

A preliminary study on designing ecological corridors in Xishuangbanna National Nature Reserve with 3S techniques

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Abstract This paper is based on the fieldwork in Xishuangbanna National Nature Reserve in Yunnan Province of China. GPS data of Asian elephants were collected and analyzed with the remote sensing satellite photos of the region to estimate the landform physiognomy of different colors. We also analyzed a series of ecological factors including altitude, landform, relief, villages and roads which affected the distribution and movement of Asian elephants. The results suggested the possibility of designing and establishing corridors in Xishuangbanna National Nature Reserve to protect the population of wild elephants in the region.

Keywords Asian elephant, 3S, ecological corridor, Xishuangbanna

1 Introduction

The Asian Elephant (*Elephas maximus*) is ranked as an endangered species by International Union for the Conservation of Nature and Natural Resources (IUCN), with an estimated population of about 34000–54000 around the world and only 200–250 in China (Santiapillai and Jackson, 1990; Wang, 1998). The current refuge of wild Asian elephants in China is the south and southwest of Yunnan Province. More than 90% of wild Asian elephants in China occur in Xishuangbanna, which is located in the extreme southern part of Yunnan (Feng and Zhang, 2005).

The main pressure which threatens the survival of wild Asian elephants has shifted from illegal poaching in the past to the habitat fragmentation and the severe human-elephant conflict right now (Feng and Zhang, 2005; Zhang and Wang,

2003, Zhang et al., 2003). Xishuangbanna National Nature Reserve, which is the main refuge of wild Asian elephants in China, includes five isolated sub-reserves, Mengyang, Menglun, Mengla, Shangyong and Mangao. Owing to the population growth and technique improvement, cultivation and plantation had improved a lot to meet the need of local people's life. Most areas outside the protected area had become farmlands and plantations, which resulted in the deterioration and fragmentation of the seasonal tropical rainforest ecosystem in this region. So each sub-reserve had become an "isolated green island" and the "Island Distribution Phenomenon" is becoming more and more notable in Xishuangbanna (Li, 1999).

Meanwhile, farmlands, rubber plantations and other artificial establishments had badly inhibited the gene flow among sub-reserves. As the largest herbivore, an Asian elephant needs a large continuous habitat to meet its foraging and breeding. Moreover, most wild elephants in Xishuangbanna are now divided into three isolated populations in three sub-reserves but the intercommunication among these sub-reserves is impossible now. So the fated degeneration will be expected if no measure is taken to resolve the problem.

Based on these considerations, we thought that building ecological corridors to link the isolated sub-reserves was exigent in order to protect wild elephants and the biodiversity. The aim of this study was to discuss the possibility and design of ecological corridors linking sub-reserves based on the fieldwork and the 3S techniques.

2 Studied site and methods

2.1 Studied site

Studies were carried out in Xishuangbanna National Nature Reserve, which is located at the latitudes of 21°10'–22°24' N and the longitudes of 100°16'–101°50' E. The total area of it

is 247439 hm². As a mountainous area with numbers of broad basins, the terrain of Xishuangbanna stands higher in the east, north and west than in the middle, tilting gradually from the north to the south. The branches of the Mekong River crisscross Xishuangbanna with green woods along the riverside. Tiny brooks originating deep in the jungles converge into the roaring Mekong River.

The climate type of this area belongs to the semi-humid tropical monsoon climate with the annual temperature between 15.1°C and 21.7°C, and the annual rainfall between 1196 and 2492 mm. The period between May and October is the rainy season with frequent and constant rainfalls. The dry season starts in November and ends in the following April with a serious spring drought.

Xishuangbanna National Nature Reserve is constituted by five sub-reserves: Mangao (7870 ha), Mengyang (99840 ha), Menglun (10933 ha), Mengla (926833 ha) and Shangyong (31184 ha) (Fig. 1). Wild Asian elephants distribute in only three of them: Mengyang, Mengla and Shangyong.

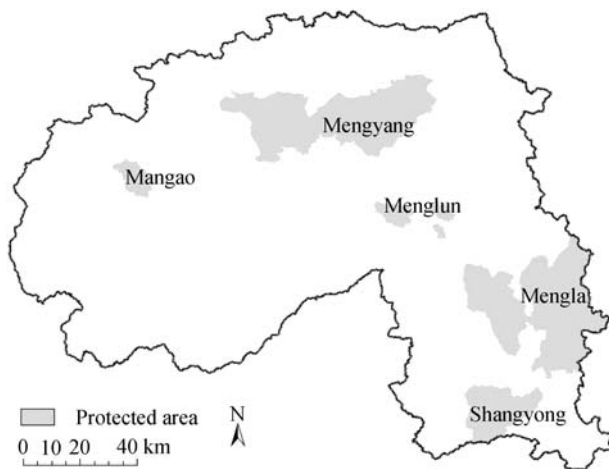


Fig. 1 Distribution of sub-reserves of Xishuangbanna National Nature Reserve

2.2 3S techniques

A geographic information system is a system for the management, analysis, and display of geographic knowledge, which is represented by use of a series of information sets such as maps and globes, geographic datasets, processing and workflow models, data models, and metadata.

The Global Positioning System (GPS) is a space-based radio-navigation system consisting of a constellation of satellites and a network of ground stations used for monitoring and controlling. A minimum of 24 GPS satellites orbit the Earth at an altitude of approximately 11000 miles providing users with accurate information on the position, velocity, and time anywhere in the world under all weather conditions.

Remote Sensing is the science and art of acquiring information (spectral, spatial, temporal) about material objects,

areas or phenomena without coming into physical contact with the object, area or phenomenon under investigation.

2.3 Sample plots in fieldwork

During our transect survey and tracking of wild elephants in the fieldwork, plots were sited at intervals of 2 km and variables such as longitude\latitude, elevation, gradient, aspect and vegetation type were recorded within the plots.

2.4 Interpretation of remote sensing satellite image

Mainly based on visual interpretation, Landsat 7 ETM+ Image taken in April 5, 2002 was interpreted using the supervised classification of Erdas Imagine 8.4. Information from the fieldwork was supplied to modify the results. So a map of the land use in Xishuangbanna could be gained.

2.5 Collecting administration information

Administration information such as counties, villages and roads were supplied by Science and Technique Institute of Xishuangbanna National Nature Reserve.

2.6 Planning and designing corridor routes on map

Information such as the distribution of counties, villages and roads as well as the elephant distribution range was represented on satellite images using GIS and then discussion was made on the probability of designing suitable corridor routes based on the above information as well as the habitat preference and migration pattern of elephants.

3 Results and discussion

3.1 Current distribution of wild Asian elephants in Xishuangbanna

Asian elephants used to distribute in large-scale areas in Xishuangbanna, but their distribution range has changed a lot in the past four decades (Table 1), owing to habitat decrease and fragmentation (Wu et al., 1999). At the time of our study, wild elephants mainly occurred in Mengyang, Mengla and Shangyong as well as the surrounding areas. Though having the largest population, the elephants in Mengyang were absolutely isolated from the populations in the other areas. The elephants in Shangyong and Mengla could migrate across the national boundary to Laos; however, the poaching pressure on them in Laos were more severe.

3.2 Determination of corridor routes

One important aim of planning and designing ecological corridors was to build a passage for elephants in Mengyang to migrate outside to communicate with those in Mengla and

Table 1 Change of distribution range of Asian elephants in Xishuangbanna in past four decades

Time	Mengyang sub-reserve and its surrounding areas	Menglun, Mengla sub-reserves and their surrounding areas	Shangyong sub-reserve and its surrounding areas
Time between 1960–1970	28	37	38
Metaphase of 1980s	136	23	60
Time between 1996–1997	115–137	0	50–60
Time between 2003–2004	130–140	20–30	40–50

Note: Data between 2003–2004 was collected by our staff from fieldwork, and others from Wu et al. (1999)

Shangyong and even those in Laos. Mangao sub-reserve was located far away from the others and no elephants lived there, so planning corridors linking it to the others was beyond consideration. Menglun sub-reserve was located between Mengyang and Mengla sub-reserves. It would be ideal if corridors could be established to link it with Mengyang and Mengla. But the large number of villages, farmlands and plantations as well as busy roads made it almost impossible to build corridors along this route because the moving of lots of villages, redistribution of collectivistic forests and large amounts of compensation would be insuperable. So it was suggested that corridors be established to link Mengyang, Mengla and Shangyong.

Details of the corridor routes should be determined based on comprehensive consideration. To link Mengyang and Mengla, a linear corridor would not be adopted because it

would traverse a large number of villages and farmlands. And a suitable corridor should traverse areas with less villages and more natural forests. Figure 2 showed that the long and narrow area which was located north to Mengla sub-reserve and west to the national boundary was occupied by continuous natural forests with few villages and many rivers in it. Earlier studies had indicated that a linear natural forest zone between isolated habitats had nice potential and obvious advantages for corridor building (Marcelo and Claude, 1999; Susan and Claude, 1999). So this area was called a “Green Passage”. And more inspiringly, there had been a few records of elephant activities in this area. So the “Green Passage” would be ideal for corridors linking Mengyang and Mengla.

Within and around the areas of the designed corridor linking Mengyang and the “Green Passage”, there were only a few villages. Relocation of these villages would be much easier; moreover, there would be little human disturbance after the establishment of the corridor. In addition, many rivers and brooks distributed in this area could not only meet the foraging and drinking needs of animals, but also provide convenience for their migration. However, a road linking Jiangcheng and Mengxing crossed this area and the corridor would have to cross the road. So several sections of the road should be carefully selected for reconstruction, i.e. bridges and tunnels should be built to make animals migrate safely.

Mengla and Shangyong were adjacent to each other, and the areas linking the southeastern part of Mengla and the northeastern part of Shangyong were covered mainly with natural forests, so corridors could be established there (Fig. 3). The panorama of the corridors was shown in Fig. 4.

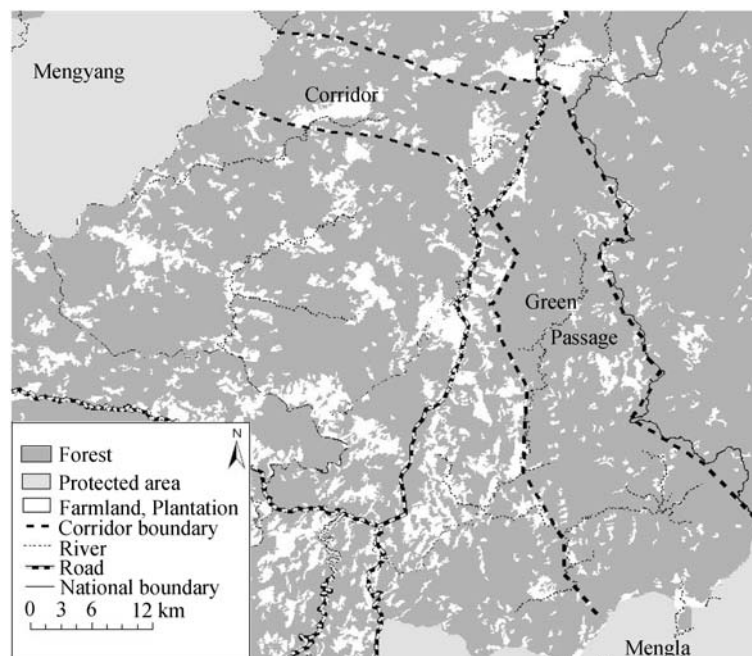


Fig. 2 “Green Passage” and the corridor linking Mengyang and “Green Passage”

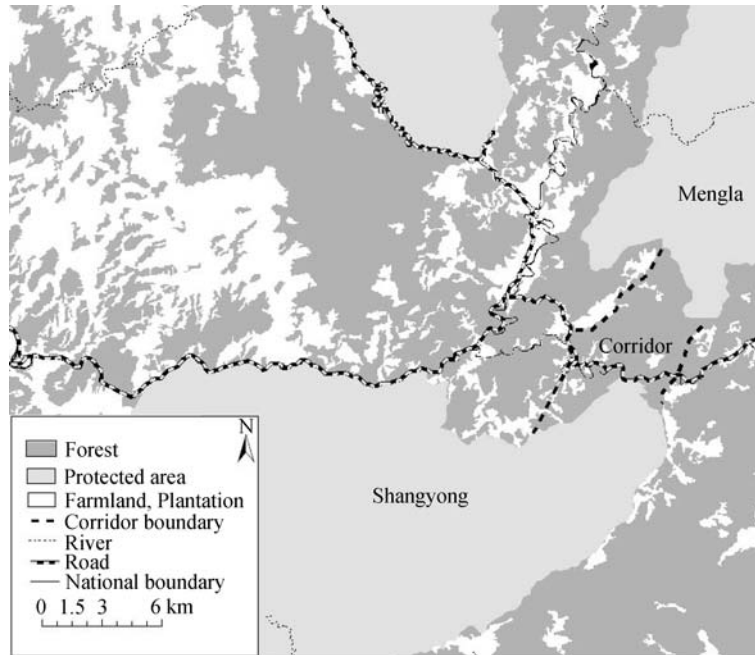


Fig. 3 Corridor linking Mengla and Shangyong

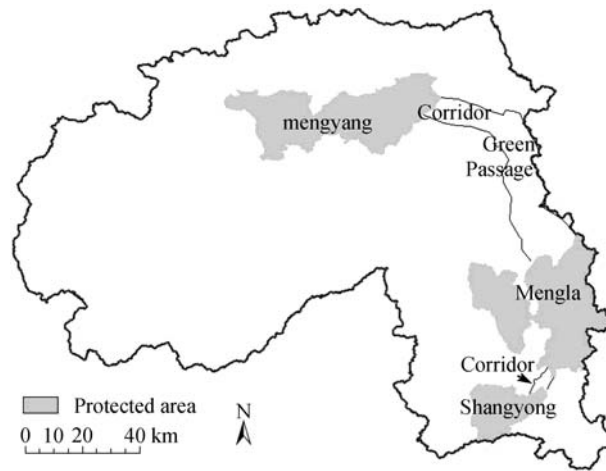


Fig. 4 Panorama of designed corridors

3.3 Suggestions on the building and maintenance of the corridors

1. Factors affecting elephants' habitat selection should be comprehensively considered in the route design of the corridors because elephants selected habitats under the influence of factors such as altitude, gradient and vegetation type, i.e. elephants preferred areas at altitudes below 1000 m to areas at altitudes between 1000 and 1400 m, and they randomly selected areas above 1400 m (Feng and Zhang, 2005).

2. On the course of animals' migration, behaviors such as foraging, drinking, resting, playing and breeding could also

proceed along the corridors. So a corridor should be designed not only as a migration path, but also as a suitable habitat with complex vegetation types and landscapes to satisfy different needs of animals, i.e. bamboo and bananas which were preferred by elephants could be planted artificially in the corridors. In addition, many animals including elephants often patronized sodium pools and absorbed salt, so some artificial sodium pools should be built along the areas of the corridors to satisfy their salt requirements and induced them to migrate along the corridors (Bonnie and Richard, 1995; Zhang and Wang, 2003). But what needed to be pointed out was that crops which were widely cultivated and had become the food source of elephants should be avoided in the areas of the corridors.

3. The length of the corridors should be short as much as possible in order to enable animals to migrate through them within the shortest time (Bonnie and Richard, 1995). Then the chances of small weak animals being caught or killed and large animals imposing adverse impacts on the local masses would be reduced.

4. The area of the corridors should have certain width, depending on the goal species (Bonnie and Richard, 1995). The scope of elephants' activities was wider, so the width of the corridors should be greater. Other details should be determined by field survey and local vegetation.

5. Natural or artificial obstacles should be avoided within the areas of the corridors, i.e. high and steep mountains, deep and broad rivers and wide busy highways which could hamper animals' migration (George, 2001). So a detour and pass should be made when the corridors encountered those obstacles. As to those that had no chance to make a detour, transformation should be carried on as much as possible, i.e. bridges and tunnels should be built in some sections of highways which were located right on the routes of animals' migration to enable them to cross safely.

6. The border of the corridors and their surrounding areas should be relatively gentle in order to increase species diversity within the border district of the corridors (Allison and Robert, 1997).

7. Most areas of the corridors linking Mengyang and Mengla would be adjacent to the national boundary and the elephants from Mengyang could cross the boundary to Laos through the corridors. On the one hand, international cooperation between China and Laos should be carried out to protect Asian elephants together; on the other hand, there had always been more serious illegal poaching outside the border, so how to launch effective international cooperation to attack illegal poaching and the transnational construction of protected areas would be key problems in protecting wild elephants and other endangered species.

8. Because fetching crops by elephants had become comparatively general in the past few years, land utilization near the corridors would need to be planned and transformed, i.e. industrial crops such as tea and hot pepper could be planted and artificial facilities such as ditches, electric rails could also be set up in farming areas which elephants had frequently visited (Zhang and Wang, 2003).

9. Essential assessments should be taken to examine the utilization of the corridors by elephants and other protected animals. If a corridor was not selected for the migration route, reasons should be analyzed and a new corridor might be needed if necessary.

10. The newly built corridors would be fragile and the maintenance of them would be very important. Destruction to vegetation within the corridor areas should be forbidden. And moreover, the local masses could be hired to participate in the work of management. It could not only facilitate the maintenance of the corridors, but also offer employment opportunities to local people.

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References

- Allison M F, Robert D B (1997). A framework for the design of wildlife conservation corridors with specific application to southwestern Ontario. *Landscape and Urban Planning*, 37: 163–186
- Bonnie R, Richard L K (1995). Influence of corridor continuity and width on survival and movement of deermice. *Biological Conservation*, 71: 269–274
- Feng L M, Zhang L (2005). Habitat selection by Asian elephant (*Elephas Maximus*) in Xishuangbanna, Yunnan, China. *Acta Theriologica Sinica*, 25(3): 229–236. (in Chinese)
- George R H (2001). Communicating clearly about conservation corridors. *Landscapes and Urban Planning*, 55: 195–208
- Li Z X (1999). A study of using GIS for protecting the tropical forest in Mengyang Nature Reserve of Xishuangbanna, China. *Yunnan Geographic Environment Research*, 11(2): 60–67 (in Chinese)
- Marcelo G G, Claude G (1999). The conservation value of linear forest remnants in central Amazonia. *Biological Conservation*, 91: 241–247
- Santiapillai C, Jackson P (1990). The Asian Elephant—An Action Plan For Its Conservation. IUCN/SSC Asian Elephant Specialist Group, IUCN. Switzerland: Gland
- Susan G L, Claude G (1999). Tropical wildlife corridors: Use of linear rainforest remnants by arboreal mammals. *Biological Conservation*, 19: 231–239
- Wang S (1998). *China Red Data Book of Endangered Animals*. Beijing: Science Press
- Wu J L, Jiang W G, Hu J S, Li Z Q, Li C H (1999). Changes of distribution range of Asian elephant in Xishuangbanna in last 40 years. *Chinese Wildlife*, 20: 8–9 (in Chinese)
- Wu Z L, Peng M C, Yang Z B, Liu L Y (1997). Ecological environment pattern in Mengyang Nature Reserve of Xishuangbanna. *Chinese Journal of Applied Ecology*, 8: 1–7 (in Chinese)
- Zhang L, Wang N (2003). An initial study on habitat conversation of Asian Elephant conflict in Simao, China. *Biological Conservation*, 112: 453–459
- Zhang L, Wang N, Wang Y N, Ma L C (2003). A preliminary study on the habitat and behaviors of Asian Elephant (*Elephas Maximus*) in Simao, Yunnan, China. *Acta Theriologica Sinica*, 8(23): 185–192 (in Chinese)