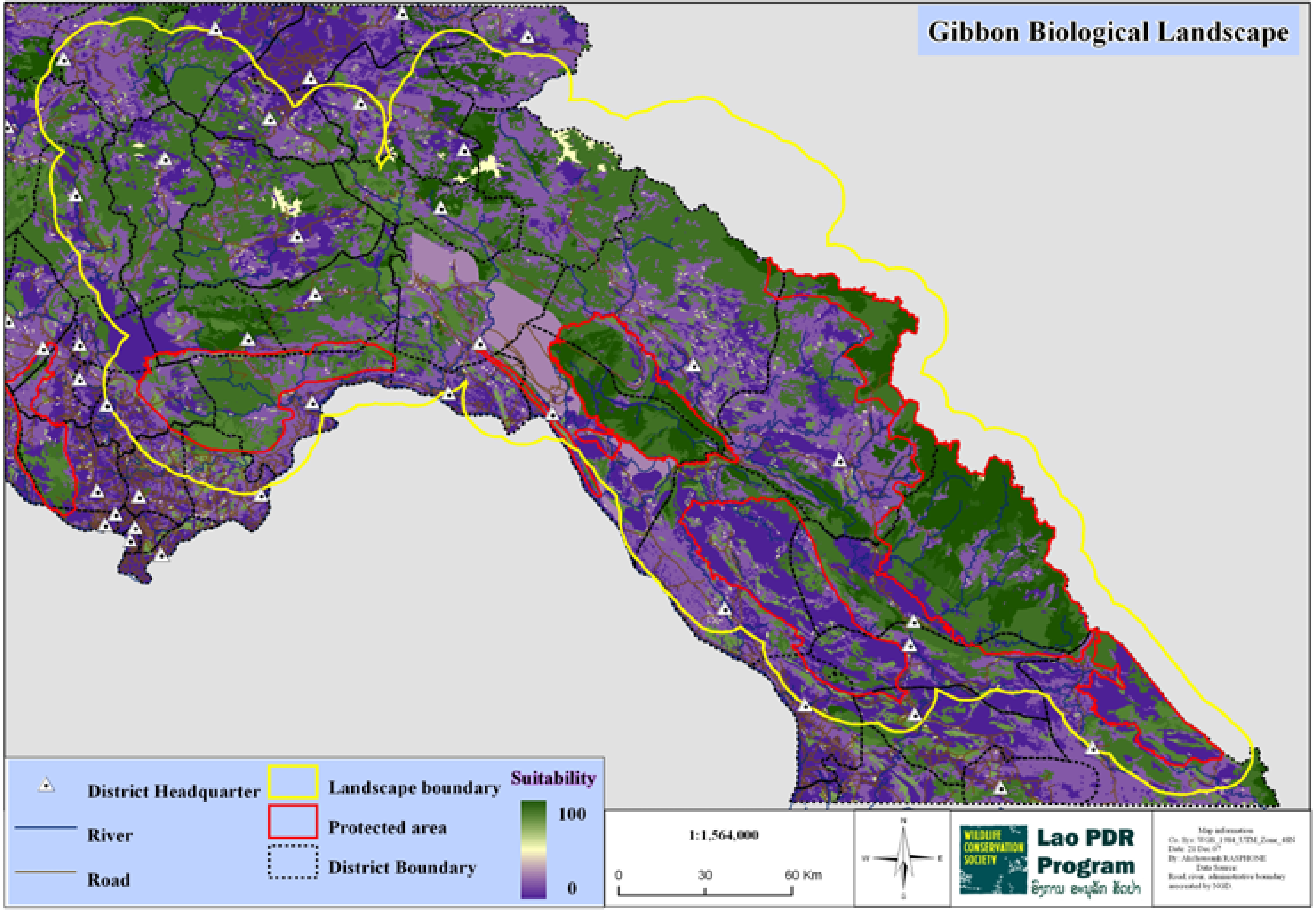
White-cheeked Crested Gibbon Biological Landscape

(15)

((([Elev. Pref] * [Veg. Pref] / 100) + [Hab. Patch Size]) / 2)

Table 8: White-cheeked gibbon habitat suitability scores for each vegetation type

ID	Vegetation Type	Score
1	Urban	0
2	Agriculture (Current)	0
3	Regeneration Forest	50
4	Secondary Forest	30
5	Savannah	0
6	Scrub	0
7	Grassland	0
8	Mixed Broad-Leaved	80
9	Coniferous Forest	0
11	Lower Dry Evergreen (low density)	90
	Lower Dry Evergreen (high density)	100
12	Upper Dry Evergreen (low density)	90
	Upper Dry Evergreen (high density)	100
13	Dry Dipterocarp	0
14	Bamboo	0
15	Riparian	100
16	Swamp	0
17	Rock	0
18	Water	0
19	Forest Plantation	0
21	Lower Mixed Deciduous (low density)	70
	Lower Mixed Deciduous (high density)	80
22	Upper Mixed Deciduous (low density)	70
	Upper Mixed Deciduous (High density)	80
100	Agriculture (Abandon)	10
200	Plantation Forest	0



Map 5: Biological landscape of white-cheeked crested gibbons

3.2.6. Great Hornbill

Creating biological landscape of the great hornbills (Map 6) requires accounting their habitat for both nesting and foraging (see formula ***16***). This species prefer areas that densely cover with trees, they require habitat with big trees as their nesting area. They can travel as far as 20 – 30km from their nesting area for food (Poonswad and Kemp, 1993). Elevation might be limiting factor for food availability, as they rely on mainly fruits and seeds (Poonswad and Kemp, 1993).

- **Vegetation type/cover –** as mentioned earlier considering hornbill habitat requires looking at habitat for nesting and foraging. Therefore, scoring system was used to determine separately for each type of the species required habitats as shown in Table 9 below.

Table 9: Great Hornbill nesting and foraging habitat suitability scores for each vegetation type

ID	Vegetation Type	Nesting Score	Feeding Score
1	Urban	0	0
2	Agriculture	0	0
3	Regeneration Forest	0	60
4	Secondary Forest	0	0
5	Savannah	0	0
6	Scrub	0	0
7	Grassland	0	0
8	Mixed Broad-Leaved	70	80
9	Coniferous Forest	20	0
11	Lower Dry Evergreen (Low Density)	90	100
	Lower Dry Evergreen (High Density)	100	100
12	Upper Dry Evergreen (Low Density)	90	100
	Upper Dry Evergreen (High Density)	100	100
13	Dry Dipterocarp	100	20
14	Bamboo	0	0
15	Riparian	100	100
16	Swamp	0	0
17	Rock	0	0
18	Water	0	0
19	Forest Plantation	0	0
21	Lower Mixed Deciduous (Low Density)	90	100
	Lower Mixed Deciduous (High Density)	100	100
22	Upper Mixed Deciduous (Low Density)	90	100
	Upper Mixed Deciduous (High Density)	100	100
100	Transitional Agriculture (abandoned)	0	0
200	Plantation Forest	0	0

- **Elevation -** suitable habitat of hornbill can be found within the areas that have elevation from 0 to 2000m. The higher the elevation is the less moisture in the soil which results in less fruiting trees (Poonswad and Kemp, 1993; Duckworth *et al.*, 1999).

  We reclassified elevation grid based on these criteria:
  0 – 1560m (100 scores for being the most suitable habitat)

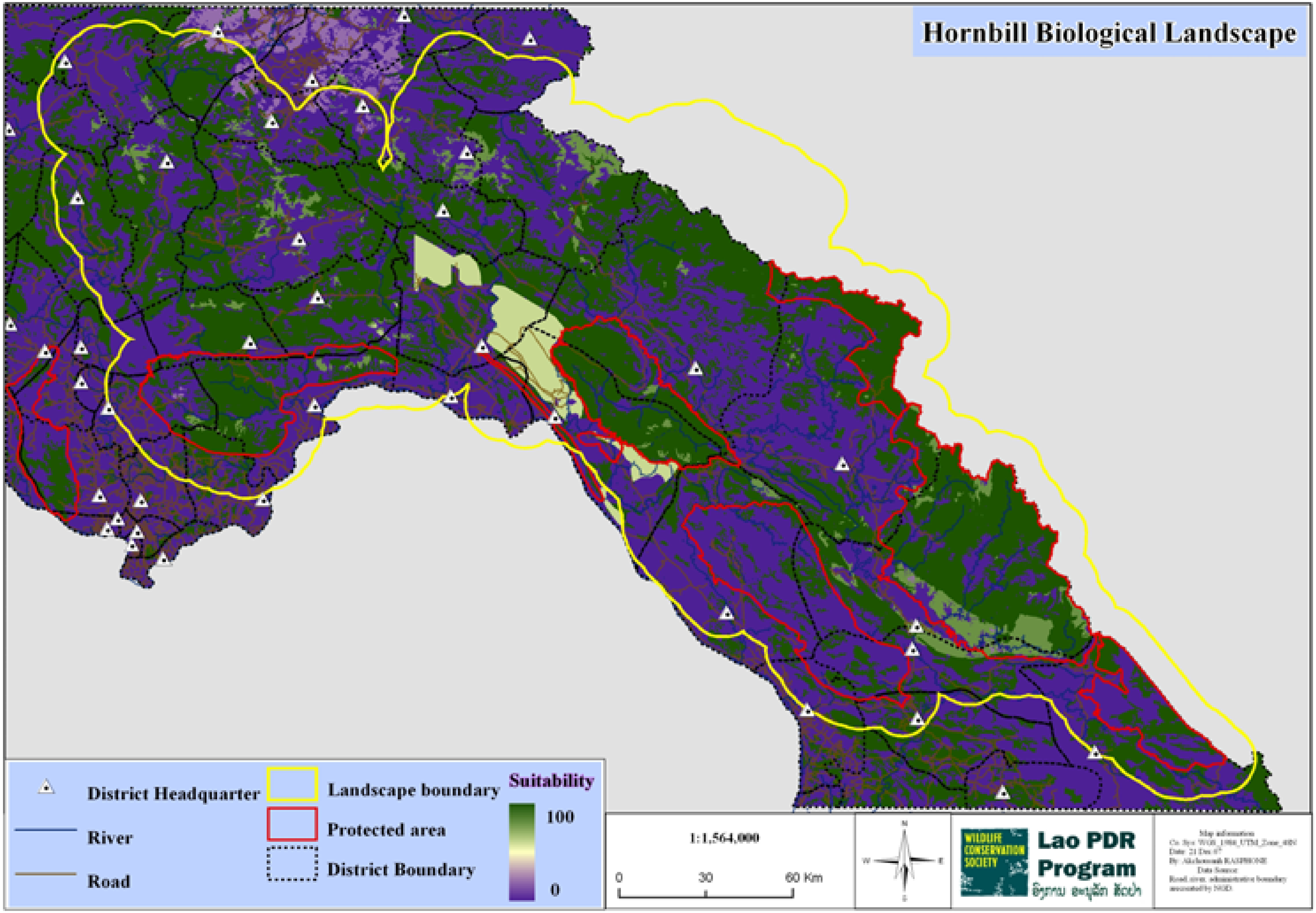
1560 – 2000m (80 scores for being suitable habitat type)
> 2000m (Considered as no habitat for the hornbill).

Great Hornbill Biological Landscape:

(16)

(max ([Veg. for Feeding], [Veg. for Nesting])) * [Elevation Pref.] / 100

Max ([Veg.for Feeding], [Veg. for Nesting]) – this part of the formula means vegetation layers for both nesting and foraging are combined by comparing suitability scores between both layers and assign highest score which belongs to either foraging or nesting to each overlapping area.



Map 6: Biological landscape of great hornbills

3.3. Building Threat Landscapes

Threat landscape is also known as human landscape or area where different types of human activities occur that have impacts on wildlife habitat and population.
Our team reviewed previous literatures of Nam Kading NPA and listed out threats to wildlife and their habitats. In Landscape Species Selection Meeting (March 2006), we presented the list of threats to attended district governors and local experts, and discussed with them to identify main threats to our landscape species. Those threats include agriculture, hunting, livestock depredation, and logging. Each threat results in different percentage of reduction in animal population. . We used the scores in Table 10 to weigh the threats to generate the species loss layer and then current biological landscapes.

Table 10: The percentage reduction of population in the places where the threat is the most severe

	% reduction in population				
	agriculture conflict	livestock conflict	logging	hunting-trade/subsistence	prey depletion
Elephants	90	0	0	100	0
Wild Pig	50	0	0	70	0
Tiger	0	70	0	90	90
Gibbon	0	0	90	100	0
Serow	0	0	0	95	0
Hornbill	0	0	100	100	0

3.3.1. Agriculture

Threat related to agriculture area is commonly known as human-animal conflict near agriculture field. Wild pigs and elephants tend to be the only species in the selected species list that are directly affected by this problem. This type of threat landscapes (see formula ***19*** and ***20***) were built using different criteria for each mentioned species based on their preference and behaviors.

Three things were considered in creating agriculture threat landscape:

- **Buffered Urban Areas -** we considered the influence of urban settlements by a buffer representing the 'hinterland' area. This hinterland was assumed to be of 10km radius for national capital, and 5km radius for provincial capitals and major towns as below.

- **Distance to Agriculture and Urban Areas** – all permanent agriculture areas were extracted from land cover layer and merged with buffered urban area. Distance to these areas was then calculated using distance function (see formula ***17***) to produce (**Dist. to Agri-urban**) layer before determining severity of threat to species.

  For elephants, we assume that, for a 15km radius (range), the threat is 100 % within the first 25% of the radius (= 3.75km) starting from agriculture and urban areas, then linearly decreases, until it falls to nil as it reaches 15km. linear function was applied.

(17)
Ele. Dist.= Int (con ([Dist. to Agri-urban] ≤ 3750, 100, con ([Dist. to Agri-urban] > 3750 and [Dist. to Agri-urban] ≤ 15000, -0.0089 * [Dist. to Agri-urban] + 133, 0)))

For wild pigs, we assume that, for a 2km radius (range), the threat is 100 % within the first 25% of the radius (= 0.5km) starting from agriculture and urban areas, then linearly decreases (see formula ***18***), until it falls to nil as it reaches 2km.

(18)
Wild Pig Dist.= Int (con ([Dist. to Agri-urban] ≤ 500, 100, con ([Dist. to Agri-urban] > 500 and [Dist. to Agri-urban] ≤ 2000, -0.067 * [Dist. to Agri-urban] + 133.3, 0)))

- **Population Pressure-** this was run with AML that calculates impact of 2 people per 1 sq km. It was run just on population size of the village and not multiplied by any weight and without accounting urban settlements.

***(19)* - Agriculture Threat Landscape for Elephant**

Con ([Urban Buffer] = *assigned value*, 100, [Ele. Dist] > 0, (([Population Pressure] + (3 * [Ele. Dist])) / 4, 0)

***(20)* - Agriculture Threat Landscape for Wild Pig**

Con ([Urban Buffer] = *assigned value*, 100, [Wild Pig Dist] > 0, (([Population Pressure] + (3 * [Wild Pig Dist])) / 4, 0)

3.3.2. Hunting

Hunting is considered to be the main direct threat effecting abundance and distribution of landscape species. In the beginning of the analysis process, we identified two types of hunting: hunting for trade and for subsistence. According to the Bolikhamxay district governors, areas identified for subsistence hunting are overlapping with the area where there is an incident of hunting for trade. Therefore, we decided to build a landscape that represents severity of hunting for trade (using formula ***30***).

To create this hunting model (Map 7), we did cost-surface analysis, looked at a combination of population pressure (based on 2 people per 1 sq km) and travel routes access. In the area where we have roads, we have more markets where people can sell wildlife. We assumed that villages closer to the markets will tend to hunt both for subsistence and trade; villages further away from markets tend to hunt primarily for subsistence, so the impact is much smaller.

- **Access** - The access layer is used to make the distinction between the population hunting more for trade and population hunting more for subsistence. The villages closer to transportation routes (weighted according to their impact) are more prone to hunting for trade and vice versa.
  Roads and rivers were reclassified based on their impact on landscape and how people use them to travel across the region. Major roads have the highest impact, followed by major rivers and then smaller/unpaved roads and finally small rivers that within a dry season can be used as a path to walk through the forest. Linear distance function then was applied to each type of roads and rivers

  Classify roads as such:
  - **major roads impact** = 100
    We assume that, for a 20km radius (range), the threat is 100 % within the first 25% of the radius (=5km) starting from the major roads, then linearly decreases, until it falls to nil as it reaches 20km (see formula ***21***).

    (21)
    *Int (con ([Major Road Distance] le 5000, 100, con ([Major Road Distance] gt 5000 and [Major Road Distance] le 20000, -0.0067 * [Major Road Distance] + 134, 0)))*

  - **unpaved/temp/other roads impact** = 50
    For this, we assume that, for a 15km radius (range), the threat is 50 % within 5km starting from the unpaved roads, then linearly decreases, until it falls to nil as it reaches 15km (see formula ***22***).

    (22)
    *Int (con ([Unpaved Road Distance] lt 5000, 50, con ([Unpaved Road Distance] gt 5000 and [Unpaved Road Distance] lt 15000, -0.005 * [Unpaved Road Distance] + 75, 0)))*

  - **footpath** = 30
    For this, we assume that, for a 15km radius (range), the threat is 30 % within 5km starting from the footpaths, then linearly decreases, until it falls to nil as it reaches 15km (see formula ***23***).

    (23)
    *Int (con ([Foot Path Distance] le 5000, 30, con ([Foot Path Distance] gt 5000 and [Foot Path Distance] le 15000, -0.003 * [Foot Path Distance] + 45, 0)))*

  Classify rivers as such:
  - **major rivers impact** = 80
    For this, we assume that, for a 20km radius (range), the threat is 80 % within 5km starting from major rivers, then linearly decreases, until it falls to nil as it reaches 20km (See formula ***24***).

    (24)
    Int (con ([Major River Distance] le 5000, 80, con ([Major River

*Distance] gt 5000 and [Major River Distance] le 20000, -0.005 * [Major River Distance] + 107, 0)))*

- **smaller rivers impact** = 30
  For this, we assume that, for a 15km radius (range), the threat is 30 % within 5km starting from small rivers, then linearly decreases, until it falls to nil as it reaches 15km (see formula ***25***).

  (25)
  *Int (con ([Small River Distance] le 5000, 30, con ([Small River Distance] gt 5000 and [Small River Distance] le 15000, -0.003 * [Small River Distance] + 45, 0)))*

- **Cost-surface Analysis** - created based on the recoded slope, major and unpaved roads, major and small rivers. The difficulty of moving across the roads and rivers is defined by the steepness of the terrain. This is kept separate from the difficulty of moving across the vegetated terrain that is also modified by the overall difficulty of not moving across the major transportation routes.

  <u>Process of building the cost surface</u>
  Table 11 shows the weights assigned to different type of roads and rivers within 100m buffer, which represent level of difficulty in traveling from place to place within the landscape.

  Table 11: The weight/score within 100m radius from roads and rivers

Rivers		Rivers		Roads		Roads		Roads	
major	score	small	score	major	score	unpaved	score	footpath	score
100 m	5	100m	15	100 m	0	100m	10	100m	15

  SLOPE
  Slope can be limited factor especially along the river in Nam Kading where the river is surrounded by boulders and steep slopes that serve as a barrier to the movement. We reclassified slope degrees according to the difficulty of traveling through landscape at different slopes as following:

Slope	score
0-2	1
2-5	5
5-10	10
11-15	20
16-20	50
21-25	60
26-30	80
30-35	100
>35	1000

VEGETATION
We reclassified vegetation cover according to the difficulty of moving across it (Table 12); rock was assigned to no data (1000) as not penetrable area for people.

Table 12: The difficulty score of moving through different types of land cover.

Land Cover	score
Urban	5
Agriculture	5
Regeneration Forest	20
Secondary Forest	20
Forest Plantation	20
Savannah	20
Scrub	80
Grassland	20
Mixed Broad-Leaved	30
Coniferous Forest	20
Lower Dry Evergreen	40
Upper Dry Evergreen	40
Lower Mixed Deciduous	40
Upper Mixed Deciduous	40
Dry Dipterocarp	20
Bamboo	80
Riparian	90
Swamp	100
Water	5
Rock	1000

Cost-surface (*Using Raster Calculator*):

Again, the cost surface calculation is based on the recoded slope, major and unpaved roads, major and small rivers (see equation ***26***). The difficulty of moving across the roads and rivers is defined by the steepness of the terrain. This is kept separate from the difficulty of moving across the vegetated terrain that is also solely define by the steepness and not by the major transportation routes.

(26)
Cost-surface = con ([Slope] > 0 & [Major Road] == 0, [Slope] + [Major Road], [Slope] > 0 & [Small River] == 15, [Slope] + [Small River], [Slope] > 0 & [Unpaved Road] == 10, [Slope] + [Unpaved Road], [Slope] > 0 & [Major River] == 5, [Slope] + [Major River], [Slope] > 0 & [Foot Path] == 15, [Slope] + [Foot Path], [Slope] > 0 & [Vegetation Class] > 0, [Slope] + [Vegetation Class] + [Major Road])

Final Cost-surface:

Every place has score above 1000 is assigned value 2000 to treat those areas equally impassable (use formula 27). This is just a matter of preference on how to recode the final cost surface values.

(27)
Con ([Cost-surface] ge 1000, 2000, [Cost-surface])

- **Population Pressure -**
  This process was run AML (Arc Macro Language) Script (**Appendix 1**) that calculates of the intensity of hunting based on the village size and the village proximity to various transportation routes (major roads, rivers, etc.) The model is based on the principle of the cost surface analysis. Detailed description on how to run the AML script can be found in **Appendix 3**.

- **Impact of Village Location -**
  We added the layer to the hunting layer to incorporate the more hunting around each village (more subsistent hunting). We assumed that within 500 meters from the village impact is 100 and then it decreases to 0 once it reached 5000 km from the village (see equation ***28***).

  (28)
  Village Threat = Int (con ([Distance to Village] le 500, 100, con ([Distance to Village] gt 500 and [Distance to Village] le 5000, (-0.02) * [Distance to Village] + 111, 0)))

  Then we modified with the hunting around each village within 5 km from the village location using equation ***(29)***.

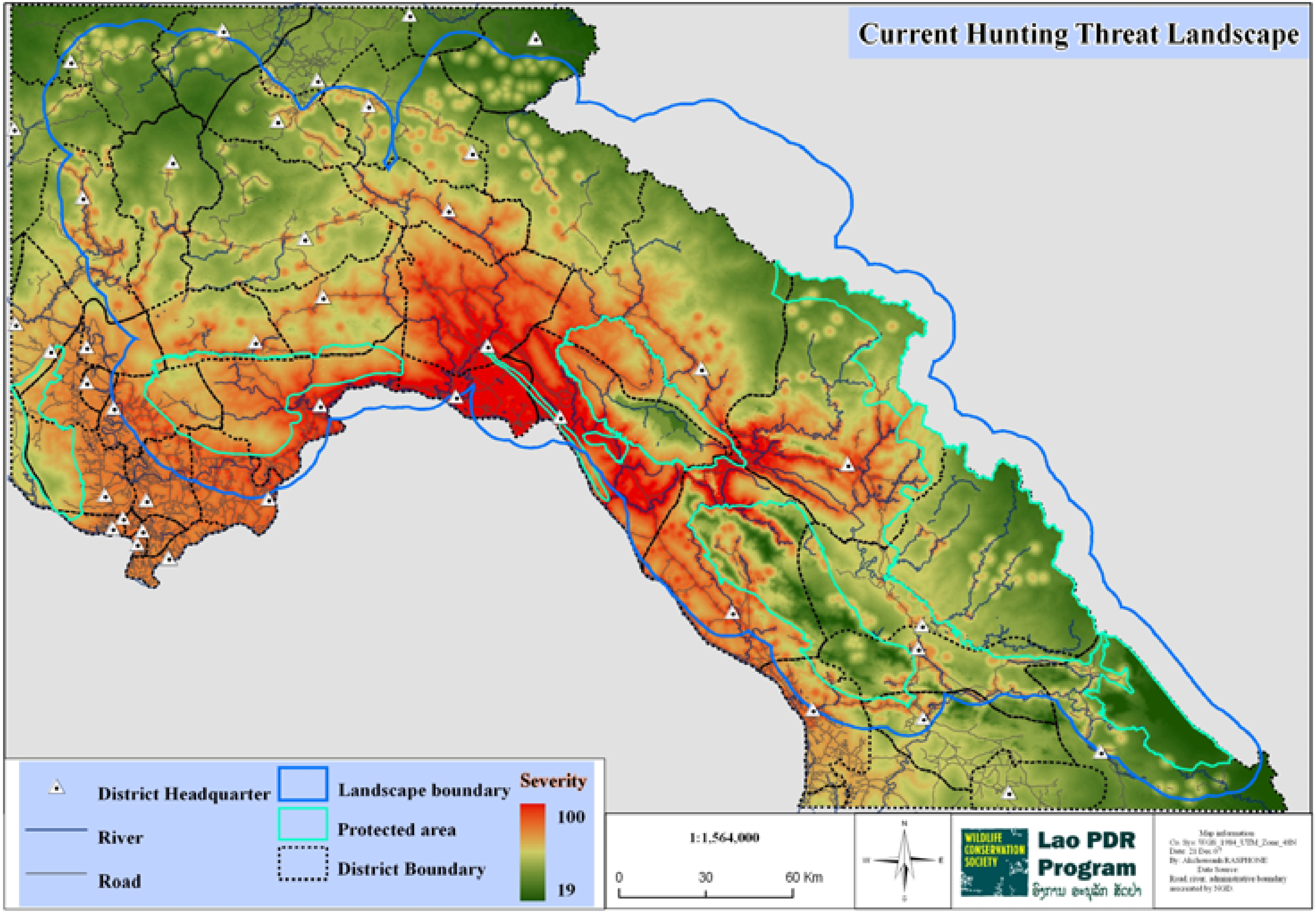
  (29)
  Modified Village = (([Village Threat] + ([Population Pressure] * 2)) / 3)

Hunting Threat

We brought the maximum values of modified with villages and trade layers

(30)

Max ([Modified Village], [Population Pressure])



Map 7: Severity of hunting threat landscape

3.3.3. Livestock

Potential conflict between humans and tiger is somewhat of a different nature. Whereas pig and elephant conflicts take place within and nearby agricultural lands (crop raiding), tiger conflict occurs in terms of livestock depredation. An average area of livestock ranging is around 2.5km around villages (Arlyne Johnson, personal communication, June 5, 2006), which is considered as a (no go) dangerous place for tigers. However, urban areas do not have livestock, so may not constitute areas of such threat. We removed those from the analysis.

We based our assumption on distance to livestock areas and population pressure (run with AML) represents impact of 2 people per 1sq km disregarding urban settlements.

- **Urban Settlement Buffer -** we considered the influence of urban settlements by a buffer representing the 'hinterland' area. This hinterland was assumed to be of 10km radius for national capital, and 5km radius for provincial capitals and major towns. The urban buffered was converted to grid where the urban area was assigned value 0 and 1 to no data area.

- **Distance to Village Livestock –** linear distance function ***(31)*** was used to calculate this. We assume that, for tiger, for a 10km radius (range), the threat is 100 % within the first 25% of the radius starting from the livestock areas, then linearly decreases, until it falls to nil as it reaches 10km.

(31)

*Int (con ([Distance to Lifestock] le 2500, 100, con ([Distance to Lifestock] gt 2500 and [Distance to Lifestock] le 10000, (-100/7500) * [Distance to Lifestock] + 133, 0)))*

- **Population Pressure –** This layer was run using AML script (**Appendix 2**) that calculates the impact of population based on only population size within villages. Detailed description on how to run the script is included in **Appendix 3**.

Livestock Threat Landscape:

Formula ***(32)*** is used for creating the final threat landscape associated with human-animal conflict near livestock areas.

(32)

Con ([Urban Buffer] eq 0, 0, ((2 * [Population Pressure]) + [Distance to village Livestock]) / 3)

3.3.4. Logging

Logging is a one of the most important threats to the hornbill habitat. Hornbills tend to use big trees as their nesting spots. Therefore, logging contributes significantly to the declination of this species. Logging is driven by vegetation types suitable for cutting, distance to road and slope. These factors can be combined using formula ***34*** to produce logging threat landscape.

- **Vegetation Type/Cover –** we reclassified vegetation cover layer based on land cover type by rating the level of logging severity (rating scale is from 0 – 100 most severe) (see Table 13). This layer need to be refined based on type of land allocation:

a) Chances of cutting trees in protected areas are lower so we decrease the threat by 75 percent (this what you already have)

b) Chances of cutting trees in the production forest are much higher and we could increase the threat by 50 percent.

c) Chances of cutting trees around villages are much higher and we could increase the threat by 50 percent. Layer of 3km buffer around village location was used in this process.

Table 13: The level of logging severity score for each vegetation type

ID	Vegetation Type	score
1	Urban	0
2	Agriculture	0
3	Regeneration Forest	60
4	Secondary Forest	0
5	Savannah	0
6	Scrub	0
7	Grassland	0
8	Mixed Broad-Leaved	80
9	Coniferous Forest	100
11	Lower Dry Evergreen	80
12	Upper Dry Evergreen	60
13	Dry Dipterocarp	60
14	Bamboo	0
15	Riparian	100
16	Swamp	0
17	Rock	0
18	Water	0
19	Forest Plantation	0
21	Lower Mixed Deciduous	80
22	Upper Mixed Deciduous	60
100	Transitional Agriculture	0
200	Plantation Forest	0

Note: *All the areas that have value exceed 100 should be assigned to value 100 as it is the highest threat value.*

- **Slope –** the slope layer was reclassified based on criteria defined for logging severity:

  0 – 10% = 100
  11 – 15% = 70
  16 – 20% = 10
  > 20 = 0

- **Distance to Roads –** we separate the severity related to distance to roads into 2 types, distance to major roads and to footpath.
  - **Major Roads**
    Level of logging severity of particular areas is determined by distance from roads. Calculate distance to major roads and use Linear Function *(33)*. The criteria we set for defining areas where there's a high logging threat based on distance to big roads:
    ≤ 5km → risk is 100;
    > 5km and ≤10km → risk is 50,
    < 10km → risk is 0.

    (33)
    Int (con ([Distance to Major Road] gt 10000, 0, con ([Distance to Major Road] le 10000 and [Distance to Major Road] gt 5000, (-50/5000) * [Distance to Major Road] + 100, 100)))
  - **Footpaths**
    We calculated distance to the footpaths and then reclassified according to the given severity scores:

    0 – 5000m → 20
    > 5000m → 0

Logging Threat Landscape:

(34)

Int ([Vegetation Type] * [Slope] * (max ([Dist. To Major Road], [Dist. To Footpath])) / 10000)

To combine impact of distance to major road and distance to footpath on longing activity, we kept the maximum value of the each overlapping area of the 2 layers.

3.4. Refining Biological and Threat Landscapes

In November 2006, our living landscape team traveled to Pakxan; Bolikhamxay Province, to hold the 4th Conservation Biodiversity strategy meeting. The meeting's participants include the director and Assistant Director of Integrated Ecosystem and Wildlife Management Project (IEWMP), district governors and WCS staff. Gosia Bryja (Conservation Scientist/GIS Analyst, WCS New York Living Landscape Program) and Etienne Delattre (GIS/Landscape Analyst, WCS Asia Program) came to help preparing for the meeting.

The aim of the meeting was to review each biological and human landscape. The processes of how each landscape was generated were briefly described and a lot of time spent on discussion of the landscapes' accuracy. Our team prepared a number of questions regarding species biological and human landscape to guide the district guys on how we preferred the landscapes to be checked. In the meeting, district officer reviewed and edited the landscapes (Figure 4). More information can be found in "Lao P.D.R., October 30th – November 10th, 2006" trip report by Gosia Bryja, available at WCS library.

Figure 4: ***A district representative is checking result of the landscape***

Through this meeting, we obtained a lot of new information that could be used such as where hunting take place, how people travel across the landscape, where new agricultural fields are located, where elephants and tigers run into conflict with people, where our landscape species still present, where the good habitats are for them to exist, etc. All the information was carefully recorded (current/ past presence) and digitized into the computer by Etienne.

After we collected all the new information from all the participants, our team traveled back to Vientiane and worked on refining all the landscapes based on those information.

Main changes to the maps include (Bryja, 2006a):

1. Incorporating already logged areas into all biological landscape (no longer good habitat)
2. Incorporating information on higher rates of hunting around the villages (5 km buffer). We also decided not to use a subsistence hunting map since a lot of hunting for subsistence overlaps with areas where the hunting for trade takes place. We decided, thus, to use one map for hunting and refine it with the information about higher rates of hunting around the villages.
3. Refining the layer representing the conflict with elephants and wild pigs in the agricultural areas by adding information about new fields and assigning higher weight to the population pressure layer.
4. Modifying the layer representing the conflict with tigers where people keep livestock by assigning higher weight to the population pressure layer.
5. Improving our logging model by adding information about plantation forest and refining the influence of road on the risk of logging.

3.5. Building Conservation Landscapes

The main purpose of building species conservation landscapes was to provide a tool supporting the revision of the conceptual model and identifying interventions for the Nam Kading NPA management plan (Bryja, 2006b).

Our original idea of combining biological and threat landscape was to produce a conservation landscape. The conservation landscapes were done for each species at that stage as the management plan should be vary according to a species' biological characteristics. The first (**Qualitative**) method was developed by Gosia Bryja and Dr. Karl Didier; Landscape Ecologist; WCS – Living Landscape Program. Each biological and threat landscape was divided into three levels of high, medium and low biological quality and threat impact, respectively. The final conservation landscape was derived from a simple overlay technique of the two landscape types. This method of creating conservation landscapes was applied to all selected landscape species.

We also considered creating conservation landscapes using the second (**Quantitative**) method developed by Dr. Eric Sanderson; Associate Director/Landscape Ecologist/GIS Specialist. Working on this method required our team to set our species population target. Quantitative information about species potential, current and future abundance was delivered by this analysis method. We have so far used this method for two of our landscape species; tigers and white-cheeked crested gibbons. The process on how the biological and human landscapes were combined will be explained in the next sections.

3.5.1. Elephant

We defined thresholds for reclassifying the biological and threat landscapes of the elephants.

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- **Reclassify Biological Landscape**- The created landscape represents potential habitat quality (Figure 5) or potential animal abundance and it's values can be recoded as below (see Figure 6):
    - 0 as no habitat – new value = 0
    - 1-20 as low habitat – new value = 10
    - 20 -50 as medium, included agric. areas – new value = 20
    - >50 as good habitat – new value = 30

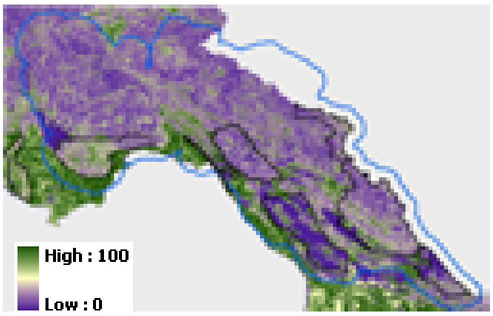


Figure 5: *Elephant Potential Landscape*

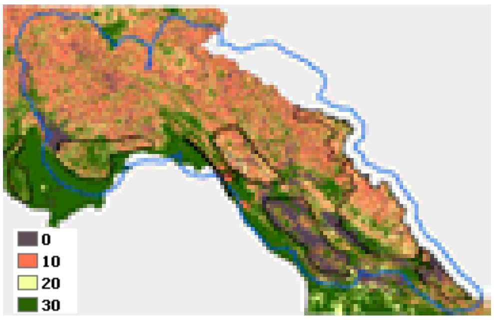


Figure 6: *Reclassified Elephant Potential Landscape*

- **Reclassify Threat Landscape** – Two threat landscapes were considered for the elephant conservation landscape which are hunting and agriculture threat. Before we reclassified the threat landscape, we combined the threat layers and calculate areas where potential loss of population can occur at different severity levels of impact.
  According to Table 10:

1. ***Hunting*** - potentially reduce 100 % of elephant population
2. ***Agriculture conflict*** - potentially reduce 90 % of elephant population.

- **Combine Threats (Figure 7)**
  We combined these two threats using the above weight of reduction and the following formula ***(35)***.

  (35)
  100 - (((100 - [Agric. Conflict] * 0.9) * (100 - [Hunting] * 1)) / 100)

- **Potential Impact**
  This layer represents level of severity of threats where there is species potential abundance (i.e. reduction of potential habitat quality to support high density of elephants due to current threats). We overlaid the combined threat layer with the potential biological landscape (using ***(36)***).

  (36)
  [Biological Landscape] * [Combined Threat] / 100

  We reclassified this potential impact layer based on the following thresholds in order to get 'Threat Reclass.' Layer (see Figure 8).

  - 0 as no habitat, no lost – new value = 0
  - < 10 as low lost – new value = 1
  - > 10 < 40 as medium lost – new value = 2
  - > 40 as high lost – new value = 3

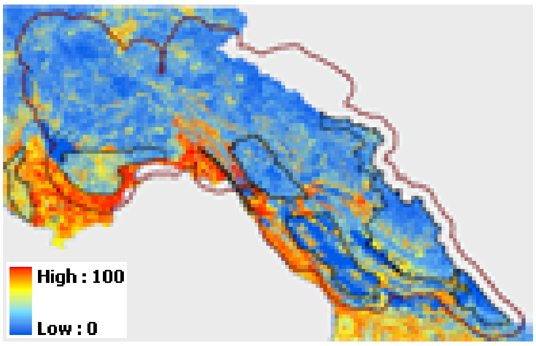


Figure 7: *Combine Threat Landscape*

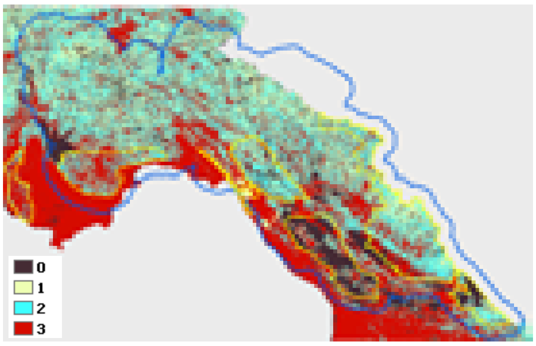


Figure 8: *Reclassified Threat Landscape*

Elephant conservation landscape was derived by applying formula **37** below

.

(37)

Current Conservation Landscape:

[Biological Landscape Reclass.] + [Threat Reclass.]

Values contained within each grid cell were label as:

- 33 - High Bio High Threat
- 32 - High Bio Med Threat
- 31 - High Bio Low Threat
- 23 - Med Bio High Threat
- 22 - Med Bio Med Threat
- 21 - Med Bio Low Threat
- 11 - Low Bio Low Threat
- 0 - No Habitat

3.5.2. Gibbon

We created conservation landscapes of gibbon using both qualitative ***(39)*** and quantitative method, as each method provide different kinds of information.

Conservation Landscape Using Qualitative Method

- **Reclassify Biological Landscape**- Thresholds used for reclassify the gibbon potential biological landscape (Figure 9) are:

  - 0 as no habitat – new value = 0
  - 1- 40 as low habitat – new value = 10
  - 40 - 60 as medium, incl. agric – new value = 20
  - >60 as good habitat – new value = 30

Figure 10 represents result of potential biological landscape recoding.

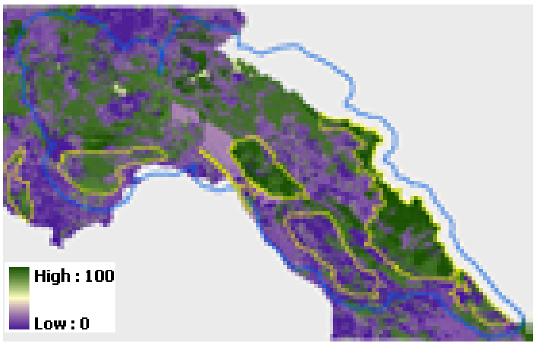


Figure 9: *Gibbon Potential Landscape*

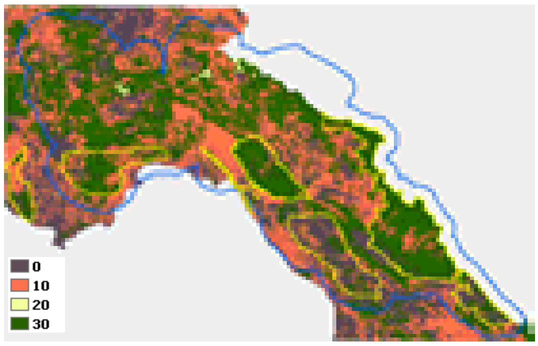


Figure 10: ***Reclassified Gibbon Potential Landscape***

- **Reclassify Threat Landscape** – We considered logging and hunting as the main threat to gibbon population. However, as logging is not seen as an on going threat, we already incorporated past/current logged area in the gibbon biological landscape to reduce quality of their habitat. Based on Table 10, hunting threat has 100% reduction of gibbon population. Therefore, hunting is the only threat for the gibbons (see Figure 11).

  In order to generate a potential impact landscape, we multiply the threat landscape with the potential biological landscape (see ***(38)***).

Potential Impact:

(38)
[Potential Biological Landscape] * [Hunting Threat] / 100

Potential impact layer was reclassified in order to get the reclassified threat layer (Figure 12), based on the following thresholds:

- 0 as no habitat, no lost – new value = 0
- 1 -30 as low lost – new value = 1
- 30-40 as medium lost – new value = 2
- > 40 as high lost – new value = 3

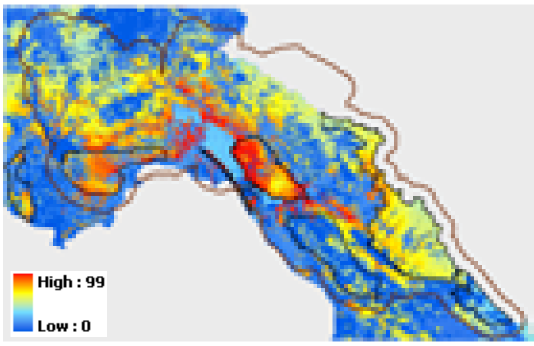


Figure 11: *Gibbon Combined Threat Landscape*

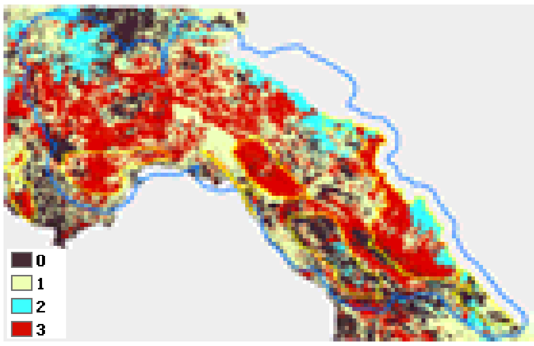


Figure 12: *Gibbon Reclassified Threat Landscape*

Current Conservation Landscape:

(39)

[Biological Landscape Reclass.] + [Threat Reclass.]

Values contained within each grid cell were label as:

- 33 - High Bio High Threat
- 32 - High Bio Med Threat
- 31 - High Bio Low Threat
- 23 - Med Bio High Threat
- 22 - Med Bio Med Threat
- 21 - Med Bio Low Threat
- 12 - Low Bio Med Threat
- 11 - Low Bio Low Threat
- 0 - No Habitat

Conservation Landscape Using Quantitative Method

This analysis method consists of a number of steps:

1. **Setting Population Target Levels for the species**.
   Optimal density of gibbons in the best habitat would be 1 family group per 30 hectares. Estimating an average of 4 individuals per family group, this would equate to a density of ~13 individuals / sq km. (CITE; Historical Level)

2. **Translating Potential Biological Landscapes into abundance**

Biological models represent the potential animal habitat in the absence of threat. In order to compare them to the population target levels and combine them with the human landscapes, we need to translate them into units of abundance (e.g. numbers of individuals per mapping unit, biomass per unit, etc.).

According to Eric's instruction, highest potential abundance (HPA) should be calculated by using formula ***40***:

(40)

HAP = # animals/ sq km * Analysis cell size

Our analysis grid cell size is 0.01 sq km (100 meters * 100 meters = 10, 000 sq meters)

HPA = 13 animals/km^2 * 0.01 km^2/cell = 0.13 gibbons

To rescale the biological landscape expressed in units of 0 - 100, multiply highest potential abundance estimate (HPA) by the biological landscape score divided by 100, as follows ***(41)***:

(41)

Total Potential Abundance (TPA) = HPA * biological landscape / 100

TPA = [bio. landscape] * 0.13 / 100

Potential numbers of gibbon in the landscape are 320, 722 gibbon

3. Combining Threat Landscapes

Threats to gibbons are divided into two types, inside and outside threats. Inside threats refer to those that indirectly impact on animal population such as logging and habitat fragmentation which limited them from traveling in a wider area to find food. Meanwhile, the outside threat represents direct threat like hunting, for instance.

Both logging and habitat fragmentation were already incorporated into the biological landscape. Therefore, we considered only hunting threat for past/present threat (Figure 13). According to Table 8, hunting has 100% reduction of gibbon population. The past/current and future threats to the species were generated. The past/current hunting threat was calculated originally without reservoirs (Nam Thuen1 and Nam Thuen2 hydro power projects) as this represents what was happening to animals till now. Once we incorporate the reservoirs into the hunting layer, we are changing the hunting pattern in the future and how that will affect animals in the future.

To calculate the future threat landscape (Figure 14), we decided to include logging threat (90% reduction of population) (see equation ***42***). This is to shows, in the worse case scenario, where and how many animals we can potentially lose if these human activities are continued in the same paste.

(42)

Total (%) of Future Reduction (TFR) = 100 - (((100 - [Future Hunting] * 1) * (100 - [Logging] * 0.9)) / 100)

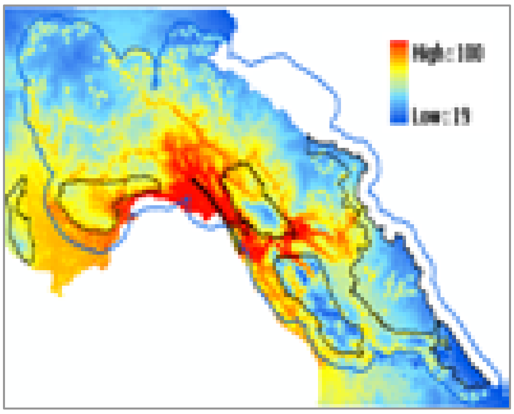


Figure 13: *Total (%) of Past/Current Reduction*

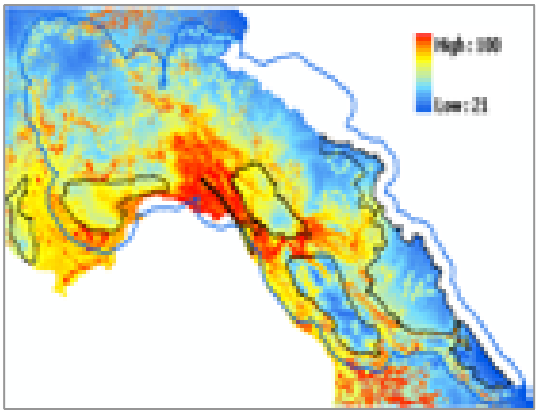


Figure 14: *Total (%) of Future Reduction*

4. **Mapping Potential Conservation Impact.**
We combined biological and threat landscapes to indicate the potential impact that conservation actions could have across the landscape, in terms of number of animals. This is what in the qualitative method represented % of habitat loss (in this case now, it will be number of animals lost)

- **Calculate the total impact of threats on species**
Total impact of threat is also known as total conservation impact (see equation ***43***). This calculation can tell us how many we lost. At the mean time, this can tell us how many we can potentially bring back.

(43)

Total Conservation Impact = Total Potential Abundance * Total (%) of Reduction / 100

= 183,982 gibbons

- **Calculate the current biological landscape *(44)* layer in order to evaluate the potential of future impacts.**
This is the layer that tells you how many animals you have on the current landscape. This is a current abundance estimated after threats.

(44)

Current Biological Landscape = Total Pot. Abun – Total Current Conservation Impact

Current number of gibbons estimated is 136,472
There are 5416 gibbons in the NK NPA

- **Calculate the future impacts. (future conservation impact layer)**

This is the layer that shows how many animals you can potentially lose if future threats happen (see equation ***45***). This layer along with the past conservation impact layer will be used to make decision on where to work.

(45)

Future Cons Impact = Current Biological Landscape * Total (%) of Future Reduction / 100

78,114 gibbons we can potentially lose in the future

- **Calculate the future biological landcape :**
  Future biological landscape (see equation ***46***) indicates the number of animals you will have if threats are happening.

(46)

Fut Bio Landscape = Current Biological Landscape - Future Conservation Impact

57,129 gibbons

5. **Conservation Landscapes.**
   The conservation landscape is an annotation of our conservation impact layer. The decisions on where to work is based on how many animals we need to bring back (our population targets)

3.5.3. Hornbill

The conservation landscape of the hornbills was created the same way as gibbon, except the thresholds for reclassifying biological and human landscape are different.

- **Reclassify Biological Landscape**
  Potential landscape of hornbills (Figure 15) was recoded based on the following thresholds in order to produce a new layer (Figure 16) for the analysis:
  - 0 as no habitat – new value = 0
  - 1-60 as medium habitat – new value = 20
  - >60 as good habitat – new value = 30

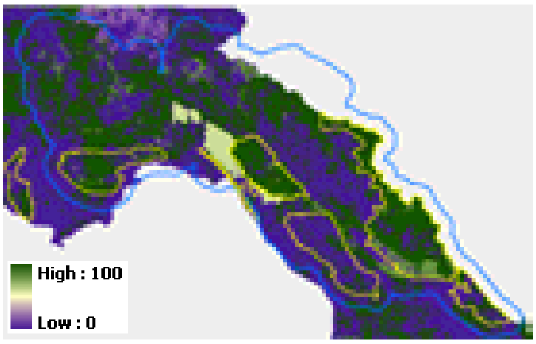


Figure 15: *Hornbill Potential Landscape*

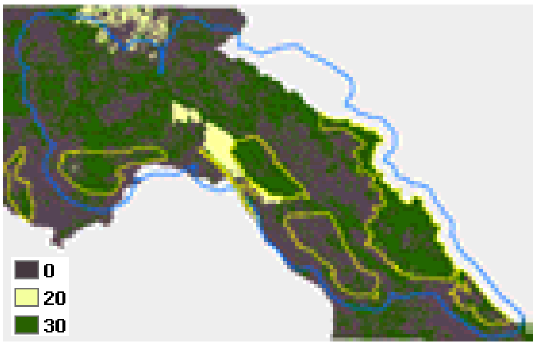


Figure 16: *Reclassified Hornbill Potential Landscape*

- **Reclassify Threat Landscape**
  There are two main threats affecting hornbill abundance which are logging and hunting threat. The same as the gibbon's case, logging threat was already considered while generating the biological landscape. Therefore, hunting threat (100% reduction in population) was the only threat we considered during this process (Figure 17). The threat was multiply with the potential biological landscape to generate potential impact layer. Below are the thresholds we used to reclassify this potential impact layer (Figure 18):

    - 0 as no habitat, no lost – new value = 0
    - 1-30 as low lost – new value = 1
    - 30-40 as medium lost – new value = 2
    - > 40 as high lost – new value = 3

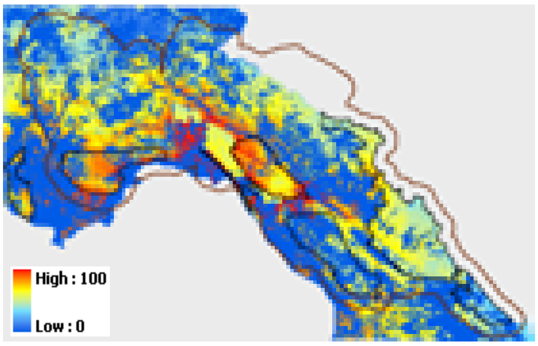


Figure 17: *Hornbill Combined Threat*

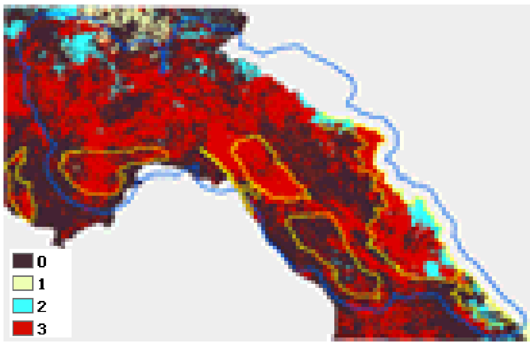


Figure 18: *Hornbill Reclassified Threat Landscape*

The same formula (***39***) was used to create the final conservation landscape of the hornbills. Each value of the grid cell was label as:

- 33 - High Bio High Threat
- 32 - High Bio Med Threat
- 31 - High Bio Low Threat
- 23 - Med Bio High Threat
- 22 - Med Bio Med Threat
- 21 - Med Bio Low Threat
- 12 - Low Bio Med Threat
- 11 - Low Bio Low Threat
- 0 - No Habitat

3.5.4. Serow

- **Reclassify Biological Landscape**
  Below are thresholds used for recoding biological landscape of Serows (Figure 19):
    - 0 as no habitat – new value = 0
    - 1-30 as low habitat – new value = 10
    - 30-50 as medium, incl. agric – new value = 20
    - >50 as good habitat – new value = 30

  The result of recoding process is shown in Figure 20.

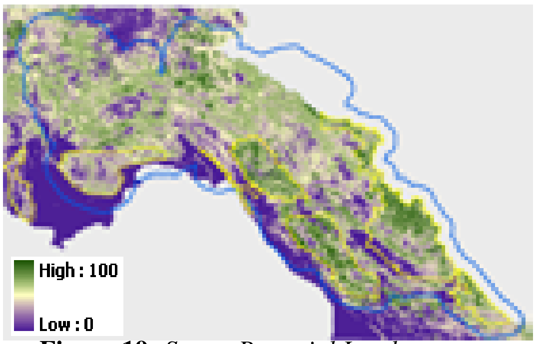


Figure 19: *Serow Potential Landscape*

Figure 20: *Reclassified Serow Potential Landscape*

- **Reclassify Threat Landscape**
  Hunting seemed to be the only threat to serow population which accounts 95% reduction of species abundance. This can be generated using equation ***47***.

  (47)
  Threat Impact = *100 - (100 - ([Hunting Threat] * 0.95))*

  We then multiplied the threat impact layer with the potential biological landscape to get potential impact layer (Figure 21), and reclassified it based on the following thresholds which resulted a new layer (Figure 22):

  - 0 as no habitat, no lost – new value = 0
  - 1 - 30 as low lost – new value = 1
  - 30- 40 as medium lost – new value = 2
  - > 40 as high lost – new value = 3

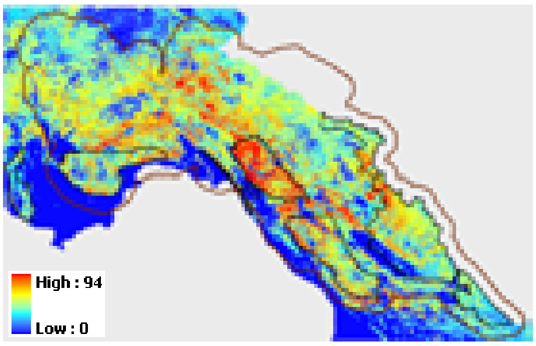


Figure 21: *Serow Combined Threat Landscape*

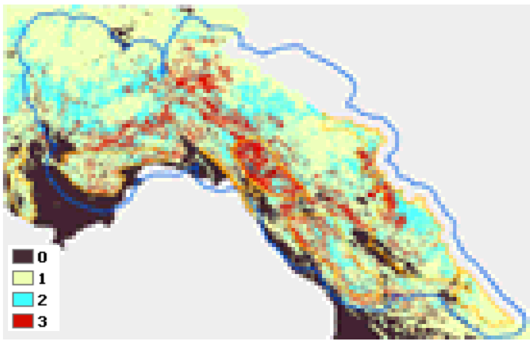


Figure 22: *Serow Reclassified Threat Landscape*

The new biological layer and threat layer were then combine using the same formula (***39***) (for conservation landscape) and each value was assign label as:

- 33 - High Bio High Threat
- 32 - High Bio Med Threat
- 31 - High Bio Low Threat

- 23 - Med Bio High Threat
- 22 - Med Bio Med Threat
- 21 - Med Bio Low Threat
- 11 - Low Bio Low Threat
- 0 - No Habitat

3.5.5. Tiger

Tiger is one of the species that we also created the conservation landscape using the quantitative method.

Conservation Landscape Using Qualitative Method

- **Reclassify Biological Landscape**

  Thresholds defined for recoding biological landscape (Figure 23) are as below:
  - 0 as no habitat – new value = 0
  - 1 -30 as low habitat – new value = 10
  - 30-70 as medium, incl. agric – new value = 20
  - >70 as good habitat – new value = 30

  The recoded layer is shown in Figure 24.

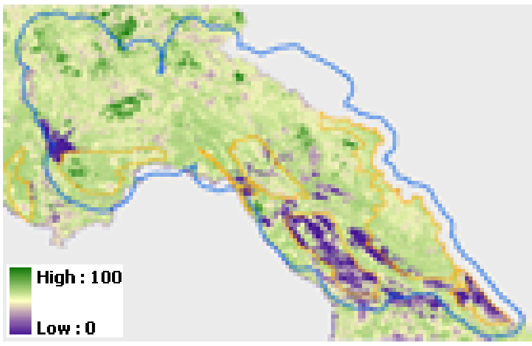


Figure 23: *Serow Potential Landscape*

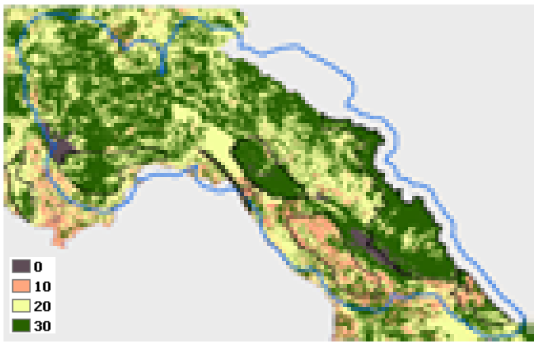


Figure 24: *Reclassified Serow Potential Landscape*

- **Reclassify Threat Landscape**

  We identified 3 threats for tiger which are:
  1. Hunting - potentially causes 90 % reduction of tiger population.
  2. Livestock predation - potentially causes 70 % reduction of tiger population.
  3. Prey depletion (the same as hunting layer which is referred to hunting of tiger preys) - potentially causes 90 % reduction of tiger population.

  Equation ***48*** was applied to combine these three threats to tiger.

  (48)

  Combined Threat Impact = *100 - (((100 - [Livestock] * 0.7) * (100 - [Hunting] * 0.9) * (100 - [Hunting] * 0.9)) / 10000)*

  The same principle was applied to produce potential impact layer (Figure 25) and then reclassified the layer as (see Figure 26, output layer):

- 0 as no habitat, no lost – new value = 0
- 1-50 as low lost – new value = 1
- 50-60 as medium lost – new value = 2
- > 60 as high lost – new value = 3

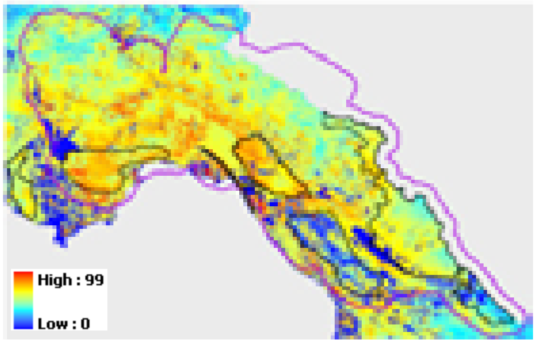


Figure 25: *Tiger Combined Threat Landscape*

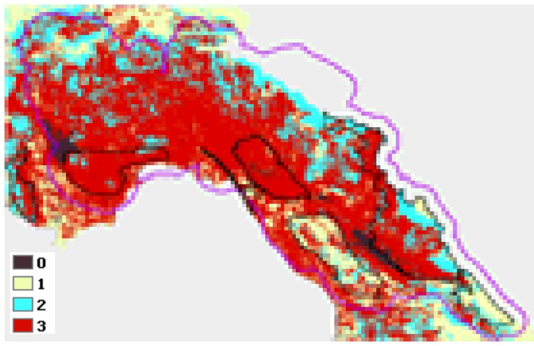


Figure 26: *Tiger Reclassified Threat Landscape*

Again, both potential biological and impact landscape were combined (see formula ***39***) and assigned label to values of grid cells in the layer:

- 33 - High Bio High Threat
- 32 - High Bio Med Threat
- 31 - High Bio Low Threat
- 23 - Med Bio High Threat
- 22 - Med Bio Med Threat
- 21 - Med Bio Low Threat
- 11 - Low Bio Low Threat
- 0 - No Habitat

Conservation Landscape Using Quantitative Method

1. **Setting Population Target Levels for each species**.
   Optimal density of tigers in the best of conditions would be 3 individuals / 100 sq. km. (CITE; Historical Level)

2. **Translating Potential Biological Landscapes into abundance**
   Highest potential abundance (HPA) should be calculated by using formula ***49***:

   (49)
   HAP = # animals/ sq km * Analysis cell size

   Our analysis grid cell size is 0.01 sq km (100 meters * 100 meters = 10, 000 sq meters). 1sqkm can contain 0.03 tigers

   $$\textbf{HPA} = 0.03 \text{ animals/km}^2 * 0.01 \text{ km}^2\text{/cell} = 0.0003 \text{ tigers}$$

   From here we could then calculate total potential abundance by applying equation ***50*** which gave us the result of 1140 tigers.

(50)
Total Potential Abundance (TPA) = HPA * biological landscape / 100

3. **Combining Threat Landscapes**
   There are 2 types of threats including threats that affect habitat quality and species abundance (inside and outside threat). We treated the prey depletion as the threat that does not affect tiger mortality directly, rather indirectly by reducing the habitat quality. On the other hand hunting and livestock depredation affect tiger's mortality directly. As a result we first used prey depletion threat directly in evaluating reduced habitat quality (translated to tiger abundances) and then we applied threats of hunting and livestock depredation. We kept hunting and livestock depredation as independent from each other and then we summed them.

   - **Create reduced potential biological landscapes**
     First step we reduced the habitat quality (tiger abundance) due to the prey depletion. We then applied the quality reduction to **prey density** layer. It is one of our two inputs to the tiger biological model. As we assumed, hunting has 90% reduction of tiger population. Equation 51, 52 and 53 were applied respectively in order to complete this step.

(51)
Percentage of reduced prey densities due to hunting =*(([Past/Current Hunting] * 0.9) * [Prey Density]) / 100*

(52)
Reduced quality of prey densities layer = *[Prey Density] - [Reduced Prey Density]*

Reduced Potential Biological Landscape:

(53)

([Tiger Preferred Habitat] + (3 * [Reduced Quality of Prey Density])) / 4

Now we can convert the reduced biological landscape to abundance (using equation ***54***) **-** this is the landscape we used to deduct further tiger losses due to hunting for tigers and livestock depredation.

(54)
Red. Potential Abundance (RPA) = [**Reduced Pot. Bio.**] * 0.0003 / 100
= 688 or 689 Tigers

Now we can estimate the tiger reduction due to prey density (see equation ***55***) that will be added to other impacts

(55)
Impact due to Prey Depletion = [TPA] - [RPA]

= 445 or 446 Tigers

- **Percent reduction of tiger population due to hunting for tigers and livestock depredation (Combined Threat,** equation ***56*****).**
    - Hunting - 90 % reduction of tiger pop
    - Livestock predation - 70 % reduction of tiger pop

(56)

Percentage of Reduction = *100 - (((100 - [Livestock Predation] * 0.7) * (100 - [Hunting] * 0.9)) / 100)*

4. **Mapping of Potential Conservation Impact.** This is what we have done where we calculated the percentage of animals lost (percentage of reduction). We will just translate it into numbers by multiplying it with the reduced potential abundance (see equation ***57***), as we already accounted for the reduced prey densities. This is not a conservation impact layer yet because we need to sum all the number of animal lost due to both inside and outside threat.

(57)

Threat Impact = *RPA * Percentage of Reduction / 100*

= 412 tigers

Now we have to calculate the total animals lost including loss due to prey depletion (see equation ***58***)**. THIS IS A CONSERVATION IMPACT LAYER**

Total Loss (Conservation Impact):

(58)

[Threat Impact] + [Impact due to Prey Depletion]

= 858 Tigers

Future biological landscape or future potential abundance was then created (see equation ***62***) to estimate how many tigers that our future habitat can support if the current trend of threats continues. This process involves calculating total future potential threat impact. Before calculating total potential threat or conservation impact on tiger population ***(61)***, we have to calculate the Current Biological Landscape ***(59)*** and percentage of future reduction based on identified threats ***(60)***.

(59)

Current Biological Landscape (Current Abundance) = *TPA – Total Loss*

= 276 tigers *(There are 6 tigers within NK NPA)*

(%) of Future Reduction caused by future livestock predation, hunting impact and prey depletion

- Hunting (future hunting layer)- 90 % reduction of tiger pop
- Prey depletion (future hunting layer) - 90 % reduction of tiger pop
- Livestock predation - 70 % reduction of tiger pop

(60)

100 - (((100 - [Livestock Predation] * 0.7) * (100 - [Future Hunting] * 0.9) * (100 - [Future Hunting] * 0.9)) / 10000)

Now we can calculate the total future conservation impact on tiger population using current abundance layer.

Total Future Potential Conservation Impact (Future Loss):

(61)

([Current Abundance] * [% Future Reduction]) / 100

= 208 Tigers

(62)

Future Biological Landscape = [Current Abundance] – [Total Future Loss]

= 69 Tigers

5. **Conservation Landscapes.**
   The conservation landscape is an annotation of our conservation impact layer. The decisions on where to work is based on how many animals we need to bring back (our population targets)

3.5.6. Wild Pig

- **Reclassify Biological Landscape**
  Biological or potential landscape of wild pigs (Figure 27) is reclassified following the below thresholds which resulted a new layer as shown in Figure 28:
  - 0 as no habitat – new value = 0
  - 1-33 as low habitat – new value = 10
  - 33-75 as medium, incl. agric – new value = 20
  - >75 as good habitat – new value = 30

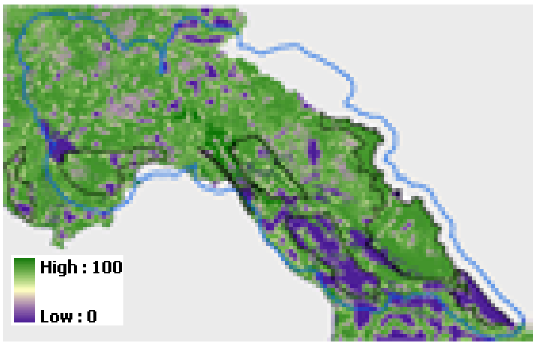


Figure 27: *Wild Pig Potential Landscape*

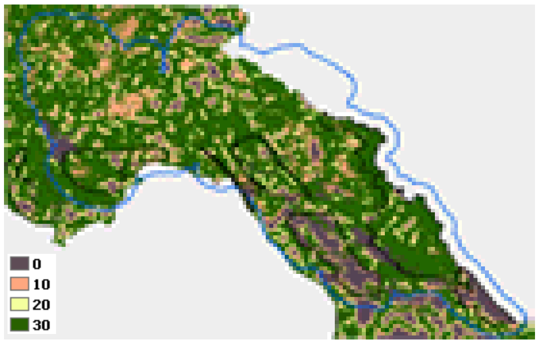


Figure 28: *Reclassified Wild Pig Potential Landscape*

- **Reclassify Threat Landscape**
  Like elephants, main threats to wild pigs are hunting and agriculture conflict where percent reduction is 70 and 50, respectively.

  (63)
  Combined Threat Impact = *100 - (((100 - [Hunting] * 0.5) * (100 - [Agric. Conflict] * 0.7)) / 100)*

  The potential impact of threat (see Figure 29) then calculated and reclassified as followings (see recoded result layer in Figure 30):
    - 0 as no habitat, no lost – new value = 0
    - 1-30 as low lost – new value = 1
    - 30 - 45 as medium lost – new value = 2
    - > 45 as high lost – new value = 3

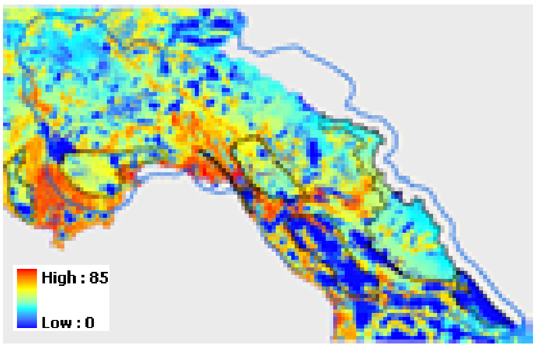


Figure 29: *Wild Pig Combined Threat Landscape*

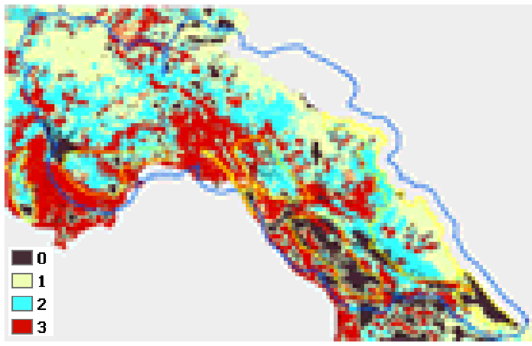


Figure 30: *Wild Pig Reclassified Threat Landscape*

The same as other conservation landscapes, we combined (using formula ***39***) the potential biological landscape and the potential impact of threat landscape.

Labels of grid values:

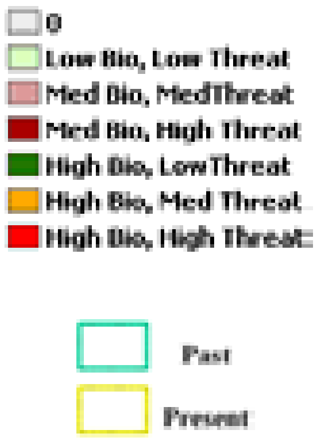
- 33 - High Bio High Threat
- 32 - High Bio Med Threat
- 31 - High Bio Low Threat
- 23 - Med Bio High Threat
- 22 - Med Bio Med Threat
- 21 - Med Bio Low Threat
- 11 - Low Bio Low Threat
- 0 - No Habitat

4. Results

A number of maps were created as a result of the analysis including species potential biological landscape, human landscape and conservation landscape maps, which can be found Appendices.

4.1. Qualitative Method of Conservation Landscape

The final conservation landscape is the result of biological and threat landscapes overlaid. The result of conservation landscape for each species is represented as the areas of habitat quality scale and threat impact scale as high, medium and low.



This is the legend for conservation landscape where the grey color indicates areas of unsuitable habitat type and no impact of threats to the species. All the legend description, low; med; and high bio, refer to low; medium; and high habitat quality. Each color represents level of habitat quality and threat severity.

The symbol labeled as "Past" or "Present" represent the areas reported (by the district governors and local experts) of some species sightings in the past or stilling encounter them in the present time.

Elephant

According to the result of elephant conservation landscape (Map 8), the landscape determined mainly by areas of high habitat quality with high threat and low habitat suitability level with low threat impact. Based on the information obtained from the district governors and local experts, the elephants still exist in the black boundary areas. This reflects the situation where severity of threats from hunting and human-elephant conflict has pushed this species to utilize the low habitat suitability areas. One thing can be observed from this landscape is that the threat to elephants is low in most protected areas and habitat quality in most parks is not very good for this species. Therefore, this indicates that working toward conserving this species should also take into account areas beyond the national parks.

White-cheeked Crested Gibbon

Map 9 shows that gibbon population is under high impact of hunting, especially inside Nam Kading protected area where gibbons are still present. Those areas that represent good habitat of the gibbons with medium level threat are mostly along the Annamite mountain range near to the Vietnam border. Based on the information given, gibbons are still seen in the area around Nam Kading NPA which corresponds with this landscape model. Areas identified by local knowledge as past gibbon areas are noted as absent of gibbons. These areas correspond to areas where selective logging has taken place and possible disturbance and local extirpation of the gibbons has occurred.

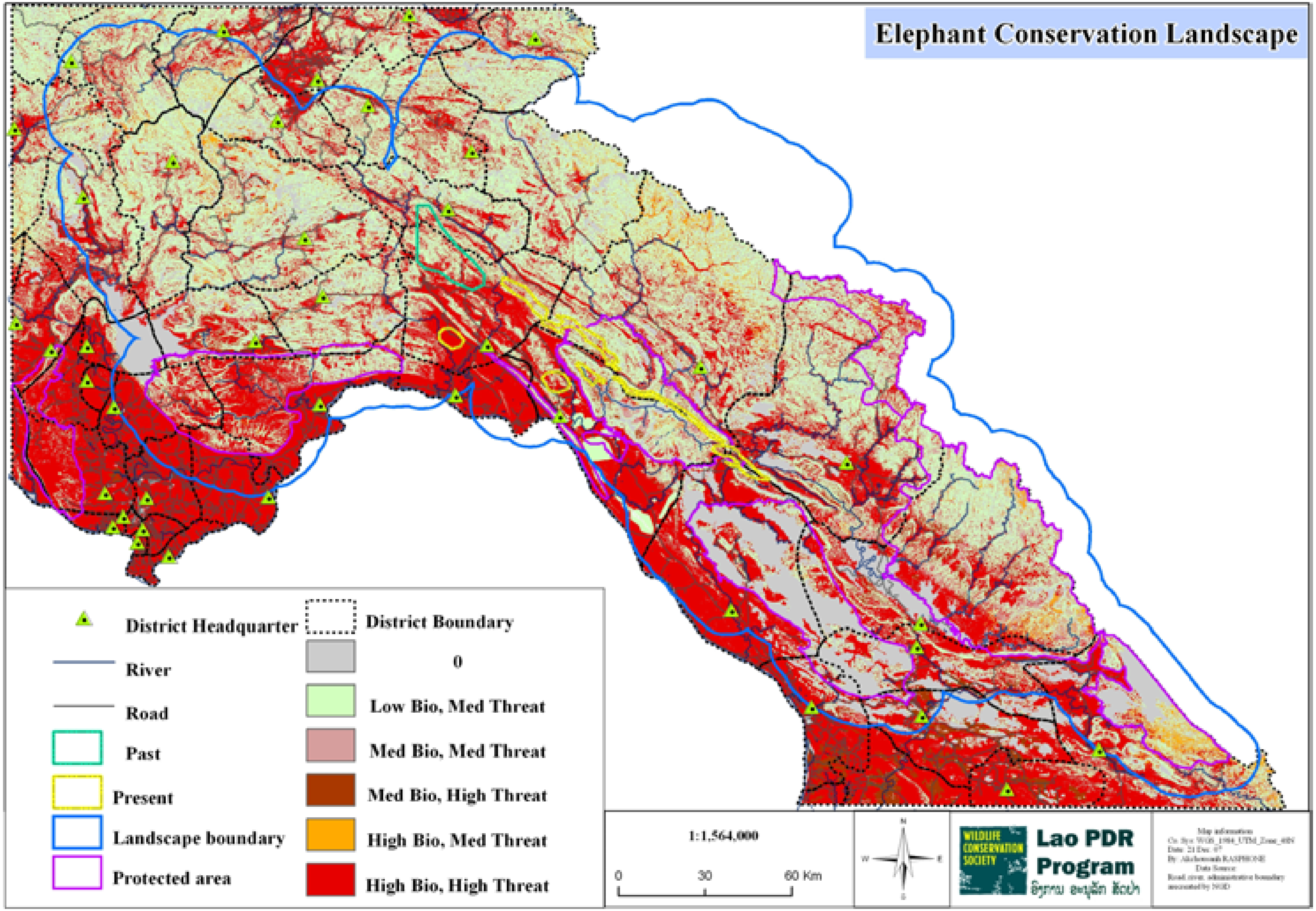
Great Hornbill
The conservation landscape of this species (see Map 10) is similar to the gibbon's in that threat is high throughout the landscape. Unlike gibbon, fragmentation is not a limiting factor for the hornbill as it can reach new habitat easily; therefore people still see this species, flying past areas of non optimal habitat or areas of high threat. Threat impact in most areas of the landscape including most of the protected areas, is high, however the areas are still highly suitable for the hornbills. Minimizing threat in the protected areas can create reasonably large and safe habitat for this species.

Serow
High impact of hunting mainly concentrates in the centre (especially Nam Kading NPA) of the landscape where habitat is most suitable for serows (see Map 11) . There are more areas with low impact of threat compared to mother conservation landscapes most likely due to the inaccessible habitat preference of this species (it prefers steep Karst or rugged areas). There is one interesting thing to be noted for this map, the areas along the Lao-Vietnamese border turn out to be a high bio –low threat area but, none of the local experts reported the existence of this species.
One of the reasons why our model shows those areas along Lao-Vietnamese border as high bio-low threat is likely because the information on the Vietnam's side was not incorporated into producing this landscape. The impact of threat is presumed to be high on the Vietnam side given the higher population density.

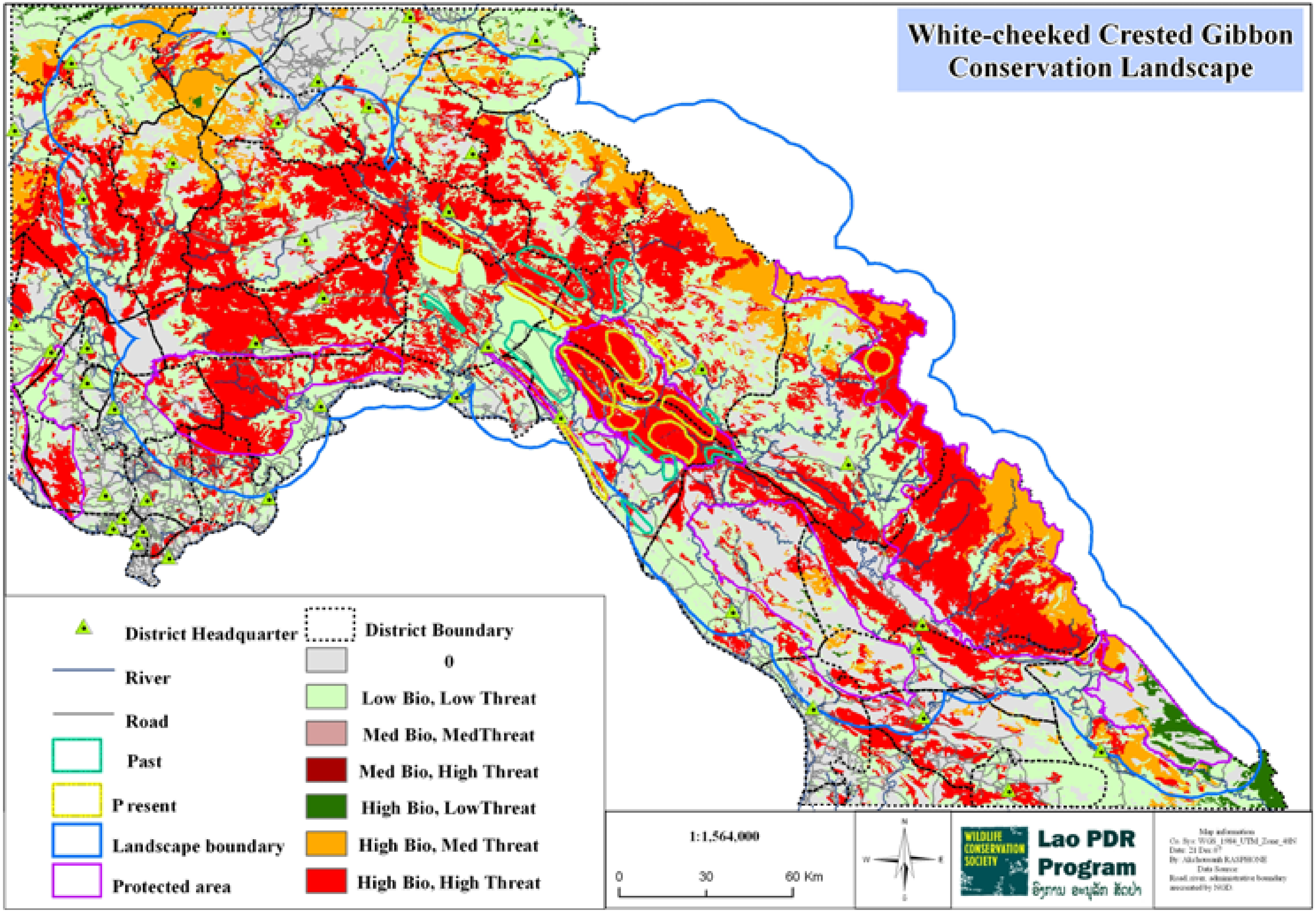
Tiger
According to Map 12, it can be observed that there are a lot of very good tiger habitats but at the same time, tigers are under high threat from both hunting and tiger-large livestock conflict. Deciding about where we should start working on conserving tiger habitat will not be that easy, as the threat impact seems to spread out over the landscape. The area within the yellow circle where threat impact on tiger is in the medium level with the medium and high habitat quality can be considered for a corridor between protected areas. Logically protection should begin in areas where legal mandate exists to protect the species (ie: the NKNPA and surrounding PA's) A corridor shoud be considered also to facilitate dispersal of individuals.

Wild Pig
The very server threat to wild pigs occurs mainly around the agricultural, according to the analysis result (see Map 13), as they get into conflict with people. Some of those areas are where there have been some reports about wild pig's presence (black polygons). Moreover, this species seem to be heavily hunted around villages and those areas that are easy to get to.

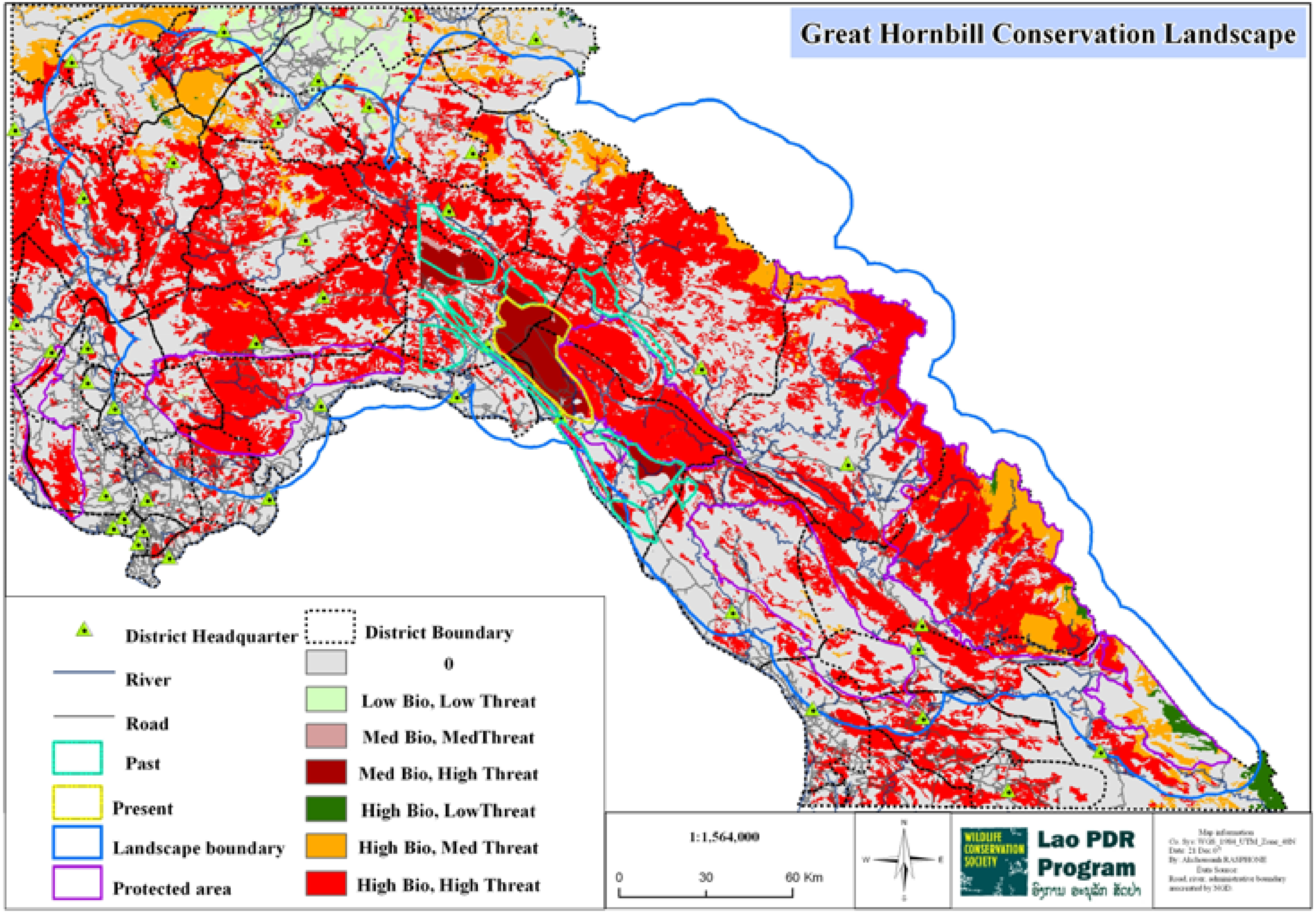
Most protected areas within this landscape contain very high quality habitat for wild pigs. Though wild pig can reproduce quickly, this extend of threat can cause a serious loss of their population as well as decrease food source for tigers and for local people. Protection should be afforded the wild pig population in protected areas while hunting regulations in accordance with Lao law encouraged for surrounding villages.



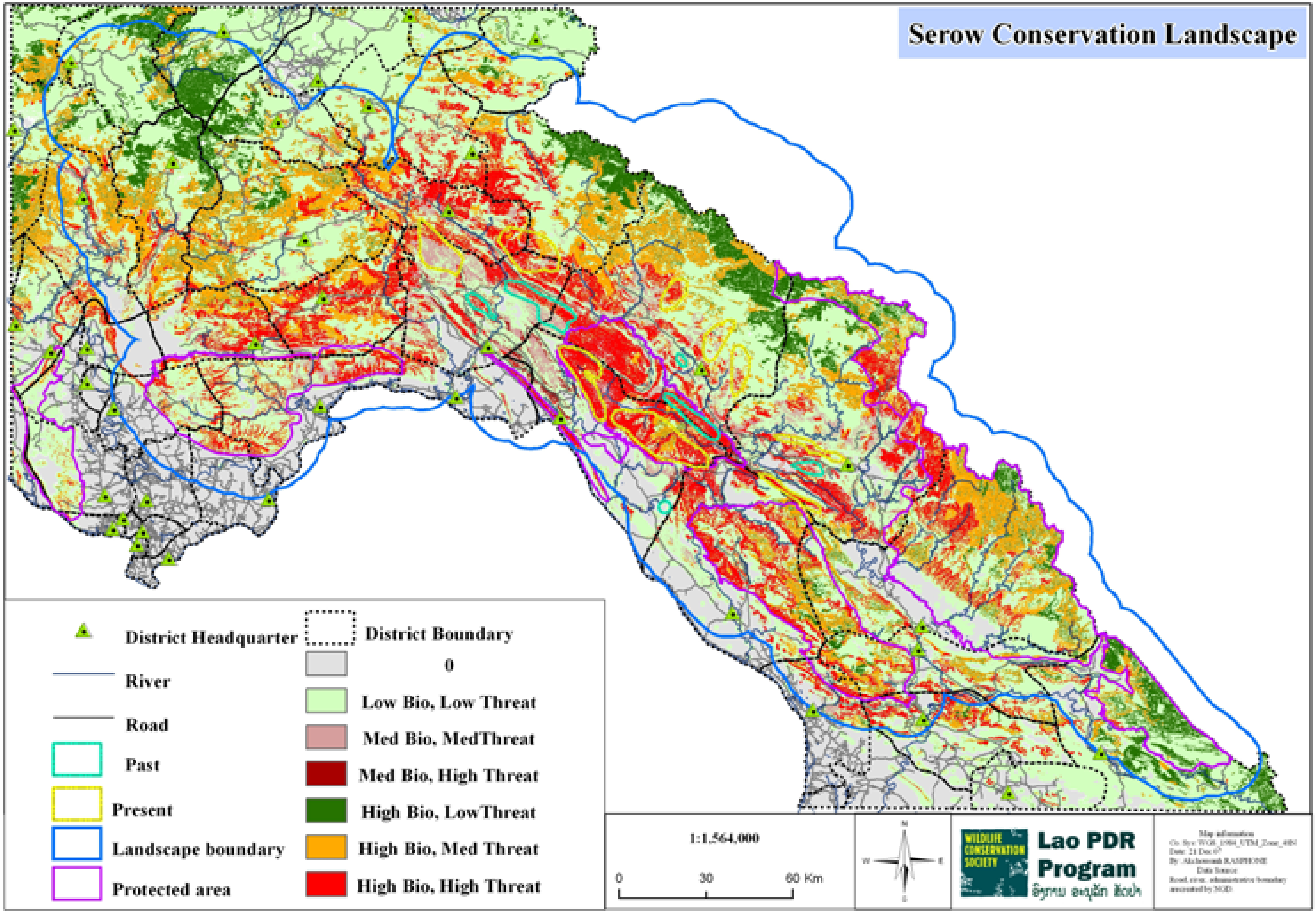
Map 8. Conservation landscape of elephants (Qualitative Representation)



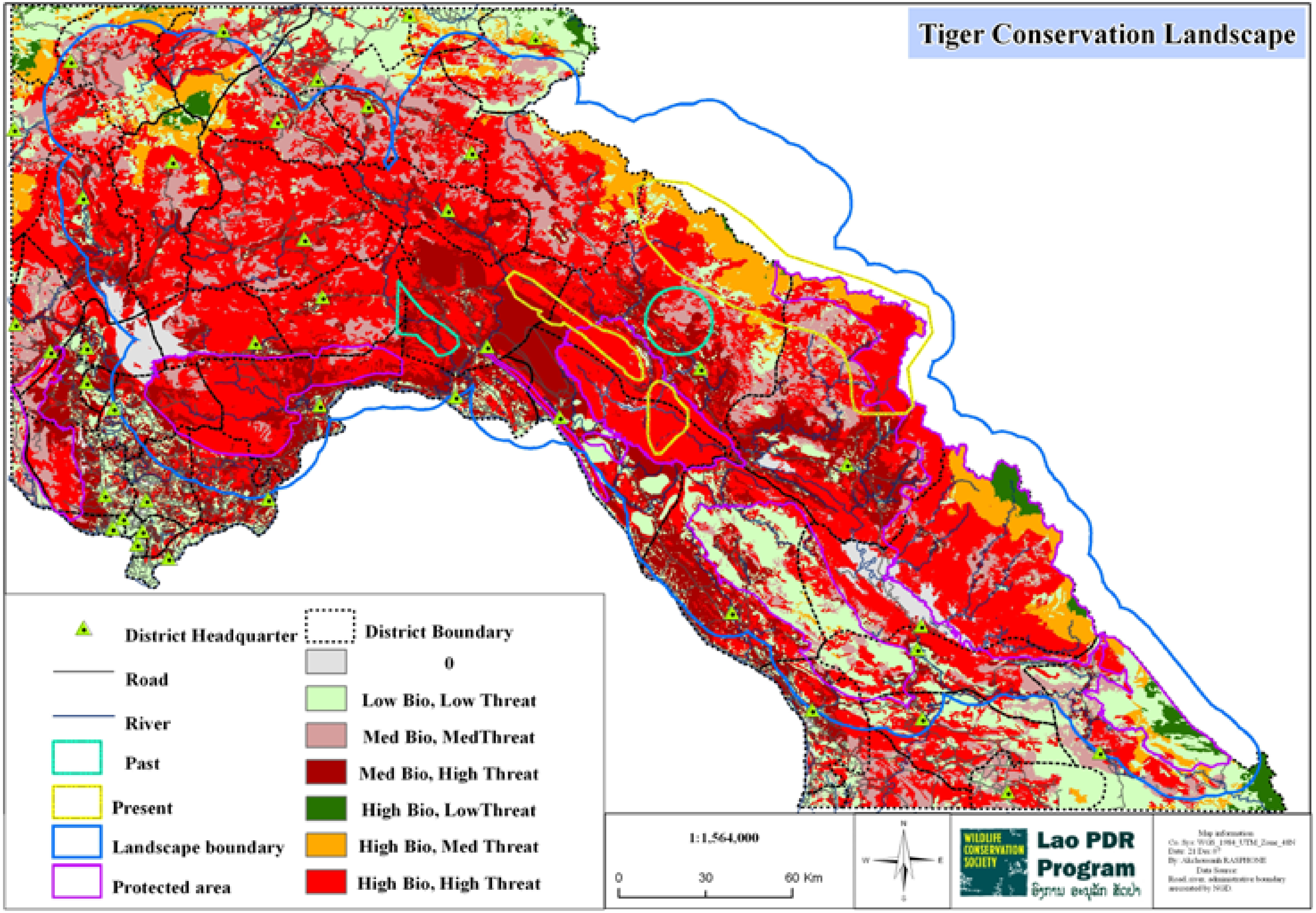
Map 9. Conservation landscape of white-cheeked crested gibbons (Qualitative Representation)



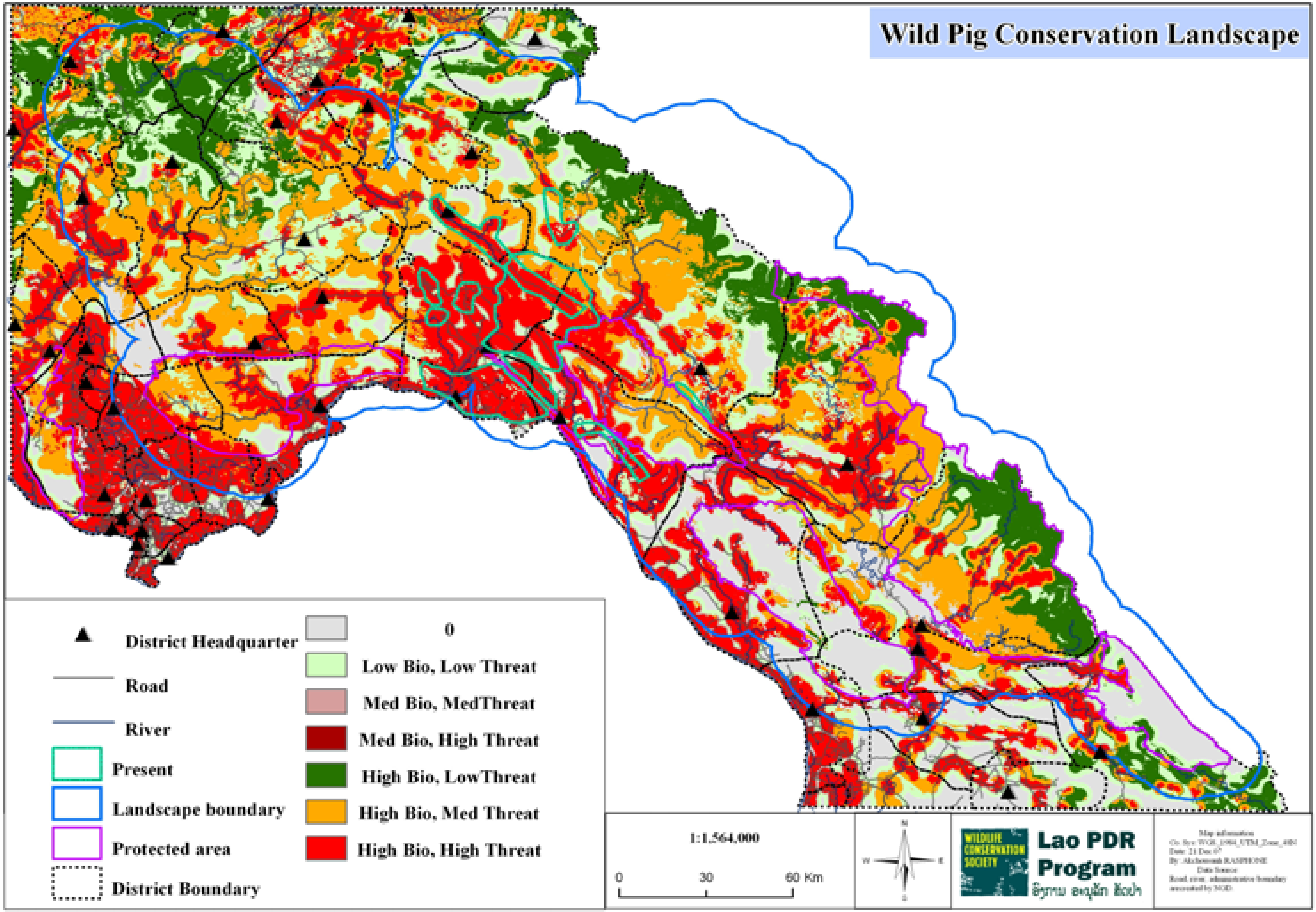
Map 10. Conservation landscape of great hornbills (Qualitative Representation)



Map 11. Conservation landscape of serows (Qualitative Representation)



Map 12. Conservation landscape of tigers (Qualitative Representation)



Map 13. Conservation landscape of wild pigs (Qualitative Representation)

4.2. Quantitative Method of Conservation Landscape

These sections will discuss about the result of the conservation landscapes for white-cheeked crested gibbons and tigers. As mentioned earlier that this method provides ability to translate the information on the landscape into number of species abundance or loss, color scale bar on each map represents number of animals at each spot. For all the maps showing state of animal abundance, the greener the area the higher the number of animals. As for the maps showing stage of loss in population abundance, the redder the area is, the higher the number of animal loss.
An important thing to keep in mind when viewing the result of this analysis method is that animal abundance number does not represent the real estimate of species population but, it indicates how many species that this landscape can accommodate.

4.2.1. Gibbon

Diagram in Figure 31 shows that the landscape (Map 14) from the time that the datasets were collected without accounting threats which can accommodate about 320,722 gibbons. Once hunting threat to gibbon was incorporated into the analysis, the results indicates that the threat impact eliminate gibbon habitat that can accommodate about 183,982 individuals. Hence, our current landscape (Map 15) is left with habitat for 136,472 gibbons (5,416 gibbons in Nam Kading NPA).

In the worse case scenario, if hunting and logging is continued with the same impact we will lose habitat for 78,114 gibbons. Our future landscape (Map 16) will remains with habitat for only 57, 129 gibbons. There is no certain time length for this to happen. This consequence can be seen in a few days or weeks when the threat to this species gets to this full estimated extend.

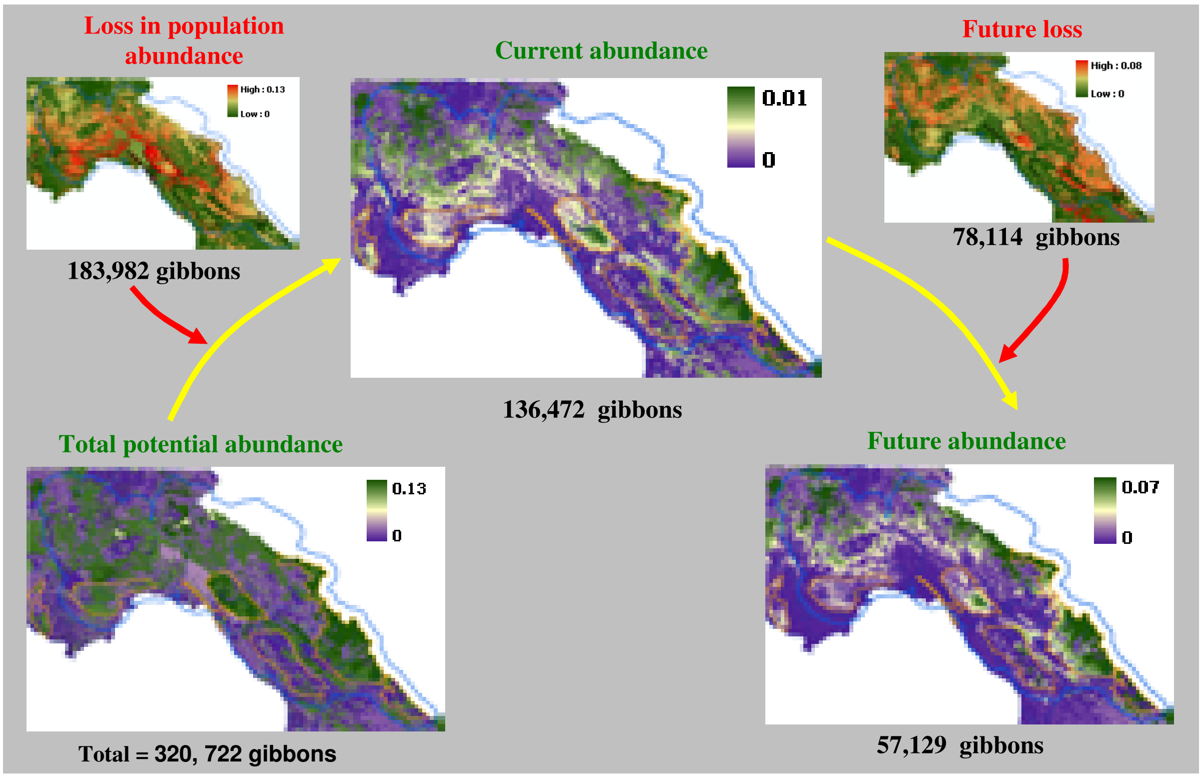


Figure 31: *Gibbon Conservation Landscape (as number of species abundance)*

4.2.2. Tiger

Tigers are one of the big animals that require large habitat area, according to our analysis results (Figure 32), our potential landscape (see Map 17) without threat has suitable habitat for only 1,140 tigers. Impact of threats to tigers including tiger-livestock conflict and hunting causes about 76% loss of the potential tiger habitat within our landscape; which left our current landscape (see Map 18) with habitat for only 277 tigers (6 tigers in Nam Kading NPA).

There will be only 25% of our current tiger habitat left (Map 19) if the severity of threats continues in the same scale. If our management plan is effective, we can potentially save habitat for 208 tigers.

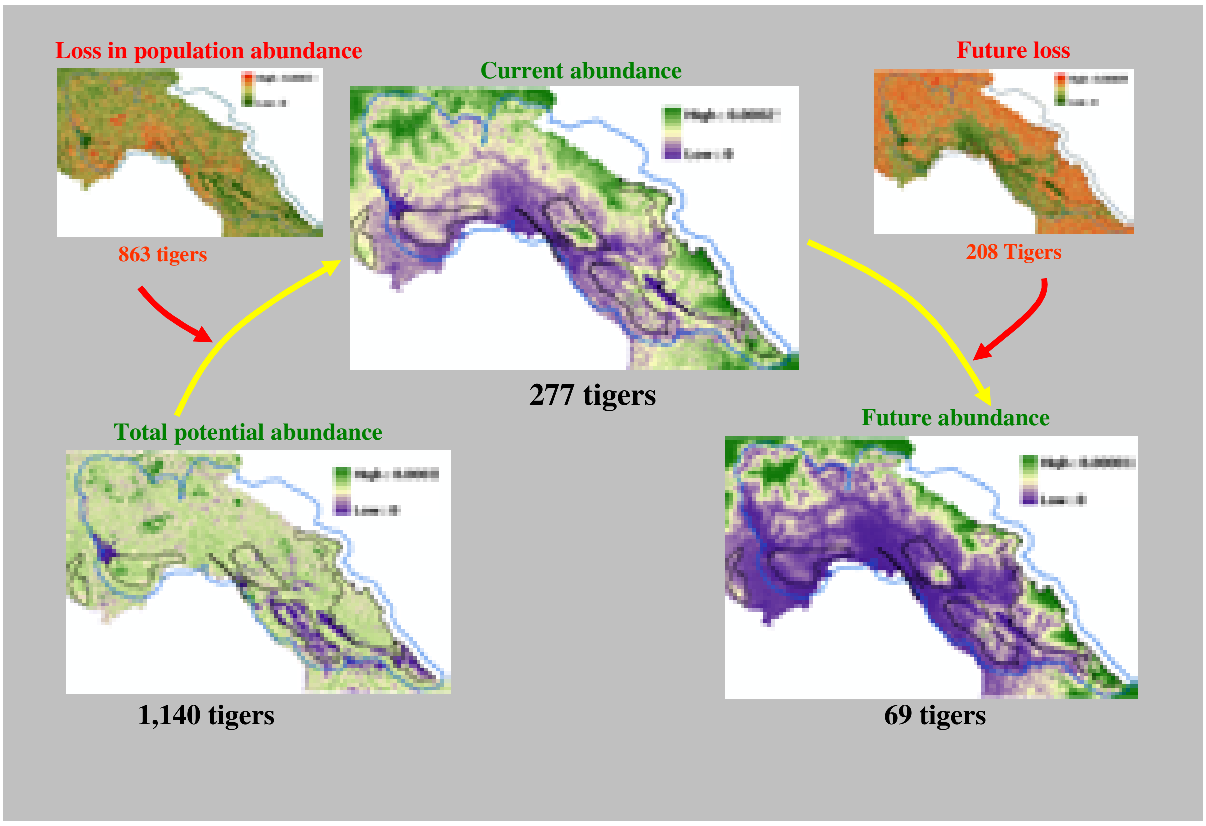
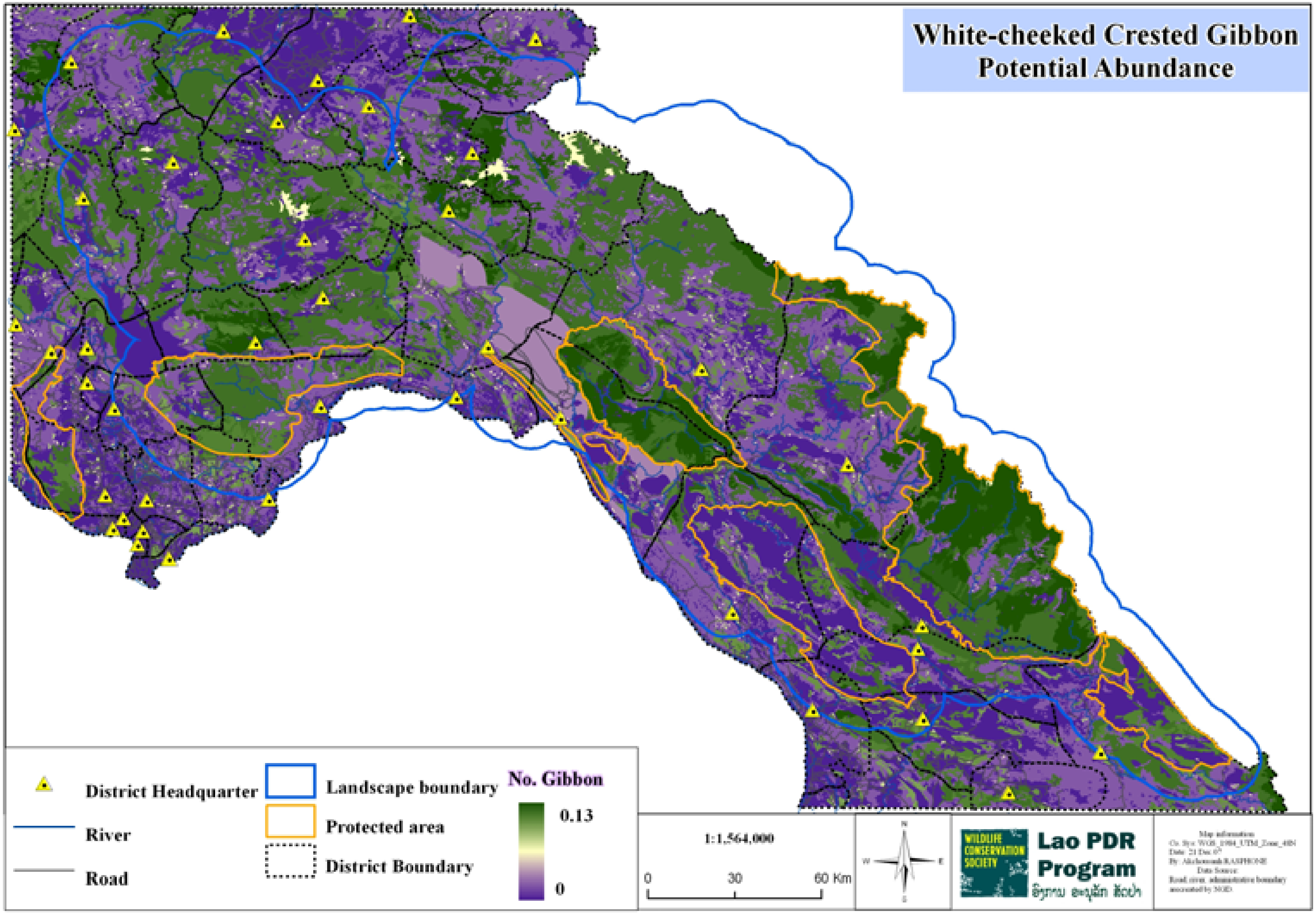
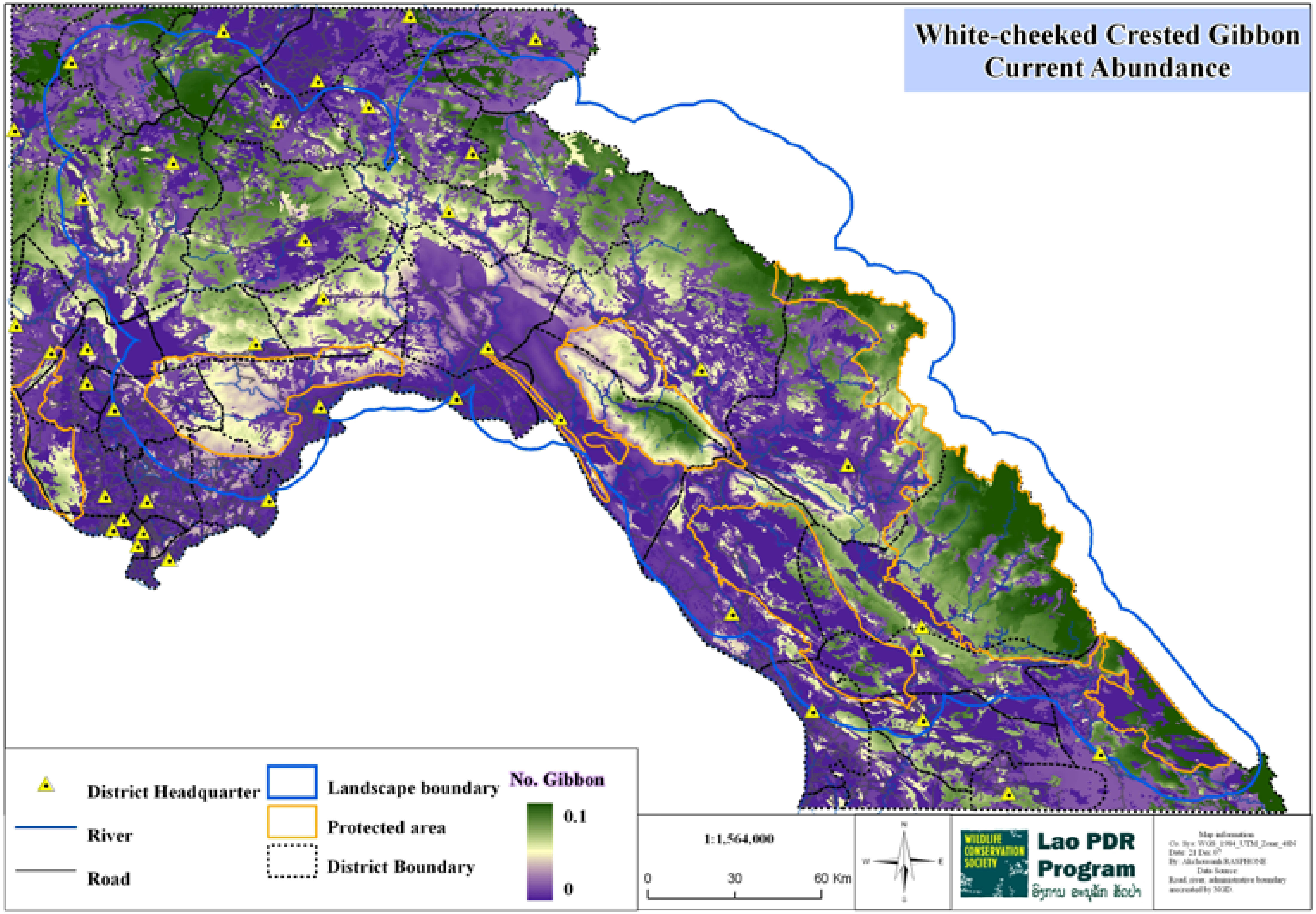


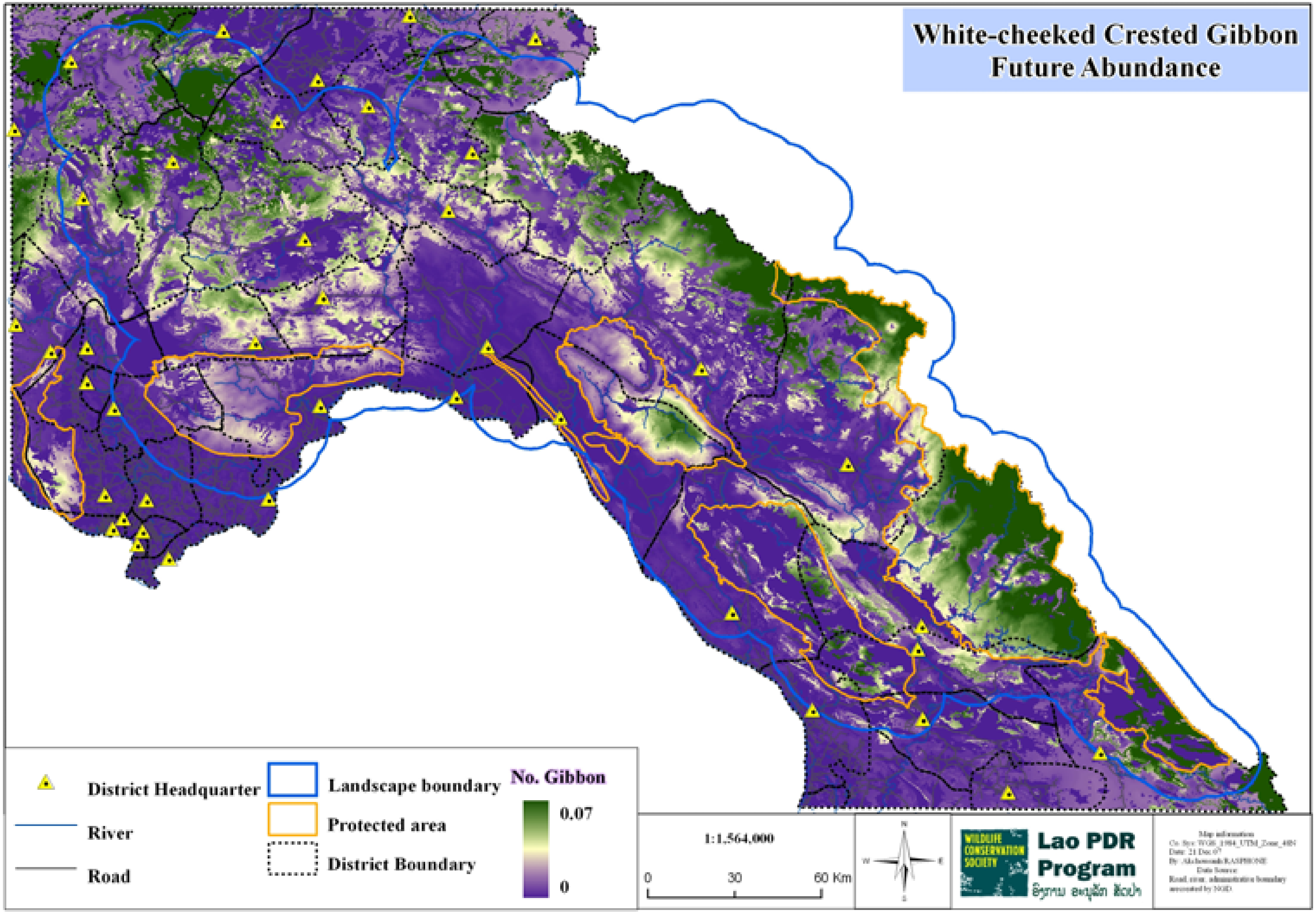
Figure 32: *Tiger Conservation Landscape (as number of species abundance)*



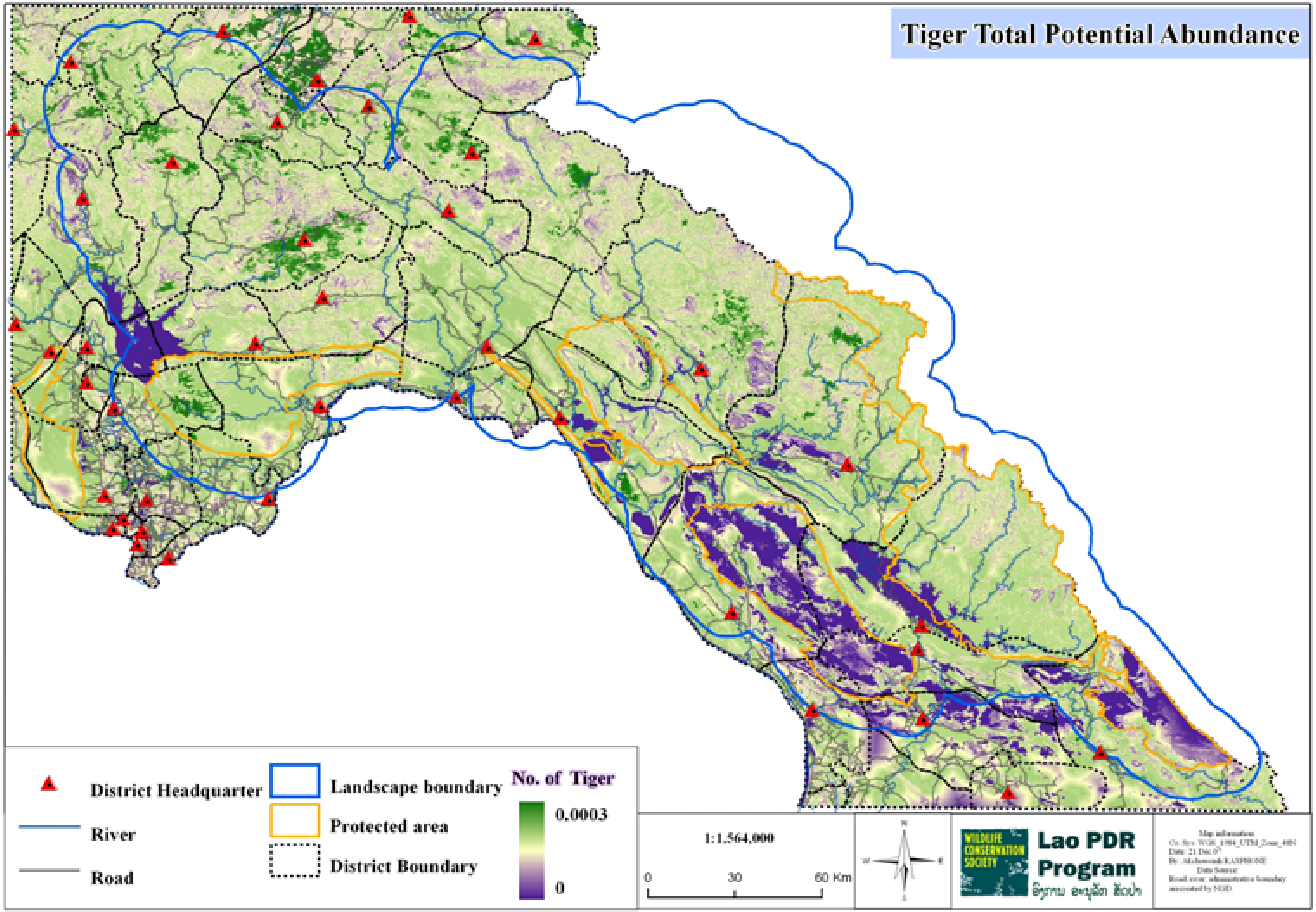
Map 14. White-cheeked crested gibbon potential abundance landscape (Quantitative Representation)



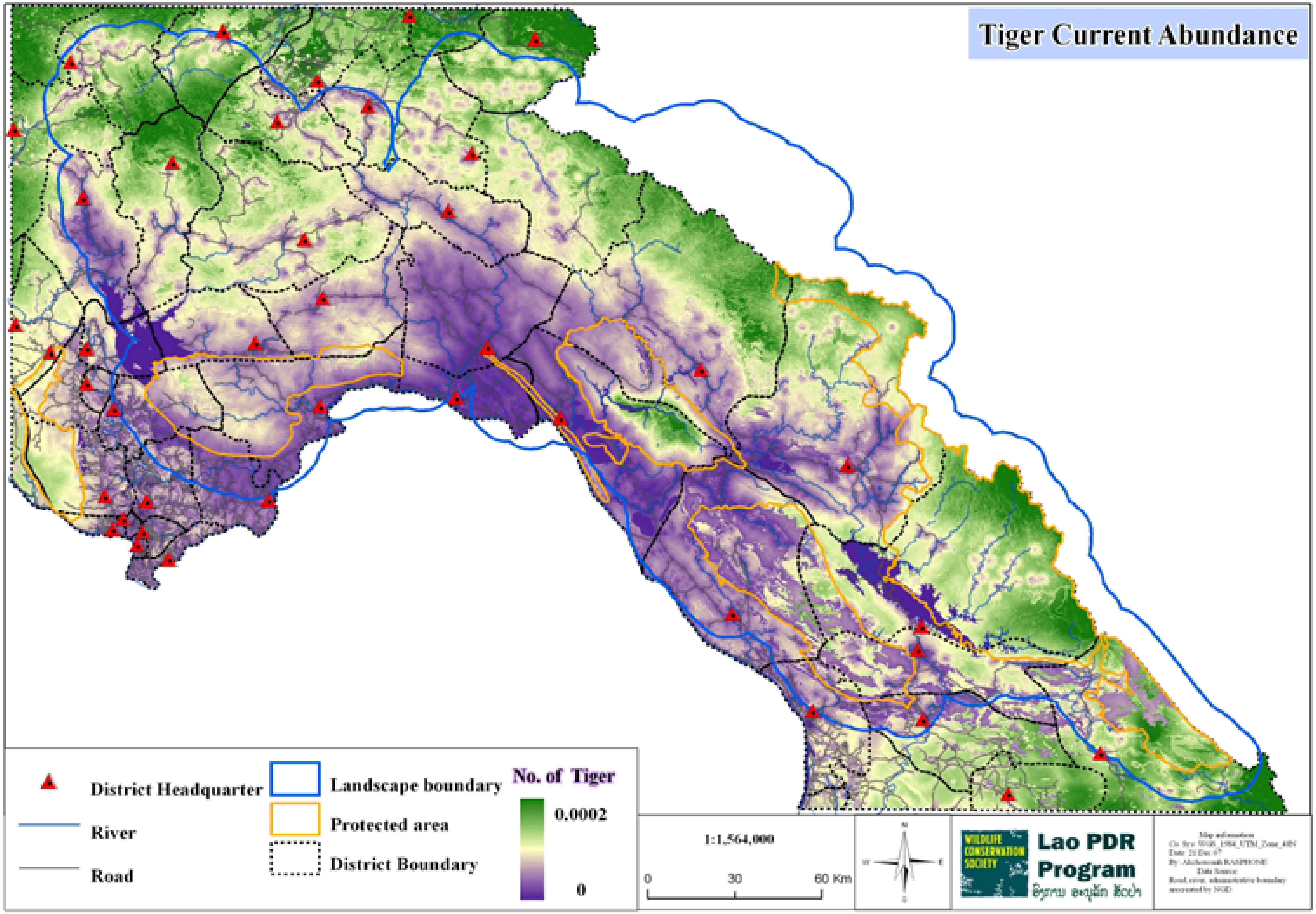
Map 15. White-cheeked crested gibbon current abundance landscape (Quantitative Representation)



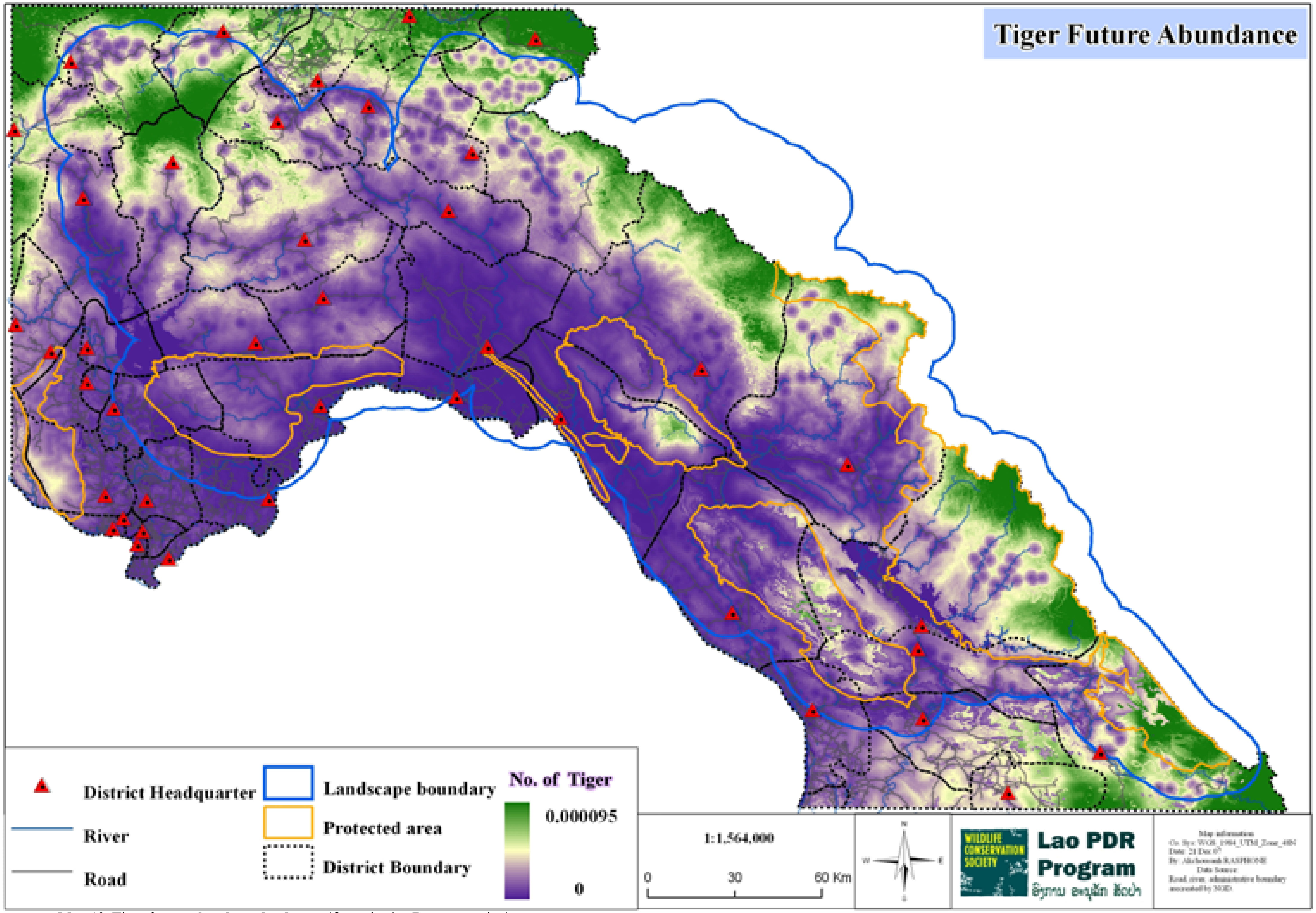
Map 16. White-cheeked crested gibbon future abundance landscape (Quantitative Representation)



Map 17. Tiger potential abundance landscape (Quantitative Representation)



Map 18. Tiger current abundance landscape (Quantitative Representation)



Map 19. Tiger future abundance landscape (Quantitative Representation)

5. Discussion and Recommendations

The process of collecting data and the workshops facilitated discussion and focused stakeholders on targeted outcomes for the landscape. The maps produced provided a valuable visual aid to target conservation actions at a landscape scale and to give a broad picture of the situation for each of the landscape species. The maps were particularly useful in conceptual modeling for the landscape species (Johnson *et al* 2007).

Working with diverse group of stakeholders, most with limited background in modeling, meant that at times communication of the modeling concept and interpretation of the results was lost on some stakeholders. Lack of understanding in a participatory process such as the LSA can result in a breakdown of trust and credibility of by stakeholders towards the lead agency, in this case WCS. This can have repercussions for implementation of the plan (Sarkar *et al.*, 2006). As a process the LSA could benefit from methods that are more accessible methods in the modeling.

In addition, building conservation landscapes for these 6 species took 18 months and input from two international GIS consultants working with WCS Lao staff. Lack of suitable data was also an issue for some of the analysis and checking and correcting errors in these data sets took up a much of the first 2-3 months. Several sources of information that would have been useful in the models could not be incorporated at the required scale (e.g. precipitation, soils, mineral licks, and presence absence data for species). Many things we wish we could have included in doing the analysis process but, many required resources were not available during the time we undertaking this task. As such, below is a list of things to be considered in creating conservation landscapes in the future:

Quantitative modeling in the landscape could be improved by the incorporation of additional field records and a more accurate idea of the present and potential carrying capacity of habitats identified.

In all the process and modeling have been highly valuable to the overall plan for conservation in the Nam Kading Landscape and the methods has gained considerable support within partner agencies for other sites in Laos as a methods of strategic planning at a landscape scale.

The process

- Investigate more accessible modeling frameworks to increase stakeholder understanding and buy in to modeling process
- Consider available layers and their condition and subsequent time involved in the process

The modeling

- Updating data sets such as road, river, population, and vegetation/land cover.
- Rerunning all the conservation landscapes using the Quantitative method for each species with the most recent data sets and incorporate data sets from the Vietnamese side into creating threat landscapes.
- Combined species conservation landscape using the Quantitative method should be produced to ease prioritization of areas in order to base the conservation plan on, for all landscape species.

- Quantitative method of analysis should be applied to all other selected species to calculate abundance of each species based on habitat quality.
- Analysis results from Quantitative method should be used with caution, as number of abundance indicates landscape's carrying capacity for each species type.
- Individual Accumulation vs. Conservation Category graphs for each species is worth creating. This is one of products from this analysis that can also be used in the process of defining where to work.

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APPENDICES

Appendix 1: AML for Population Pressure Based on Cost-surface

```
/* costweight AML creates the sum of all cost distance surfaces
/* weighted by the population size in the village and the distance to markets or other factor
/* the final cost surface has to converted to the pressure map by reversing the cost values
/* and normalizing them on the scale 0 – 100
/*
/* History
/* Gosia Bryja – May, 2006

/*-----------------------------------------------------------------------

&sv incov [response ‘Name of human feature coverage (point cov only)?’]
&sv index  [response ‘Number of features in feature coverage?’]
&sv pop_item [response ‘Name of item that contains population variable?’]
&sv pop_weight [response ‘Name of item that contains weight?’]
&sv aoi_grid [response ‘Name of the area of Interest Grid?’]
&sv cell_size [response ‘Output Grid cell size?’]
&sv costgrid  [response ‘name of cost grid?’]
&sv outputgrid  [response ‘name of output grid?’]


&echo &on

GRID
Setwindow %aoi_grid%
setcell %cell_size%

&    vi = 1
last_press = 0
Quit

&DO I = 1 &to %index%

        reselect %incov% village%i% point
        res %incov%# = %i%
        [UNQUOTE ‘’]
        n
        n

GRID
Setwindow %aoi_grid%
setcell %cell_size%

vill%i% = pointgrid (village%i%, %pop_item%, #, #, #, #)
describe vill%i%
```

```
const_%i% = %grd$zmax%
popv_%i% = pointgrid(village%i%, %pop_weight%,#,#, %cell_size%,nodata)
describe popv_%i%
conv_%i% = %grd$zmax%
/*---------calculate the distance surface around the village

Dist%i% = costdistance (vill%i%, %costgrid%, #, #, #, #)


/* ---------to calculate  Hunting influence =
HF_v%i% = (Dist%i% * const_%i% * conv_%i%)
null%i% = con (isnull (HF_v%i%), 0, HF_v%i%)
kill const_%i%
kill HF_v%i%
kill village%i%
kill Dist%i%
kill vill%i%
kill popv_%i%
kill conv_%i%

/* ---------to calculate sum cost distance for each village

&If %i% < %index% &Then &do
                cum_press = null%i% + last_press
        kill last_press
                rename cum_press last_press
                kill null%i%

        &end
        &Else &do
                cum_press = null%i% + last_press
                rename cum_press %outputgrid%
                kill null%i%
                kill last_press
        &end

        &    vi = %i% + 1
QUIT
&end
  &severity &error &fail
  &return

/*===========================================================================
==========
/* END OF FILE
```

Appendix 2: AML for Population Pressure Based on Population Size

```
/*--------------------------------------------------------------------------------------
/*  Name: poppressure.aml
/*   Date: 20 August 2003
/*  Purpose: Create a grid that calculates cumulative human pop pressure of point human features
/*          based on a feature variable.
/*
/* The program calculates the cummulative population pressure for all grid cells of a
/* landscape (e.g., poppress100) from a point coverage (e.g., settlements- must be an
/* ArcInfo coverage, not a shapefile) with a field defining population (e.g., field = epop),
/* and an input grid defining the area of interest (aoi_grid).  The program will prompt the
/* user for input coverages, grids, and field names.  As currently written, pressure from
/* each settlement is calculated with this equation:
/* (-1 *  sqrt(population) * sqrt(pi) * (distance from settlement) / 1000) + (population).
/* Here, pressure is equal to the population size at a distance of 0, and decreases linearly
/* to a pressure of zero at a distance also defined by the population size.  This distance
/* is the radius of a circle with area = population * 1 km2 and is based on each person
/* requiring 1 km2 of land area to support a diet entirely comprised of bushmeat (cite?).
/* The cummulative pressure at any grid cell, then, is the sum of the pressure from all
/* settlements on the landscape.   The program was written by Karl Didier and Gillian
/* Woolmer, WCS LLP-NY.
/*
/*---------------------------------------------------------------------------------------

&sv incov [response 'Name of population coverage (point cov only)?']
&sv count  [response 'Number of features in feature coverage?']
&sv pop_item [response 'Name of field that contains population number?']
&sv aoi_grid [response 'Name of mask Grid?']
&sv cell_size [response 'Output Grid cell size?']
&sv out_grid  [response 'Output Grid Name?']

&severity &error &ignore
&echo &on

GRID
Setwindow %aoi_grid%
setcell %cell_size%

last_press = 0
Quit

&DO I = 1 &TO %count%

        reselect %incov% settle_%i% point
        res %incov%# = %i%
```

```
        [UNQUOTE "]
        n
        n
GRID
Setwindow %aoi_grid%
setcell %cell_size%

        pop_%i% = pointgrid(settle_%i%, %pop_item%,#,#, %cell_size%,nodata)
        describe pop_%i%
        const_%i% = %grd$zmax%
        dist_%i% = int(EUCDISTANCE(pop_%i%) + 0.5)
        inter_%i% = int(((-1) * sqrt(const_%i%) * sqrt(PI) * dist_%i% / 1000) + const_%i% +
0.5)
        press_%i% = int(con(inter_%i% > 0, inter_%i%, 0))
        kill dist_%i% all
        kill inter_%i% all
        kill pop_%i% all
        kill const_%i% all
    kill settle_%i% all

        &If %i% < %count% &Then &do
                cum_press = press_%i% + last_press
                kill last_press all
                rename cum_press last_press
                kill press_%i%
        &end
        &Else &do
                cum_press = press_%i% + last_press
                rename cum_press %out_grid%
                kill press_%i%
        &end
        &sv i = %i% + 1
QUIT
&end
/*--------------------------
/*  Kill calculation grids
/*--------------------------

/*&DO i = 1 &TO %count%
/*      KILL grid_%i%
/*      Kill pointcov_%i%
/*i = i + 1
/*&END
&SEVERITY &ERROR &FAIL

&RETURN
```

Appendix 3:

Species Conservation Landscape Modeling Workflow Document for Central Lao PDR (Mainly around Nam KadingNational Protected Area, Bolikhamxay)

Species Conservation Landscape Modeling Workflow Document for Central Lao PDR (Mainly around Nam KadingNational Protected Area, Bolikhamxay)

Table of Contents

Landscape data

bnd_nk - **Final landscape (analysis mask)** – landscape grid clipped to the boundary of Laos (combination of extent of lc_NGD_NK, Dem_nk and gridded country boundary)
landscape - grid of the landscape shapefile defining the whole extent of the analysis
TCL_UTM – tiger conservation landscape derived from TCL analysis
TCL_PA_bnd – combined TCL_UTM with the file PA.shp to expand tiger landscape and include the protected areas within the region
TCL_PA_bnd_10km – buffered TCL_PA_bnd.shp with 10 km. It is based on the information provided by Arlyne. According to the study, she noticed a significant drop off in the prey abundance within 10 km from the village. Residents of the village can cover 10 km within 6 hours (possible daily trips) and often they keep livestock within this distance. Therefore 10 km gives a good indication of the extent of potential influence of human activities from the village.

refined_bnd.shp - refined landscape boundaries, where a special effort has been put on …

Vegetation data

MRC vegetation

1. veg_MRC_NK.shp clipped Forest_Landcover_LaoPDR_UTM48 with landscape.shp
2. vegmrc - veg_MRC_NK.shp converted to grid on column F93
3. **lc_MRC_NK** - vegmrc clipped to bnd_nk and all null values within the boundary converted to value 0 – no data

con (isnull ([vegmrc]), 0, [vegmrc])

NGD vegetation

1. landcover_NGD – original landcover data….
2. veg_NDG_NK - landcover_NGD clipped with landscape.shp and reclassified with new land cover classes and new codes (.xls). Reclassification procedure can be found in ***reclass_veg_NGD***.xls file
3. vegngd - veg_NGD_NK gridded on RECL_ID field (recl_descry – provides info about reclassified vegetation types)
4. vegngdDem - vegngd refined with DEM (dem_50m) where

10 Dry Evergreen	elevation	
11	<=800	Lower Dry Evergreen
12	>800	Upper Dry Evergreen
20 Mixed Deciduous		
21	<=800	Lower mixed deciduous
22	>800	Upper mixed deciduous

con ([vegngd - vegngd] eq 10 and [dem_50m] le 800, 11, [vegngd - vegngd] eq 10 and [dem_50m] gt 800, 12, [vegngd - vegngd] eq 20 and [dem_50m] le 800, 21, [vegngd - vegngd] eq 20 and [dem_50m] gt 800, 22, [vegngd - vegngd])

In this grid class 10 (Dry Evergreen) was substituted with class 11(Lower Dry Evergreen) and 12 (Upper Dry Evergreen), anc class 20 (Mixed Deciduous) with classes 21 (Lower Mixed Deciduous) and 22 (Upper Mixed Deciduous),

5. **lc_NGD_NK –** vegetation layer where a small polygon along the boundary that had no value was assigned a value of 17 based on adjacent vegetation.
6. **lc_NGDagr_NK – updated vegetation layer where cells with original value = 2** for class agriculture are given either a new value = 2 (agriculture, current) or value = 100 (agriculture, abandoned), after having refined the agriculture class based on data population 2005 vs. 2000
7. **lc_agr_pln_nk –** vegetation layer that includes plantation forest. This layer is created by combining by following the steps below:
   - Convert all features in allplantations.shp to one single feature
   - Convert allplantations.shp to grid (plantation)
   - Plantation_0 - Convert No Data in plantation grid to any value and give the plantation area a value of 0.
   - In map calculator option, enter :
([Plantation_0] = 0.AsGrid).con (200.AsGrid, [Lc_ngdagr_nk])
   - We'll get final vegetation cover where all the cells that have value of 200 are known as plantation forest area/cell.
8. **lc_agr_pln_ed** - **Vegetation cover** for the whole original landscape updated by including edited agriculture, plantation, selective logging coverages.
   agric_ed0 - con (isnull ([agric_ed]), 0, [agric_ed])
   plant_ed0 - con (isnull ([plant_ed]), 0, [plant_ed])
   selog_ed0 - con (isnull ([selog_ed]), 0, [selog_ed])
   1. con ([agric_ed0] eq 1, 2, [lc_agr_pln_nk]) = Calculation
   2. con ([plant_ed0] == 200, 200, [Calculation]) = Calculation2
   3. con ([selog_ed0] == 500, 3, [Calculation2]) = **lc_agr_pln_ed**
9. **lc_agr_pln_rs** - **Final vegetation cover** for the whole original landscape updated by including the reservoir areas of NT1 and NT2
   NT_reservs – convert NT_reservoir.shp to grid. NT_reservoir.shp was created from merging NT1_reservoir.shp and NT2_Reservoir.shp.
   NT_reservs0 - con (isnull ([NT_reservs]), 0, [NT_reservs])

   → **con ([lc_agr_pln_ed] >= 0 & [nt_reservs0] == 1, 18,[lc_agr_pln_ed])**
10.

Rocks/karst layer

Karst layer was created by combining a digitized from Aster image polygons with rock data taken from landcover_NGD.shp file

1 karst_Aster_Digit.shp – digitized polygons of rock from Aster imag
ery 2003

4. karst_aster_digit.shp combined with bare rock data derived from cover_NGD to get karst_UTM
5. karst_Utm_NK – clipped karst_UTM with the landscape polygon
6. **karst** – gridded karst_Utm_NK shapefile and then
7. **karst_nk** - all null values converted to 0 within the bnd_nk mask
   con (isnull ([karst]), 0, [karst])

Rivers data

There are still some problems with small rivers that are part of the major river network. They have to be checked and attributed have to be adjusted. There might be some additional editing needed to reconnect some small rivers.

Major_lakes – polygons derived from **river_poly_NDG_nk** polygon shapefile

Rivers_null – river_line_ngd_nk converted to grid based on CLSID field that represents small and major rivers

Rivers – Recoded **Rivers_null** to represent 1 as major rivers and value of 2 as small rivers. Null value we recoded to 0

> con (is null ([**Rivers_null**]), 0, con ([**Rivers_null**]) eq 5111, 1, [**Rivers_null**] eq 5101, 2, 0))

for Nam Kading area – Nam Kading river we used location of rapids to reselect impassable section of rivers and the ones that are not used as intensively

rapids.shp location of rapids on Nam Kading river
impassable. Shp - based on rapids.shp we selected section of rivers that are impassable
riv_imp_0 - impassable. Shp converted to grid impassable (riv_imp) and then null values converted to 0

> con (isnull ([riv_imp]), 0, [riv_imp])

impassable_buff5km – buffered impassable. Shp with 5km and sections beyond the rapids were just cut off.

Imp_buf5km0 – gridded impassable section of the river with 5 km buffer around it.and then null values converted to 0

partially-impassable.shp – section of the Nam Kading river still impassable for non motorized boats

riv_prt gridded **partially-impassable.shp (riv_prtimp)** and then null values converted to 0

partially_buff5km – buffered **partially-impassable.shp** with 5km and sections beyond the rapids were just cut off.

prtimp_buf5km0 – gridded partially impassable section of the river with 5 km buffer around it.and then null values converted to 0

Roads data

majorRoads_NK.shp – reselected main roads from Roads_NK. We selected all roads AND some foopaths. We also added new unpaved road within Nam Kading park. We did not select all footpaths because we were unsure how people use them (many of them might be temporary and more related to the village locations that were considered as an impact) and had doubts about their accuracy. They also might not have as much impact on the landscape. However we did consider (on screen) and added selected footpaths across the landscape when:

- they obviously departed from and linked a 2005 settlement which otherwise would have been left disconnected in the middle of nowhere;
- they joined a classified major road or a segment of river;
- they linked a (density of) agriculture areas to a nearby village (2005).

Note that roads with no attribute information about the type were deleted.

Paved_roads – reselected paved roads from major **Roads_NK.shp**
unpaved_temp_roads – reselcted other roads from majorRoads_NK.shp

Majroads – gridded **majorRoads_NK.shp** on CSID field

Villages data

Village_nk – original point file of villages clipped with landscape.shp, based on population census year 2005 - 3632 points originally. This dataset contains figures on # hh and # pop, however not completely.

Biological Landscapes

WHITE- CHEEKED CRESTED GIBBON

Bio-landscape Note: unlike for the elephant biolandscape, we opted here for the version RG 4 (which means 8 adjacent cells), as we thought we had been already quite conservative in considering fragmentation (impassable roads and rivers) across the landscape, while we thought that gibbons would potentially jump "from 1 square corner to another" (not counting any regrowth), so 8 adjacent cells was more appropriate. As for patchiness factor, we retained GB's 6 classes for patch size, as it provided with more range/variety in the landscape for future intervention.

gibbiol = Gibbon biological landscape is defined by the preference for habitat with high density of tree cover, elevation below 2000 m (elevation might be limiting food availability) while patch viability is added, as they have very limited dispersal capabilities and do not cross open spaces. (In ArcGIS)

((([gbelevpref] * [gbvegagrpref] / 100) + [gbvegrgrec]) / 2)

gbelevpref – gibbon were found in the elevation between 0 and 2000 m. It is hard to say if they can get higher as the vegetation and availability of fruits might be limited above this elevation.

We reclassified dem_nk elevation grid into two classes. Gibbons prefer habitat below 2000m altitude. In the absence of data above 2000m, we provisionally classified that as no habitat.

gbvegrgrec – We reclassify gbvegrg (using count) with different classes according to the importance of each patch size to the vialibility of the Gibbon population (how many groups that could help sustain?).

con ([gbvegrg].link eq 1 & ([gbvegrg].count >= 31 & [gbvegrg].count <= 90), 10,
[gbvegrg].link eq 1 & ([gbvegrg].count >= 91 & [gbvegrg].count <= 180), 50,
[gbvegrg].link eq 1 & ([gbvegrg].count >= 181 & [gbvegrg].count <= 1800), 80,
[gbvegrg].link eq 1 & ([gbvegrg].count >= 1801 & [gbvegrg].count <= 3750), 90,
[gbvegrg].link eq 1 & [gbvegrg].count > 3750, 100, 0)

gbvegrg - We generated a group region of gbvegrec in ArcView using Grid Analyst Extension/Group Region in order to be able to calculate patchiness. Option **"Four Orthogonal Neighbors" (which means taking into consideration EIGHT nearest neighbors !!!)** should be selected to generate this.
(we decided to choose that option because, for gibbon, we had already been conservative in unsuitable habitats in one hand, and fragmentation caused by presence of roads and rivers in other hand. Opting for "**EIGHT nearest neighbors" option (which means four orthogonal cells) further downgrade several patches, whether we still consider that gibbon could reach and use them – not counting on possible regrowth).**

gbvegrec – reclassification of gbvegagrpref with classes > =70 given a value = 1 and class < 70 a value = 0.

In order to avoid the pitfall of having a min patch size layer which would eliminate non-core habitat patches although some may well be used as corridor in between good patches, we introduce patch **viability**.

gbvegagrpref - We considered the impact of road on gibbon, by extracting the major roads (Value = 1) from gbvegriver1, as we considered that major road can have an impact in their movement between different patches of habitats.

con ([majroads_0] == 1, 0, [gbvegriver1])

majroads_0 - replacing null values of majroads_RECL **to value = 0 for gibbon analysis**
con (isnull ([majroads_RECL]), 0, [majroads_recl])

majroads_RECL – reclassified majroads into two classes, footpath = 2 and major roads = 1.

gbvegriver1- we considered the impact of the river system on gibbon. We used **rivers** grid. We extracted the main river (Value = 1) from gbvegdens as it is no habitat for gibbon.

Con ([rivers] == 1, 0, [gbvegdens])

gbvegdens – we merge the results of the refining gbvegmrc with the reclassified gbvegclass taking into account the canopy density factor

Con ([gbvegmrc] > 0 and [gbvegclass] > 0, [gbvegmrc], [gbvegclass])

gbvegmrc - refined lc_agr_pln_rs grid with MRC vegetation cover lc_mrc_nk grid to make an additional distinction between high and low density forest canopy so we can rate them accordingly. We used evergreen (high cover density (11) and low convert density (12)) to refine Dry Evergreen forest suitability (11 & 12). We used Mixed (evergreen & deciduous, high (17) and low cover density (18)) to refine Mixed Deciduous (21 & 22).

Con ([lc_agr_pln_rs] eq 11 and [lc_mrc_nk] eq 11 or [lc_agr_pln_rs] eq 12 and [lc_mrc_nk] eq 11, 100, [lc_agr_pln_rs] eq 11 and [lc_mrc_nk] eq 12 or [lc_agr_pln_rs] eq 12 and [lc_mrc_nk] eq 12, 90, [lc_agr_pln_rs] eq 21 and [lc_mrc_nk] eq 17 or [lc_agr_pln_rs] eq 22 and [lc_mrc_nk] eq 17, 80, [lc_agr_pln_rs] eq 21 and [lc_mrc_nk] eq 18 or [lc_agr_pln_rs] eq 22 and [lc_mrc_nk] eq 18, 70, 0)

gbvegclass – reclassified lc_agr_pln_rs vegetation grid into the preference classes (veg_reclass). Gibbon require relatively high density of tree cover to obtain fruits and avoid open areas. Their home range and dispersal capabilities are very limited and they do not cross area further than 50 – 100 meters. They may have to compensate for the lower quality habitat (lower cover density) with a larger home ranges.
veg_reclass – reclassification file for ArcGIS for gibbon vegetation preferences.

GREAT HORNBILL

Bio-landscape Note: after checking the landscape on screen and spotting a rather odd value for the forest patches on the Nakhai Plateau which had a low value compare to the neighboring areas, we with Arlyne decided to revisit the scoring of habitat preferences, e.g. by increasing the value for broadleaves forest while a couple of others were also modified (see XL sheet

hornbiol – hornbill biological landscape is defined by the preference for habitat with high density of tree cover, elevation below 2000 m (elevation might be limiting food availability). They require forest habitat with big trees as their nesting area. They can travel as far as 20-30 km from their nesting areas for food.

Formula to be used to calculate:

(max ([hornvegforag], [hbnestvegdens])) * [hbelevpref] / 100

hbelevpref – suitable habitat of hornbill can be found within the areas that have elevation from 0 to 2000m. The higher the elevation is the less moisture in the soil which results in less fruiting trees.

We reclassified dem_nk elevation grid based on the criteria: 0 – 1560m (100 scores for being the most suitable habitat), 1560 – 2000m (80 scores for being suitable habitat type), and above 2000m is considered to be as no habitat for the hornbill.

hbnestvegdens – we merge the results of the refining gbvegMRC with the reclassified gbvegclass taking into account the canopy density factor

Con ([hbvegnestmrc] > 0 and [hornvegnest] > 0, [hbvegnestmrc], [hornvegnest])

hbvegnestMRC - refined lc_agr_pln_rs grid with MRC vegetation cover lc_mrc_nk grid to make an additional distinction between high and low density forest canopy so we can rate them accordingly. We used evergreen (high cover density (11) and low convert density (12)) to refine Dry Evergreen forest suitability (11 & 12). We used Mixed (evergreen & deciduous, high (17) and low cover density (18)) to refine Mixed Deciduous (21 & 22).

Con ([lc_agr_pln_rs] eq 11 and [lc_mrc_nk] eq 11 or [lc_agr_pln_rs] eq 12 and [lc_mrc_nk] eq 11, 100, [lc_agr_pln_rs] eq 11 and [lc_mrc_nk] eq 12 or [lc_agr_pln_rs] eq 12 and [lc_mrc_nk] eq 12, 90, [lc_agr_pln_rs] eq 21 and [lc_mrc_nk] eq 17 or [lc_agr_pln_rs] eq 22 and [lc_mrc_nk] eq 17, 100, [lc_agr_pln_rs] eq 21 and [lc_mrc_nk] eq 18 or [lc_agr_pln_rs] eq 22 and [lc_mrc_nk] eq 18, 90, 0)

hornvegforag - reclassified lc_agr_pln_rs vegetation grid into preference classes (foraging_Veg_reclass.dbf).

hornvegnest - reclassified lc_agr_pln_rs vegetation grid into preference classes (hornest_Veg_reclass.dbf). Hornbill can pass over urban areas and they preferable habitats that has % of crown cover of 31-72%. They need big trees (54-157 dbh) for nesting. (reclassified in ArcGIS using Reclassify.. option in Spatial Analyst menu)

ELEPHANTS

Bio-landscape Note: we opted for the version RG 8 (which means 4 adjacent cells), as we considered a more conservative option (given Elephant are already so generalist that we would have found them almost everywhere but on steep terrain). Relatedly, we opted for the so-called version 2, ranking the abandoned agriculture as vegpref value = 100 and the current agriculture as vegpref value = 70 (given in the mean time the agriculture threat will cover the risk encountered).

elebiol = Elephant biological landscape is defined by the slope as the limiting factor regarding movement of elephant across the landscape. Preference of habitat comes as secondary factor; they do cross open spaces, only urban, agriculture and rocky area are not suitable. Given the home range of elephant (100 km2), patches that is smaller than that surrounded by unsuitable patches are excluded. Distance to water (assumed to be > 15km) does not constitute a factor in this landscape.

[elepref] * [eleminpatch]

Patchiness

We wanted to express the fact that patches of suitable quality (slope + vegetation) with an area smaller than home range (100 km2) AND surrounded by 'impassable' patches unsuitable for dispersal (slope and/or agric/urban/rocks, none of those ever to be changed), should be removed from the suitable quality class.

eleminpatch – eliminated non-core habitat patches. Core habitat patches from **elereggr** with value of 1 but < 100 sq km (10,000 cells) are eliminated (value = 0).

Con (([elereggr].Link) == 1 & ([elereggr].Count) < 10000, 0, 1) – ArcGIS ????

(([Elereggr . Link] = 1) and ([Elereggr . Count] < 10000. AsGrid)). con (0.AsGrid, 1.AsGrid)

elereggr – we generated a group region (Eight Nearest Neighbors) of elecollapse in ArcView using Grid Analyst Extension in order to be able to calculate patchiness. Due to error in extension we used "**Eight Nearest Neighbors**" option which will give result of "**Four orthogonal neighbors**".

elecollapse – we collapsed (Reclassify)all suitable classes into one single class (=1) and unsuitable class into a class (= 0) by reclassifying elepref.

elepref - we merge the slope and habitat layers.

[eleslppref] * [elevegdampref] / 100

Habitat

Most habitat types were treated as suitable; only rocks and urban areas are no-go areas (= 0). Hence we did not want to perform a neighboorhood analysis, as whatever suitable habitat type that is (all but urban and rocks), will be used or crossed by elephants. We treated agriculture as habitat of little use (= 10) but not of no value given they are important and would be used during elephant movement between good patches. **Abandoned agriculture plots (leg = 100) are classified as high value habitat (= 100).** Though water was considered a favorable habitat, large flooded areas created from dams were removed from that suitable classe.

elevegdampref – elevegclass minus the large waterbodies areas

[elevegpref] * [rivdamsrecl]

elevegpref – reclassified lc_agr_pln_rs vegetation grid into the preference classes (veg_reclass – info table). Elephants prefer a wide range of habitat with a preference for open and disturbed areas; they do occur in denser forest areas; they would avoid human-made types of habitat.

veg_reclass – reclassification file for ArcGIS for elephant vegetation preferences. The file is in Info table

rivdamsrecl - rivdams reclassified into value = 0 if large waterbodies, value = 1 if no data.

con (isnull ([rivdams]), 1, 0)	**ArcGIS**
([Rivdams].IsNull).con (1.AsGrid,0.AsGrid)	**ArcView**

rivdams – converted rivdams.shp to grid using RECL_ID field

rivdams.shp – merged rivdams_nk.shp and NT_reservoirs.shp
rivdams_nk.shp – extracted water polygons from Lc_ngd_nk.shp and cleaning up to retain only the two major waterbodies occuring in the landscape (from dams) and the Mekong river, incl. filling of islands.

Rivers

Distance to water was potentially a factor. It turned out it was **not** (always within 15km range).

distrivperm – distance grid of rivperm_nk.shp.
No permanent rivers/waterbodies were further away than 14.5km.

rivperm_nk.shp – rivers shp combining permanent rivers from river_line_ngd_nk.shp, permanent waterbodies (con. to lines) from river_poly_ngd_nk.shp and waterbodies extracted from landcover_ngd.shp

river_line_ngd_nk.shp – rivers shp (lines) incl. permanent and intermittent rivers/streams.
river_poly_ngd_nk.shp - rivers shp (polys) for permanent waterbodies.
landcover_ngd.shp – landcover (NGD)

Slope

eleslppref – reclassification of sl_nk_int slope grid into seven classes:

0 – 2	=100
3 – 5	= 80
6 – 10	= 60
11 - 15	= 30
16 – 20	= 20
21 – 30	= 10
30 >	= 0

The slope classes were determined by referring to the this graph:

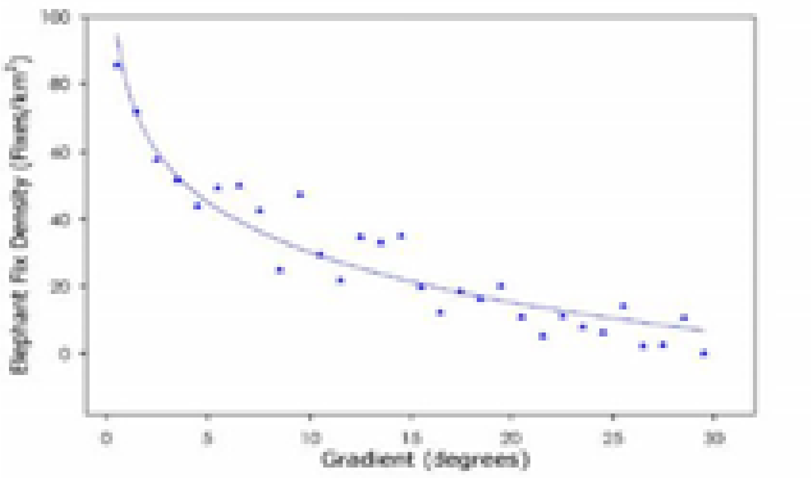

Figure S1: Decreasing elephant fix density with increasing hillslope. $R^2 = 0.90$ (for details of method see supplemental methods: slope and elevation)

([sl_nk_int] <= 20).con (1.AsGrid, 0.AsGrid)

sl_nk_int – sl_nk continuous grid transformed into integer grid.

[Sl_nk].Int

sl_nk – slope grid derived from DEM (MRC) 50m res., resampled to 100m.

WILD PIG

Bio-landscape Note: to be consistent with the above, we opted for the so-called version 2, ranking the abandoned agriculture as vegpref value = 100 and the current agriculture as vegpref value = 90 (given in the mean time the agriculture threat will cover the risk encountered).

Pigbiol - wild pigs are mostly found in the areas that have no more than 4km proximity to water and slope of areas less than 45%.

[pigdisrivpref] * [pigslppref] * [pigvegpref] / 10000 pigslppref – reclassification of Sl_nk_int slope grid into two classes. Slope greater than 45 % are considered as no-go area (value = 0).

([Sl_nk_int] <= 45).con (100.AsGrid, 0.AsGrid) *(ArcView)*

con ([sl_nk_int] <= 45, 100, 0) *(ArcGIS)*

sl_nk_int – sl_nk continuous grid transformed into integer grid.

[Sl_nk].Int *(ArcView)*

int ([sl_nk]) *(ArcGIS)*

sl_nk – slope grid derived from DEM (MRC) 50m res., resampled to 100m.

pigdisrivpref – Good habitat for wild pig should lines within 4 km distance from the rivers or water bodies. Calculating this has involved the use of Linear Function (Y = SLOPE * Distance + INTERCEPT). SLOPE and INTERCEPT can be calculated in Microsoft Excel (Insert → Function… →select category called 'Statistical' → select function that you want to calculate SLOPE or INTERCEPT) and then enter the Y cells and X cells. The criteria we set for defining suitable habitat based on distance to water being: at 2km or below → suitability level is 100, at value 3km from river → suitability is 50, and at 4km or above → suitability is 0. We enter this value in excel spreadsheet to calculate SLOPE and INTERCEPT:

100	2000m
0	4000m

=INTERCEPT(A4:A5,B4:B5) = 200
=SLOPE(A4:A5,B4:B5) = -0.05 This can be referred back to linear_function.xls

This calculation was done using Map Calculator… in Analyst menu (ArcView)

([Pigdistmajriv] <= 2000).con (100.AsGrid, (([Pigdistmajriv] > 2000) and ([Pigdistmajriv] <= 4000)).con ((-100/2000).AsGrid * [Pigdistmajriv] + 200.AsGrid, 0.AsGrid)).int

pigdistmajriv – Calculate distance from rivers (**River_line_NGD_NK.shp**) by using **Distance → Straight Line**… option under **Spatial Analyst** menu.

pigvegpref - reclassified lc_agr_pln_rs vegetation grid into preference classes (pig_veg_recls). Wild pig depends can be found in most habitats that have less than 4km proximity to water. (Reclassified in ArcGIS using Reclassify.. option in Spatial Analyst menu).

SEROW

Bio-landscape Note: after a careful look at both landscapes, with or without the distance to slope as a criteria, including displaying with a distinct color the value 0, we thought that that landscape as is looked a bit odd, while we do not have sufficient information to willingly double count and integrate slope + distance to slope factors. So we dropped the distance to slope criteria to retain the slope factor only.

serowbiol – Serow biological landscape is defined by the steep slope rocky areas that covered by the thick bush at elevation lower than 2700m. They shelter in deep bush or scrub during the day and go out to feed in more open areas in late evening. They eat almost any vegetation but prefer grass, tender leaves and shoots.

[srdisslpref] * [srvegpref] * [srslppref] / 10000

srdisslpref – Good habitat for serow should lines within 1 km distance from the steep slope areas. Calculating this has involved the use of Linear Function (Y = SLOPE * Distance + INTERCEPT). SLOPE and INTERCEPT can be calculated in Microsoft Excel (Insert → Function… →select category called 'Statistical' → select function that you want to calculate SLOPE or INTERCEPT) and then enter the Y cells and X cells. The criteria we set for defining suitable habitat based on distance to steep areas: at 500m or below → suitability level is 100, at value 750m from steep areas → suitability is 50, and at 1km or above → suitability is 0. We enter this value in excel spreadsheet to calculate SLOPE and INTERCEPT:

100	500m
0	1000m

=INTERCEPT(A4:A5,B4:B5) = 200
=SLOPE(A4:A5,B4:B5) = -0.2   This can be referred back to linear_function.xls

This calculation was done using Map Calculator… in Analyst menu (**ArcView**)

([Dist_selslp] <= 500).con (100.AsGrid, (([Dist_selslp] > 500) and ([Dist_selslp] <= 1000)).con ((-100/500).AsGrid * [Dist_selslp] + 200.AsGrid, 0.AsGrid)).int

ArcGIS

Int (Con ([dist_selslp] <= 500, 100, con ([dist_selslp] > 500 & [dist_selslp] <= 1000, (-0.2 * [dist_selslp] + 200), 0)))

dist_selslp – We run distance analysis of **srselectslp** using Spatial Analyst/ Distance/ straight line

srselectslp – All areas with slope greater than 15% are selected and assigned value of 1. Everything else was assigned NO Data value.

setnull ([sl_nk_int] lt 15, 1)

srslppref – Serows inhabit limestone mountains and cliffs at elevation of up to 2700m. They are typically found on steep and rocky slopes. We reclassified slope **sl_nk_int** into new classes as below:

slope 0 - 10 - value of 50
slope 11 - 15 - value of 80
16 – 77 or above - value of 100 (as the best habitat)

srvegpref – reclassified **lc_agr_pln_rs** vegetation grid into preference classes (serow_reclass). Serows can be found in rugged mountains or ridges, covered with thick bush or forest.

TIGER

tigerbiol - reclassified **lc_agr_pln_rs** vegetation grid into preference classes (tiger_reclass). Tiger can be found in variety of environments including forests, grasslands and swamps. Tigers seem to thrive in areas of dense vegetation with numerous sources of water and large populations of ungulate prey (WWF 2006).

New Biological Landscape

1. **tigerhab -** reclassified **lc_agr_pln_rs** vegetation grid into preference classes (tiger_reclass). This layer represents the tiger habitat preference including easiness of hunting. It is of course linked to the prey density as this is difficult to separate from the habitat usage, but we tried to code habitats more as the tiger preference overall regardless of where prey is.

2. **tigerprey –** the habitat classes reclassified according to the prey density and then modified by slope and proximity to water. We assume that prey densities are higher on flat areas and closer to water bodies. Reclass **lc_agr_pln_rs** vegetation grid into preference classes (prey_reclass).

   1. **preyslope -** reclasss slope according to the prey density. (slope_reclass)

0-20	100
20-30	80
30-40	60
40-50	40
> 60	20

   2. Now we can generate the layer that shows linear decrease of habitat quality (prey density) with the distance from the water bodies.
      a. **Riv_dist** – the layer with the distance to rivers run with Spatial Analyst/Distance/Staight line function
      b. **Preywater**- Linear decrease of habitat quality. The maximum value is 15217 m so we will not place any limit on the distance. And 15217 m will be considered 0 and up to 2000 m will be considered 100 (based on wild pig movement dispersal)

ArcGIS

Int (Con ([Riv_dist] <= 2000, 100, con ([Riv_dist] > 500, (-0.00757 * [Riv_dist] + 115), 0)))

Int (Con ([Riv_dist] <= 2000, 100, con ([Riv_dist] > 2000, (-0.00757 * [Riv_dist] + 115), 0))) ???

3. **Totalprey -** Now we can modify the tigerprey layer with preyslope and preywater to adjust for the prey densitites on different slopes and within different distances to water.

([tigerprey] * [preywater] * [preyslope]) / 10000

4. Now we put the landscapes together to get the final biological landscape fpr tiger. WE can assign weight of 3 to prey density and weight 1 to habitat preference.

Final **tigerbiol** layer – tiger biological landscapes

([tigerhab] + (3 * [totalprey])) / 4

Human Landscapes

THREATS

AGRICULTURE

FOR ELEPHANT

ele_c_thrt = layer of agricultural threat refined with the population landscape (how people use it outside of the urban areas)

ele_c_thrt = con ([urbanbuff0] eq 2, 100, [ele_c_agr] gt 0, (([popressure] + (3 * [ele_c_agr])) / 4), 0)

ele_c_agr = layer that represents the threat from agriculture to the elephant based on its dispersal distances (**distagriurb**). We assume that, for elephant, for a 15km radius (range), the threat is 100 % within the first 25% of the radius (= 3.75km) starting from distagriurb, then linearly decreases, until it falls to nil as it reaches 15km.

Int (con ([distagriurb] le 3750, 100, con ([distagriurb] gt 3750 and [distagriurb] le 15000, -0.0089 * [distagriurb] + 133, 0)))

ArcView

([Distagriurb] <= 3750).con (100.AsGrid, (([Distagriurb] > 3750) and ([Distagriurb] <= 15000)).con ((-100/11250).AsGrid* [Distagriurb] + 133.AsGrid, 0.AsGrid)).int

distagriurb – distance grid from **agricurb.shp** using distance function

agriurb.shp – merge of **agricperm.shp** and **urbanbuff.shp**

Urbanbuff0 - grid conversion of urbanbuff.shp - converted to grid and null values within the bnd_nk mask assigned a value = 1 and urban cells assigned a value = 2.

([Urbanbuff].IsNull).con (1.AsGrid,2.AsGrid)

urbanbuff – grid of urbanbuff.shp area

urbanbuff.shp – we considered the influence of urban settlements by a buffer representing the 'hinterland' area. This hinterland was assumed to be of 10km radius for national capital, and 5km radius for provincial capitals and major towns as below.

urban.shp - urban areas from both coverages were not consistent one to another. We chose to consider the urban influence of only major towns of the landscape, e.g. the provincial capitals. We selected from urban_NGD.shp only the urban area polygons which were consistent with the MRC dataset.

urban_MRC. shp - extraction of all polygons of leg 94 (= urban area) from the MRC landcover dataset Veg_mrc_nk.shp

urban_NGD.shp - extraction of all polygons of leg 1 (= urban area) from the NGD landcover dataset Veg_ngd_nk.shp

agricperm.shp **–** selection of all polygons considered as current agriculture (RECLID = 1) from agric.shp and updated by adding new areas that obtained after the map checking workshop**.**

agric.shp **– extraction of all polygons of leg 2 (= agriculture area) from the reclassified** Veg_ngd_nk.shp

CORRECTIONS AFTER WORKSHOP FOR THE FINAL CONSERVATION LANDSCAPES – DONE ONLY FOR NAM KADING

create a new threat layer based on new agriculture layer that incorporates current and future scenarios based on the information obtained during the workshop.

A. Present based on agric_curf

Agriurb_cur.shp – merge of agric_curf.shp (updated agricultural areas agric.shp , added new areas that obtained after the map checking workshop) and urbanbuff.shp

agr_c_dis – distance to the agricultural fields layer

ele_c_agr = layer that represents the threat from agriculture to the elephant based on its dispersal distances (as above)

ele_c_agr = Int (con ([agr_c_dis] le 3750, 100, con ([agr_c_dis] gt 3750 and [agr_c_dis] le 15000, -0.0089 * [agr_c_dis] + 133, 0)))

FINAL:

ele_c_thrt = layer of agricultural threat refined with the population landscape (how people use it outside of the urban areas)

ele_c_thrt = con ([urbanbuff0] eq 2, 100, [ele_c_agr] gt 0, (([popress_b] + (3 * [ele_c_agr])) / 4), 0)

B. based on the future agriculture layer – agriurb_fut

Agriurb_Fut.shp – merge of agric_fut.shp (updated agricultural areas, added new areas that obtained after the map checking workshop) and urbanbuff.shp

ele_f_agr = layer that represents the threat from agriculture to the elephant based on its dispersal distances (as above)

ele_f_agr = Int (con ([agr_f_dis] le 3750, 100, con ([agr_f_dis] gt 3750 and [agr_f_dis] le 15000, -0.0089 * [agr_f_dis] + 133, 0)))

FINAL:

ele_f_thrt = layer of agricultural threat refined with the population landscape (how people use it outside of the urban areas)

ele_f_thrt = con ([urbanbuff0] eq 2, 100, [ele_f_agr] gt 0, (([popress_b] + (3 * [ele_f_agr])) / 4), 0)

FOR WILD PIG

pig_c_thrt = layer of agricultural threat refined with the population landscape (how people use it outside of the urban areas)

pig_c_thrt = con ([urbanbuff0] eq 2, 100, [pig_c_agr] gt 0, (([popressure] + (3 * [pig_c_agr])) / 4), 0)

pig_c_agr = layer that represents the threat from agriculture to the elephant based on its dispersal distances (**distagriurb**). We assume that, for pig, for a 2km radius (range), the threat is 100 % within the first 25% of the radius (= 0.5km) starting from distagriurb, then linearly decreases, until it falls to nil as it reaches 2km.

Int (con ([distagriurb] le 500, 100, con ([distagriurb] gt 500 and [distagriurb] le 2000, -0.067 * [distagriurb] + 133.3, 0)))

ArcView

([Distagriurb] <= 500).con (100.AsGrid, (([Distagriurb] > 500) and ([Distagriurb] <= 2000)).con ((-100/1500).AsGrid* [Distagriurb] + 133.AsGrid, 0.AsGrid)).int

distagriurb – distance grid from **agricurb.shp** using distance function

agriurb.shp – merge of **agricperm.shp** and **urbanbuff.shp**

Urbanbuff0 - grid conversion of urbanbuff.shp - converted to grid and null values within the bnd_nk mask assigned a value = 1 and urban cells assigned a value = 2.

([Urbanbuff].IsNull).con (1.AsGrid,2.AsGrid)

urbanbuff – grid of urbanbuff.shp area

urbanbuff.shp – we considered the influence of urban settlements by a buffer representing the ‘hinterland’ area. This hinterland was assumed to be of 10km radius for national capital, and 5km radius for provincial capitals and major towns as below.

urban.shp - urban areas from both coverages were not consistent one to another. We chose to consider the urban influence of only major towns of the landscape, e.g. the provincial capitals. We selected from urban_NGD.shp only the urban area polygons which were consistent with the MRC dataset.

urban_MRC. shp - extraction of all polygons of leg 94 (= urban area) from the MRC landcover dataset Veg_mrc_nk.shp

urban_NGD.shp - extraction of all polygons of leg 1 (= urban area) from the NGD landcover dataset Veg_ngd_nk.shp

agricperm.shp – selection of all polygons considered as current agriculture (RECLID = 1) from **agric.shp.**

agric.shp – extraction of all polygons of leg 2 (= agriculture area) from the reclassified Veg_ngd_nk.shp

CORRECTIONS AFTER WORKSHOP FOR THE FINAL CONSERVATION LANDSCAPES – DONE ONLY FOR NAM KADING

We created a new threat layer based on new agriculture layer that incorporates current and future scenarios that were refined during the workshop in November

A. Present based on agric_curf.shp

Agriurb_cur.shp – merge of agric_curf.shp and urbanbuff.shp

agr_c_dis – distance to the agricultural fields layer

pig_c_agr = layer that represents the threat from agriculture to the elephant based on its dispersal distances (as above)

pig_c_agr = Int (con ([agr_c_dis] le 500, 100, con ([agr_c_dis] gt 500 and [agr_c_dis] le 2000, -0.067 * [agr_c_dis] + 133.3, 0)))

FINAL:
pig_c_thrt = layer of agricultural threat refined with the population landscape (how people use it outside of the urban areas)

pig_c_thrt = con ([urbanbuff0] eq 2, 100, [pig_c_agr] gt 0, (([popress_b] + (3 * [pig_c_agr])) / 4), 0)

B. Future based on the future agriculture layer – agriurb_fut.shp

Agriurb_Fut.shp – merge of agric_fut.shp and urbanbuff.shp

pig_f_agr = layer that represents the threat from agriculture to the elephant based on its dispersal distances (as above)

pig_f_agr = Int (con ([agr_f_dis] le 500, 100, con ([agr_f_dis] gt 500 and [agr_f_dis] le 2000, -0.067 * [agr_f_dis] + 133.3, 0)))

FINAL:
pig_f_thrt = layer of agricultural threat refined with the population landscape (how people use it outside of the urban areas)

pig_f_thrt = con ([urbanbuff0] eq 2, 100, [pig_f_agr] gt 0, (([popress_b] + (3 * [pig_f_agr])) / 4), 0)

LIVESTOCK

FOR TIGER

Potential conflict between humans and tiger is somewhat of a different nature. Whereas pig and elephant conflicts take place within and nearby agricultural lands (crop raidings), tiger conflict occurs in terms of livestock depredation.
An average area of livestock ranging is around 2.5km around villages. That area is considered a no go area. However, urban areas do not have livestock, so may not constitute areas of such threat. We removed those from the analysis.

tigliv_thrt - We used tiglivvill and Population density grid (popressure) to derive the final livestock threat landscape for tigers.

con ([urbanbuff0] eq 0, 0, ((2 * [popressure]) + [tiglivvill]) / 3)

tiglivvill – grid expressing the threat of human-tiger conflict (livestock depredation) around villages. To express the threat of the human-sp. conflict occurring around livestock area, we express it in terms of threat = F(dist to livestock area), as a linear function.
We assume that, for tiger, for a 10km radius (range), the threat is 100 % within the first 25% of the radius starting from distbuffvill, then linearly decreases, until it falls to nil as it reaches 10km.

([Distbuffvill] <= 2500).con (100.AsGrid, (([Distbuffvill] > 2500) and ([Distbuffvill] <= 10000)).con ((-100/7500).AsGrid* [Distbuffvill] + 133.AsGrid, 0.AsGrid)).int

Distbuffvill2 – distance grid from vill_buf.shp using distance function.

vill_buf.shp is a buffer of 2.5km around each village (dissolved), as a proxy to represent the 'livestock' area of the landscape.

Villbuff.shp. is a buffer of 2.5km around each village outside of urban areas (used urbanbuff0 to select urban villages) (dissolved), as a proxy to represent the 'livestock' area of the landscape.

Liv_lands_pop - is the shapefile containing villages outside of the urban areas. It was created from Lands_pop.shp that has all villages for the landscape in it.

urbanrecl – urbanbuff reclassified into value = 0 if urban, value = 1 if no data.

([Urbanbuff].IsNull).con (1.AsGrid,0.AsGrid)

urbanbuff – grid of urbanbuff.shp area

urbanbuff. shp – we considered the influence of urban settlements by a buffer representing the 'hinterland' area. This hinterland was assumed to be of 10km radius for national capital, and 5km radius for provincial capitals and major towns as below.

urban.shp - urban areas from both coverages were not consistent one to another. We choose to consider the urban areas and influence for only major towns of the landscape, e.g. the provincial capitals. We selected from urban_NGD.shp only the urban area polygons which were consistent with the MRC dataset.

urban_MRC. shp - extraction of all polygons of leg 94 (= urban area) from the MRC landcover dataset Veg_mrc_nk.shp

urban_NGD.shp - extraction of all polygons of leg 1 (= urban area) from the NGD landcover dataset Veg_ngd_nk.shp

CORRECTIONS AFTER WORKSHOP FOR THE FINAL CONSERVATION LANDSCAPES – DONE ONLY FOR NAM KADING and Used Population pressure files used for Nam Kading only

We used Tiglivvill and Population density grid (poppress_b) to derive the final threat landscape for tigers. We weighted Population layer higher than we did it originally.

Tiglvst_nk = con ([urbanbuff0] eq 2, 0, ((2 * [popress_b]) + [Tiglivvill]) / 3)

LOGGING

FOR HORNBILL

logging – logging is a one of the most important threats to the hornbill habitat. Hornbills tend to use big trees as their nesting spots. Therefore, logging contributes significantly to the declination of this species.

Logging is driven by vegetation types suitable for cutting and it is refined (multiplication) by the distance to road and slope.

Int ([logvegpref] * [logslpref] * (max ([majroadpref], [disfpathpref])) / 10000)

logvegpref – Normalize value of veg_npa_ppa by apply 100 to all values above 100. This way we would maintain original vegetation reclassification according to its threat of being cut. If we increase the value of reclassified vegetation types such as 100 or 70 by 50 percent it means that in the production forest it would all become 100 – this is the highest threat value anyway.

con ([veg_npa_ppa] ge 100, 100, [veg_npa_ppa])

veg_npa_ppa

d) Chances of cutting trees (logvegclss) in protected areas (nbca_ppa_nk_0) are lower so we decrease the threat by 75 percent (this what you already have)

Con ([logvegclss] > 0 & [nbca_ppa_nk_0] > 0, [logvegclss] * 0.75, [logvegclss])

e) Chances of cutting trees (logvegclss) in the production forest (proforst_nk_0) are much higher and we could increase the threat by 50 percent.

Con ([logvegclss] > 0 & [proforst_nk_0] > 0, [logvegclss] + [logvegclss] * 0.5, [logvegclss])

f) Chances of cutting trees (logvegclss) around villages (vill_buff3_0) are much higher and we could increase the threat by 50 percent.

Con ([logvegclss] > 0 & [vill_buff3_0] > 0, [logvegclss] + [logvegclss] * 0.5, [logvegclss])

veg_npa_ppa = Con ([logvegclss] > 0 & [nbca_ppa_nk_0] > 0, [logvegclss] * 0.75, [logvegclss] > 0 & [proforst_nk_0] > 0, [logvegclss] + [logvegclss] * 0.5, [logvegclss] > 0 & [vill_buff3_0] > 0, [logvegclss] + [logvegclss] * 0.5, [logvegclss])

vill_buff3_0 – Create 3km buffer around village locations and grid, then turn all null value to 0.

([Vill_buff3].IsNull).con (0.AsGrid,1.AsGrid)

proforst_nk_0 – All null values in pro_forst_nk are converted to value 0

con (isnull ([pro_forst_nk]), 0, [pro_forst_nk])

pro_forst_nk – production forest areas grid generated from converting product_frst_fipd_nk.shp to grid by using Poly_No field.

nbca_ppa_nk_0 – All null values in nbca_ppa_nk are converted to value 0

con (isnull ([nbca_ppa_nk]), 0, [nbca_ppa_nk])

nbca_ppa_nk – this was generated from converting nbca_&_ppa_lls_bnd.shp to grid by using NBCA1_ field.

nbca_&_ppa_lls_bnd.shp – generated from combination of NBCA_LLS_bnd.shp and PPA.shp

majroadpref – **Level of logging severity of particular areas is determined by distance from roads**. Calculating this has involved the use of Linear Function (Y = SLOPE * Distance + INTERCEPT). SLOPE and INTERCEPT can be calculated in Microsoft Excel (Insert → Function… →select category called 'Statistical' → select function that you want to calculate SLOPE or INTERCEPT) and then enter the Y cells and X cells. The criteria we set for defining areas where there's a high logging threat based on distance to big roads: at 5km or below → risk is 100, at value below 10km from big roads → risk is 50, and at above 10km → risk is 0. We enter this value in excel spreadsheet to calculate SLOPE and INTERCEPT:

	A	B
4	100	0
5	50	5000m
6	0	10000m

=INTERCEPT(A4:A5,B4:B5) = 100
=SLOPE(A4:A5,B4:B5) = - 0.01   This can be referred back to linear_function.xls

This calculation was done using Map Calculator… in Analyst menu (ArcView)

```
([Logdismajroad] > 10000).con (0.AsGrid, (([Logdismajroad] <=10000) and ([Logdismajroad] >
5000)).con ((-50/5000).AsGrid * [Logdismajroad] + 100.AsGrid, 100.AsGrid)).Int
```

logdismajroad – Big roads or major roads (e.g. paved road, improved unpaved road, unpaved and temporary road) are extracted from **mojorRoads_NK.shp** and the distance to those roads (**bigroad.shp**) was calculated by using Distance → Straight Line… option under Spatial Analyst menu.

disfpathpref - calculated distance to the footpaths (logdisfpath) is then reclassified according to the given severity scores:

0 – 5000m → 20
> 5000m → 0

logdisfpath – footpaths are extracted from **mojorRoads_NK.shp** and the distance to those footpaths (**footpath.shp**) was calculated by using Distance → Straight Line… option under Spatial Analyst menu.

logslpref – The slope (sl_nk_int) layer was reclassified based on criteria defined for logging severity:

0 – 10% = 100
11 – 15% = 70
16 – 20% = 10
> 20 = 0

The reclassified vegetation file is called log_slope_recls (info table format).

logvegclss- we reclassified **lc_agr_pln_rs** based on land cover type by rating the level of logging severity (rating scale is from 0 – 100 most severe). The reclassified vegetation file is called log_veg_recls (info table format).

HUNTING

Hunting for Trade

We used a combination of population pressure (based on 2 people per 1 sq km) and travel routes access. In the area where we have roads, we have more markets where people can sell wildlife. Villages closer to the markets will tend to hunt both for subsistence and trade. Villages further away from markets tend to hunt primarily for subsistence, so the impact is much smaller.

hunttradthrt – this is calculated population pressure where villages closer to the road are weighted higher (See population_trade). The hunting for trade thus equals popwgt100 grid

[popwgt100]

Hunting for Subsistence

We used population pressure based on 2 people per 1 sq km as a proxy for hunting for subsistence. This is based on the assumption taken from the tropical studies, where… people need 1 sq km to support themselves entirely from bushmeat hunting. In Laos people do not depend entirely on the hunting for food but also perform other activities like growing crops. Therefore 2 people per 1 sq km seemed to appropriately reflect the resource extraction in the region. We weighted villages further from the road higher. I added field subweight and calculated it as an inverse to weight field used for hunting-trade.

[100 – weight]

huntsubs – this is calculated from [Subpop100] * 100 / 106470

[Subpop100]

Subsisthrt = we equal to population pressure grid

[poppress]

Hunting for Conflict/Recreation

a. Conflict with livestock (for **tiger**)

Derived from the distance to village (2.5 km) where livestock is being kept and tiger dispersal distance.

Tiglivthrt – distance to village (2.5km treated as a high threat that decreases within 10 km of tiger dispersal distance. We assumed that within 25% of tiger 10 km dispersal distance the threat remains at the value of 100.

Livsthtr - This layer is modified with the population pressure layer and tiger livestock

[tiglivthr] * [poppress] / 100

b. Agriculture conflict (for **elephant** and **wild pig**)

Conflict around the current agricultural fields is specific for elephants and wild pigs. Since both species have very different dispersal patterns and range over a different distances (elephant – 15 km radius, wild pig – 2 km radius) they are affected by the proximity to current agriculture in a different way. For elephants the radius around the agricultural field is much larger than for wild pigs.

Eleagurbthrt – the threat to elephants based on the distance to agricultural fields
Pigagurbthrt – the threat to wild pigs based on the distance to agricultural fields

Prey Depletion (for Tiger)

We used threat to wild pigs as a proxy of prey depletion for now. We assumed that the more they are affected by human activities the lower densities will be in the region and thus less food for tigers.

Preydplthrt = equals to the threat to wild pigs caused by the hunting for conflict at agricultural fields

[Pigagurbthrt]

ACCESS THREAT – Based on ROADS and RIVERS

The access layer is used to make the distinction between the population hunting more for trade and population hunting more for subsistence. The villages closer to transportation routes (weighted according to their impact) are more prone to hunting for trade and vice versa, villages further away from transportation routes hunt more for subsistence.

Reclassify roads and rivers based on their impact on landscape and how people use them to travel across the region. Major roads have the highest impact, followed by major rivers and then smaller/unpaved roads and finally small rivers that within a dry season can be used as a path to walk through the forest.

classify roads as such:

- major roads impact = 100
- unpaved/temp/other roads impact = 50
- footpath = 30

classify rivers as such:

- major rivers impact = 80
- smaller rivers impact = 30

Steps

1. Calculated distance for each one of the above categories using a Distance function (Straight line). Files that were used are under Roads and River folder.

    - Rivmajordist – distance to major rivers

- Rivsmalldist – distance to smaller rivers
- Roadpav_dist – distance to paved roads / major roads
- Roadunpv_dist – distance to smaller unpaved roads

2. Calculate buffer score using the following equations.

Mjrrds_thrt - major roads with an impact of 100 between 0 and 5 km that decreases linearly to value of 0 impact at 20km

*Int (con ([mjrd_dist] le 5000, 100, con ([mjrd_dist] gt 5000 and [mjrd_dist] le 20000, -0.0067 * [mjrd_dist] + 134, 0)))* (ArcGIS)

Smrds_thrt – smaller/unpaved roads with an impact of 50 between 0 and 5 km that decreases linearly to value of 0 impact at 15km

con ([unpv_dist] lt 5000, 50, con ([unpv_dist] gt 5000 and [unpv_dist] lt 15000, -0.005 * [unpv_dist] + 75, 0)) *(ArcGIS)*

Foot_thrt - footpath with an impact of 30 between 0 and 5 km that decreases linearly to value of 0 impact at 15 km

Int (con ([foot_dist] le 5000, 30, con ([foot_dist] gt 5000 and [foot_dist] le 15000, -0.003 * [foot_dist] + 45, 0)))

Majriver_thrt – major rivers with an impact of 80 between 0 and 5 km that decreases linearly to value of 0 impact at 20 km

Int (con ([rivmajordist] le 5000, 80, con ([rivmajordist] gt 5000 and [rivmajordist] le 20000, -0.005 * [rivmajordist] + 107, 0))) *(ArcGIS)*

Smriver_thrt – small rivers with an impact of 30 between 0 and 5 km that decreases linearly to value of 0 impact at 15 km

Int (con ([rivsmalldist] le 5000, 30, con ([rivsmalldist] gt 5000 and [rivsmalldist] le 15000, -0.003 * [rivsmalldist] + 45, 0))) *(ArcGIS)*

3. Select the maximum score for each grid cell so we can identify the highest threat in the given location from one of the travel routes

Access_thrt – the final pressure grid based on the access routes

max ([majriver_thrt],[mjrrds_thrt],[smrds_thrt],[smriver_thrt],[foot_thrt])

4. We redefine the **Access**_pres grid within the areas of impassable and partially passable areas around the Nam Kading river

NEW ACCESS LAYER CREATED ON THE BASE OF INCORPORATING NEW MAJOR ROAD

Access2 – the layer of access without incorporating the accessible and partially accessible areas. The same procedures just using a new recoded major road layer (newmjrd_thrt grid). The layer is located in Access/NewRoad_version folder.

SETTLEMENT THREAT – Based on Village Population Data (Census 2005)

We undertook two different approaches to reflect variation of people behaviour on the landscapes

Population Pressure

Pressure program *(ArcInfo AML)*

(-1 * sqrt(1000) * sqrt(3.14) * ([Distance to rapids1]) / 1000) + (1000)

We adjusted it – to support 2 people per sq km as people are more opportunistic here and they also do other activities not only rely on hunting for food. We divided the population by half to run the program. Replace the value of where the village is with the actual population number of the village.

Population pressure for the whole Landscape: Namkading\HumanInputs\PopPressure\Popress_noCost

Population Pressure/Poppress_noCost folders

Popress – run all villages at the same time including villages within urban areas

popress_urb - final grid run with AML that calculates impact of 2 people per 1 sq km was run just on population size of the village and not multiplied by any weight. It was run on the village coverage without urban settlements (deducted by urbanbuff0)

Population pressure – hunting for trade

We weighted different villages differently depending on their proximity to roads and other travel routes. The program was then re-rerun.

PopTrade – final grid that represent 2 people per 1 sq km run on Pop2 field. The grid represent hunting pressure for trade multiplied by trade field

Population pressure – hunting for subsistence

We weighted different villages differently depending on their proximity to roads and other travel routes. The program *(ArcInfo AML)* was then re-rerun.

PopSubs – final grid that represent 2 people per 1 sq km run on Pop2 field. The grid represent hunting pressure for subsitence multiplied by Subs field

Population pressure for The Nam Kading area Namkading\Namkading_NK\Analysis\Before_Workshop\Threat_landscapes\Hunting

Popress_a – run all villages at the same time including villages within urban areas

popress_b - final grid run with AML that calculates impact of 2 people per 1 sq km (C:\Namkading_Aug06\PopPressure\Pressureprogram) was run just on population size of the village and not multiplied by any weight. It was run on the village coverage without urban settlements (deducted by urbanbuff0)

- Use village population data and access layer to sample:
  - ArcToolBox → Spatial Analyst → Extraction → Sample
  - Input Raster: Access Layer (Access_thrt)
  - Input Location Raster/point data: population data (Lands_pop)
  - Output layer location: *put it in anywhere you want.*
- Once that done:
  - Link the table to the original population layer (remember to create a new Column in the population layer's attributes first – can call it 'Trade').
  - Copy the information from the linked table to the Trade column (the information about scores that were assigned for each village depends on which area of severity it falls into. To copy, right click on the trade column and click on Calculate Values… just double click on the column you want to copy the values off and click OK.
- To run AML:
  - Open ArcInfo 'Arc'
  - The data required are population (in coverage format) and cost surface layer. Put them all in the same folder.
  - Arc: *w g:\work\wcs….\hunting* (**This command will change the directory to** *g:\work\wcs….\hunting* **where you want your file to run.)**
  - *SHAPEARC* (to change shapefile to Arc coverage)
  - *Lc* (to check if the file created by listing the coverages in out orking directory)
  - *Lg* (to list the grid layers in the working directory)
  - Copy all the scripts "PressureProgramme" to the same working folder
  - Arc : &r <Name of AML file> → ENTER
  - : pop_hunt (name of the pop coverage you want to use) → ENTER
  - No feature: (enter number of features of the pop_hunt layer that you want to run)
  - …. Pop number: POP (The column that contains the number of people in each village)
  - …mask grid: travcost_cur (to set the analysis extend to the same layer as travcost_cur)
  - Grid cell size: 400 (to make it run faster)
  - Output grid: <Name> → ENTER
  - Once this process is done, we need to normalize it)
  - Arc: &r <name of the AML file that can be used to normalize> (normailis.aml)
  - Output grid name: <Name of output grid that you'll produce>
  - Immerdiate grid : <any name you want to put, it's only immediate file>
  - Interest grid: <name of the grid (can be any grid) that you want base your analysis extend on>
  - Grid cell size: 100 (This is where you can go back to the original grid size)
  - Name of output: <name of the final output>
  - …: Q (to quite)

Population pressure – hunting for trade

We weighted different villages differently depending on their proximity to roads and other travel routes. The program was then re-rerun.

PopTrade – final grid that represent 2 people per 1 sq km run on Pop2 field. The grid represent hunting pressure for trade multiplied by trade field

Population pressure – hunting for subsistence

We weighted different villages differently depending on their proximity to roads and other travel routes. The program *(ArcInfo AML)* was then re-rerun.

PopSubs – final grid that represent 2 people per 1 sq km run on Pop2 field. The grid represent hunting pressure for subsitence multiplied by Subs field

Population pressure based on the cost surface

Cost-surface analysis

Data in Folder Travel_cost

We could create two different cost-surfaces depending on the season dry season vs. wet season when certain roads are no longer accessible and when rivers can play more important role for people to navigate across the landscape. Hunting is more opportunistic in Lao and people once performing other activities may hunt for other species if they encounter them. Certain species are hunted for food, and once bigger are found they can be either sold to the markets..
All hunting is primarily restricted by access to places and how easy it is to travel through the landscape.

Run cost.aml to calculate the pressure of individual villages on the landscape based on the cost-surface (how they can move across the landscape taking into account different landscape structures – roads, rivers, mountains)

In cost_surface_inputs FOLDER

ROADS and RIVERS
smriv_rec – The river grid that represents the river distance layer recoded so, within 100 meter buffer of river the values are 15 and then everything else is 1. (Don't forget to set your analysis mask).

- Calculate the distance to the small rivers (small_rivers.shp) first, no maximum distance.

- Then : smriv_rec =

  con ([smriv_dist]) <= 100, 15, 0)

majriv_rec - The river grid that represents the river distance layer recoded so, within 100 meter buffer of river the values are 5 and then everything else is 1.

- Calculate the distance to the small rivers (River_Major_line_NGD_NK) first.
- And use the same formula as above to generate **majric_rec**.

  con ([majriv_dist]) <= 100, 5, 0)

I used only Weighting system within 100 meters, as this is really the weight of the road/river and the buffer from the road does not matter as much.

The weight **Within 100 meter** and outside = 0

Rivers		Rivers		Roads		Roads		Roads	
major	score	small	score	major	score	unpaved	score	footpath	score
100 m	5	100m	15	100 m	0	100m	10	100m	15

As above for roads

Various scenarios of wieightin outside of roads
Majrds_rec4 - Major roads – **0** – outside weighted as 200

Set the maximum distance to 100m.
con ([Distance to bigroad selection] <= 100, 0, 200)

majriv_rec - Majriv = **5**

unprd_rec - Unpaved roads = **10**
smriv_rec - Small rivers = **15**

foot_rec - Footpath = **15**

SLOPE

Slope can be limited factor especially along the river in Nam Kading where the river is surrounded by boulders and steep slopes that serve as a barrier to the movement.
Slp_rec – reclassified slope degrees according to the difficulty of traveling through landscape at different slopes
Scores as following:

Slope	
	score
0-2	1
2-5	5
5-10	10
11-15	20

16-20	50
21-25	60
26-30	80
30-35	100
>35	1000

VEGETATION
We reclassified vegetation cover according to the difficulty of moving across it.

Veg_reclass – reclassify rock to no data as not penetrable area for people. Later on this becomes 1000

Land Cover	score
Urban	5
Agriculture	5
Regeneration Forest	20
Secondary Forest	20
Forest Plantation	20
Savannah	20
Scrub	80
Grassland	20
Mixed Broad-Leaved	30
Coniferous Forest	20
Lower Dry Evergreen	40
Upper Dry Evergreen	40
Lower Mixed Deciduous	40
Upper Mixed Deciduous	40
Dry Dipterocarp	20
Bamboo	80
Riparian	90
Swamp	100
Water	5
Rock	1000

IMMPASABLE AREAS
We incorporated information about the areas that are not as easily accessible along the Nam Kading River due to high rapids. This information was reviewed with Arlyne who collected all information along the river.

Get immpasable areas:
Imp_buf100 - I recoded 0 in Imp_buf5km0 to the value of 100 to represent outside difficulty of movement within the buffer
prtim_buf50- I recoded 0 in Prtim_buf5km0 to the value of 50 to represent outside difficulty of movement within the buffer

Impassable Area

imp_rec0 – *riv_imp_1000* and *imp_buf5km0* put together, where the river is recoded to 1000 and the buffer around the river to 100.

con ([riv_imp_1000] eq 1000 and [imp_buf5km0] eq 5, 1000, [imp_buf5km0] eq 5, 100)

buffer the shapfile and then recode it to imp_dist where the distance 0 – 500m is called 1 and the rest 0 ?

Partially impassable
prtim_rec0 – I put together *riv_prt_cost* and *prtim_buf5km* where the river is coded 100 and area within 5 km of buffer around the river is recoded to 90

con ([riv_prt_cost] eq 100 and [prtim_buf5km0] eq 5, 100, [prtim_buf5km0] eq 5, 90)

buffer the shapfile and then recode it to prtim_dist where the distance 0 – 500m is called 1 and the rest 0"

Partially and impassable put together

imp_prt_all – Combined two layer of passable and partially impassable areas.

con ([imp_rec0] ge 100 and [imp_dist] eq 1, 1000, [imp_rec0] eq 100, 110, [prtim_rec0] ge 90 and [prtim_dist] eq 1, 100, [imp_rec0] eq 90, 90, [prtim_rec0])

FINAL COST SURFACE:

I created various Scenarios of Cost surface depending on how much we wanted transportation routes to be emphasized for the analysis.

NOTE: I did not leave all grids I created because it was too many, so I selected the only ones we actually used for the analysis. But I keep just general idea here.

Cost_surf files – created based on the recoded slope, major and unpaved roads, major and small rivers. The difficulty of moving across the roads and rivers is defined by the steepness of the terrain. This is kept separate from the difficultu of moving across the vegetated terrain that is also modifie by the overall diffuclty of not moving across the major transportation routes. Depending on what impact I have outside the major roads, I was including different **majrds_rec** files (1 – 5).

con ([slp_rec] > 0 & [majrds-rec4] == 0, [slp_rec] + [majrds-rec4], [slp_rec] > 0 & [smriv_rec] == 15, [slp_rec] + [smriv_rec], [slp_rec] > 0 & [unprd_rec] == 10, [slp_rec] + [unprd_rec], [slp_rec] > 0 & [majriv_rec] == 5, [slp_rec] + [majriv_rec], [slp_rec] > 0 & [foot_rec] == 15, [slp_rec] + [foot_rec], [slp_rec] > 0 & [veg_reclass] > 0, [slp_rec] + [veg_reclass] + [majrds-rec4])

Travel Cost Final

everything above 1000 called 2000
con ([Cost_surf_5] ge 1000, 2000, [Cost_surf_5])

From here you can use the Travel Cost Final layer to run the following steps for Hunting

HUNTING based on the COST SURFACE

WHOLE LANDSCAPE

We experimented with the analysis to test the impact of the area outside of roads and resolution on the results. I am including only the results we decided to use for the workshop.

Folder *PopPressure/* *cell400_final_6fin*
The analysis run **travcost6** with the cell size of 400.

- Use village population data and access layer to sample:

  - ArcToolBox → Spatial Analyst → Extraction → Sample
  - Input Raster: Access Layer (Access_thrt)
  - Input Location Raster/point data: population data (Lands_pop)
  - Output layer location: *put it in anywhere you want.*
- Once that done:
  - Link the table to the original population layer (remember to create a new Column in the population layer's attributes first – can call it 'Trade').
  - Copy the information from the linked table to the Trade column (the information about scores that were assigned for each village depends on which area of severity it falls into. To copy, right click on the trade column and click on Calculate Values… just double click on the column you want to copy the values off and click OK.
- To run AML:
  - Open ArcInfo 'Arc'
  - The data required are population (in coverage format) and cost surface layer. Put them all in the same folder.
  - Arc: *w g:\work\wcs….\hunting* (**This command will change the directory to** *g:\work\wcs….\hunting* **where you want your file to run.)**
  - *SHAPEARC* (to change shapefile to Arc coverage)
  - *Lc* (to check if the file created by listing the coverages in out orking directory)
  - *Lg* (to list the grid layers in the working directory)
  - Copy all the scripts "Costweight_arcInfo" to the same working folder
  - Arc : &r <Name of AML file> → ENTER
  - : pop_hunt → ENTER
  - No feature: (enter number of features of the pop_hunt layer that you want to run)
  - Pop variable: POP (The column that contains the number of people in each village)
  - ……. weight: Trade (The field that contains weights of population pressure)
  - …interest grid: travcost_cur (to set the analysis extend to the same layer as travcost_cur)
  - Grid cell size: 400 (to make it run faster)
  - Output grid: <Name> → ENTER
  - Once this process is done, we need to normalize it)
  - Arc: &r <name of the AML file that can be used to normalize> (normailis.aml)
  - Output grid name: <Name of output grid that you'll produce>
  - Immerdiate grid : <any name you want to put, it's only immediate file>
  - Interest grid: <name of the grid (can be any grid) that you want base your analysis extend on>
  - Grid cell size: 100 (This is where you can go back to the original grid size)
  - Name of output: <name of the final output>
  - …: Q (to quite)

Trade400_6fin – Final layer for the hunting for trade run on pop and trade field

Subs400_6fin – Final layer for the hunting for subsistence run on pop and subs field

fin_hunt_cur1 – current hunting threat version1 that was run for the whole landscape at the same time.
G:\Living_Landscape\Namkading\HumanInputs\hunting\current

fin_hunt_cur2 – current hunting threat version2 that was run for two parts of the landscape separately as we assumed that people may not really travel from one end to the another. This version represents a little bit less hunting impact.
G:\Living_Landscape\Namkading\HumanInputs\hunting\current

fin_hunt_fut1 – future hunting threat version1 that was run for the whole landscape at the same time.
G:\Living_Landscape\Namkading\HumanInputs\hunting\future

fin_hunt_fut2 – future hunting threat version2 that was run for two parts of the landscape separately as we assumed that people may not really travel from one end to the another. This version represents a little bit less hunting impact.
G:\Living_Landscape\Namkading\HumanInputs\hunting\future

NAM KADING AREA ONLY

VERSION 1 - Folder *pop_NK/* *cell200__6fin* **((USED FOR THE WORKSHOP))**
The analysis run **trav6nk** with the cell size of 200.

Trade200thrt – Final layer for the hunting for trade run on pop and poptrade fields (now it should be trade field)

Subs200thrt – Final layer for the hunting for subsitence run on pop and popsubs fields (now it should be subs field)

VERSION 2 - Folder *pop_NK/* *cell400__6fin*
The analysis run **trav6nk** with the cell size of 400.

Trade400thrt – Final layer for the hunting for trade run on pop and poptrade fields (now it should be trade field)

Subs400thrt – Final layer for the hunting for subsitence run on pop and popsubs fields (now it should be subs field)

MODIFICATION OF SUBSISTENCE HUNTING WITH THE DISTANCE RUN MODEL: in the cell200_6fin_dist folder

Run at the cell 200 (dist200s_6f2) _ FINAL SELECTED FOR THE ANALYSIS

AML

```
/* reclassify distance for the costsurface

rec%i% = con (euc%i% ge 30000, 150, 0)

/* create costsurface for the location

cost%i% = con (%costgrid% ge 1000, 2000, %costgrid% ge 400 and %costgrid%
le 1000, 1000, %costgrid% ge 0 and rec%i% eq 0, %costgrid%, rec%i% +
%costgrid%)
```

MODEL RUN ON THE BASE OF NEW ACCESS2 LAYER THAT INCORPORATED NEW IMPROVED UNPAVED ROAD AND TREATS IT AS THE MAJOR ROAD – (NOTE – COST SURFACE DID NOT INCORPORATE THAT) \. The results are in Trade_newRoad_future folder

Trade400_f6 – model run for the trade on 400 cell on trav6nk cost surface, Run with the regular AML not restricting the movement**.**

CORRECTIONS AFTER WORKSHOP FOR THE FINAL CONSERVATION LANDSCAPES – DONE ONLY FOR NAM KADING

PRESENT HUNTING (use 400 cell resolution)

Close to the village people might get pigs..so we are adding the layer to the hunting layer to incorporate the more hunting around each village (more subsistent hunting). . We are deciding on the **400** resolution grids for the analysis

Vill_thrt - I used villages and then assumed that within 500 meters from the village impact is 100 and then it decreases to 0 once it reached 5000 km from the village.

int (con ([Distance to newpop1 point] le 500, 100, con ([Distance to newpop1 point] gt 500 and [Distance to newpop1 point] le 5000, (-0.02) * [Distance to newpop1 point] + 111, 0)))

Now we could think about modifying threat from hunting with the threat around the village as an additional layer that we could emphasize the hunting around the villages.

Modified with the hunting around each village within 5 km from the village location
Trd400_mod = (([vill_thrt] + ([trade400thrt] * 2)) / 3)

Final – where we bring the maximum values of modified with villages and trade layers

Trd400vill_c = max ([Trd400_mod], [trade400thrt])

FUTURE HUNTING (use 400 cell resolution)

We added current and future landscapes together, to keep the original values in the current landscapes instead of lowering them with the new future landscape. We are deciding on the 400 resolution grids for the analysis (trade400_f6)

Trd400add_cf = max ([trade400thrt], [trade400_f6])

Modified with the hunting around each village within 5 km from the village location

Trd400mod_cf = (([vill_thrt] + ([Trd400add_cf] * 2)) / 3)

Final – where we bring the maximum values of modified with villages and trade layers

Trd400vill_cf = max ([Trd400mod_cf], [Trd400add_cf])

Conservation Landscapes – FIRST SUGGESTIONS

ELEPHANT

1. Simple overlap of threat and biological landscapes

This is accomplished with 3 steps: (1) collapse biological landscape into 3 equal classes (10, 20, 30 = low, medium, high habitat quality) using the reclassify menu and the reclassified legend file collapsebio102030.avc, (2) collapse threat landscape into 3 equal classes (1, 2, 3 = low, medium, and high threat) using collapsethreats123.avc, (3) add the results of steps 1 and 2. The resulting grid has 9 different combinations of habitat quality and threat level (e.g., 23 = medium habitat quality, high threat; 31 = high habitat quality, low threat). The legend file combo.avl will label and shade these combinations appropriately.

eleconsag – the threat to elephant from agriculture (Elehagthrt) combined with the biological landscape (elebiol), so one can see where this threat overlaps with high biological areas.
([Reclass of Elebiol] + [Reclass of Elehagthrt])

eleconstrade – the threat to elephant from hunting for trade (Eletradethrt) combined with the biological landscape (elebiol), so one can see where this threat overlaps with high biological areas.
([Reclass of Elebiol] + [Reclass of Eletradethrt])

Since hunting for trade was assigned low value of threat (20 out of 100), the resulting landscape has a low threat value for all habitat quality types.

eleconsland – the combined conservation landscape for elephant (elebio and elethreatlnd collapsed into 3 groups and put summed together)

([Reclass of Elethreatlnd] + [Reclass of Elebiol])

2. Benefit/Ratio Conservation landscape

1. We evaluated by how much the population of elephants would be reduced in the location where the threat is the most severe. Both agricultural and hunting for trade threat would result in 15% reduction of elephant population. We applied the following formula to calculate the reduction in population:

```
100 – ((100-(0.15*Agriculture))* (100-(0.15*Hunting-Trade))/100)
```

elepercred – we calculated the percentage reduction in population abundance of elephants due to agriculture and hunting for trade

101 - ((100 - (0.15 * [elehagthrt])) * (100 - (0.15 * [Eletradethrt])) / 100)

9. Calculate the actual population loss due to threats based on the percentage reduction of abundance

```
Species lost= Potential Hab Eff. * % Tot reduction in Abundance/100
```

Eleloss – we calculated the number of elephants potentially lost due to current and past impacts of agriculture and hunting for trade applying the formula:

Int (([elebiol] * [elepercred]) / 100)

10. Calculate the current landscape that represents what is happening on the ground.

Biological effective habitat – species lost

Elecurrent – current elephant biological landscape

[elebiol] - [eleloss1]

11. Weighted cost layer (just a sample)

Elecost - For the purpose of demonstration I assumed that reduction of conflict at the agricultural fields is higher than reduction of hunting for trade and this it was weighted 0.9 whereas hunting for trade was assigned the weight of 0.7

([elehagthrt] * 0.9) + ([Eletradethrt] * 0.7)

12. Calculate benefit/ratio

Elebencost – benefit and cost of conservation of elephant population

[eleloss] / [elecost]

([Agric_ed] .IsNull).con (0.AsGrid, 2.AsGrid)

Conservation Landscapes – FINAL NOVEMBER 2006

Elephant

Elebiol = potential habitat quality / potential abundance

- no habitat displayed as 0
- low habitat
- medium habitat = agric
- high habitat all above agric

- agric. not ideal habitat but important when come between patches of best habitat

- (overlay with workshop's current / future conflicts and current presence)

- eleph already squeezed between good and no habitat, difficulty to move around, have to pass through agric because no other ways

elebiol_rec - recoded elebiol

new classes:

- 0 as no habitat – new value = 0
- 1-20 as low habitat – new value = 10
- 20 -50 as medium, incl. agric – new value = 20
- >50 as good habitat – new value = 30

Threat

1. hunting-trade (fin_hunt_fut1) potentially 100 % reduction of ele pop
2. agriculture conflict potentially 90 % reduction of ele pop

ele_red_c = past/current activities weighted = total weighted impact of past/current activities

Ele % reduction = 100 - (((100 - [ele_c_thrt] * 0.9) * (100 - [fin_hunt_fut1] * 1)) / 100)

ele_lost_c = (species lost) combination elebiol and elethreat to express the % of the potential abundance (quality) in the unit lost due to past/current human impacts

(reduction of potential habitat quality to support high density of ele due to current threats)

[elebiol] * [ele_red_c] / 100

ele_bio_curr = current habitat quality / current abundance

[elebiol] – [ele_lost_c]

elethr_c_rec - recoded legend of ele_lost_c

new classes:

- 0 = no habitat, no lost – new value = 0
- < 10 = low lost – new value = 1
- > 10 < 40 medium lost – new value = 2
- > 40 high lost – new value = 3

ele_cons_c – final current conservation landscape

[elethr_c_rec] + [elebiol_rec]

Leg

- 33 high bio high thr
- 32 high bio med thr
- *31 high bio low thr*
- 23 med bio high thr
- 22 med bio med thr
- *21 med bio low thr*
- *11 low bio low thr*
- 0 no hab

Pig

Pigbiol = potential habitat quality / potential abundance

- no habitat displayed as 0
- low habitat
- medium habitat = agric
- high habitat all above agric

- agric. not ideal habitat but easy habitat

- (overlay with workshop's current / future conflicts and current presence)

pigbio_rec - recoded pigbiol

new classes:

- 0 as no habitat – new value = 0
- 1-33 as low habitat – new value = 10
- 33-75 as medium, incl. agric – new value = 20
- >75 as good habitat – new value = 30

Threat
1. hunting trade — potentially 70 % reduction of pig pop
2. agriculture conflict — potentially 50 % reduction of pig pop

pig_red_c = past/current activities weighted = total weighted impact of past/current activities

Pig % reduc = 100 - (((100 - [pig_c_thrt] * 0.5) * (100 - [fin_hunt_fut1] * 0.7)) / 100)

pig_lost_c = (species lost) combination pigbiol and pigthreat to express the % of the potential abundance (quality) in the unit lost due to past/current human impacts

(reduction of potential habitat quality to support high density of pigs due to current threats)

[pigbiol] * [pig_red_c] / 100

pig_bio_curr = current habitat quality / current abundance

[pigbiol] - [pig_lost_c]

pigthr_c_rec - recoded legend of pig_lost_c

new classes:
- 0 = no habitat, no lost – new value = 0
- 1-30 = low lost – new value = 1
- 30-45 medium lost – new value = 2
- > 45 high lost – new value = 3

pig_cons_c – final current conservation landscape

[pigthr_c_rec] + [pigbio_rec]

Leg
- 33 high bio high thr
- 32 high bio med thr
- 31 high bio low thr
- *23 med bio high thr*
- *22 med bio med thr*
- *21 med bio low thr*
- *11 low bio low thr*
- 0 no hab

Serow

Serbiol = potential habitat quality / potential abundance

serbio_rec - recoded serowbiol

new classes:

- 0 as no habitat – new value = 0
- 1-30 as low habitat – new value = 10
- 30-50 as medium, incl. agric – new value = 20
- >50 as good habitat – new value = 30

Threat

1. hunting potentially 95 % reduction of serow pop

ser_red_c = past/current activities weighted = total weighted impact of past/current activities

Serow % reduction = 100 - (100 - ([fin_hunt_fut1] * 0.95))

ser_lost_c = (species lost) combination serbiol and serthreat to express the % of the potential abundance (quality) in the unit lost due to past/current human impacts

(reduction of potential habitat quality to support high density of serows due to current threats)

[serowbiol] * [ser_red_c] / 100

ser_bio_curr = current habitat quality / current abundance

[serowbiol] - [ser_lost_c]

serthr_c_rec - recoded legend of ser_lost_c

new classes:

- 0 = no habitat, no lost – new value = 0
- 1-30 = low lost – new value = 1
- 30-40 medium lost – new value = 2
- > 40 high lost – new value = 3

ser_cons_c – final current conservation landscape

[serthr_c_rec] + [serbio_rec]

Leg

- 33 high bio high thr
- 32 high bio med thr
- 31 high bio low thr
- *23 med bio high thr*
- *22 med bio med thr*
- *21 med bio low thr*
- *11 low bio low thr*
- 0 no hab

Tiger

Tigbiol = potential habitat quality / potential abundance

tigbio_rec - recoded tigerbiol

new classes:

- 0 as no habitat – new value = 0
- 1-30 as low habitat – new value = 10
- 30-70 as medium, incl. agric – new value = 20
- >70 as good habitat – new value = 30

Threat

4. hunting (fin_hunt_fut1) potentially 90 % reduction of tiger pop
5. livestock predation potentially 70 % reduction of tiger pop
6. prey depletion (fin_hunt_fut1) potentially 90 % reduction of tiger pop

tig_red_c = past/current activities weighted = total weighted impact of past/current activities

Tig % reduction = 100 - (((100 - [tigliv_thrt] * 0.7) * (100 - [fin_hunt_fut1] * 0.9) * (100 - [fin_hunt_fut1] * 0.9)) / 10000)

tig_lost_c = (species lost) combination tigbiol and tigthreat to express the % of the potential abundance (quality) in the unit lost due to past/current human impacts

(reduction of potential habitat quality to support high density of tigers due to current threats)

[tigerbiol] * [tig_red_c] / 100

tig_bio_curr = current habitat quality / current abundance

[tigerbiol] - [tig_lost_c]

tigthr_c_rec - recoded legend of tig_lost_c

new classes:

- 0 = no habitat, no lost – new value = 0
- 1-50 = low lost – new value = 1
- 50-60 medium lost – new value = 2
- > 60 high lost – new value = 3

tig_cons_c – final current conservation landscape

[tigthr_c_rec] + [tigbio_rec]

Leg

- 33 high bio high thr
- 32 high bio med thr
- 31 high bio low thr
- 23 med bio high thr
- *22 med bio med thr*
- *21 med bio low thr*
- *11 low bio low thr*
- *0 no hab*

Gibbon

Gibbiol = potential habitat quality / potential abundance

gibbio_rec - recoded gibbiol

new classes:

- 0 as no habitat – new value = 0
- 1-40 as low habitat – new value = 10
- 40-60 as medium, incl. agric – new value = 20
- >60 as good habitat – new value = 30

Threat

1. hunting potentially 100 % reduction of gibbon pop

Logging is not considered as a ongoing threat given past/current logging has been incorporated (a posteriori) into our agr_pln layer and on the gibbon biological landscape.

gib_red_c = past/current activities weighted = total weighted impact of past/current activities

Gib % reduction = 100 – (100 – [fin_hunt_fut1] * 1)

Gib % reduction = [fin_hunt_fut1]

gib_lost_c = (species lost) combination gibbiol and gibthreat to express the % of the potential abundance (quality) in the unit lost due to past/current human impacts

(reduction of potential habitat quality to support high density of gibbons due to current threats)

[gibbiol] * [gib_red_c] / 100

gib_bio_curr = current habitat quality / current abundance

[gibbiol] - [gib_lost_c]

Threat

1. logging potentially 90 % reduction of gibbon pop

gib_red_cf = current + future activities weighted = total weighted impact of current/future activities

Gib % reduction = 100 - (((100 - [fin_hunt_fut1] * 1) * (100 - [logging] * 0.9)) / 10000)

gib_lost_cf

[logging] * [gib_red_cf] / 100

While this landscape should be shown to the audience to highlight areas of future logging threat, we are actually reducing the value of areas which are yet to be logged. In reality we wouldn't use it as such in calculating conservation landscape given logging is yet to actually occurs there.

gibthr_cf_rec - recoded legend of gib_lost_c

new classes:

- 0 = no habitat, no lost – new value = 0
- 1-30 = low lost – new value = 1
- 30-40 medium lost – new value = 2
- > 40 high lost – new value = 3

gib_cons_cf – final current conservation landscape

[gibthr_cf_rec] + [gibbio_rec]

Leg

- 33 high bio high thr
- 32 high bio med thr
- 31 high bio low thr
- 23 med bio high thr
- 22 med bio med thr
- 21 med bio low thr
- 12 low bio med thr
- 11 low bio low thr
- 0 no hab

Hornbill

Hornbiol = potential habitat quality / potential abundance

hornbio_rec - recoded hornbiol

new classes:

- 0 as no habitat – new value = 0
- 1-60 as medium habitat – new value = 20
- >60 as good habitat – new value = 30

Threat

1. hunting trade potentially 100 % reduction of hornbill pop

Logging is not considered as a ongoing threat given past/current logging has been incorporated (a posteriori) into our agr_pln layer and on the hornbill biological landscape.

horn_red_c = past/current activities weighted = total weighted impact of past/current activities

Horn % reduction = 100 – (100 – [fin_hunt_fut1] * 1)

Horn % reduction = [fin_hunt_fut1]

horn_lost_c = (species lost) combination hornbiol and hornthreat to express the % of the potential abundance (quality) in the unit lost due to past/current human impacts

(reduction of potential habitat quality to support high density of hornbills due to current threats)

[hornbiol] * [horn_red_c] / 100

horn_bio_curr = current habitat quality / current abundance

[hornbiol] - [horn_lost_c]

Threat

2. logging potentially 100 % reduction of hornbill pop

horn_red_cf = current + future activities weighted = total weighted impact of current/future activities

Horn % reduction = 100 - (((100 - [fin_hunt_fut1] * 1) * (100 - [logging] * 1)) / 10000)

horn_lost_cf

[logging] * [horn_red_cf] / 100

While this landscape should be shown to the audience to highlight areas of future logging threat, we are actually reducing the value of areas which are yet to be logged. In reality we wouldn't use it as such in calculating conservation landscape given logging is yet to actually occurs there.

hnthr_cf_rec - recoded legend of horn_lost_c

new classes:

- 0 = no habitat, no lost – new value = 0
- 1-30 = low lost – new value = 1
- 30-40 medium lost – new value = 2
- > 40 high lost – new value = 3

horn_cons_cf – final current conservation landscape

[hnthr_cf_rec] + [hornbio_rec]

Legend

- 33 high bio high thr
- 32 high bio med thr
- 31 high bio low thr
- 23 med bio high thr
- 22 med bio med thr
- 21 med bio low thr
- 12 low bio med thr
- 11 low bio low thr
- 0 no hab

hunting - loads of elephant habitat in Laos; definitely hunting
they may hunt for tigers n elephants, but prob not a full-time job
same for tigers - absolutely it's hunting; habitat not a problem
both - habitat loss and hunting; but with almost EVERY species of wildlife I can think of in Laos, there is more habitat than there are animals; that is, if hunting stopped today, 100%, populations of almost every species in Laos would increase dramatically. Habitat is not the main shortcoming

Building Conservation Landscape Using Eric's Method

Gibbon

6. **Population Target Levels for each species**.
   Optimal density of gibbons in the best habitat would be 1 family group per 30 hectares. Estimating an average of 4 individuals per family group, this would equate to a density of ~13 individuals / sq km. (CITE; Historical Level)

7. **Gib_TPA - Potential Biological Landscapes translated into abundance**
   Biological models represent the potential of the landscape in the absence of threat. In order to compare them to the population target levels and combine them with the human landscapes, we need to translate them into units of abundance (e.g. numbers of individuals per mapping unit, biomass per unit, etc.).

   According to Eric instruction, highest potential abundance (HPA) should be calculated by using this formula:

   HAP = # animals/ sq km * Analysis cell size

   Our analysis grid cell size is 0.01 sq km (100 meters * 100 meters = 10, 000 sq meters)

   HPA = 13 animals/km^2 * 0.01 km^2/cell = 0.13 gibbons

   To rescale the biological landscape (gibbiol) expressed in units of 0 - 100, multiply highest potential abundance estimate (HPA) by the biological landscape score divided by 100, as follows:

   Total Potential Abundance (TPA) = HPA * biological landscape / 100

   Gib_TPA = [gibbiol] * 0.13 / 100

   Potential numbers of gibbon in the landscape are 320, 722 gibbon

8. **Threat Landscapes** are your models of the distributions of human activities that affect your species. You only need to bring prepare those Threat Landscapes which have important impacts on the 2-3 species you've selected. Please be prepared to answer questions about whether these landscapes represent past, likely future, or current impacts on landscape species.

a. In you case, we have to think about past/current and future threats. For example, I think we will have to use the hunting pressure we calculated originally without reservoirs as this represents what was happening to animals till now (how many we lost so far). Once we incorporate the reservoirs into the hunting layer, we are changing the hunting pattern in the future and how that will affect animals in the future. WE cannot use this layer as the estimate of animals lost from past till now because, people could not access certain areas (e.g. Nam Kading river rapids) but now they will be able to. SO in this case we will have to break it into past/future and this is how you decision on where to work have to combine this information.

Gib_TPCR - Total (%) of Past/Current Reduction

hunting potentially 100 % reduction of gibbon pop

Logging – Logging is not considered as a ongoing threat given past/current logging has been incorporated (a posteriori) into our agr_pln layer and on the gibbon biological landscape.

Fragmentation - The impact of fragmentation on the gibbon population was incorporated into biological model. We estimated that size of connected patches and assigned a suitability value to the patches. This is the file **gbvegrgrec.**

So both logging and fragmentation were already incorporated into biological landscapes (Eric calls it inside threats)

Gib_TPCR = 100 – (100 – [fin_hunt_cur1] * 1)

Gib_TPCR = [fin_hunt_cur1]

Gib_TFR1 - Total (%) of Future Reduction

hunting potentially 100 % reduction of gibbon pop

Gib_TFR1 = 100 – (100 – [fin_hunt_fut1] * 1)

Or **Gib_TFR1 =** [fin_hunt_fut1]

Gib_TFR2 - Total (%) of Future Reduction in the worse case scenario

hunting potentially 100 % reduction of gibbon pop

logging potentially 90 % reduction of gibbon pop

Future activities weighted = total weighted impact of current/future activities

Gib_TFR2 = 100 - (((100 - [fin_hunt_fut1] * 1) * (100 - [logging] * 0.9)) / 100)

9. Maps of Potential Conservation Impact. Combine your Biological and Threat Landscapes to indicate the potential impact that conservation actions could have across the landscape, in terms of number of animals. This is what in our exercise represented % of habitat loss (in our case now it will be number of animals lost)

Calculate the total impact of threats on species – this is what we have done where we calculated the percentage of animals lost. We will just translate it into numbers now since we have a biological landscape in numbers.

Total Conservation Impact = Total Pot. Abun * Total (%) of Reduction / 100

This is our conservation impact layer!!!! – as it tells us how many animals we lost and this is a layer to be annotated. This layer will tell us how many animals we lost.

Gib_TCI_Cur – Conservation impact on gibbon population. **This is the layer to be annotated. It tells us how many gibbons we have lost so far.**

Gib_TCI_Cur = [Gib_TPA] * [Gib_TPCR] / 100

We have lost 183,982 gibbons

Now we calculate the current biological landscape layer in order to evaluate the potential of future impacts.
This is the layer that tells you how many animals you have on the current landscape. This is a current abundance estimated after threats.

Current Biological Landscape = Total Pot. Abun – Total Current Conservation Impact

Gib_CBL – Current abundance of gibbon population.

Gib_CBL **=** [Gib_TPA] - [Gib_TCI_Cur]

Current number of gibbons is 136,472
There are 5416 gibbons in the NK NPA

Now we can calculate the future impacts. (future conservation impact layer)

Future Cons Impact = Current Biological Landscape * Total (%) of Future Reduction / 100

Gib_FCI1 – Total future threat impact on gibbon population.

Gib_FCI1 = [**Gib_CBL**] * [**Gib_TFR1**] / 100

71,556 gibbons we can potentially lose in the future

This is the layer that shows how many animals you can potentially lose if future threats happen. This layer along with the past conservation impact layer will be used to make decision on where to work.

Gib_FCI2 – Total future threat impact on gibbon population for worse case scenario where potential impacts of logging was incorporates in the future threat layer.

Gib_FCI2 = [**Gib_CBL**] * [**Gib_TFR2**] / 100

78,114 gibbons we can potentially lose in the future if we take into account the logging threat

Calculate the future biological landcape :

Fut Bio Landscape = Current Biological Landscape - future conservation impact

Gib_FBL1 - future biological landscape that indicates the number of animals you will have if threats are happening.

Gib_FBL1 = [**Gib_CBL**] – [**Gib_FCI1]**

63,884 gibbons

Gib_FBL2 - future biological landscape that indicates the number of animals you will have if the logging impacts on the ground are as severe as we calculated in Gib_FCI2 layer.

Gib_FBL2 = [**Gib_CBL**] – [**Gib_FCI2]**

57,129 gibbons

10. **Conservation Landscapes.** As suggested in Eric instruction. It will be an annotation of your conservation impact layer.. **Here you have to make a combined decision and look past and future impact layers. You should also have a separate layer of logging vulnerability in the future to evaluate where is the highest chance to logging happening. You decisions on where to work is based on how many animals you need (your population targets) – that in turn is driven by the cost and feasibility of doing conservation as well as probability of threat happening (that is more for the future)**

Tiger

6. **Population Target Levels for each species**.
   Optimal density of tigers in the best of conditions would be 3 individuals / 100 sq. km. (CITE; Historical Level)

7. **Tig_TPA - Potential Biological Landscapes translated into abundance**
   Biological models represent the potential of the landscape in the absence of threat. In order to compare them to the population target levels and combine them with the human landscapes, we need to translate them into units of abundance (e.g. numbers of individuals per mapping unit, biomass per unit, etc.).

According to Eric instruction, highest potential abundance (HPA) should be calculated by using this formula:

HAP = # animals/ sq km * Analysis cell size

Our analysis grid cell size is 0.01 sq km (100 meters * 100 meters = 10, 000 sq meters)

1sqkm can contain 0.03 tigers

HPA = 0.03 animals/km^2 * 0.01 km^2/cell = 0.0003 tigers

To rescale the biological landscape (tigerbiol) expressed in units of 0 - 100, multiply highest potential abundance estimate (HPA) by the biological landscape score divided by 100, as follows:

Total Potential Abundance (TPA) = HPA * biological landscape / 100

Tig_TPA = [tigerbiol] * 0.0003 / 100
1140 tigers

8. **Threat Landscapes** are your models of the distributions of human activities that affect your species. You only need to bring prepare those Threat Landscapes which have important impacts on the 2-3 species you've selected. Please be prepared to answer questions about whether these landscapes represent past, likely future, or current impacts on landscape species.

    a. In you case, we have to think about past/current and future threats. For example, I think we will have to use the hunting pressure we calculated originally without reservoirs as this represents what was happening to animals till now (how many we lost so far). Once we incorporate the reservoirs into the hunting layer, we are changing the hunting pattern in the future and how that will affect animals in the future. WE cannot use this layer as the estimate of animals lost from past till now because, people could not access certain areas (e.g. Nam Kading river rapids) but now they will be able to. SO in this case we will have to break it into past/future and this is how you decision on where to work have to combine this information.
    b. There are 2 types of threats including threats that affect habitat quality and species abundance.

Note: Just to simplify I will split it into 2 versions

VERSION 1

Version 1 – where we keep hunting for prey/tiger and livestock depredation as dependent on each other.

(%) of Past/Current Reduction caused by current hunting and prey depletion

hunting (fin_hunt_cur1)	potentially 90 % reduction of tiger pop
prey depletion (fin_hunt_cur1)	potentially 90 % reduction of tiger pop
livestock predation	potentially 70 % reduction of tiger pop

Tig_PCR1 = 100 - (((100 - [tigliv_thrt] * 0.7) * (100 - [fin_hunt_cur1] * 0.9) * (100 - [fin_hunt_cur1] * 0.9)) / 10000)

(%) of Future Reduction caused by future hunting impact and prey depletion

hunting (fin_hunt_fut1)	potentially 90 % reduction of tiger pop
prey depletion (fin_hunt_fut1)	potentially 90 % reduction of tiger pop
livestock predation	potentially 70 % reduction of tiger pop

Tig_FR1 = 100 - (((100 - [tigliv_thrt] * 0.7) * (100 - [fin_hunt_fut1] * 0.9) * (100 - [fin_hunt_cur1] * 0.9)) / 10000)

9. **Maps of Potential Conservation Impact.** Combine your Biological and Threat Landscapes to indicate the potential impact that conservation actions could have across the landscape, in terms of number of animals. This is what we have done where we calculated the percentage of animals lost. We will just translate it into numbers now since we have a biological landscape in numbers

Conservation Impact = Total Pot. Abun * (%) of Reduction / 100

We keep hunting for prey/tiger and livestock depredation as dependent on each other

Tig_TCI_Cur1 – total current conservation impact on tiger population.

Tig_TCI_Cur1 = ([Tig_TPA] * **Tig_PCR1) / 100**

Before calculating the total future conservation impact on tiger population, we have to calculate the Current Biological Landscape first.

Current Biological Landscape = Total Pot. Abun – Total Current Conservation Impact

Tig_CBL1 – Current abundance of tiger population. – report the current animal numbers

Tig_CBL1 = [Tig_TPA] - [Tig_TCI_Cur1]

Now we can calculate the total future conservation impact on tiger population starting with current tiger distribution (CBL1).

Tig_TCI_FR1 – total future potential conservation impact on tiger population.

Tig_TCI_FR1 = ([**CBL1**] * **Tig_FR1) / 100**

<u>Future Biological Landscape</u>

Tig_FBL1 – Future abundance of tiger

Fut. Bio. Landscp = Total Cur. Abun – Total Future Conservation Impact

Tig_FBL1 = [Tig_CBL1] – [Tig_TCI_FR1]

10. Conservation Landscapes. As suggested in Eric instruction. It will be an annotation of your conservation impact layer..

VERSION 3

This version follows the concept of inside/outside threats. WE can treat the prey depletion as the threat that does not affect tiger mortality directly, rather indirectly by reducing the habitat quality. On the other hand hunting and livestock depredation affect tiger's mortality directly. AS a result we will first use prey depletion threat directly in evaluating reduced habitat quality (translated to tiger abundances) and then we apply threats of hunting and livestock depredation. WE will keep hunting and livestock depredation as independent from each other and thus we will sum them.

Create reduced potential biological landscapes

1. First step we will reduce the habitat quality (tiger abundance) due to the prey depletion. We will apply the quality reduction to **totalprey** layer, as the layer that represents the prey densities that are affected by hunting. It is one of our two inputs to the tiger biological model

prey depletion (fin_hunt_cur1) potentially 90 % reduction of tiger pop

redprey = layer that represents the % of reduced prey densities due to hunting

redprey = (([fin_hunt_cur1] * 0.9) * [totalprey]) / 100

preydepl – layer that represents the reduced quality of prey densities layer. We can refer to it as current prey densities

preydepl = [totalprey] - [redprey]

Recreate biological model with reduced values for prey densities –
Redtigerbio = Reduced biological landscape (reduced abundance)

redtigerbio = ([tigerhab] + (3 * [preydepl])) / 4

We replaced totalprey with preydepl file to account for the reduced prey densities. This is the landscape we will use to deduct further tiger losses due to hunting for tigers and livestock depredation.

Now we have to convert the reduced biological landscape to abundance
Tig_RedPA = [**redtigerbio**] * 0.0003 / 100

688 or 689 Tigers

Now we estimate the tiger reduction due to prey density that will be added to other impacts
Impact due to prey depletion

Tig_TPrey_C3 = [Tig_TPA] - [Tig_RedPA]

445 or 446 **Tigers**

(%) of Past/Current Reduction caused by current hunting and prey depletion

hunting (fin_hunt_cur1)	potentially 90 % reduction of tiger pop
livestock predation	potentially 70 % reduction of tiger pop

Now we will be calculating the percent reduction of tiger population due to hunting for tigers and livestock depradataion.

Tig_PCR3 = 100 - (((100 - [tigliv_thrt] * 0.7) * (100 - [fin_hunt_cur1] * 0.9)) / 100)

11. **Maps of Potential Conservation Impact.** Combine your Biological and Threat Landscapes to indicate the potential impact that conservation actions could have across the landscape, in terms of number of animals. This is what we have done where we calculated the percentage of animals lost. We will just translate it into numbers now since we have a biological landscape in numbers

Threat Impact = Total Pot. Reduced Abun * (%) of Reduction / 100

Now when we calculate the impact on tigers due to hunting and livestock we will multiply it with the reduced biological landscape, as we already accounted for the reduced prey densities

Tig_TCI_Cur3 – total impact on tiger population where we sum impact from hunting for prey and tigers with impact from livestock depredation (This is not a conservation impact yet because we are summing threats)!!!.

Tig_TCI_Cur3 = ([Tig_PCR3] * [Tig_RedPA]) / 100

412 tigers

Now we have number of animals lost due to hunting for tiger and livestock depredation. TIG_tot_loss - Now we have to calculate the total animals lost including loss due to prey depletion. THIS CONSERVATION IMPACT LAYER

TIG_tot_loss = [Tig_TCI_Cur3] + [Tig_TPrey_C3]

858 Tigers

Before calculating the total future conservation impact on tiger population, we have to calculate the Current Biological Landscape first and Conservation Impact layer.

Current Biological Landscape = Total Pot. Abun – Total number of animals lost

Tig_CBL3 – Current abundance of tiger population.

Nw we substract the total impact on tigers due to hunting for prey/for tigers and livestock depradation from the original ideal potential biological landscape.

Tig_CBL3 = [Tig_TPA] - [TIG_tot_loss]

276 tigers (There are 6 tigers within NK NPA)

FUTURE LANDSCAPE

(%) of Future Reduction caused by future hunting impact and prey depletion

hunting (fin_hunt_fut1)	potentially 90 % reduction of tiger pop
prey depletion (fin_hunt_fut1)	potentially 90 % reduction of tiger pop
livestock predation	potentially 70 % reduction of tiger pop

Tig_FR3 = 100 - (((100 - [tigliv_thrt] * 0.7) * (100 - [fin_hunt_fut1] * 0.9) * (100 - [fin_hunt_fut1] * 0.9)) / 10000)

Now we can calculate the total future conservation impact on tiger population starting with current tiger distribution (Tig_CBL3).

Tig_TCI_FR3 – total future potential conservation impact on tiger population.

Tig_TCI_FR3 = ([Tig_CBL3] * [Tig_FR3]) / 100

208 Tigers

<u>Future Biological Landscape</u>

Tig_FBL3 – Future abundance of tiger

Fut. Bio. Landscp = Total Cur. Abun – Total Future Conservation Impact

Tig_FBL3 = [Tig_CBL3] – [Tig_TCI_FR3]

69 Tigers

12. Conservation Landscapes. As suggested in Eric instruction. It will be an annotation of your conservation impact layer.