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Changes of Landscape Structure for the Recent 20 Years in the Wangsuk Stream Basin of the Central Korea

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ABSTRACT: Landscape changes for 20 years between 1981 and 2001 in the Wangsuk stream basin located on the central Korea were investigated on the basis of physiognomic vegetation map made from the aerial photograph interpretation and field check. Changes of landscape structure were noticeable in agricultural field and forest landscape elements. Changes in the agricultural fields due to transformation of agricultural pattern into the institutional agriculture dominated landscape change, although urbanization also contributed to such change. The former change due to change of food production structure originated from socio-economic development during this period and the latter to the overpopulation of Seoul. As energy sources for heating and cooking, fertilizer, and fodder for livestock transform from plant materials to fossil fuel, manufactured one, and grain, succession of forest escaped from direct human disturbance dominated change of landscape structure in forested land. Differently from the positive landscape change in the upper area, change in the lower area deteriorated landscape quality by increasing artificial land. It was estimated that such landscape deterioration in the Wangsuk stream basin would influence water quality of the stream. In order to realize sustainable land-use against such environmental degradation, systematic environmental management based on landscape ecological perspective such as "an eco-plan for creating riparian vegetation belt," which is under preparation by Ministry of Environment, was recommended.

Key words: Disturbance, Institutional agriculture, Landscape change, Urbanization, Wangsuk stream

INTRODUCTION

Landscape is an ecological system, which comprehends natural factor as well as human factor (Naveh and Lieberman 1994, Zonneveld 1995). Landscape pattern is an important concept to identify and classify the landscape as a complex of landform, soil bodies, vegetation units, and human activities (Zonneveld 1995). Landscape pattern is determined as the ecological consequences of natural environment and human activities (Turner et al. 2001). Even though so, it can also influence a variety of ecological phenomena, such as structure and function of population and community (Hansson 1979, Danielson 1991, Soule et al. 1992, Pulliam et al. 1992) and the spread of disturbance (Franklin and Forman 1987, Turner 1987, Turner et al. 1989).

Factors causing landscape heterogeneity are identified to natural and anthropogenic disturbances (Turner et al. 2001, Mazzoleni et al. 2004). Natural disturbances such as typhoons and landslides induce new patches in a matrix and produce heterogeneous landscapes. Its occurrence depends on the natural conditions. Anthropogenic disturbances such as agricultural and forestry activities induce new patches such as croplands and clear cutting area in a forested matrix. The occurrence of anthropogenic disturbance depends on socio-economical environments (Kamada and Nakagoshi 1996). The regime of the anthropogenic disturbances changes in accordance with a social change. The landscape structures, for example the number and size of patches, are changed as a resultant with a social change.

Landscape structure is maintained or changed depending on the relative importance between natural and anthropogenic disturbances (Birks et al. 1988, Kamada and Nakagoshi 1996). In the region where human impact is less, natural disturbance dominate landscape structure, whereas artificial disturbance play such a role in the region in which human effect is bigger. But in recent years, human impact has been an important factor causing landscape heterogeneity (Turner and Bratton 1987, Resica et al. 1997).

The regime of human land use and natural disturbance varies in the local region in relation to the natural and social environments. The factors making the unique landscape in each region can be specified by comparing the several landscapes (Turner and Ruscher 1988). Information about the spatial pattern of land mosaics, vegetation dynamics, and relationship between landscape change and intensity of past and present disturbances on landscapes can be acquired by comparing landscape maps sequentially (Küchler and Zonneveld 1988, Zonneveld 1995).

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River basin has been under human impact for a long time since ancient times. In particular, landscape structure in the watershed around a big city is dominated by excessive land use and thereby shows rapid change. Such changes reflecting socio-economic change are in progress toward two directions. That in lowland exploited densely is progressed towards deterioration of landscape and the other escaped from excessive use is to the recovery of natural feature. This study aims at identifying changes occurring in river basins of the central Korea and furthermore clarifying causal factors inducing such changes.

METHODS

Study Area

Study area was chosen in the Wangsuk stream basin located on the central Korea (Fig. 1). The basin is spread from the northern, Pocheon-gun to the southern, Guri-shi (Gun: county or district, Shi: city), Gyunggi Province (37° 33' 40.1" ~ 37 ° 46' 44.5"N, 127 ° 07' 37.6" ~ 127 ° 13' 54.8"E). This region is bordered on Seoul and thereby new cities such as Namyangju-Shi and Guri-Shi are emerged in order to accommodate over-flowed population from Seoul. But this region had been under less developmental pressure due to military security before 1990s. Gwangneung National Arboretum is located on the northern tip of this area and thereby forms a dense forest. But as moves the southern part, downstream of the Wangsuk stream, which is closer to Seoul, Jinjeob-eup, Onam-eup, Toegye-won-eup, Namyangju-shi and Guri-shi (Eup: town) appear successively and forest area decreases and urbanized area increases.

Methods

The physiognomic vegetation maps in 2001 were made from the aerial photograph (1:15,000) interpretation and field check (Küchler and Zonneveld 1988). Field check was carried out from March to October in 2001. Those in 1981 were prepared by combining forest cover maps and topographic maps at scale of 1:25,000. The forest cover maps were constructed by Forest Research Institute, based on interpretation of monochrome aerial photographs (1:15,000 scale), taken in 1981. Vegetation landscape maps were constructed with ArcView GIS (ESRI 1996).

Socio-economic changes were investigated by population size of major cities in the study area and supplemented by GNP in the national level of Korea (Guri-shi 2003, Namyangju-shi 2003, Korea

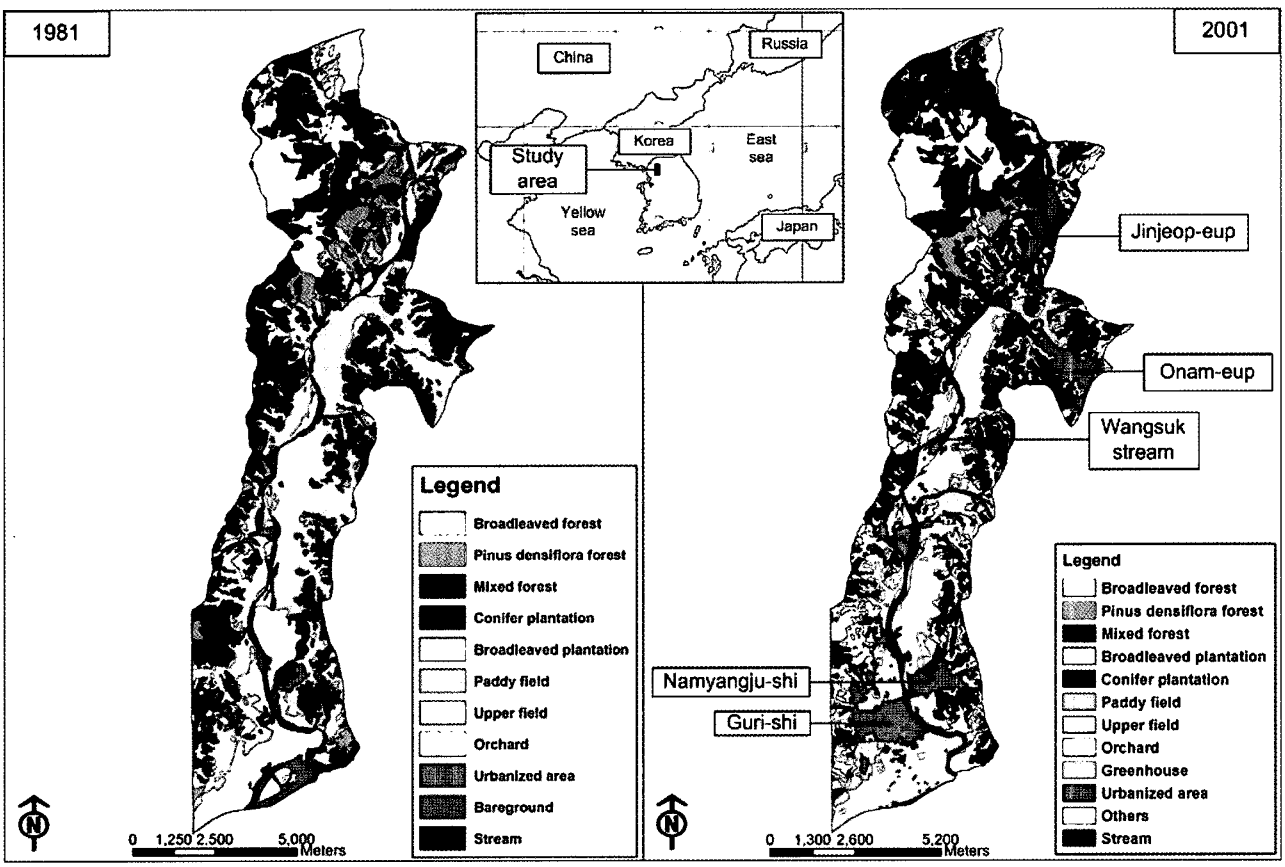

Fig. 1. Maps showing landscape changes between 1981 (left) and 2001 in the Wangsuk stream basin.

National Statistical Office 2002).

RESULT

Landscape Structure

Landscape structure of the Wangsuk stream basin was depicted in Fig. 1 and configuration of landscape elements identified from the vegetation maps was shown in Table 1. In the Wangsuk stream basin, dominant element was forest. Forested land, in particular, occupied extensive area in northern upstream area. As move from upstream toward downstream area, forest decreased, whereas agricultural area and urbanized area increased. Among forest landscape elements, mixed forest occupied the largest area and conifer plantation and broadleaved forest were followed in 1981. In 2001, coni-fer plantation occupied the largest area and broadleaved forest and mixed forest were followed. Agricultural field occupied the largest area next to forest landscape element. In 1981, agricultural fields were composed of paddy field, upper field and orchard but greenhouse for institutional agriculture appeared newly in 2001. Urbanized area increased noticeably in 2001. Stream decreased a little, whereas others increased more or less.

Table 1. A change of area of landscape units between 1981 and 2001 in the Wangsuk stream basin

Landscape element type	1981		2001	
	Area (ha)	Percentage	Area (ha)	Percentage
Secondary forest				
Broadleaved forest	854.3	8.3	1,391.3	13.6
Mixed forest	1,860.8	18.2	1,177.6	11.5
Conifer forest	396.0	3.9	162.8	1.6
Subtotal	3,111.1	30.4	2,731.7	26.6
Plantation				
Broadleaved plantation	90.6	0.9	58.0	0.6
Conifer plantation	1,537.1	15.0	1,994.0	19.4
Subtotal	1,627.7	15.9	2,052.0	20.0
Agricultural field				
Paddy field	3,439.5	33.6	818.8	8.0
Upper field	1,135.0	11.1	632.3	6.2
Orchard	43.7	0.4	159.3	1.6
Greenhouse	–	–	1,984.8	19.4
Subtotal	4,618.2	45.1	3,595.2	35.1
Urbanized area	339.2	3.3	1,429.6	13.9
Stream	479.0	4.7	335.9	3.3
Others	65.6	0.6	108.3	1.1
Total	10,240.8	100	10,252.7	100

Landscape change was less in the upstream basin but the change became larger as move toward the downstream (Fig. 1).

Changes of Major Landscape Elements

Changes of forest landscape elements for 20 years from 1981 to 2001 in the Wangsuk stream basin were shown in Fig. 2. Total area of forest was hardly changed. Compared between natural forest and artificial plantation, the former decreased, whereas the latter increased. Compared among forest types, pine and mixed forests decreased, while broad-leaved forest increased.

Changes of agricultural landscape elements were shown in Fig. 3. Both paddy and upper fields decreased noticeably. Instead, greenhouse, which was not existed in 1981, occupied very large area and orchard also increased much.

Socio-Economic Changes

Changes of population size in Namyangju-shi and Guri-shi, which are major cities in this study, were shown in Fig. 4. Both cities showed steep increase in population size since 1980s but that of Namyangju-shi was more rapid. GNP of Korea also increased rapidly since the mid-1980s (Korea National Statistical Office 2002).

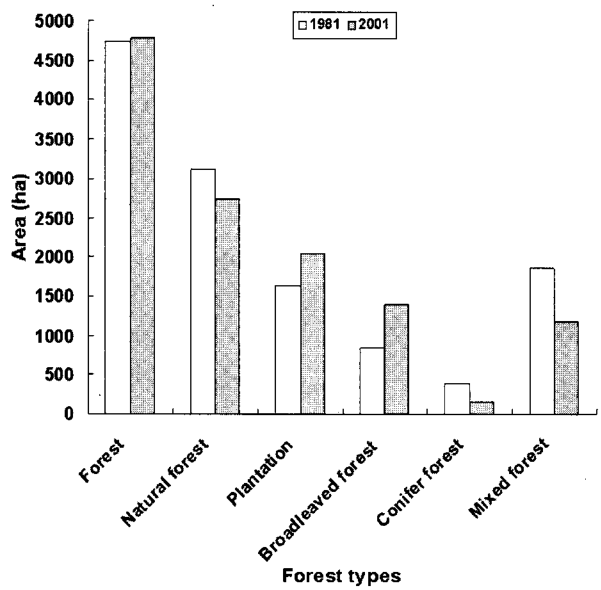

Fig. 2. Changes of forest landscape elements for 20 years between 1981 and 2001.

DISCUSSION

Understanding land-use changes and their ecological implications presents a fundamental challenge to ecologists. Land cover today is altered principally by direct human use such as agriculture, rearing of livestock, forest harvesting, settlement, construction, mining, and the like (Meyer 1995, Dale et al. 2000). Over the centuries, two important trends are evident: the total land area dedicated to human uses has grown dramatically, and increasing production of goods and services has intensified both use and control of the land (Richards 1990). The rate of land cover alteration is accelerating worldwide, particularly in regions with rapid population growth like this study area. Forests and wetlands have undergone especially large changes (Houghton 1995).

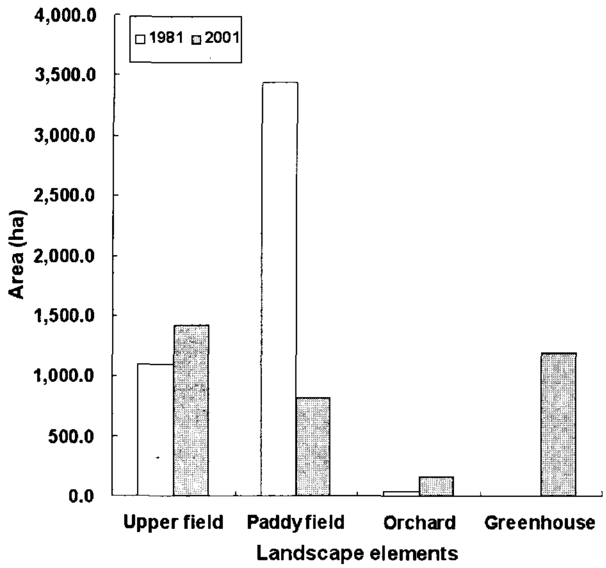

Fig. 3. Changes of agricultural landscape elements for 20 years between 1981 and 2001.

Land-use activities change landscape structure by altering the relative abundances of natural habitats and introducing new land-cover types. Introduction of new cover types can increase biodiversity by providing unique habitats, but natural habitats are often reduced, leaving less area available for native species. Land-use activities may alter the spatial pattern of habitats, often resulting in fragmentation of once continuous habitat and reduction in the biodiversity of native species. Natural patterns of environmental variation can also be altered by land use, especially if disturbance regimes are changed. For example, the environment may be changed directly when fire control and logging alter the frequency and extent of natural fires. Thus, effects on landscape structure should be considered when decisions about development locations, densities, and uses of the land are made (Turner et al. 2001).

Since vegetation is the most notable feature of landscape, its dynamic changes demonstrate the impact of socio-economic factors on its evolution. In the past, the balance of these activities resulted in

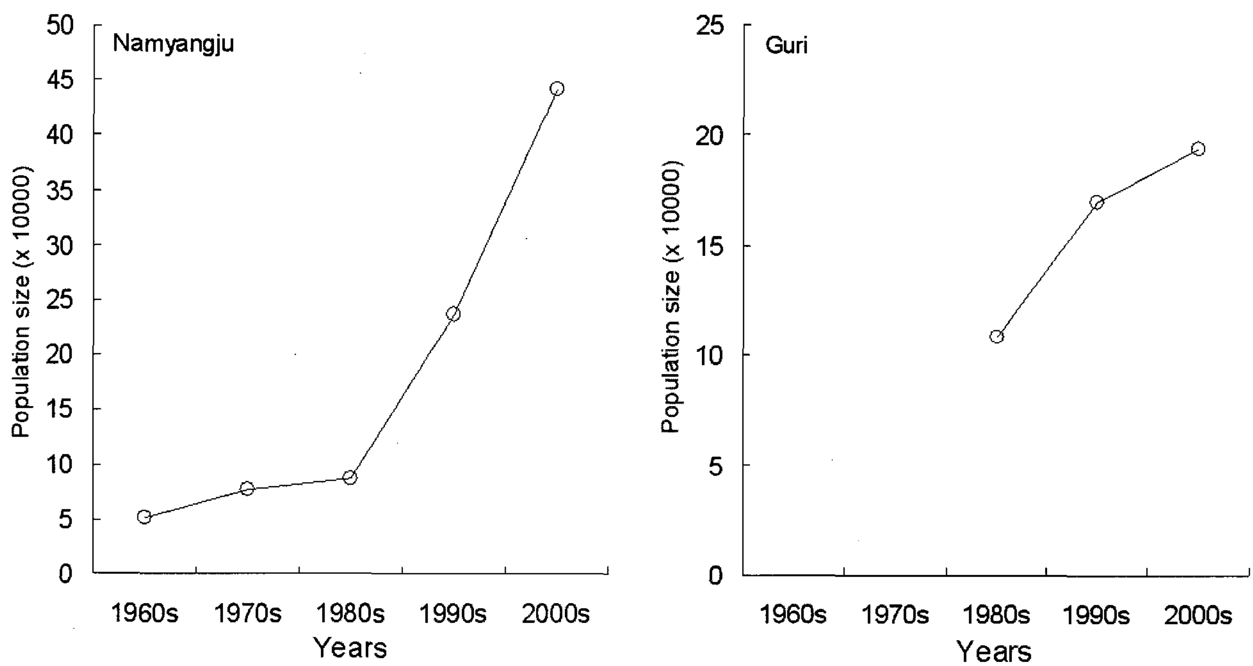

Fig. 4. Changes of population size in major cities in the study area, Namyangju-shi (left) and Guri-shi (right). Guri-shi was segregated from Namyangju-shi in 1986.

a complex, highly heterogeneous and stable landscape. The stability is now threatened by neo-technological interventions, which has intensified the activities, leading to landscape homogeneity and instability (Papanastasis et al. 2004).

Landscape, like other environmental units is dynamic in structure, function and spatial pattern (Forman 1995). In some cases, the evolutionary regime is dominated by natural disturbances such as typhoon and landslide (Heinselman et al. 1981). In others, land-use practices predominate so that changes in a landscape are due to the changes in management practices and the social, political and economic forces controlling land use (Heinselman et al. 1981). The fact that landscapes are dynamic requires that time or temporal changes, be considered in quantitative landscape studies. The Geographical Information System (GIS) can deal with such temporal changes, and has emerged as the most useful tool in addressing questions of landscape dynamics (Regato-Pajares et al. 2004).

Rural areas in Korea have undergone significant land use changes over the last a few decades. After having been extensively used for centuries for traditional human activities, such as agriculture, logging or cutting to get timber, fuel, organic fertilizer, feed for livestock, and so on, advance of the living standard originated from rapid economic growth caused such changes. Such changes occurred in accordance with socio-economic change. Change of eating habits, increase of leisure activities, energy transformation, substitution of organic fertilizer into chemical one, conversion of building materials from timber to concrete-steel frame, conversion of feed for livestock to grain, and so on can be presented as the examples of such changes. Such changes dominated land use changes (Kim 2000).

The study area had been extensively used for centuries for traditional human activities, such as general lives, agriculture and forestry, which had led to the establishment of a man-maintained dynamic equilibrium (Lee et al. 2001, Cho et al. 2006). Land use of the upper area, in which use by forestry played a central role, was largely reduced with the socio-economic change due to rapid economic growth, such as fuel revolution. Successional change of pine and mixed forests into broad-leaved forest reflect the trend (Fig. 2). In this respect, landscape change in the upper area can be evaluated as positive one. But insect damage including pine gall midge also contributed greatly to such changes on the other hand (Lee 1989).

Changes of agricultural type also contributed significantly to land use change. For example, much of traditional agricultural field was transformed to greenhouse and some was to orchard to fulfill the condition being required in the advanced living standard due to rapid economic growth accelerated since mid-1980s as was shown in temporal change of GNP (Korea National Statistical Office 2002). In particular, large area of rice paddy was transformed into greenhouse and urbanized area (Table 1). The result means loss of diverse functions of paddy field including biodiversity conservation and flood control (Lee et al. 2002).

Extension of urbanized area also played an important role in landscape change in the lower area (Fig. 1). Population increase in this area was accelerated since 1980s similarly to the case of GNP (Fig. 4). This population expansion was due to overpopulation of Seoul concentrated excessively. Expansion of such urban sprawl results in functional, structural and visual landscape degradation and loss of biodiversity (Naveh and Lieberman 1994).

Lee et al. (2001) clarified that land-use pattern of the surrounding watershed determined water quality different depending on sites in the Wangsuk stream. Considered this fact, landscape change progressed for recent 20 years in this study area that agricultural fields including rice paddy were transformed into more artificial cropland such as greenhouse or urbanized area, would be functioned in a crucial factor aggravating water quality of the Wangsuk stream. Riparian vegetation zone, including wetlands and floodplain vegetation, are conspicuous elements of many landscapes and important mediators of land-water interactions (Naiman and DeCamps 1997). In particular, freshwaters are sensitive to changes in adjacent lands (Lowance et al. 1997). In this respect, systematic environmental management based on landscape ecological perspective such as "an eco-plan for creating riparian vegetation belt", which is under preparation by Ministry of Environment, is required imperatively for sustainable land-use.

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