Journal of Environmental Sciences Vol.15, No.2, pp.222—226, 2003

ISSN 1001—0742
CN11—2629/X

Article ID: 1001-0742(2003)02-0222-05 **CLC number**: Q149 **Document code**: A

Landscape dynamitic change in Mu Us Desert derived from landsat TM data

GUAN Yan-ning[1], GUO Shan[1], XUE Yong[1], LI Rui[2], YANG Qin-ke[2]

(1. Institute of Remote Sensing Applications, Chinese Academy of Sciences, Beijing 100101, China. E-mail: guan@irsa.irsa.ac.cn; 2. Institute of Soil and Water Conservation, Chinese Academy of Sciences, Xi'an Yangling 712100, China)

Abstract: Landscape ecology emphasizes large areas and ecological effects of the spatial patterning of ecosystem. Recent developments in landscape ecology have emphasized the important relationship between spatial patterns and many ecological processes. Quantitative methods in landscape ecology link spatial patterns and ecological processes at broad spatial and temporal scales. In turn the increased attention on temporal change of ecosystem has highlighted the need for quantitative methods that can analyze patterns. This research applies quantitative methods——change detection to assess the ecosystem temporal change in the arid and semiarid area. Remote sensing offers the temporal change of ecosystem on landscape characteristics.

Keywords: landscape ecology; ecosystem change; change detection; remote sensing

Introduction

Remotely sensed data is increasing used by environmental scientists to detect ecosystem changes over broad spatial scales. Change detection analysis, employing satellite data obtained the land cover type disturbances, has been used to monitor forest defoliation (Douglas, 1994), assess vegetation responses to drought (Jacobberger-Jellison, 1994), evaluate wetland change (Jensen, 1995) and detect vegetation changes (William, 1997; John, 1998).

Ecology is generally defined as the study of the interactions between organisms and their environment. A landscape is described as a mosaic in which local ecosystems recur. The spatial elements within landscapes have been called landscape elements or local ecosystems. Thus, the landscape change represents the change of ecosystem.

1 Study areas and data acquisitions

The two study sites are located southeast of Mu Us Desert, Shaanxi (Fig.1). The study sites consists a 58000 km^2 area. Total annual precipitation averages 316—513 mm, falling primarily between July and September. This region is semiarid and supports variable vegetation cover and composition consisting of shrubs, grass and forest. Shrubs and grass are two dominant vegetation covers.

Landsat TM data were selected as the source data for ecosystem change detection. Data used to detect the ecosystem change included Landsat TM data for two epochs, 1987 and 1999. For the study site 1(127/33, path/row), the time periods of data are 1987/10/24 and 1999/10/17; for the study site 2(128/34, path/row), the time periods of data are 1987/09/29 and 1999/09/22. The objective was to select high quality and the same seasonal data to avoid deviations occurred due to the lack of available the same period data.

2 Method

2.1 Ecosystem dynamic change analysis

The remotely sensed landscape is multi-dimensional, multi-temporal and multi-scaled. The application of remote sensing techniques cannot be done without consideration of the parameters to be measured, the scale of measurement for analysis, the time frame for observation and an understanding of the processes that affect the phenomena under study. The summary of the interrelationships between remote sensing and landscape ecology is presented in Table 1 (Estes, 1980).

2.2 Temporal change analysis——multi-date change detection

Methods of digital change detection: Remote sensing images show patterns of landscape, ecosystems and vegetation types as well as man-made features within landscapes. The ecosystems are dynamic, and change rapidly. Change detection technique can survey these changes accurately so that our understanding of landscape processes increases.

The remote sensor system and environmental parameters must be considered whenever change detection takes place. The general steps required to perform remote sensing change detection using remotely sensed data are summarized in Fig. 2. One of the first requirements is to choose an appropriate change detection algorithm and the others are to select an appropriate classification scheme that identified ecosystem unit classes of interest to be monitored and eventually used in the change analysis.

Using digital change detection the selection of an appropriate change detection algorithm is very important(Jensen, 1993; John, 1998). It has a direct impact on the type of image classification to be performed and indicates whether important change information can be extracted from the data. For instance, to chosen the algorithm, multi-data composite image change detection, the change between the two satellites images can be detected. The following change detection algorithms are commonly used (Jensen, 1993):

- Change detection using write function memory insertion;
- Multi-data composite image change detection;
- Image algebra change detection (band difference or band ratio);
- Post-classification comparison change detection;

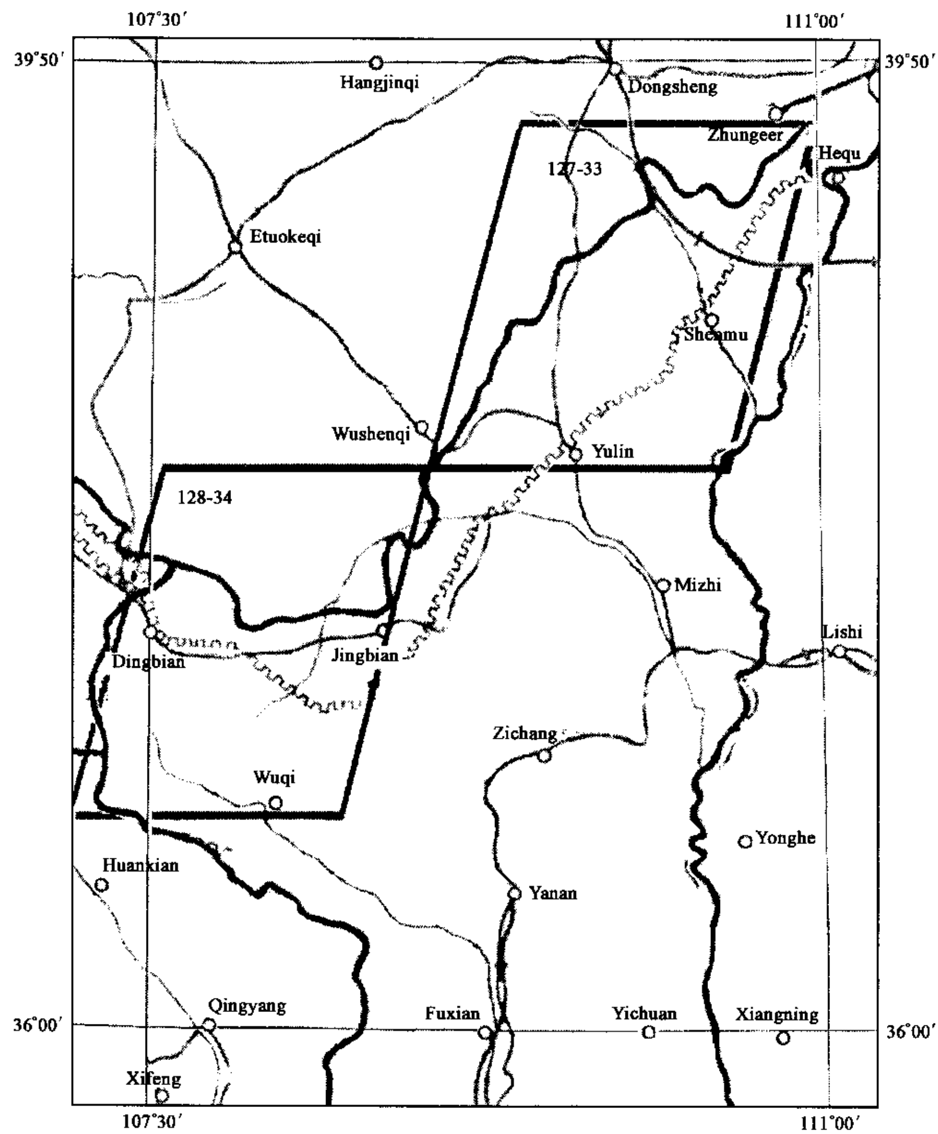

Fig. 1 The location of the study area

- Multi-data change detection using ancillary data source as data 1;
- Multi-data change detection using a binary mask applied to data 2;
- Manual, on-screen digitisation of change;
- Spectral change vector analysis;
- Knowledge-based vision system for detection change.

Table 1 Summary of interrelationships between remote sensing and landscape ecology

Landscape ecological characteristics
Study of pattern, structure, and morphology of phenomena:
Measured attributes may generally be classed into:
Physical properties
Spatial properties(e.g. shape, size, pattern, arrangement and texture)
Scale properties(micro, meso, regional or global)
Temporal properties
Remote sensing attributes
Measurement of physical properties:
An object's signature or spectral response can provide data on:
Spectral color or visual appearance
Temperature
Moisture content
Organic and inorganic composition
Measurement of spatial properties:
Provides information on geometry and position(e.g. size, shape, arrangement, and texture)
Provides both point and area information
Contributes to better preparation of thematic maps for use in spatial analysis
Provides for multiple scales of analysis(micro, meso, regional or global)
Measurement of temporal properties:
Multi-temporal analysis capability
Provides capability for analysis of landscape change through time

(Source: Estes, 1980)

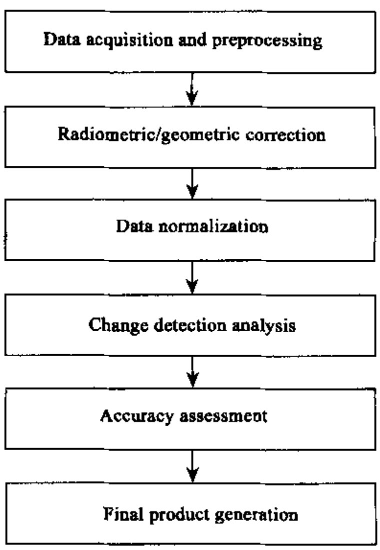

Fig.2 General steps used to conduct remote sensing change detection

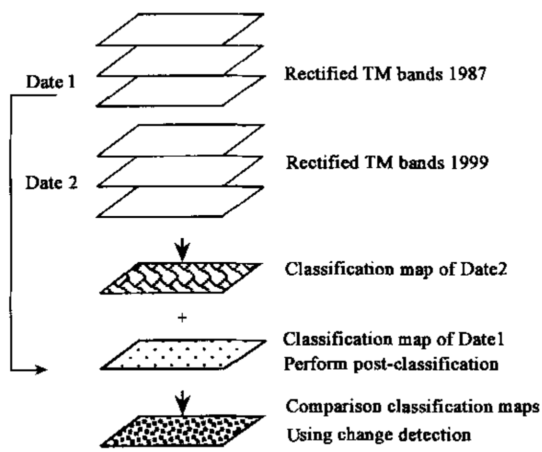

Fig.3 Multi-data composite image change detection

In this study the two data TM images used in the change detection process. Thus the algorithms—— multi-data composite image change detection was selected. Fig.3 shows the change detection scheme.

It is important to select a standardized, compatible landscape pattern classification system for change detection. The use of standardized classification systems allows change information to be widely applied. However, there are few classification systems designed specifically for change detection purposes. The classification system(Fig.4) is that used in this study.

The unsupervised classification will be employed for land classifying. The isodata algorithm will be used to perform an unsupervised classification on the ERDAS IMAGINE platform.

Post-classification is the most commonly used quantitative method of change detection (Jensen, 1993). It requires rectification and classification the remotely sensed image. The two maps are compared on a pixel by pixel using a change detection matrix. The result can be display in a change map. Every error in the individual date classification map will also be present in the final change detection map (Rutchey, 1994). Therefore, it is imperative that the individual classification maps used in the post-classification change detection method be as accurate as possible(Augenstein, 1991).

Classification system

Class 1	**Agriculture area**
Class 2	**Forest**
Class 3	**Shrub**
Class 4	**Grassland**
Class 5	**Desert and undeveloped**

Fig.4 The classification system using in the change detection

3 Results

3.1 The area change of landscape

The change detection is a technique that detects the changes between two data sets, the classification map 1987 and the classification map 1999 pixel by pixel. Based on the results of landscape change detection, the area of ecosystem temporal change can be identified.

In study area 1, the increase in the agriculture area, and a more pronounced increase in the forest and shrub. The grassland and the desert decrease. In study area 2, the area of agriculture area and forest changes obviously. The shrub is relatively stable. The grasslands decrease, and the desert increase. The total area change of ecosystem classes from 1987 to 1999 were calculated(Table 2).

Table 2 The total area change of each ecosystem units

Ecosystem units	Study area 1 1987, hm^2	Study area 1 1999, hm^2	Study area 2 1987, hm^2	Study area 2 1999, hm^2
Class 1	150513	151403	160025	174785
Class 2	234765	272679	229527	265785
Class 3	473654	490824	479334	478148
Class 4	662792	619884	765084	722633
Class 5	454475	448657	498987	500958

3.2 Landscape type change-land transformation

Table 3a and 3b are the land transformation matrixes of the two study areas. They are illustrates the landscape type change. The values are the area of the ecosystem unites.

Analysis of the landscape type change, agriculture area and desert and undeveloped are relative stable comparing with the other types. However, it is remarkable that the area of desert and undeveloped in the southwest part of the two study areas is increase. The trend of the landscape change indicates the landscape transformation is worsening in somewhere. The increases in the change map indicate the landscape transformation is worsening. The land degradation occurs.

Table 3a The land transformation matrix(study area 1)

Ecosystem unites 1987	Ecosystem units 1999				
	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	69598.620	41348.970	22780.170	11277.450	1668.690
Class 2	35059.860	77281.470	104649.480	47803.140	6810.660
Class 3	23571.090	64993.410	195042.690	178758.630	27677.880
Class 4	16107.120	38879.190	121316.850	306834.210	136224.000
Class 5	6176.520	12261.780	29864.790	118118.520	282094.200

Table 3b The land transformation matrix(study area 2)

Ecosystem unites 1987	Ecosystem units 1999				
	Class 1	Class 2	Class 3	Class 4	Class 5
Class 1	102963.150	39614.580	16665.840	6032.790	652.230
Class 2	39676.860	87362.460	86635.170	44955.360	6798.690
Class 3	13235.670	75584.970	188133.480	163463.670	37620.630
Class 4	3501.720	23791.320	163348.380	383698.800	148267.530
Class 5	647.190	3174.120	24551.550	166933.170	305648.010

4 Summary

The framework for remote sensing application in landscape ecology must be considered in reference to both the spatial and temporal condition. The individual research question associated with space, time and dynamics. An appropriate data collection design can be employed within the scope of an investigation to provide answers to the specific landscape questions under consideration. The landscape processes associated with the landscape spatial and temporal dynamics can be observed and measured using change detection.

Many change-detection studies have primarily focused on applying a multi-temporal remote sensing data. This research demonstrated the feasibility of using satellite data to assess and monitor temporal changes in the arid and semiarid landscape.

Results indicated that the ecosystem change is intense during the past ten years. This research examines the ecosystem change in two vast study sites to further understanding of regional scale processes.

Acknowledgements: The authors would like to thank the Knowledge Innovation Program (Institute of Remote Sensing Applications, Chinese Academy of Sciences and Institute of Soil and Water Conservation, Chinese Academy of Sciences) for the supplying.

References:

Augenstein E, Stow D, Hope A, 1991. Evaluation of SPOT HRV-XS data for kelp resource inventories[J]. Photogrammetric Engineering & Remote Sensing, 57(5):501—509.

Douglas M M, Barry N H, 1994. Change detection for monitoring forest defoliation[J]. Photogrammetric Engineering & Remote Sensing, 60(10): 1243—1251.

Estes J E *et al*., 1980. Impacts of remote sensing on U.S. geography[J]. Remote Sensing of Environment, (10): 43—80.

Jacobberger-Jellison P A, 1994, Detection of post-drought environmental conditions in the Tombouctou Region[J]. International Journal of Remote Sensing, 15(16): 3138—3197.

Jensen J R, Cowen D J, Narumalani S *et al*., 1993. An Evaluation of coast watch change detection protocol in South Carolina[J]. Photogrammetric Engineering & Remote Sensing, 59(6): 1039—1046.

Jensen J R, Rutchey K, Koch M S *et al*., 1995. Inland wetland change detection in the everglades water conservation area 2A using a time series of normalized remotely sensed data[J]. Photogrammetric Engineering & Remote Sensing, 61 (2): 199—209.

John G L, Ding Y, Ross S L *et al*., 1998. A change detection experiment using vegetation indices[J]. Photogrammetric Engineering & Remote Sensing, 64(2): 143—150.

Rutchey K, Velcheck L, 1994. Development of an everglades vegetation map using a spot image and the global positioning system[J]. Photogrammetric Engineering & Remote Sensing, 60(6): 767—775.

William K M, Paula F H, 1997. Detection of vegetation changes associated with extensive flooding in a forested ecosystem[J]. Photogrammetric Engineering & Remote Sensing, 63(12): 1363—1374.