# Spatial Diversity of Terrestrial Ecosystem in Northeast Thailand using Satellite data and GIS.

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**ABSTRACT:** The integration of physical and biological environments is an application approach used with objective of identifying a spatial diversity of the terrestrial ecosystem. The study area, Northeast Thailand, covers an area of about 170,000 km2 or one-third of the kingdom area. The main components of ecosystem in the Northeast was synthesized and categorized to define the possible classification. As a result, the components defined include landform, rainfall, slope and elevation, vegetation and soil. Landsat data and topographic map was used to formulate the landform layer. Analysis of daily rainfall of the past years provides the rainfall layer. Digital Elevation Model (DEM) interpolated from elevation contour map was analyzed to generate the slope and elevation layers. Normalized Difference Vegetation index (NDVI) of Landsat data and ground survey offer information on the spatial vegetation cover and type. Spatial soil layer was performed using soil series group of Department of Land Development. Each of the identified layers with their associate attribute was digitally encoded in GIS database to eventually create the thematic layers. The integration of those layers was performed as the criteria set from which the spatial diversity of the ecosystem could be identified. Overall terrestrial ecosystem includes natural ecosystem which located in the forest conservation areas whereas agricultural systems are restricted to the high, medium and low alluvial terraces. The flood plain ecosystem was found as narrow strips and isolated depression areas in the Mun, Chi and Mekhong watershed. In conclusion, with the advent of digital satellite data and GIS capability the spatial diversity can be effectively identified. The result obtained can be made available to support the strategic management of the ecosystem.

## INTRODUCTION

The management of ecosystem diversity has been increasing in recent year due to degradation that is created by human activities. At the international level the United Nations Convention on Biodiversity (Rio Convention, UNEP, 1992) focuses on strategies for conserving biodiversity, and includes explicit requirement for the monitoring of biodiversity. The biodiversity is made up of three related concepts: genetic diversity, species diversity and ecological diversity (Miller, 1991) Ecosystem units are defined based on the integration of terrain, rainfall, topography, soil characteristics and vegetations. Numerous studies have been shown the importance of integration of spatial data to portray the terrestrial ecosystem (Schneider, 1997, Jensen et al, 1996, O'Neill et al, 1997). The comprehensive methodology and standard for ecosystem mapping has been published by resource inventory committee (1998). In Thailand, there are a number of sectoral maps available (i.e soil, forest, topography maps) lack of integrated maps available. In tropical regions diversity of ecosystem is very complex and complicated. With the advent of remote sensing technology in combination with GIS terrestrial ecosystem mapping can be synthesized and established with high efficiency and reliability. The integrated mapping can be used for portraying the diversity of ecosystems from which

management practices can be developed. Moreover, the ecosystem map provides a basis for rating values of resources on which the measures for conservation can be relied.

The purpose of this study is to identify a spatial diversity of the terrestrial ecosystem in Northeast Thailand. The identification is based on computer-based GIS and remote sensing data.

## STUDY AREA

The area lies between the latitudes of 14° and 19° N and longitudes of 101° and 106° E (Figure 1). Physiographically, the area of northeast Thailand is mainly formed by the so-called Khorat Plateau. ( Moormann et al 1964 ) The plateau is an area of undulating topography developed on a sedimentary sequence of Mesozoic and early Tertiary Strata. Two shallow synclinal units, the Sakon Nakhon and Khorat basins are separated by a low-amplitude anticlinorium which has its topographic expression in the Phu Phan Hills. Land use patterns in the northeast are restricted to rice for low land and field crops for the upland and well drained soils. The isolated forest remnants typify the remaining forests in the area. Dipterocapus forest type is the main forest in this area. Soils are inherently low in fertility and have sandy texture with low cation exchange capacity.


**Figure 1** Study area

## METHODOLOGY

Classification and Mapping concept

The ecosystem classification is the stratification of a landform into ecosystem units, according to an integration of ecological features, amount of rainfall, elevation, slope, vegetation type and density and soil. The approach to mapping begins with collection of the existing component of the ecological features and the establishment of GIS databases defined. Mapping terrestrial ecosystems is an integrative process which performs analysis using GIS to capture the spatial representation of ecosystem in the study area.

Establishment of Ecosystem Unit

Existing maps and reports should be consulted, and identification of the classification concept was reviewed. In addition identification of ecosystem features was performed in terms of the concept, existing data and data to be created. Establishment of the thematic layers was described as follows

1. Landform layer:

Establishment of landform layer was prepared form the information derived from the Landsat RGB images, topographic map and field survey. The identification of landform type was based on Scholten et al (1973)

2. Rainfall layer

Daily rainfall data from 264 stations across northeast Thailand and vicinity areas at least 15 years of record were compiled as a point database for analysis. Calculation of mean annual rainfall was made of each station. Kriging interpolation was performed to create spatial mean annual rainfall across the entire northeast Thailand. The threshold of mean annual rainfall was then identified using decile range to create the decile rainfall. The decile rainfall of 10 classes was grouped into 4 levels.

3. Topography

Slope and elevation layers were generated from digital elevation model (DEM). These were, in turn, created using elevation contours of topographic maps at 1:50,000 scale. The classes of slope and elevation used for overlay analysis have been summarized in table 1.

4. Land use and Normalized Difference Vegetation Index (NDVI)

Land use are input variables for analysis to identify the class as shown in table 1. Preparation of land use layer was done using the Landsat TM acquired in table 2. The procedure of land use layer was performed by the visual interpretation of the RGB images with the following steps. First the preprocessing of the Landsat data was performed. This included geometric correction, enhancement and mosaicing. Secondly, the preliminary study was conducted to identify the land use type and to derive the available information. Finally the land use map was visually interpreted and mapped. The field survey was also conducted to support and correct the interpretation.

NDVI was used to create output image for vegetation analysis. This could bring out and enhance the differences which was unable to observed in the display of the original color bands. The NDVI used in this study was to classify the density of forest. The output NDVI image was then transformed into a thematic layer.

5. Soil and surface material

This layer was compiled from detailed reconnaissance soil map (1:100,000) of Land Development Department.

Each of the thematic layers with their associated attributes were digitally encoded in a geodatabase. These layers were then spatially overlaid to produce a composite layer. The composite layer was a combination of the coincidence of the input classes. The output classes were then assigned according to the combination of the input classes. Each output class represented an ecosystem unit existing in a given landform.

**Table 1** Thematic layers and associated attributes

| Thematic layers | | Attribute |
|---|---|---|
| **Landform** | | Flood plain : **(F)**<br>Low terrace : **(L)**<br>High to middle terrace : **(H)**<br>Dissected Erosion Surface : **(D)**<br>Mountain : **(M)** |
| **Rainfall** | | Low (<1,050) : **(1)**<br>Moderate (1,050 – 1,300) : **(2)**<br>Moderately high (1,300 – 1,600) : **(3)**<br>High (>1,600) : **(4)** |
| **Topography** | Slope | 0-2 % : **(1)**<br>2-5 % : **(2)**<br>5-12 % : **(3)**<br>12-20 % : **(4)**<br>20-35 % : **(5)**<br>> 35 % : **(6)** |
| | Elevation | < 480 m. : **(L)**<br>480-720 m. : **(M)**<br>> 720 m. : **(H)** |
| **Land use/NDVI** | Land use | Dry Evergreen Forest : **(1)**<br>Hill Evergreen Forest : **(2)**<br>Deciduous Forest : **(3)**<br>Pine Forest : **(4)**<br>Agricultural Land : **(5)**<br>Others : **(6)** |
| | NDVI | Low (<130) : **(L)**<br>High (130-255) : **(H)** |
| **Soil/Surface Material** | | Slope complex, outcrops : **(1)**<br>Fragmental/Skeletal soil : **(2)**<br>Sandy soil : **(3)**<br>Clayey/Loamy soil : **(4)**<br>Lateritic soil : **(5)**<br>Saline soil : **(6)** |

**Table 2** Landsat 5 TM data sources

| No. | Part | Row | Acquisition Date |
|---|---|---|---|
| 1 | 126 | 49 | January 19, 1999 |
| 2 | 126 | 50 | January 19, 1999 |
| 3 | 127 | 48 | December 25, 1998 |
| 4 | 127 | 49 | December 25, 1998 |
| 5 | 127 | 50 | December 25, 1998 |
| 6 | 128 | 47 | January 17, 1999 |
| 7 | 128 | 48 | January 17, 1999 |
| 8 | 128 | 49 | January 17, 1999 |
| 9 | 128 | 50 | January 17, 1999 |
| 10 | 129 | 48 | February 09, 1999 |
| 11 | 129 | 49 | February 09, 1999 |
| 12 | 129 | 50 | February 09, 1999 |

## RESULT AND DISCUSSION

Results of the diversity of ecosystem in the northeast are shown in Figure 2. The main system can be subdivided into 62 units according to the combination of the thematic layers. The ecosystem as identified is viewed at level of spatially defined area. The relations among physical variables and board types of and density of vegetation could be observed. Thus, in this study, patterns of diversity at spatial ecosystem are related to key functional factors of ecosystem. In the Northeast the forest types can be mainly classified as hill evergreen, dry evergreen, deciduous forests which depend on the temperature and moisture regimes. Hydrological pattern within the landscape in the northeast has more profound effect on the variation of vegetation rather than the amount of rainfall. More water could be accumulated in low land and poorly drained soil which provide the moisture regime suitable for water tolerant vegetations. The areas occupied by the terrestrial ecosystem in the northeast can be summarized in table 3. It can be observed that the man-induced ecosystem or agriculture cover area of 4.09, 12.75, 25.12, 30.55 and 3.99 % in the mountain, dissected erosion surface, high-middle terraces, low terrace and flood plain areas respectively. The diversity of forest types is mainly restricted in the mountain areas in which a number of plant/wildlife varieties can be found. The study provides the detail of terrestrial ecosystem in terms of spatial organization of the physical environments in relation to the forest types. In the geodatabase established can be defined the relationships among the physical environments and forest types: i.e soil-landscape and vegetation types. The study also provides overall insight into the spatial patterns of the ecological landscape which affect the vegetation ecosystem. It has become increasingly apparent that computer-based GIS and satellite data can provide the means to identify the terrestrial ecosystem effectively. Reliability was made by checking the resultant map against the field study. The potential source of error may be existed in combining a number of the sub-layers. Fore more comparable results, detailed investigations.

In conclusion, using the GIS capabilities and satellite data can offer the spatial integration of a wide variety of information for better identification of the ecosystem. Moreover, updated information can be feasible.

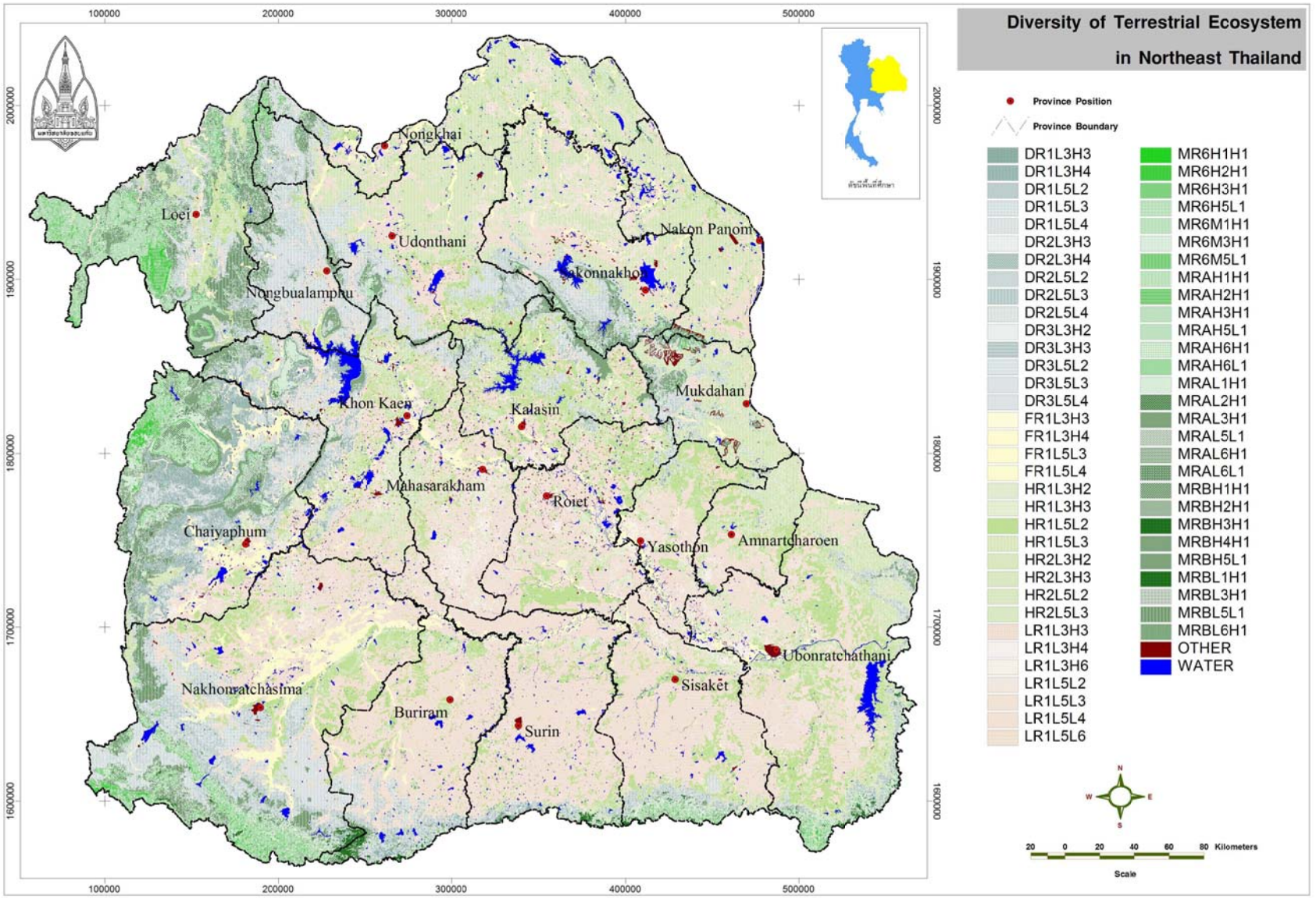


**Figure 2** Diversity of Terrestrial Ecosystem in Northeast Thailand

**Table 3** Summary of Areas Occupied by the Main Group of Terrestrial Ecosystem in the Northeast

| ECOSYSTEM GROUP | | % |
|---|---|---|
| **Landform** | **Land use** | |
| Mountain | Hill evergreen forest | 0.17 |
| | Dry evergreen forest | 3.34 |
| | Deciduous forest | 5.21 |
| | Pine forest | 0.02 |
| | Plantation | 0.11 |
| | Agriculture | 4.09 |
| Sub-total | | 8.85 |
| Dissected Erosion surface | Deciduous forest | 3.21 |
| | Agriculture | 12.75 |
| Sub-total | | 15.96 |
| High – Middle terrace | Deciduous forest | 4.17 |
| | Agriculture | 25.12 |
| Sub-total | | 29.29 |
| Low terrace | Deciduous forest | 2.85 |
| | Agriculture | 30.55 |
| Sub-total | | 33.30 |
| Flood plain | Riparian forest | 0.83 |
| | Agriculture | 3.99 |
| Sub-total | | 4.82 |
| Others (water, urban area) | | 7.78 |
| Total | | 100.00 |

Total area = 170,000 $km^2$

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