GLOBAL TRENDS AND THREATS IN THE ORDER SCANDENTIA:

AN ASSESSMENT USING IUCN RED LIST CRITERA

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

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The International Union for Conservation of Nature (IUCN) is the world's largest conservation organization. Known for their Red List of Threatened Species, the IUCN works with species specialists around the world to classify animals and plants into one of nine categories that indicate the species' risk of extinction. The Small Mammal Specialist Group (SMSG) is a species specialist group that is focused on reassessing the orders Rodentia, Scandentia, and Eulipotyphla in time for the Global Mammal Assessment in September 2016. I will be aiding the SMSG through an analysis of the Order Scandentia using the IUCN Guidelines for Use of the IUCN Categories and Criteria, through which I will analyze trends and threats in the conservation status of Scandentia. I will also compile known information on their ecology and role in human-wildlife interactions for the SMSG and IUCN. This project will aid the SMSG in reassessing the world's small mammal species and will eventually be used to update the IUCN Red List. Because the Red List is used worldwide to prioritize conservation projects and funding, the project will have large-scale impacts.

ACKNOWLEDGMENTS

I would like to acknowledge all of the many people who have helped with this project. First, Dr. Rosalind Kennerley of the Durrell Wildlife Institute and Dr. Monika Böhm of the Zoological Society of London, for their willingness to meet and discuss the finer points of this project and for their suggestions for improvement. Second, to Mr. Jeffrey Olsenholler of the Texas A&M University Department of Geography, for his invaluable help with the change difference analysis. Many thanks to the Wildlife and Fisheries Undergraduate Research Fund, the Undergraduate Research Scholars Program, and the IUCN Small Mammal Specialist Group. Finally, my most sincere thanks to my research advisor, Dr. Thomas Lacher, who has served as an advisor and mentor to me since my freshman year.

CHAPTER I

INTRODUCTION

The mammalian orders Rodentia, Scandentia, and Eulipotyphla make up more than half of the world's mammal species. Colloquially referred to as 'small mammals', many of these species are poorly studied, with little information on their basic ecology. However, it is known that many small mammal species play an important role in their communities through activities such as seed caching and dispersal, improvement of soil structure, and by serving as a prey source (Hull Sieg 1987).

In particular, the order Scandentia displays many interesting characteristics that have not yet been fully understood. This group, known as the tree shrews, consists of 20 species in two families that are found in Southeast Asia. Debate over the phylogenetic relationship of Scandentia has continued for over a century. Currently, they are viewed as an important link in the evolution of primates (Janečka 2007, Li and Ni 2016), and further study could provide more information about the beginning of primate evolution. Their relatedness to primates also makes them ideal research organisms, and they have already been used in place of primates in studies focusing on myopia, psychological stress, and viral hepatitis (Cao 2003).

In addition, tree shrews have the highest brain-to-body-mass ratio of any mammal, including humans. This could allow researchers the opportunity to better understand the role of brain mass in behavior and intelligence.

1.1 Background of the International Union for Conservation of Nature

The International Union for Conservation of Nature (IUCN) is the world's oldest and largest global environmental organization. Founded in 1948, the IUCN is the world's expert authority on the environment and sustainable development. There are more than 1,200 organizations with memberships in the IUCN, including both government and non-government organizations, and 11,000 expert volunteers from 160 countries. The IUCN is divided up into six groups, called commissions, which help unite experts from a range of disciples. These commissions include the Commission on Education and Communication, the Commission on Environmental, Economic, and Social Policy, the World Commission on Environmental Law, the Commission on Ecosystem Management, the World Commission on Protected Areas, and the Species Survival Commission.

The Species Survival Commission (SSC) works to provide the IUCN with information on biodiversity conservation, the role of species in ecosystem health and functioning, and the support of ecosystem services on human livelihoods. This information is combined into the IUCN Red List of Threatened Species. The Red List is a system for classifying species at a high risk of global extinction. Using an explicit framework, the IUCN classifies each species according to their extinction risk and aims to help in the conservation of species facing a high risk of extinction (Hoffman et al. 2008). The IUCN Red List Categories and Criteria aim to provide a system that can be applied consistently, facilitate comparisons across widely different taxa, improve objectivity when evaluating factors that affect the risk of extinction, and provide those using the Red List with a better understanding of how species are classified.

The SSC is further divided into specialist groups, which consist of experts on a particular taxa that collaborate to conduct Red List Assessments. The order Scandentia is managed by the Small Mammal Specialist Group (SMSG), which also oversees the orders Rodentia and Eulipotyphla.

1.1.1 IUCN Red List Criteria

The Red List divides species into one of nine categories: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, and Extinct. (A description of each category of the Red List can be found in Appendix 1). The 'Threatened' categories include the Vulnerable, Endangered, and Critically Endangered classifications. The Red List has set up criteria that it uses to determine if a species falls into one of the three threatened categories. There are five criteria used to classify species:

A. Population Size Reduction
B. Geographic range in the form of either extent of occurrence and/or area of occupancy
C. Small population size and decline
D. Very small or restricted population
E. Quantitative Analysis

Each of these five criteria is then further subdivided to help accurately place each taxon in the correct classification. If a taxon meets the criteria listed, it is immediately placed into the appropriate category.

1.2 IUCN Influence on Global Conservation Policy

IUCN Red List Assessments are used for the prioritization of conservation projects and funding by a number of organizations around that world. Examples of organizations that are influenced by the IUCN include the World Bank, the Global Environment Facility, the Convention on Biological Diversity, and the Millennium Development Goals. In addition to these organizations, the IUCN has also impacted a number of treaties and conventions, including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), aimed at ensuring the international trade of species does not endanger their survival. The IUCN has also been granted permanent observer status at the United Nations in New York City due to the increasing importance of environmental issues, especially those involving biodiversity and natural resource conservation. The IUCN also has representatives in other UN offices, including those in Geneva, Cambridge, Nairobi, and Vienna.

CHAPTER II

METHODS

2.1 IUCN Red List Assessments

In order to properly assess the extinction risk of the world's species, the IUCN has created a set of criteria that uses quantifiable data to provide an accurate, unbiased listing. The criteria used to classify species includes population size, area of extent and area of occurrence, and demonstrated or predicted declines in population.

2.1.1 Literature Review

Using Google Scholar, I conducted a literature review for each member of Order Scandentia. Searches were bound between 2008 and 2015, and the scientific name of each species was used as the search term. Literature that mentioned habitat, population size, distribution and range, and threats to the species were used to conduct the assessments. Once literature was collected, the new data was entered into a template form and sent to Dr. Rosalind Kennerley of the Durrell Wildlife Trust for review.

2.2 Land Use and Land Cover Change

Due to a lack of data available for the Order Scandentia in the literature review, a land use and land cover change within the range of each species was conducted. The purpose of this assessment was to determine the amount of available habitat within each species' extent of occupancy and any changes in that amount between the last Global Mammal Assessment in 2008 and the ongoing Global Mammal Assessment due in September. Because members of the Order

Scandentia are arboreal, the amount of forest habitat was used as a measure of available habitat. Due to study constraints, the amount and change in greenness over time was used as a proxy measure for deforestation.

2.2.1 Data Collection

Satellite imagery from the NASA MODIS Terra satellite was used for the land use and land cover change assessment. This satellite produces vegetation indices at 16 day intervals at varying resolutions. For the purpose of this study, the 250 meter resolution was used. Data were retrieved using the Earth Explorer website application from the United States Geological Survey. Using data from the IUCN Red List webpage for each species, I entered the coordinates for the range of each species into Earth Explorer. The date range used for forest cover data collection was January 1 to January 31 for the years 2008 and 2015. NASA data indicated that the month of January saw the period of most growth in tropical forests in this area (Lindsey 2003). This period of growth would make the areas appear greener in the satellite images, making it easier to distinguish between forested and non-forested areas.

2.2.2 Vegetation Indices

Once satellite imagery for each species was collected, the geospatial software ENVI was used to create the vegetation indices for analysis. ENVI version 4.8 was used to mosaic the satellite imagery together in cases where the species’ range was greater than the extent of a single image. ENVI version 5.1 was then used to create a normalized difference vegetation index (NDVI) for each species. NDVI data uses visible and near-visible portions of the electromagnetic spectrum to determine how green vegetation in a given area is. This index has previously been used to measure rates of deforestation in the Brazilian Amazon, and has other applications including crop yields and rangeland carrying capacities (Morton et al. 2005).

2.2.3 Change Difference Analysis

A change difference analysis was conducted using the Change Detection Difference Map tool in ENVI 5.1. This tool computes the difference in two images by subtracting the initial state image from the final state image, and the differences are characterized into change classes. In this study, the images from the year 2008 were considered as ‘initial’ and images from the year 2015 were considered ‘final’. Twenty-one change classes were used to determine the change in greenness, with classes 1-10 showing an increase in greenness, classes 14-21 showing a decrease in greenness, and classes 11-13 showing no change. Each change class represented the number of square meters that were considered to be greener, less green, or have no change. After the change difference analysis was completed, the resulting map was imported into ArcMap 10.2 to create a visual representation of the change in greenness. These maps can be found in Appendix A. The data for each of the change classes was exported to Microsoft Excel for the purpose of calculating the number of square meters where greenness has decreased.

CHAPTER III

RESULTS

For seventeen of the twenty species in Order Scandentia, I calculated the number of square meters and kilometers that showed a change in greenness. From the number of square kilometers in each change class, I also calculated the percent change in greenness for each species. The percent change in greenness can be found in Table 1. Of the 17 species analyzed using the change difference analysis, five species showed a decrease in greenness and twelve showed an increase in greenness. The percent decrease in greenness ranged from 17% to 3%, and the percent increase in greenness ranged from 5% to 20%. The average positive change in greenness was 13.55% and the average negative change in greenness was 8.11%.

Of the twelve species that showed a positive percent change in greenness, eleven of them are found in Borneo. The range of those species showing a negative percent change was more varied, and included Indonesia, the Insular Philipphines, Vietnam, and the Indian subcontinent. Distributions of each species can be seen in Table 2.

Three of the 17 species were not assessed for various reasons. One species, *Tupaia moellendorffi*¸ does not currently have any distribution data available from the IUCN. *Tupaia nicobarica* and *Tupaia chrysogaster* are both found in areas smaller than 250 square meters, and I would not have been able to accurately determine any change in greenness in these areas due to data constraints.

Table 1: Percent Change in Greenness for Members of the Order Scandentia

Species	**Percent Change in Greenness**
A. ellioti	-3.25
D. melanura	20.14
D. murina	-3.79
P. lowii	10.48
T. belangeri	-8.62
T. dorsalis	16.67
T. glis	11.44
T. gracilis	12.40
T. javanica	-17.18
T. longipes	16.67
T. minor	5.20
T. montana	18.61
T. palawanensis	-7.71
T. picta	14.64
T. splendidula	14.84
T. tana	5.04

Table 2: Members of the Order Scandentia and Their Areas of Distribution

Species	Percent Change	Distribution
T. javanica	-17.18	Indonesia
T. belangeri	-8.62	Southeast China
T. palawanensis	-7.71	Insular Philippines
D. murina	-3.79	Vietnam
A. ellioti	-3.25	India
T. tana	5.04	Borneo, Indonesia
T. minor	5.20	Borneo, Indonesia, Malaysia
P. lowii	10.48	Borneo, Indonesia, Malay Peninsula
T. glis	11.44	Indonesia, Malaysia
T. gracilis	12.40	Borneo
T. picta	14.64	Borneo
T. splendidula	14.84	Borneo
U. everetti	16.47	Southern Philippines
T. dorsalis	16.67	Borneo
T. longipes	16.67	Borneo
T. montana	18.61	Borneo
D. melanura	20.14	Borneo

CHAPTER IV

DISCUSSION

4.1 Deforestation and Oil Palm Production

Deforestation and the associated habitat loss is one of the primary threats against biodiversity today. Southeast Asia has the highest mean proportion of country-endemic bird and mammal species in the world, as well as the highest proportion of threatened species across the major taxonomic groups: vascular plants, reptiles, birds, and mammals (Sodhi et al. 2010). The deforestation rate in this area is among the highest in the world, with an average of one percent a year across the entirety of insular Southeast Asia and average rates of over five percent a year in the peat swamps of Borneo (Miettinen et al. 2011). Regional projections of this area estimate that between 13 and 42% of all species in this area could be extinct by 2100 due to a loss of habitat from deforestation, a figure which includes an 85% loss in endemic mammal species. (Brook et al. 2006). In addition to simple habitat loss, the effects of habitat fragmentation and global climate change compound the issue, causing impacts to the region that are yet unknown. However, it is likely that the majority of species in Southeast Asia are facing threats to their extinction that are greater than what is currently estimated.

Deforestation in Southeast Asia is generally attributed to the rise of cash crops. These crops include oil palm, rubber, coffee, and cashew, as well as tree species that can be used for paper. Oil palm is the most widespread cash crop in Southeast Asia, with 4.1 million hectares planted in Indonesia and 3.6 million hectares planted in Malaysia. These two counties are the largest producers of oil palm in the world (Koh and Wilcove, 2008).

Between 1990 and 2005, oil palm production in Malaysia expanded by 1,874,000 hectares, with an estimated 55 to 59% of that expansion attributed to conversion of forests (Koh and Wilcove 2008). During the same time period in Indonesia, oil palm production increased by 3,017,000 hectares, with at least 56% percent of that expansion attributed to the conversion of forest (Koh and Wilcove 2008).

Of the twelve species in Order Scandentia that showed an increase in greenness, eleven of them are found on the island of Borneo. Borneo is split between the Kalimantan state of Indonesia and the Sarawak and Sabah states of Malaysia. Due to the increase in oil palm at the expense of native forest in these two countries, it is likely that the increase in greenness shown for these species is due to the expansion of oil palm production. However, there are no data for the expansion of oil palm purely on Borneo; all figures for oil palm expansion include the entirety of both Indonesia and Malaysia. In addition, reliable imagery where the difference in native forest and oil palm plantation is clearly seen is difficult to come by (Pimm, S., Pers. Comm. April 1, 2016)

4.2 Use by the IUCN

The IUCN does not consider change in greenness a reliable measure of deforestation and its associated habitat loss because it does not fulfill any of the Red List Criteria. Therefore, the results of this project cannot be used to update the IUCN Red List Assessments for any species of the Order Scandentia. However, it is possible that the five species that showed a decrease in greenness may be moved to the Near Threatened Category. The Near Threatened (NT) category is used by the IUCN to acknowledge species that may be considered threatened in the near future. The NT category usually includes taxa which are close to meeting the criteria needed to designate a species as ‘vulnerable’ due to a reduction in numbers or range. This designation can also be given to species that are dependent on conservation efforts to prevent them from being classified in a threatened category.

The five species in this study that showed a decrease in greenness are likely candidates for a Near Threatened category of extinction risk. As deforestation in their ranges continues and new data becomes available, they will likely need to be classified into a threatened category.

CHAPTER V

CONCLUSION

This project focused on using decreasing greenness as a proxy measure for deforestation in Southeast Asia to help assess the extinction risk of members of the Order Scandentia. Five of the seventeen species assessed showed a decrease in greenness and twelve showed an increase in greenness. It is likely that the five species who displayed a decrease in greenness within their range can be listed as "Near Threatened" according to the IUCN Red List. The other twelve species that displayed a decrease in greenness were found mainly on the island of Borneo. The island of Borneo belongs to both Indonesia and Malaysia. These countries have more oil palm plantations than anywhere in the world, and some studies show that the conversion rate from native forest to oil palm plantation averages more than 50%. However, there is no data for the rate of conversion for Borneo only; further projects may want to examine the amount of native forest left on this island.

This study highlights the need for more research into the conversion rate of native forest to agroforested plantations in Southeast Asia, as well as how endemic species in this area utilize agroforested areas. Ideally, the IUCN will be able to use this study to aid in the reassessment process of the Order Scandentia and provide funding for future research into this area of the world.

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FIGURES

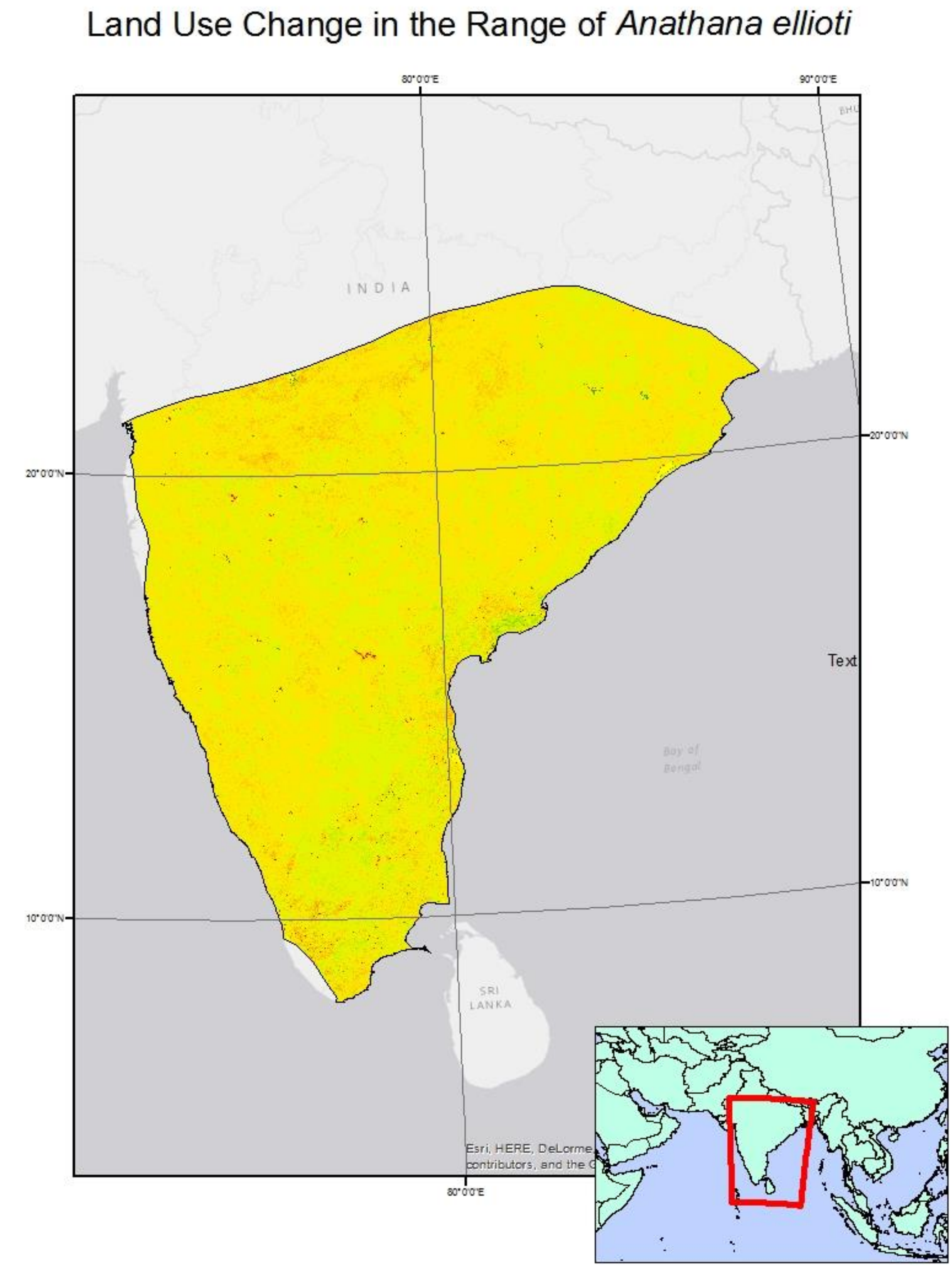

Figure 1: *Anathana ellioti*, where dark red indicates a significant loss in greenness over time and yellow indicates no change in greenness

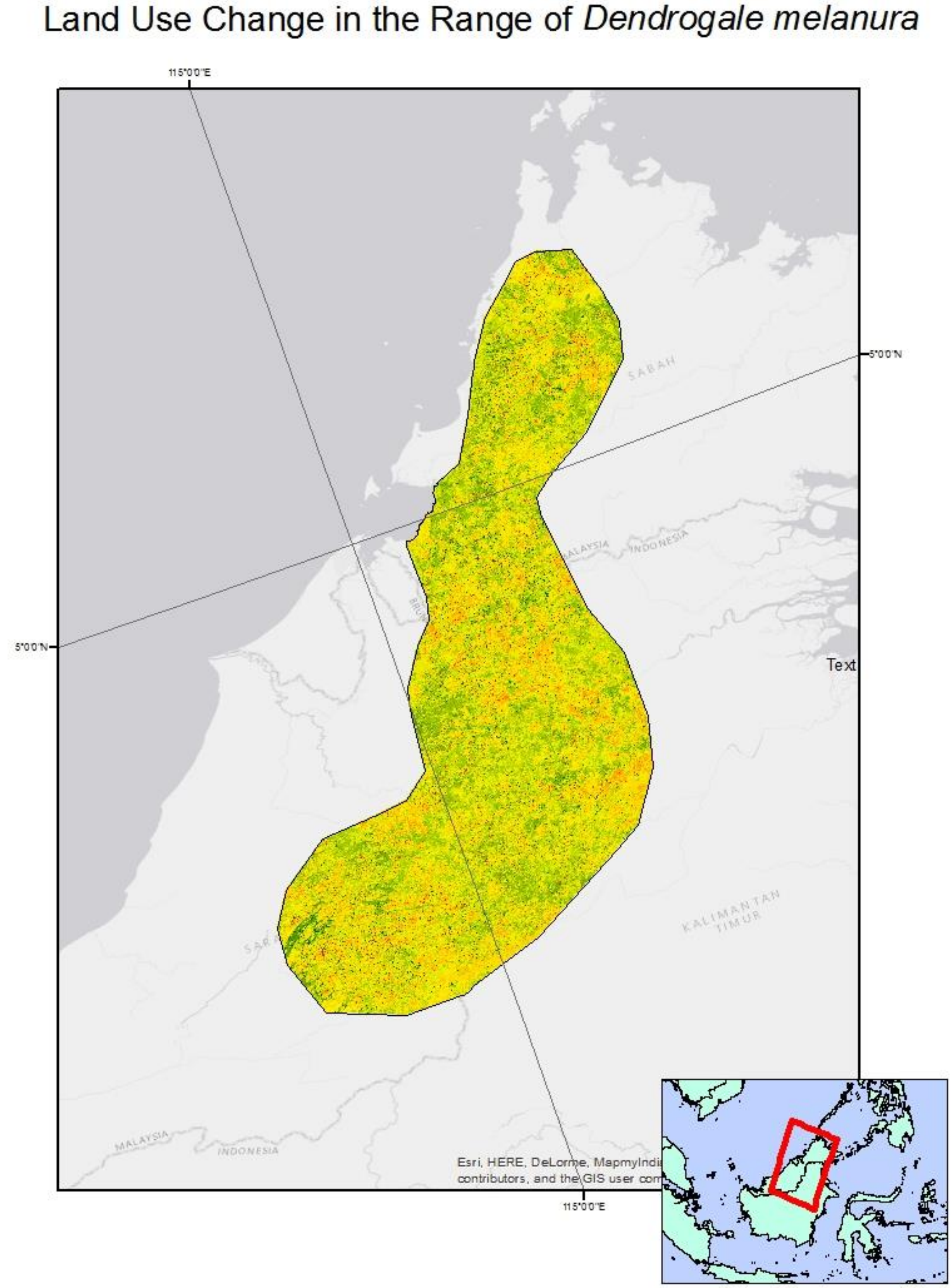

Figure 2: *Dendrogale melanura*, where dark green indicates a large increase in greenness and red indicates a decrease in greenness over time

Land Use Change in the Range of *Dendrogale murina*

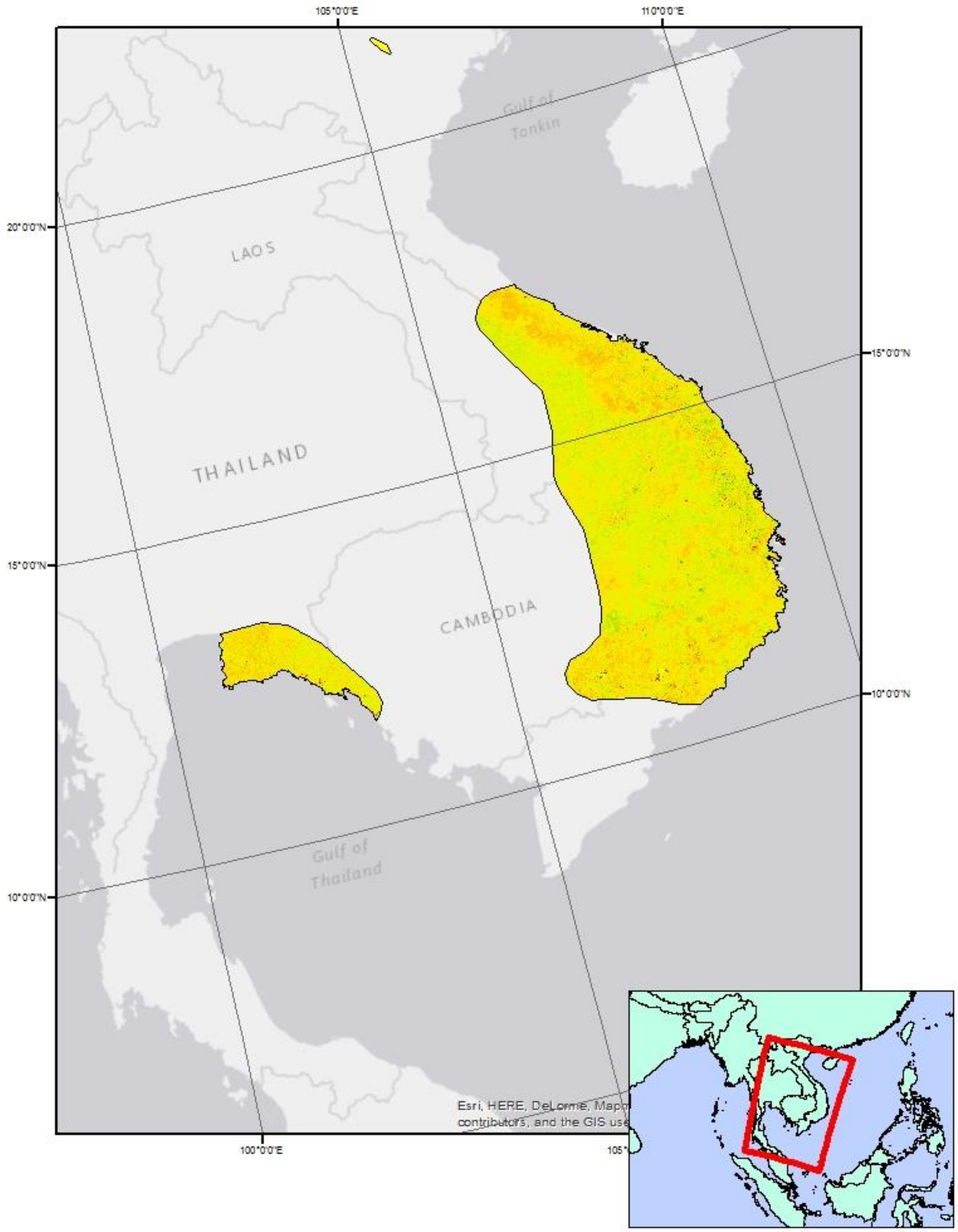

Figure 3: Dendrogale murina, where orange indicates a slight decrease in greenness and green indicates an increase in greenness over time

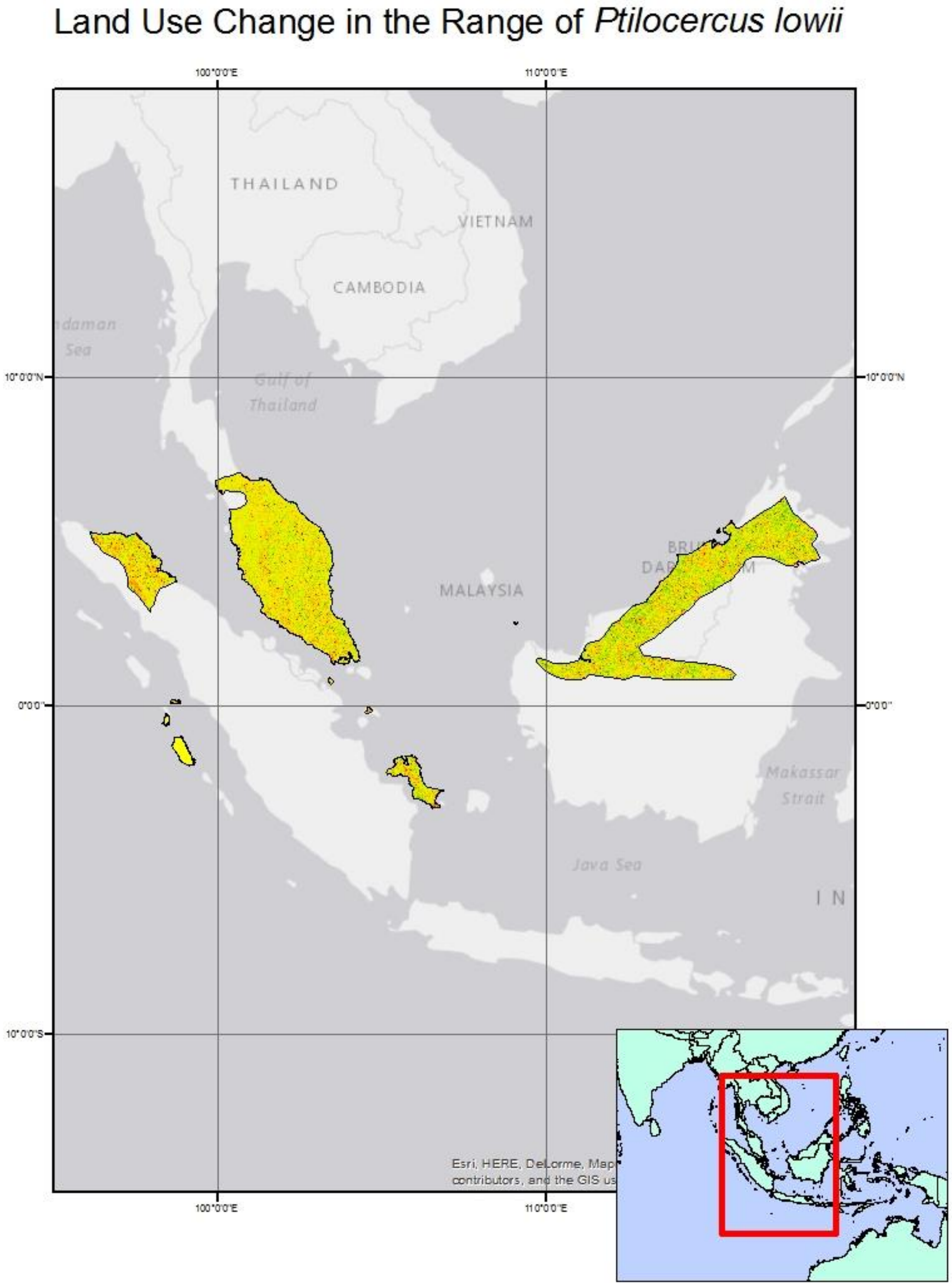

Figure 4: Ptilocercus lowii, where red indicates a decrease in greenness and green indicates an increase in greenness over time

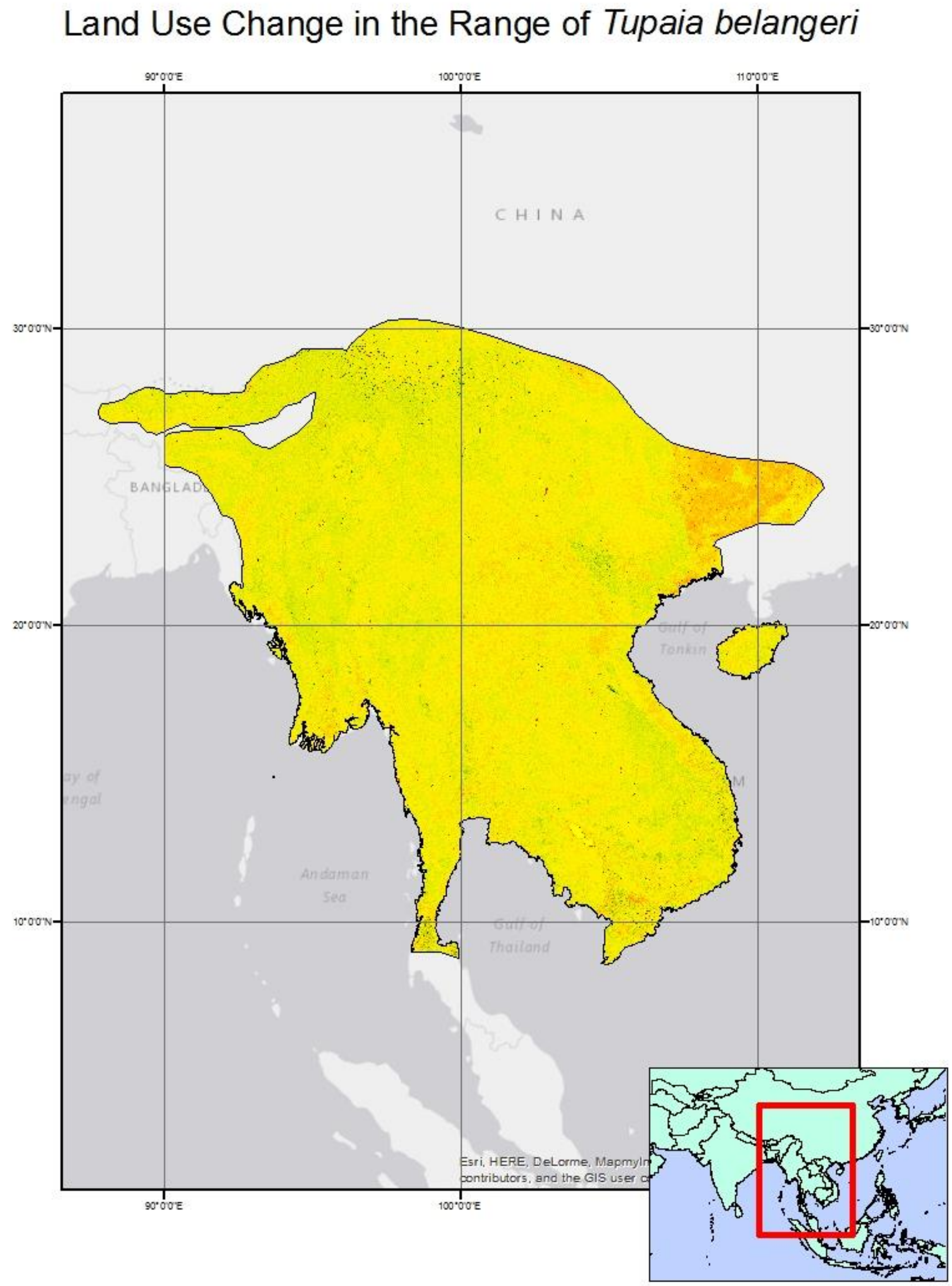

Figure 5: *Tupaia belangeri*, in which yellow indicates no change in greenness and orange indicates a slight decrease in greenness over time

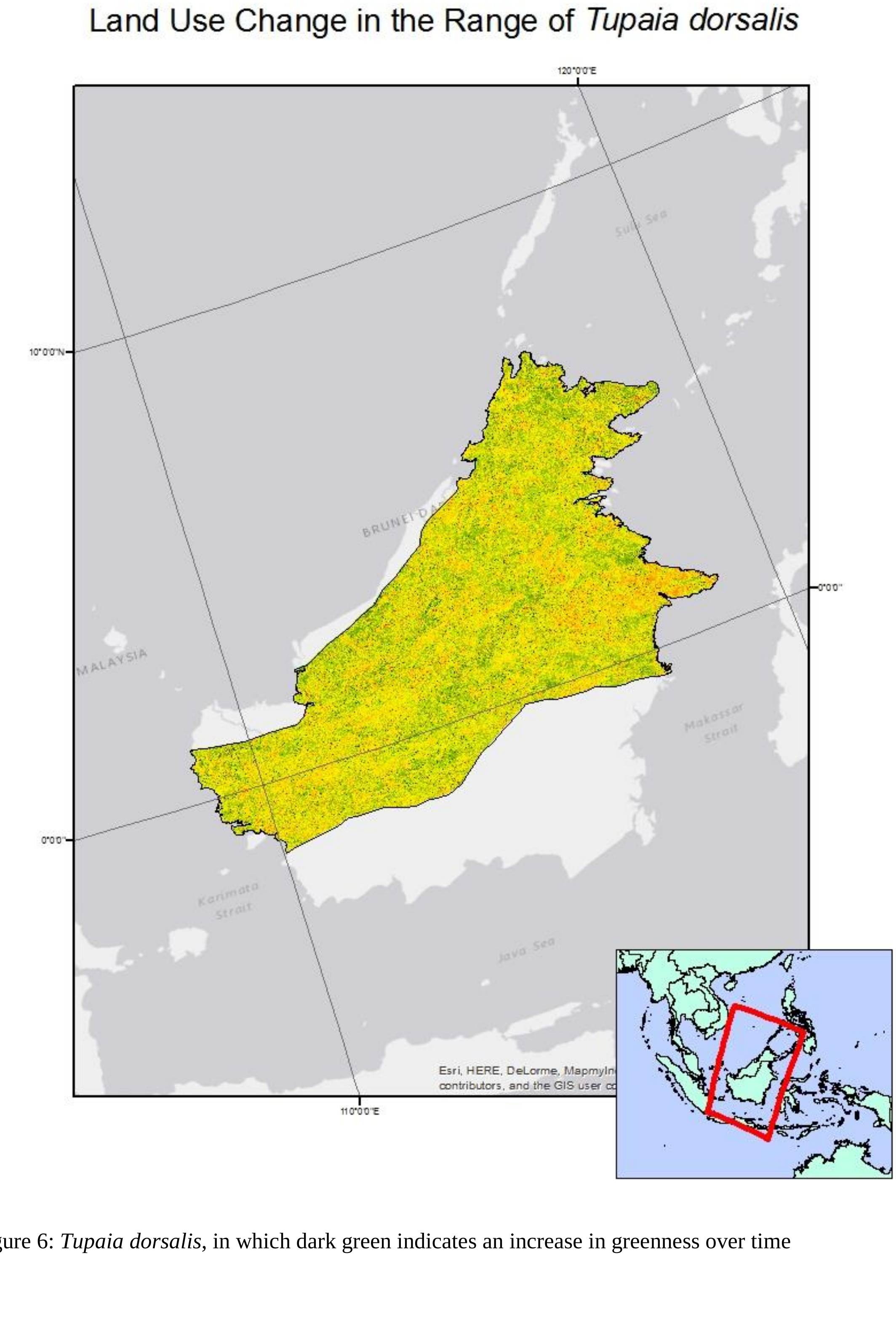

Figure 6: *Tupaia dorsalis*, in which dark green indicates an increase in greenness over time

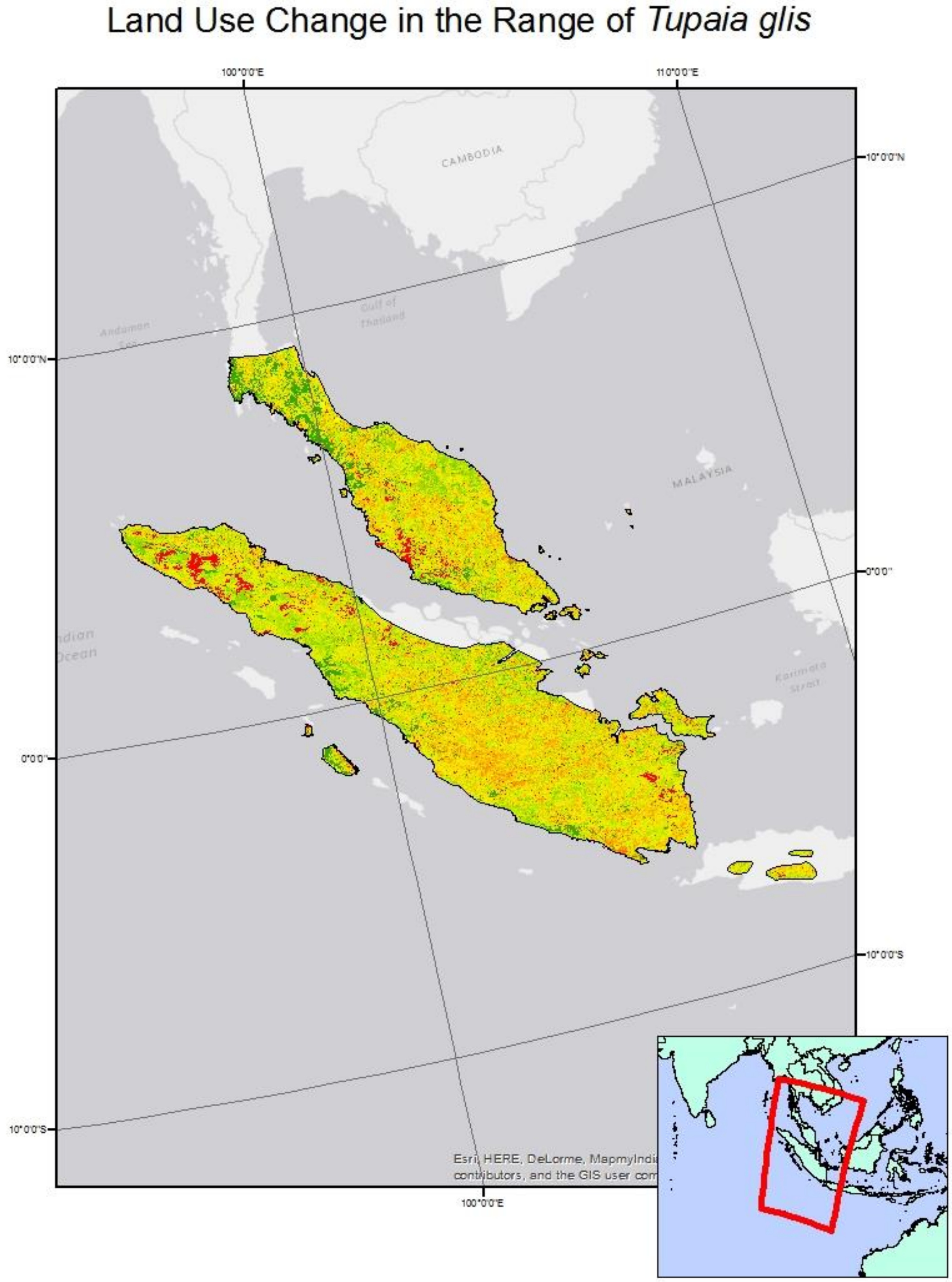

Figure 7*: Tupaia glis*¸ in which dark red indicates a significant loss in greenness over time

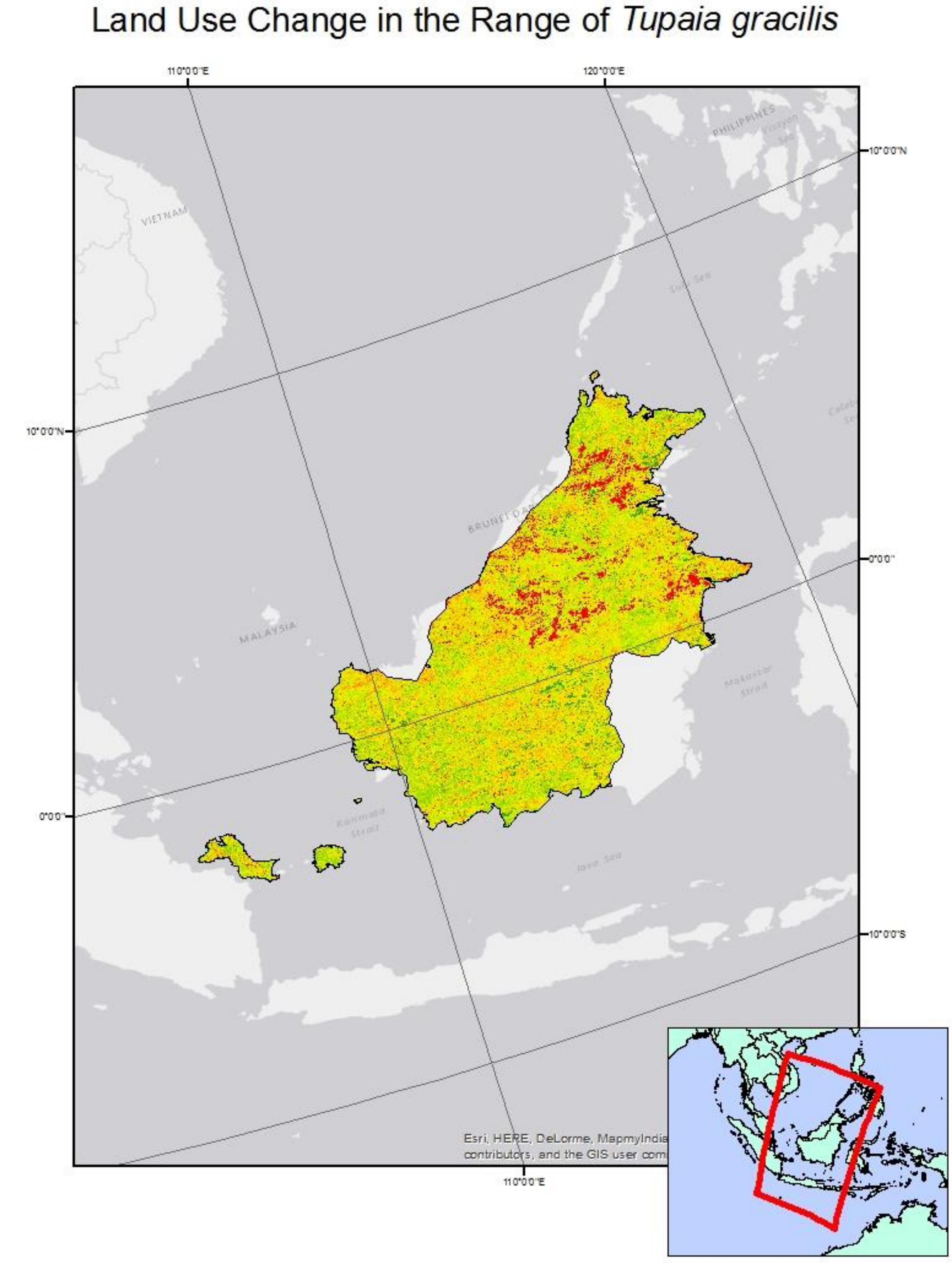

Figure 8: *Tupaia gracilis*, where dark red indicates a significant decrease in greenness over time

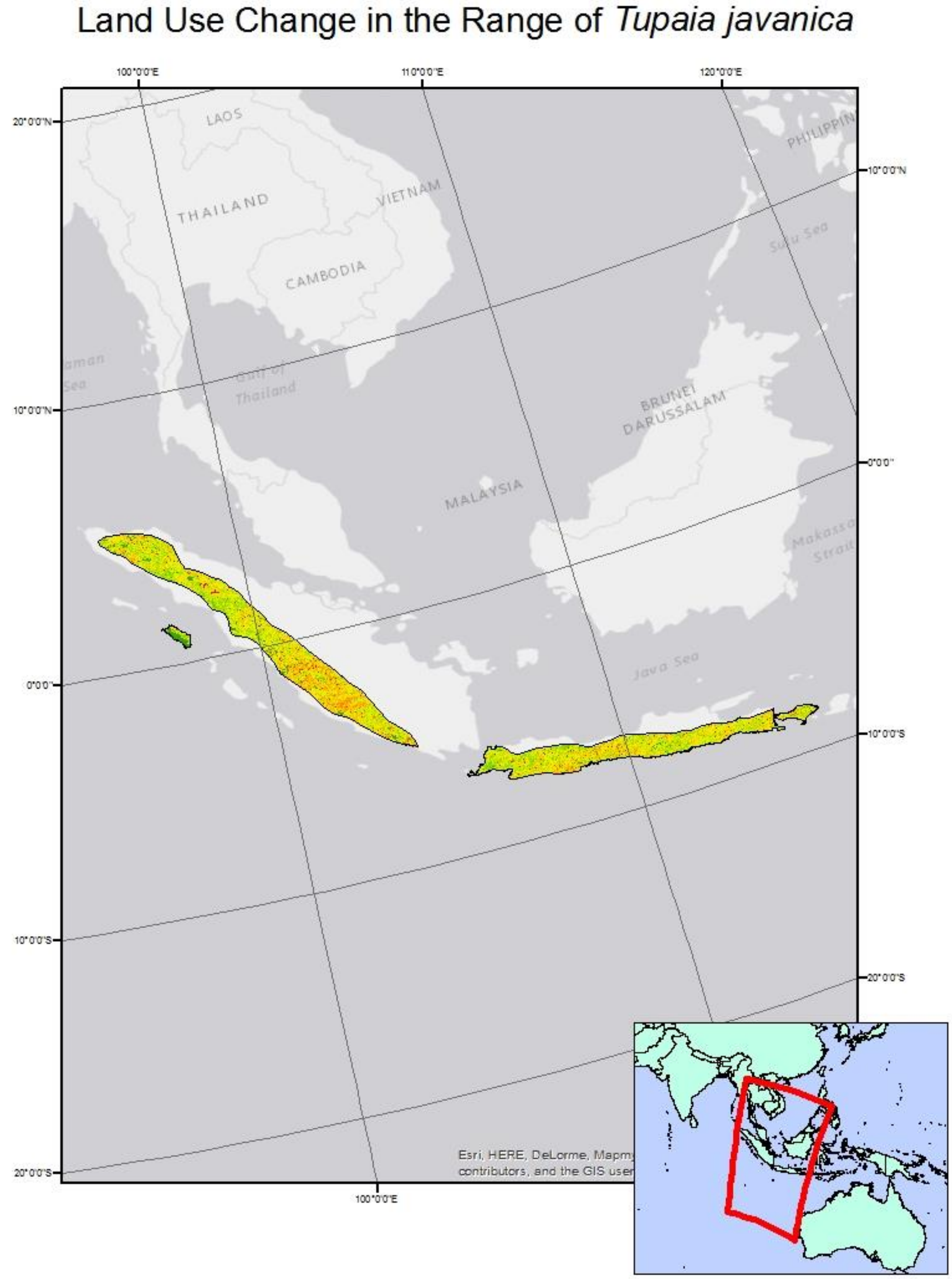

Figure 9: *Tupaia javanica*, in which dark green indicates a significant increase in greenness and orange indicates a slight loss in greenness over time

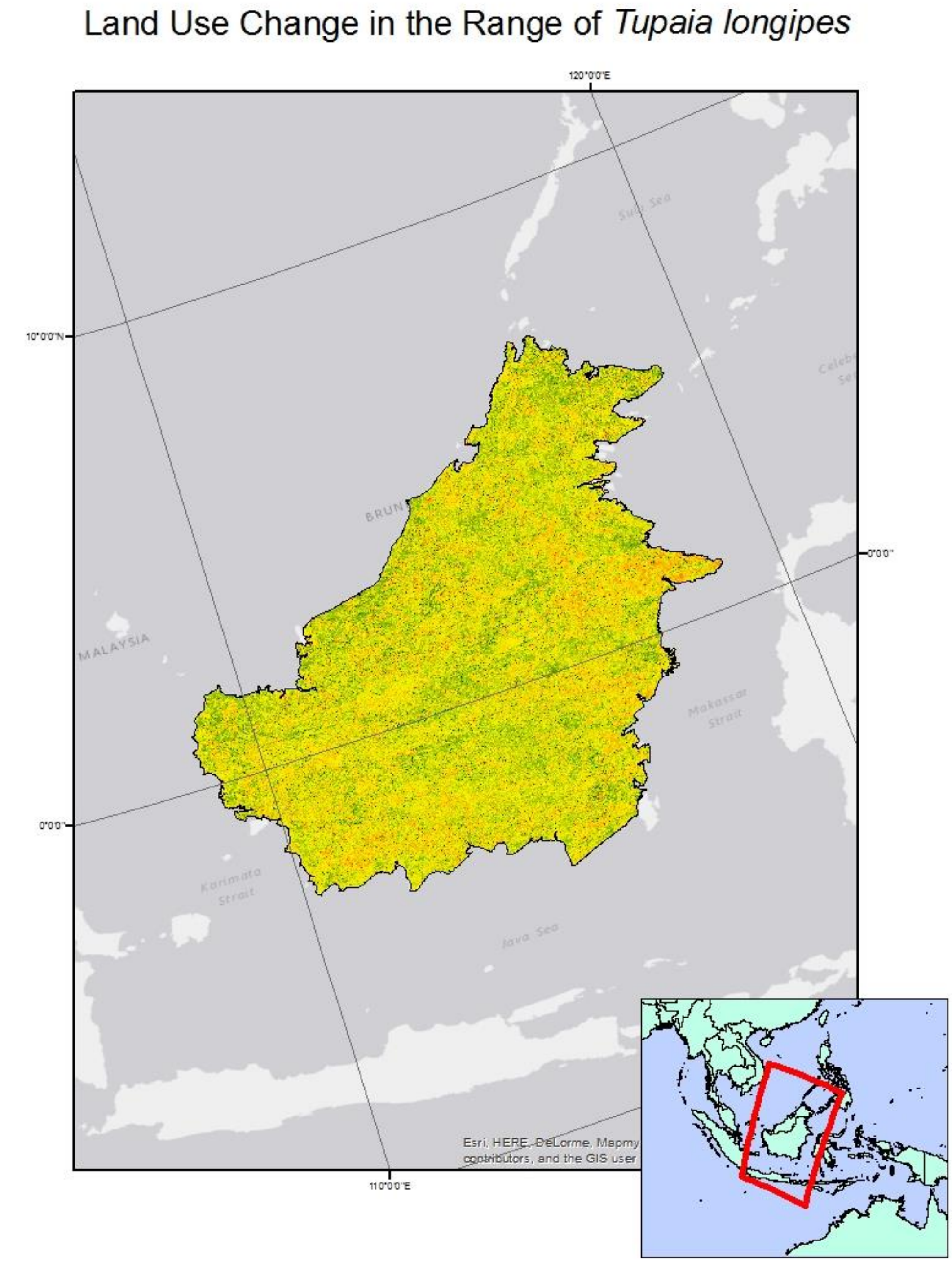

Figure 10: *Tupaia longipes,* in which light green indicates a slight increase in greenness over time

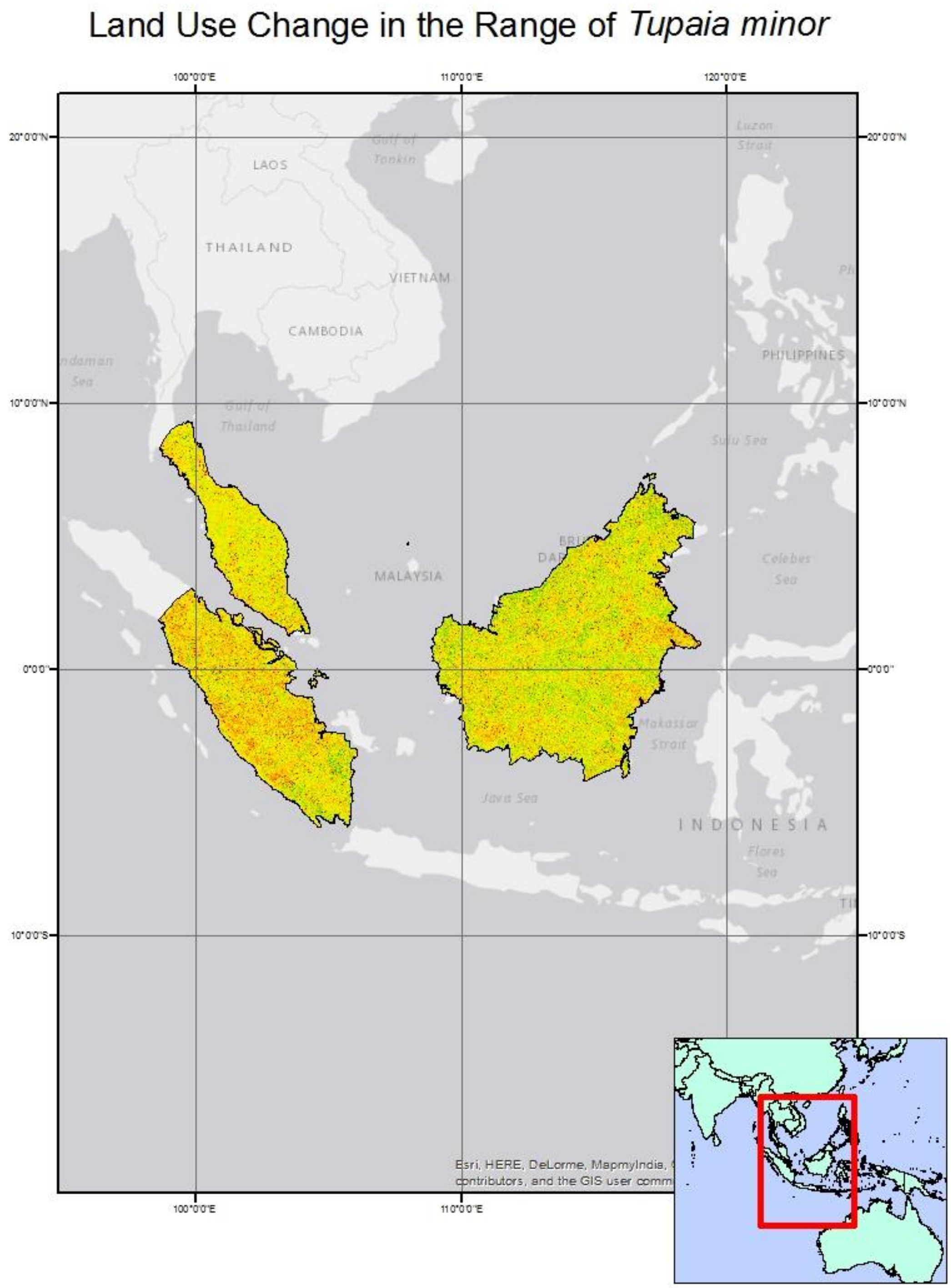

Figure 11: *Tupaia minor*, in which orange indicates a slight decrease in greenness over time

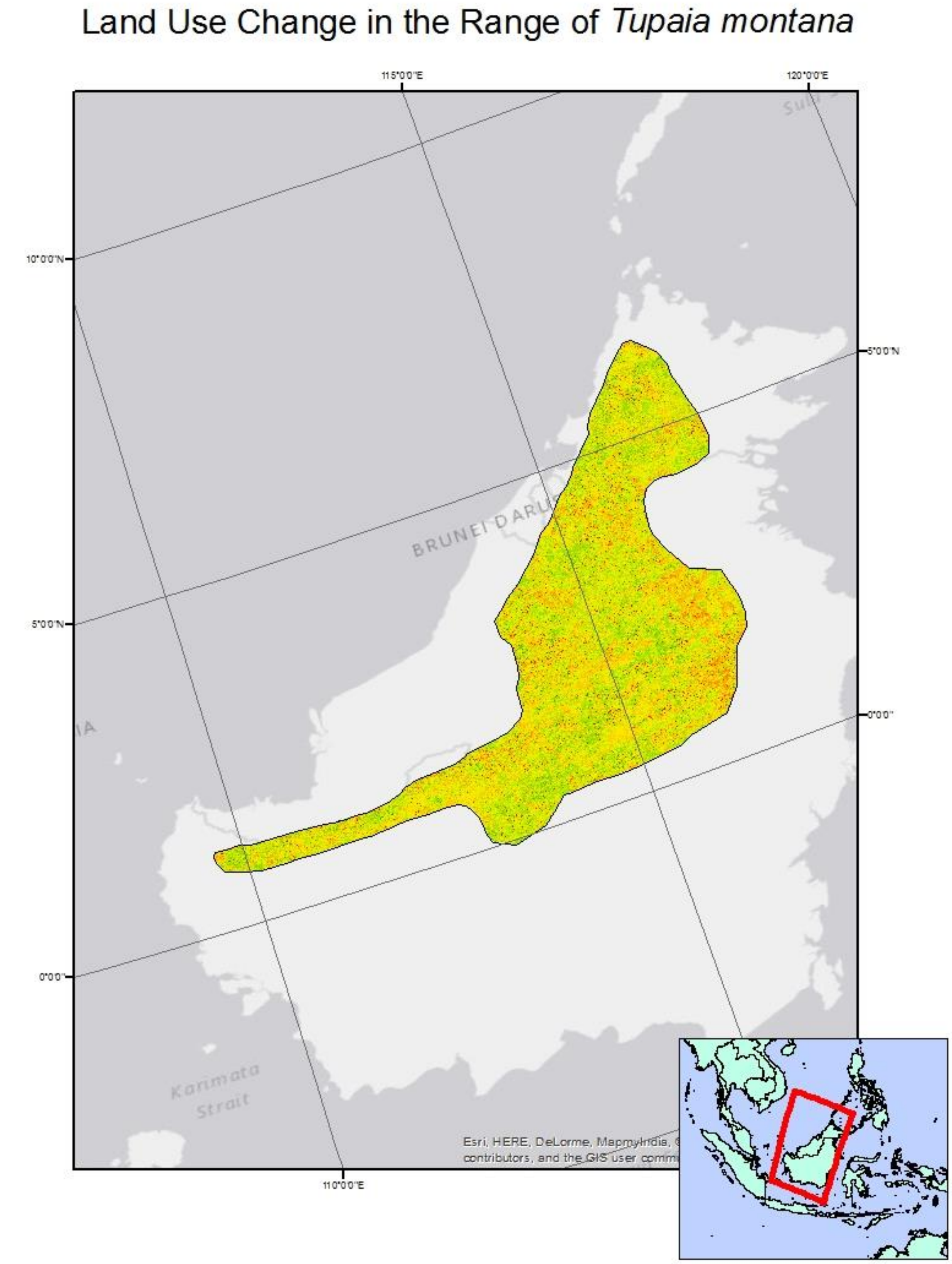

Figure 12: *Tupaia montana*, in which red shows a decrease in greenness over time

Land Use Change in the Range of *Tupaia palawanensis*

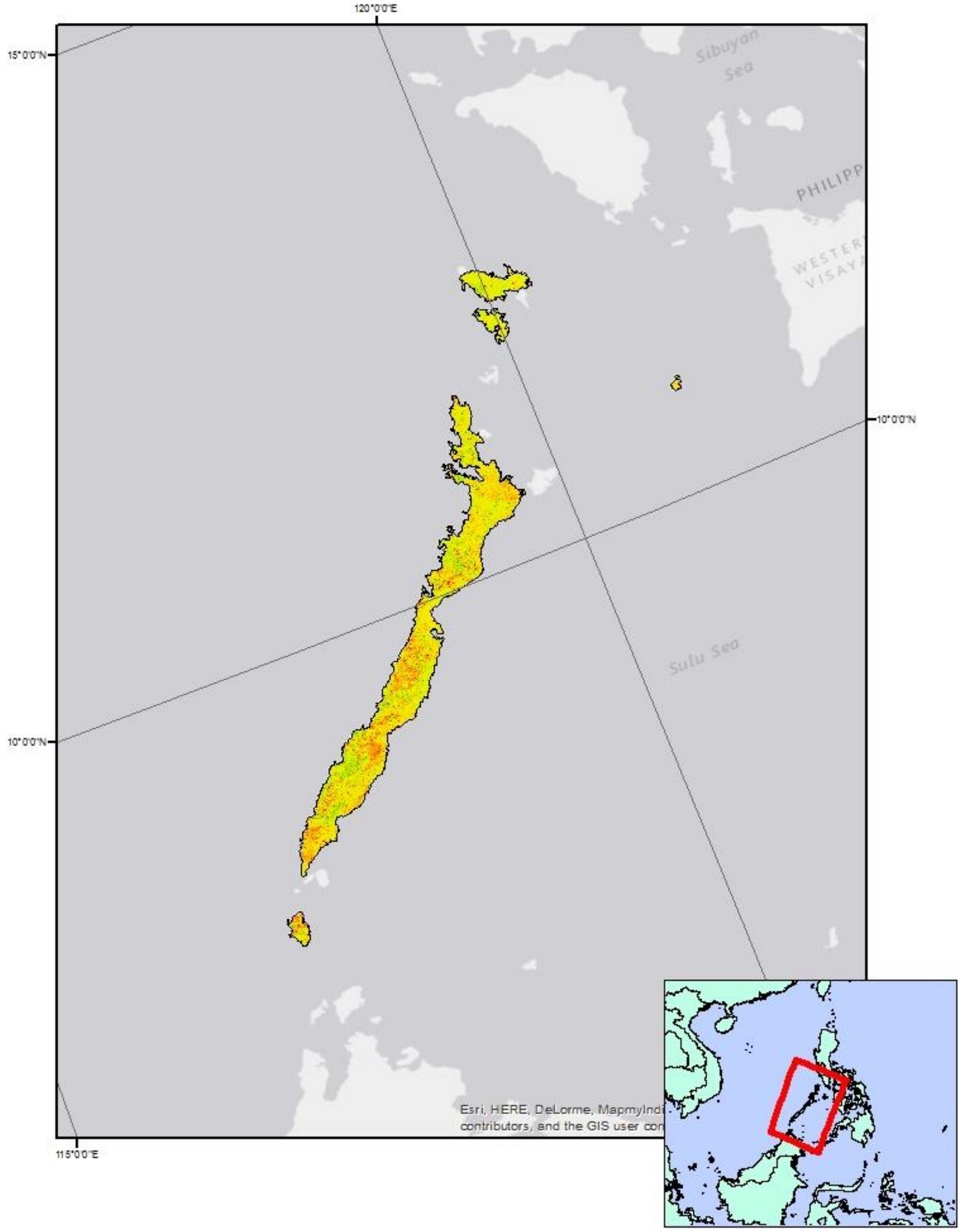

Figure 13: *Tupaia palawanensis*, in which red indicates a decrease in greenness over time

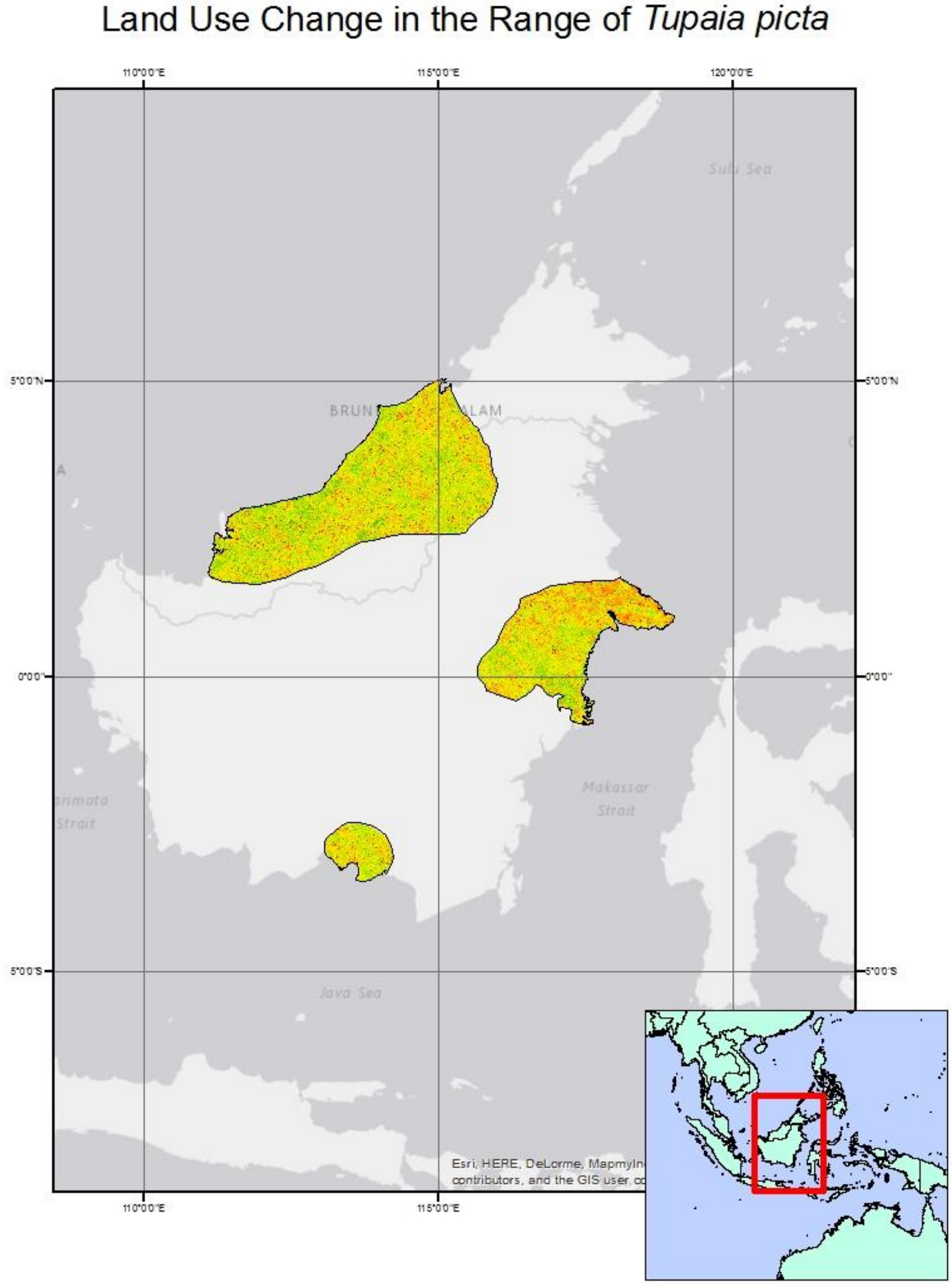

Figure 14: *Tupaia picta*, in which red indicates a decrease in greenness over time

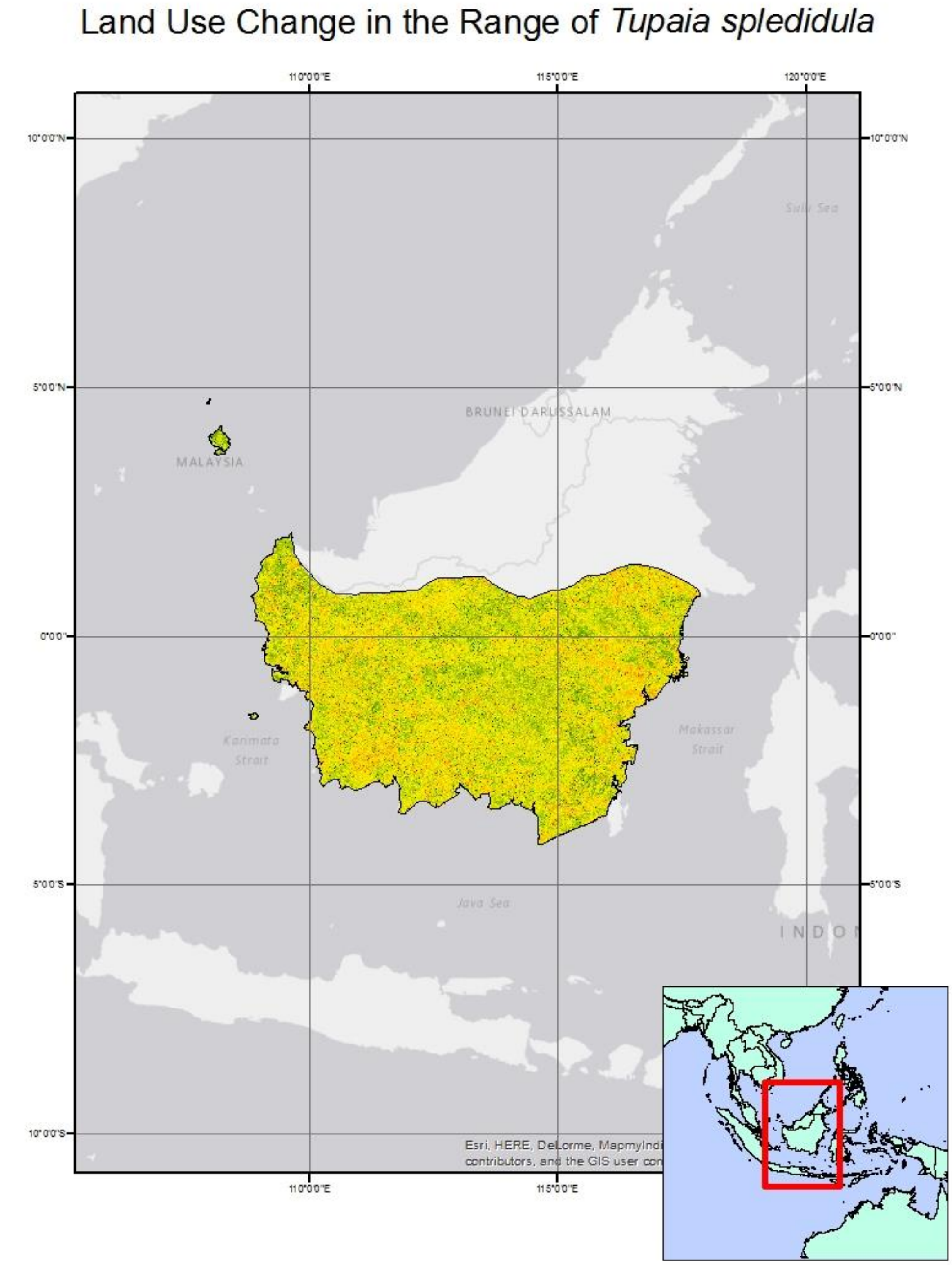

Figure 15: *Tupaia splendidula*, in which dark green indicates a significant increase in greenness over time

Figure 16: *Tupaia tana*, in which red indicates a decrease in greenness over time

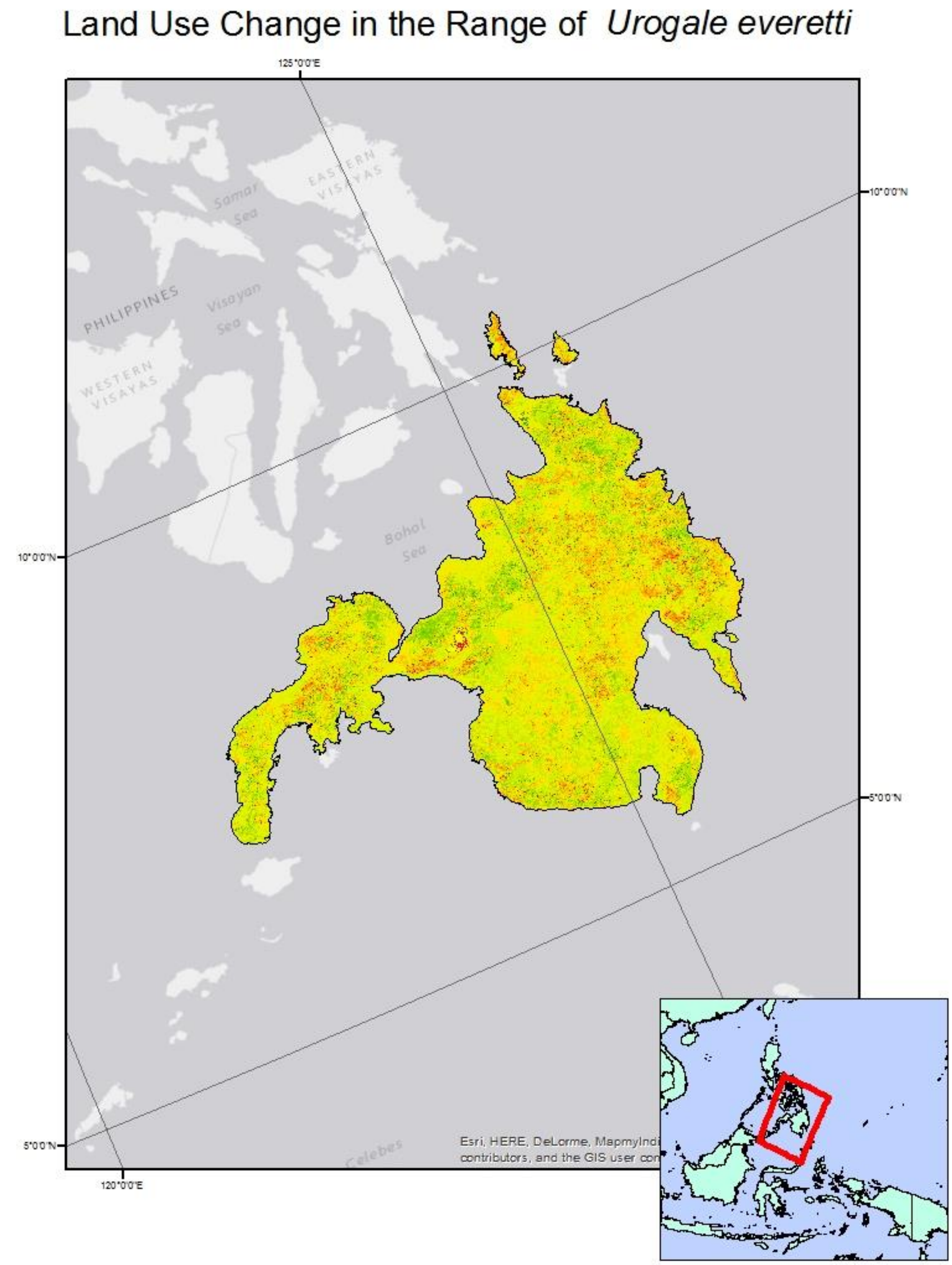

Figure 17: *Urogale everetti*, in which dark red indicates a significant decrease in greenness over time