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Changed land management policy and the emergence of a novel forest ecosystem in South Korea: landscape dynamics in Pohang over 90 years

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Abstract Ecosystem management in South Korea dramatically changed in the early 1970s, shifting from historical utilization of natural resources to a strong management system that included forest promotion and restoration. The socio-economic and biological context underpinning this effort and the ecological consequences of this new policy have not been studied in South Korea. We analyzed landscape dynamics over a 90-year period (1918–2005), with particular attention to forest soil erosion, by using historical map and satellite images in Pohang. Our analysis revealed a dramatic increase in total vegetation cover (from 10,006.9 ha in 1918 to 17,868.7 ha in 2005) and an increase in the developed area. Meanwhile, the amount of barren mountainous area declined, shrub vegetation almost completely disappeared from the given area, and the salt marsh in the estuary completely disappeared. Mean soil loss declined from 12.6 ton ha⁻¹ year⁻¹ in 1973 to 0.2 ton ha⁻¹ year⁻¹ in 2005. A gradual landscape simplification occurred during the 90-year period. Socio-economic changes were the most important factor contributing to forest growth in South Korea. Various biological factors, including the absence of apex consumers due to their local extinction in the late 20th century, likely accounted for the rapid landscape transition. The new land management policy in South Korea resulted in the emergence of a forest ecosystem that is novel to this region and differs markedly from the historical environment, with a changed spatial arrangement of landscape elements and species assemblages.

Keywords Forest restoration · Human management · Landscape dynamics · Novel ecosystem · *Quercus serrata*

Introduction

Major changes occurred in natural resources management policy in South Korea in the early 1970s, shifting from traditional utilization to strong conservation alongside nationwide forest promotion efforts. South Korea's success in promoting change from a landscape of degraded shrubs and herbaceous vegetation and bare ground to forest was praised by the international community (Lee and Suh 2005). The negative impacts of human land utilization included reductions in diversity across large areas, altered landscape appearance, and reduced natural resources. Thus, it was necessary to undertake restoration at a landscape and ecosystem level (Hobbs et al. 2007). The restoration effort took into consideration the characteristics of the target area, a detailed species introduction plan, and the local people (Cho et al. 2016).

The landscape of South Korea has been changed and dominated by anthropogenic activities, making natural areas and processes rare. There are various perspectives on the condition and dynamics of ecosystems in South Korea (i.e., the degree to which the ecosystems are degraded or altered; see Hobbs 2016). As mentioned, the landscape was degraded by overexploitation in the early and middle 20th century (Lee and Suh 2005). The historical landscape included forests, grasslands, shrub vegetation, and wildlife populations that supported apex consumers such as tiger, wolf, and fox (NIBR 2013; Ulsan Daegok Museum 2016; Kim 2017). A mixed vegetation landscape was sustained during the Joseon Dynasty (1392–1896) and Daehan-Jeguk Empire (1897–1910) but was almost completely converted into forest by the change in natural resources management policy in the 1970s. Grass and shrublands mainly created by slash-and-burn farming in low-elevation areas were managed by local people, providing essential food, fuel,

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and opportunities to raise livestock during the Joseon Dynasty period (Kang 2013; Kim 2017).

The changes in the land mosaic are the result of complex, multiple processes and are critically important to the species that inhabit this area (Brozović et al. 1997). Landscape change is caused both by natural processes and by artificial interventions, including cultural activities and management. For populous countries such as South Korea, the land management goal dictates the change in the landscape structure, the spatial arrangement of landscape elements, and species composition and interactions in the regional ecosystem. Landscapes are the scale at which people and their surrounding environments interact, and thus the composition and configuration of a landscape both profoundly affect, and are affected by, human activities (Wu 2013). Therefore, it is necessary to understand the historical landscape and its dynamics in order to interpret changes in the regional ecosystem and human interactions (White and Walker 1997).

Although the forest promotion policy was successful in South Korea, the ecological consequences of this policy have not been presented in a balanced way. By analyzing landscape dynamics over the course of 90 years and viewing Pohang as a representative area in which the forest promotion policy was successful, we provide a new understanding of the socio-economic and biological background contributing to forest promotion success and its ecological significance in South Korea.

Materials and methods

Study area

The biggest single forest restoration and promotion project by South Korean government to date is the Young-il Soil Erosion Control Project in Pohang (4,538 ha). It was designed to control the degraded mountain area and to facilitate the establishment of vegetation, starting in 1972, and the project was sustained by the central government until 1977 (Gyeongsangbuk-do 1999). Because of overexploitation of natural resources caused by human population growth in the local area, the government reached the conclusion that vegetation recovery by natural processes alone in Pohang was impossible (Gyeongsangbuk-do 1999; Cho 2005a). In particular, the severe dryness of the soil and bedrock after weathering exfoliated the mudstone became the major barrier against successional processes.

The study area (latitude N35°53'39"–N36°11'53", longitude E129°13'58"–E129°26'00") includes the Young-il soil erosion control zone in Pohang, Southeastern Korea (Fig. 1). The boundary of landscape analysis was determined by natural elements (mountain ridges and streams) and administrative borders in a 1:25,000 topographical map. The study area lies 0–500 m above sea level.

The study area is classified as a warm temperate forest zone, specifically a warm-temperate summer-green

broadleaved forest area (Kim and Lee 2006). Oak (*Quercus mongolica* and *Q. serrata*) forest dominates the ridges and slopes, while Korean red pine (*Pinus densiflora*) and *Q. variabilis* forest occupies rocky and steep habitats. Various artificial forests (*Alnus firma*, *Robinia pseudoacacia*, *Pinus thunbergii*, and *P. rigida*) cover lower and hilly areas.

During the restoration period, various introduced tree species (*A. firma*, *A. sibirica*, *P. rigida*, and *R. pseudoacacia*), a native tree species (*P. thunbergii*), a shrub (*Lespedeza bicolor*), and herbaceous plants (*Arundinella hirta*, *Themeda triandra*, and *Cymbopogon tortilis*) were planted or sowed on slopes that were stabilized by terracing, after which they were fertilized at three-year intervals (Gyeongsangbuk-do 1999).

Landscape dynamics analysis

To quantify the effect of the restoration project at the landscape level, we clarified landscape change over the course of 90 years by interpreting a topographical map from 1918 scaled at 1:50,000 (published by the Japanese Government-General of the Joseon Dynasty) and four satellite images taken in 1973, 1987, 1995, and 2005. To apply modern analysis to the map, we divided the land cover using a digitizing method according to the symbols representing nine land cover classes: broadleaved forest, coniferous forest, low vegetation, barren mountainous area, developed area, water body, rice paddy, field, and salt field. The five separately constructed digital polygon maps were compiled into a master vector data layer and converted to grid form (pixel size 30 m × 30 m).

Satellite image interpretation was carried out by applying several GIS programs (ERDAS IMAGINE 8.6, Arcview 3.2, Arcgis 8.3, and IDRISI Andes). The earliest image (1973) was from Landsat MSS (Multispectral Scanner, 80 m × 80 m resolution) data, and images from 1987, 1995, and 2005 were from Landsat TM (Thematic Mapper, 30 m × 30 m resolution) data. All images were taken in June. The phenology in those four images was similar to each other. Images were geometrically corrected by TM projection on 1:25,000-scale national topographic maps. The 1973 image was resampled to a 30 m × 30 m pixel size to correct the resolution among the satellite images and to conduct change detection analysis.

The land cover data of each image was produced using an unsupervised classification method. We extracted each land cover class by comparing already-classified images with original images and combined them into a single grid file using the 'over' function of Arcgis 8.3. We calculated the change in each individual land cover class during the 90-year period based on the total changed area during each period as follows: Total changed area = (AreaΔ 1918–1973) + (AreaΔ 1973–1987) + (AreaΔ 1987–1995) + (Area 1995–2005). The cumulative net area changed was estimated from the area gained minus the area lost. This procedure was

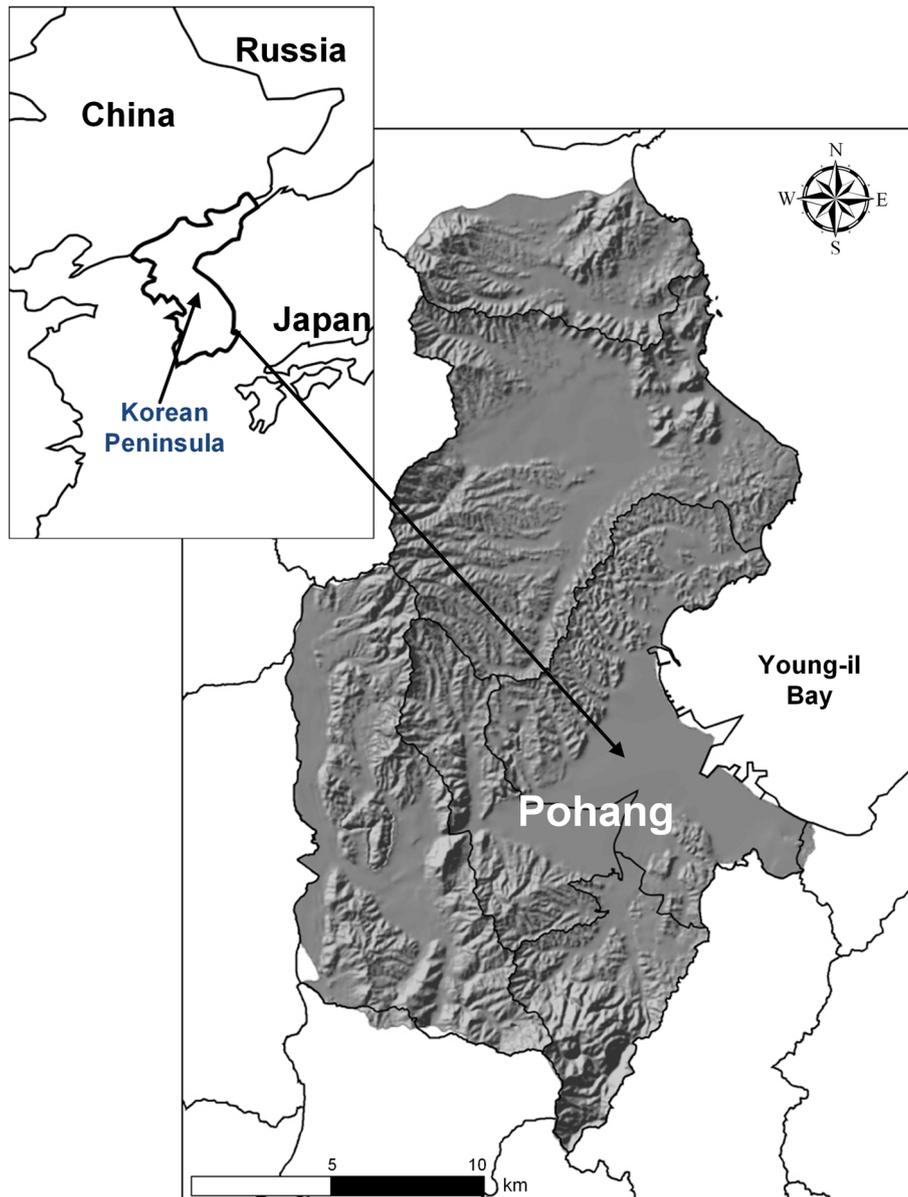


Fig. 1 Pohang is located in the Southeastern Korean Peninsula

conducted by Land Change Modeler in IDRISI Andes 15.0.

Landscape diversity was analyzed by applying Shannon's diversity index (H') (Shannon 1948) and landscape element rank-abundance curves, similar to the species rank-abundance curve (Magurran 2004). The area of each landscape element was used to calculate diversity. Before analysis, coniferous and summer-green broadleaved forests were combined as a single element (forest), and field and paddy fields were combined (field).

Soil erosion control analysis

In addition to performing quantitative landscape analysis, we assessed the functional aspect of the restoration

project by modeling surface soil erosion volume using the Revised Universal Soil Loss Equation (RUSLE) model (Renard et al. 1997) for 1973 and 2005. RUSLE can be used to compute soil loss in areas where significant overland flow occurs, but it is not designed for use with lands where no overland flow occurs, such as undisturbed forest lands (Dissmeyer and Foster 1980; USDA National Soil Erosion Research Laboratory 1995; Soil and Water Conservation Society 1995).

The equation of the RUSLE model has the following form:

$$A = R \times K \times LS \times C \times P,$$

where A [$\text{ton} (\text{area year})^{-1}$] is the average soil loss, R [$\text{MJ mm} (\text{ha hr year})^{-1}$] is the rainfall intensity factor, K (A R^{-1}) is the

soil factor, LS (dimensionless) is the topographic (length–slope) factor, C (dimensionless) is the land cover factor, and P (dimensionless) is the prevention practices factor. The R factor is modified to $R = 3.85 + 0.35P$ (where P = mean annual precipitation) (Toxopeus 1996; Oh 2004; Lee et al. 2008). The P value is manipulated by Inverse Distance Weighting (IDW) interpolation based on five Automatic Weather System (AWS) data points from Pohang-si, Yeongdeok-Gun, Ulsan-Si, and Yeongcheon-Si. To compare the soil loss amount, we classified it into six classes: none ($0 \text{ ton ha}^{-1} \text{ year}^{-1}$), rare ($0\text{--}1 \text{ ton ha}^{-1} \text{ year}^{-1}$), relatively

rare ($1\text{--}10 \text{ ton ha}^{-1} \text{ year}^{-1}$), moderate ($10\text{--}100 \text{ ton ha}^{-1} \text{ year}^{-1}$), relatively severe ($100\text{--}1,000 \text{ ton ha}^{-1} \text{ year}^{-1}$), and severe ($> 1,000 \text{ ton ha}^{-1} \text{ year}^{-1}$).

Results

Landscape dynamics after restoration

Figure 2 shows changes in land cover of the study area from 1918 to 2005. A large barren mountainous area

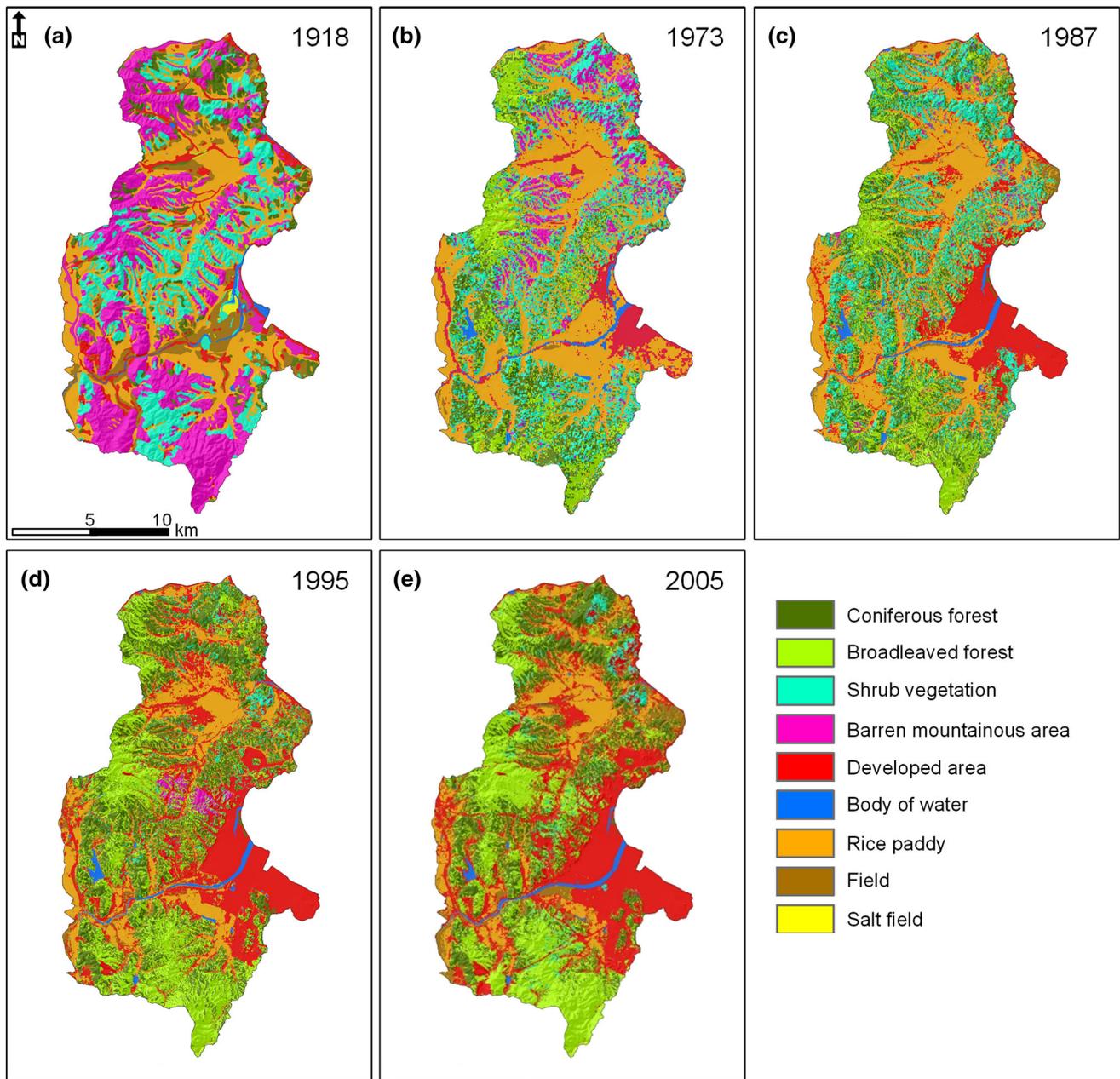


Fig. 2 Land cover changes from 1918 to 2005 in Pohang, a region that shows representative landscape change in South Korea. Shrub vegetation, including shrub and herbaceous land, was converted into forest during the period of strong forest promotion (1970s–

1980s) in South Korea. Our analysis detected a rapid expansion of the developed area and consequent landscape fragmentation during this time. (Color figure online)

and a large area with low vegetation were present in 1918 and 1973. The barren mountainous area found in 1973 was almost completely transformed to coniferous and broadleaved forest by 2005. Forest cover increased continuously from 10,006.9 ha (27.2%) in 1918 to 17,868.7 ha (48.6%) in 2005 (Table 1). The developed area also exhibited a significant increase, from 2,388.7 ha in 1918 to 10,544.8 ha in 2005, while the opposite was observed for rice paddy cover, which declined from 9,537.0 ha in 1918 to 4,662.7 ha in 2005. Between the 1970s and the 2000s, population and road length, which were indicators for regional development, increased continuously (Fig. 3).

Between 1973 and 2005, the barren mountainous area was almost completely converted into forest vegetation, while areas covered by shrub vegetation and rice paddy declined notably (Fig. 4). Land devoted to development, coniferous and broadleaved forest, and fields increased in area. Much of the area originally devoted to shrub vegetation (7,089 ha) was transferred to coniferous or broadleaved forest by forest promotion efforts such as planting trees and strongly inhibiting vegetation utilization. The increase in developed area came from the conversion of agricultural (rice paddy) land.

Figure 5 shows how forest cover increased continuously during the study period (1918–2005), while barren mountainous area decreased continuously. Shrub vegetation and rice paddy area steeply declined from 1978 to 1995.

Landscape diversity after restoration

A decline in landscape diversity (H') was observed over the course of the 90-year period, from 1.48 in 1918 to 1.19 in 2005 (Fig. 6). The landscape element rank-abundance curve also revealed a simplification of the regional ecosystem. The growth in forest vegetation area, rise in industrialization and urbanization, and associated population growth contributed to an overall landscape simplification. The landscape elements of salt marsh and barren mountainous area disappeared.

Change in annual soil loss

Using RUSLE modeling, we quantified the change in the amount of soil lost between 1973 and 2005 (Fig. 7 and Table 2). The area that had no soil loss decreased from 44.6% (in 1973) to 57.6% (in 2005), and the area with “relatively severe” soil loss largely declined from 919.3 ha (in 1973) to 47.3 ha (in 2005). Mean soil loss from forest land declined; means were 12.6, 7.7, 1.9, and 0.2 ton ha⁻¹ year⁻¹ in 1973, 1987, 1995, and 2005, respectively.

Discussion

To meet the ecosystem management goal set in the 1970s in South Korea, shrub and herbaceous vegetation and barren mountainous area were converted into forest through massive plantation activities and strong restrictions on natural resource utilization by the local people. The forest promotion and restoration efforts, which combined artificial assistance with ecological processes, were strikingly effective in increasing forest cover and controlling forest soil erosion at various specific plantations. The policy change regarding natural resources management brought not only a simplification of landscape diversity but also altered habitats and changed species interactions.

Landscape dynamics

A strong landscape management policy and changes in socio-economic context in the 1970s resulted in a successful forest promotion and restoration effort in South Korea. The expansion of nature protection awareness among the general public, as well as industrialization and urbanization, which included a fuel revolution that favored gas over wood fuel, were the relevant socio-economic factors. Those factors led to an abrupt decline in the demand for natural resources such as fuel wood and grasses for livestock (Nakagoshi 1995; Naveh 1998;

Table 1 Configuration of land cover class by area and percentage of the total study area from 1918 to 2005 in Pohang

Land cover class	1918		1973		1987		1995		2005	
	Area (ha)	%								
Coniferous forest	2577.5	7.0	5242.1	14.2	7401.6	20.1	8294.0	22.5	7509.9	20.4
Broadleaved forest	51.0	0.1	4258.4	11.6	4944.9	13.4	8548.0	23.2	9470.3	25.7
Shrub vegetation	7378.4	20.1	7441.7	20.2	6356.0	17.3	1281.8	3.5	888.6	2.4
Subtotal	10006.9	27.2	16942.2	46.0	18702.5	50.8	18123.8	49.3	17868.7	48.6
Barren mountainous area	11784.9	32.0	3087.9	8.4	706.6	1.9	340.4	0.9	–	–
Developed area	2388.7	6.5	2471.5	6.7	5239.4	14.2	8813.1	24.0	10544.8	28.7
Body of water	361.0	1.0	627.5	1.7	598.5	1.6	525.9	1.4	504.7	1.4
Rice paddy	9537.0	25.9	13579.2	36.9	11181.4	30.4	5913.6	16.1	4662.7	12.7
Field	2626.2	7.1	85.2	0.2	365.2	1.0	3076.7	8.4	3212.6	8.7
Salt field	88.8	0.2	–	–	–	–	–	–	–	–
Total	36793.5	100.0	36793.5	100.0	36793.5	100.0	36793.5	100.0	36793.5	100.0

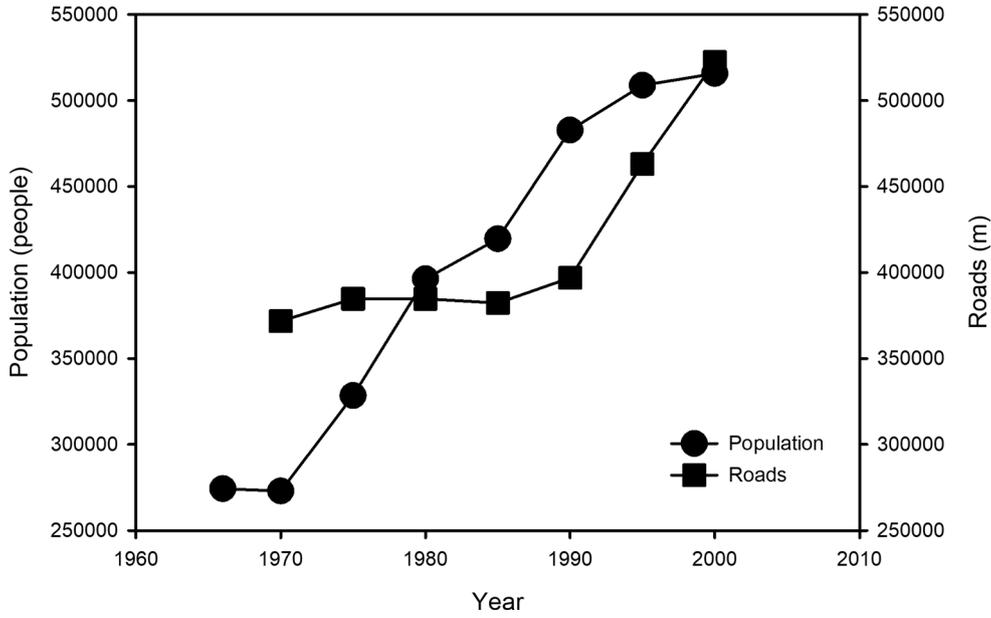


Fig. 3 Population growth and expansion of roads in recent years in Pohang

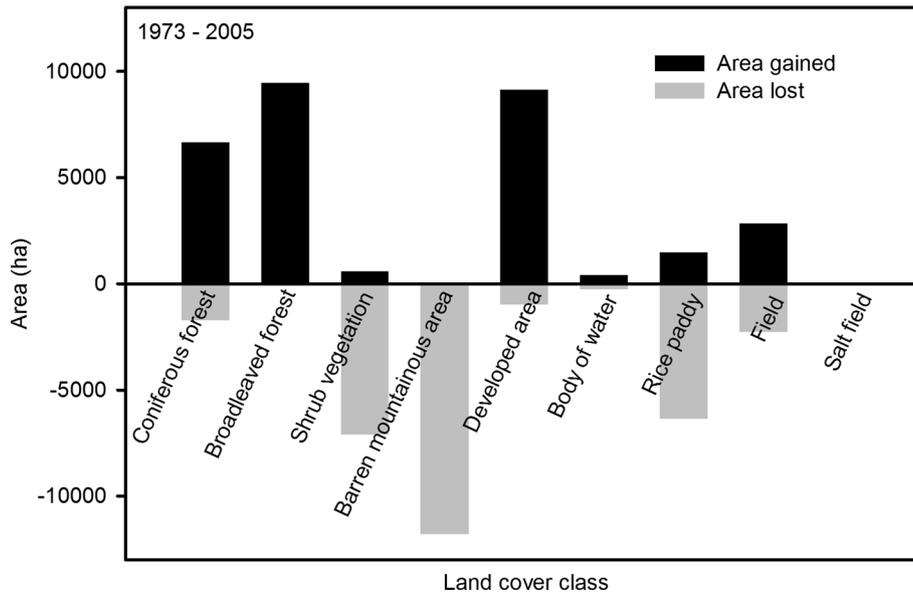


Fig. 4 Area lost and gained (i.e., gross change) according to land cover class from 1973 to 2005 in Pohang. Barren mountainous area, areas of shrub vegetation, and rice paddies declined a great deal in area, but forest vegetation such as coniferous and broadleaved forest increased

Hong et al. 2000; Lee and You 2001). At the same time, there was a nationwide movement to convert barren mountainous areas and shrub vegetation into forest through artificial plantation.

The expansion of forest cover occurred over a relatively short period due to active human intervention. As mentioned by Forman (1995), the direct and indirect effects of human activities on the surrounding landscape persist for decades or centuries, and various consequences emerge in a given land mosaic over time, such as landscape fragmentation and altered spatial arrange-

ment of ecosystem structure. Herbaceous and shrub vegetation and the area of bare ground at lower elevation areas were almost completely replaced by plantation forest. The change also caused various ecological interactions among species to change. Simple forest will continue to dominate the vegetation landscape in South Korea until there is a novel major shift in ecosystem management policy.

The developed area, including industrial complexes and residential areas, also rapidly increased (Figs. 2, 3). One of the consequences of urbanization is that the

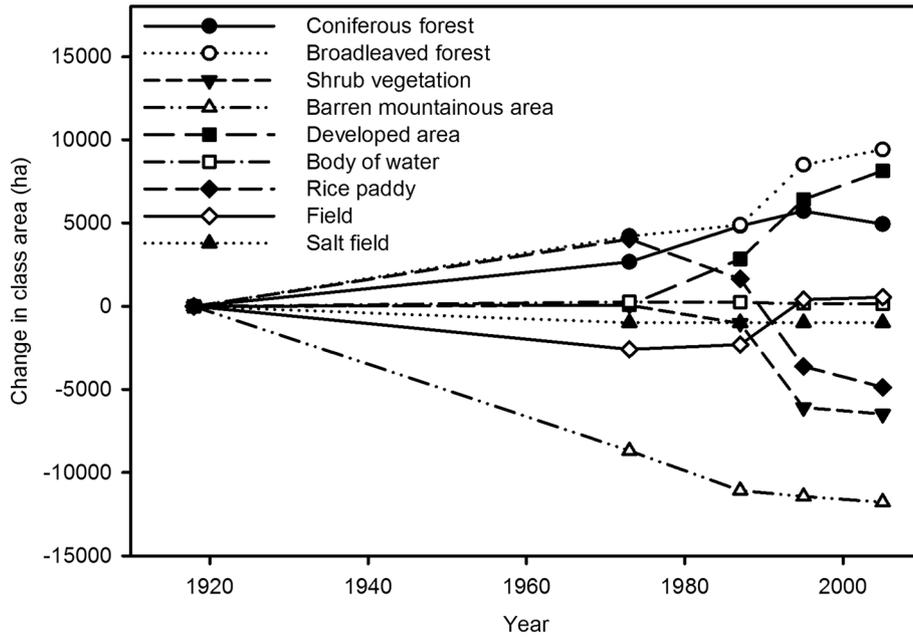


Fig. 5 Cumulative net area of land changed, according to land cover class, from 1918 to 2005 in the study area. A steeper line indicates a higher rate of change, and a flatter line indicates a lower rate of change

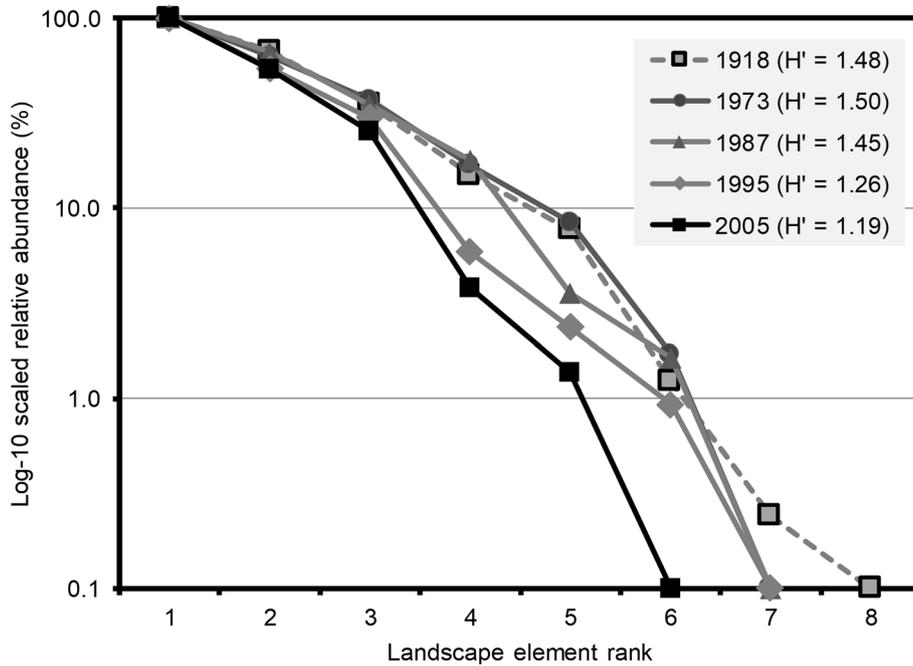


Fig. 6 Shannon's diversity index (H') and landscape element rank-abundance curves based on the area covered by various landscape elements over the course of 90 years in Pohang. Landscape

simplification due to the change in landscape management goals and urbanization gradually progressed for the past 90 years

development of the city encroaches upon agricultural land. Conversion of agricultural areas from conventional rice paddies and fields to modernized operations using greenhouses was a significant change in Asian countries (Cho 2005b; Li et al. 2005; Tan et al. 2005). The increase in urbanized area corresponds to regional

population growth, which increases the need for industrial and residential areas and roads. The increased increment of the urbanized area was consistent with increases in modern agricultural fields and broadleaved forest cover in given landscape. In the past, agricultural landscape elements functioned as a buffer zone, pre-

venting natural landscape elements from becoming isolated by diminishing the strong contrast between vegetated areas and urbanized areas. Conversion of traditional agriculture approaches (rice paddies) to modern ones (greenhouses), however, removed multi-functional characteristics of cultural agriculture (Lee and You 2001; Lankoski 2003).

The forest promotion project in South Korea was established and carried out fundamentally to prevent

soil erosion. In fact, the project succeeded so effectively that the area where erosion was “relatively severe” or “severe” decreased from 2.6% in 1973 to 0.1% in 2005 (Table 2). Intensive degradation of mountainous areas continued until the early 1970s. In mountainous areas, a dramatic change occurred as the denuded area transitioned to vegetated area between 1973 and 1987 (Fig. 7, Table 1). As mentioned, successive introduction of carefully chosen plant communities, nitrogen-fixing

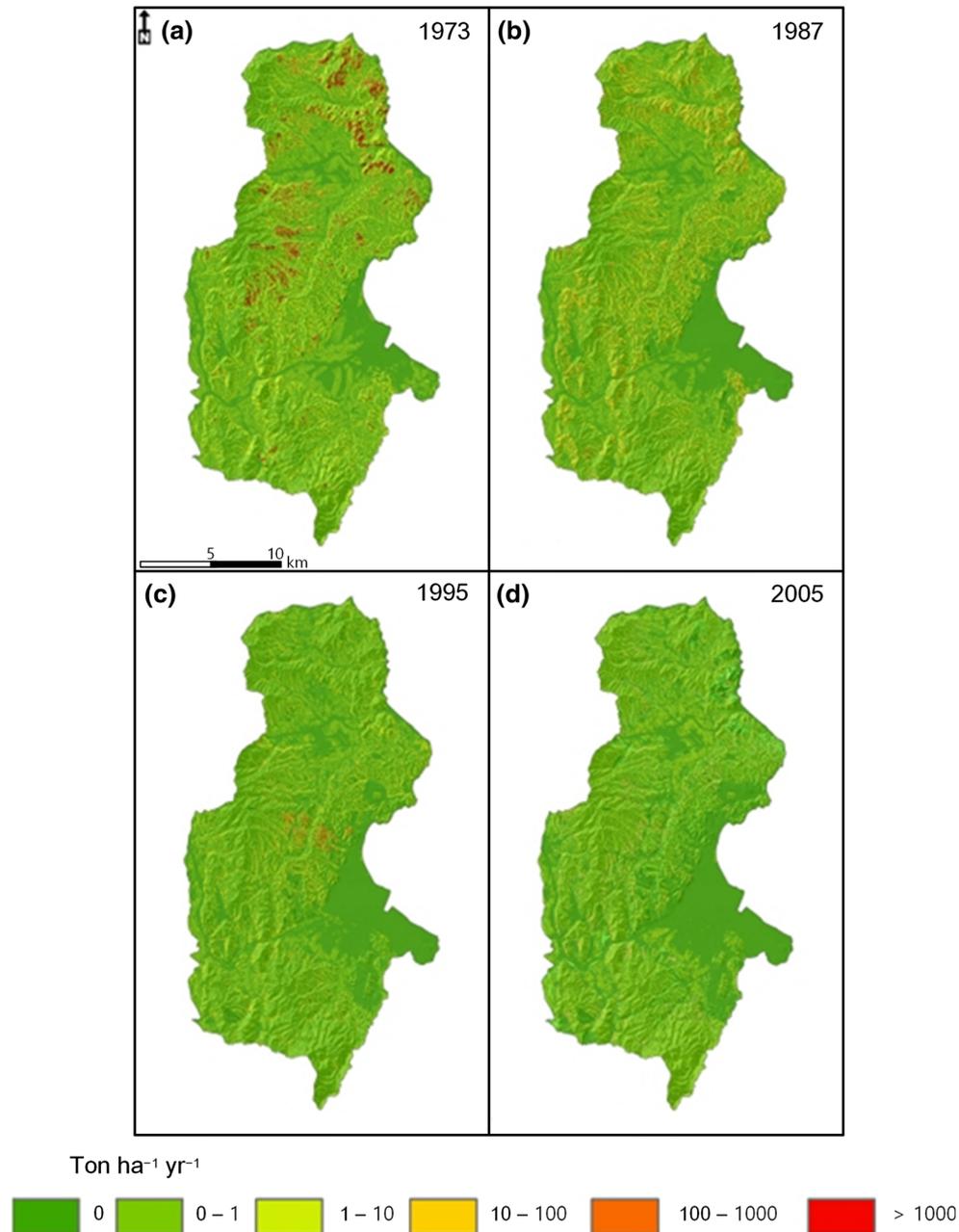


Fig. 7 Change in annual amounts of soil loss ($\text{ton ha}^{-1} \text{ year}^{-1}$) in the study area between 1973 and 2005. Forest restoration exerted a rapid control effect on mountain soil loss. Disturbance due to forest fire was a temporal agent in soil loss increment in 1995. (Color figure online)

Table 2 Change in mean annual soil loss based on RUSLE modeling between 1973 and 2005

Soil loss class (ton ha ⁻¹ year ⁻¹)	1973		1987		1995		2005	
	Area (ha)	%						
None								
0	16408.0	44.6	18060.4	49.1	20146.0	54.8	21205.9	57.6
Rare								
0–1	12725.4	34.6	12372.9	33.6	13399.5	36.4	12774.6	34.7
Relatively rare								
1–10	5932.0	16.1	3000.5	8.2	1851.2	5.0	1773.8	4.8
Moderate								
10–100	778.8	2.1	3074.4	8.4	1198.0	3.3	991.8	2.7
Relatively severe								
100–1,000	919.3	2.5	256.3	0.7	170.2	0.5	47.3	0.1
Severe								
> 1,000	29.9	0.1	28.7	0.1	28.6	0.1	–	–
Total	36793.5	100.0	36793.1	100.0	36793.5	100.0	36793.5	100.0

Revised universal soil loss equation (see “Materials and methods”)

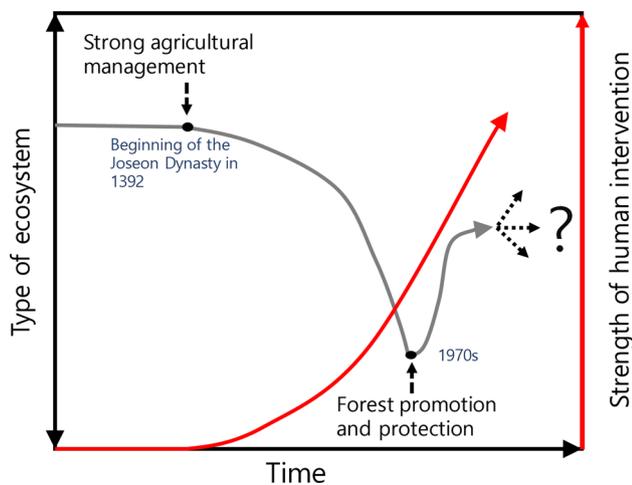


Fig. 8 Change in type of ecosystem according to the type and strength of management policy in South Korea. During the Joseon Dynasty, there was an abrupt increase in agricultural management and natural resource use, as well as in human population, which resulted in an important change in the type of dominant ecosystem state (notably, forests were reduced). A change in management goals after the Korean War promoting forest resources altered vegetation–animal interactions and abruptly rearranged the ecosystem compared with its historical condition. (Color figure online)

plants, and early seral grasses was responsible for the effective control of denuded mountain areas.

Importance of anthropogenic efforts to restore the landscape

The key to the success of the South Korean forest restoration project was the commitment of the national government and local communities (Lee and Suh 2005). Careful planning, including diagnostic evaluation of the target area, site preparation through terracing on steep slopes, and selection of a site-specific plant assemblage, was also important (Cho et al. 2016). Furthermore, intensive post-planting activities were conducted,

including periodical fertilization and weeding in the early years of the restoration project. The success of the restoration required a correct diagnosis of ecosystem damage, identification of thresholds and correct methodologies, determination of the important system characteristics in determining ecosystem recovery, and understanding to what extent restoration measures were required to overcome threshold and hysteresis effects (Hobbs et al. 2007). In South Korea, the initial site amendments, such as terracing for site stability, as well as reasonable species introduction and post-planting activities, determined the initial restoration trajectories.

Over the course of 30 years (1972–2005), eroded mountainous areas and shrub vegetation changed to forest land. The planted species became successfully established at the target site because the manager selected the correct tree and herbaceous species for various conditions. Introduced species such as *A. firma* and *R. pseudoacacia* were required in order to tolerate the conditions of the sites and to improve the infertile substrates and sandstone. Pioneer and nitrogen-fixing species were used because they can establish in resource-poor soils, accumulate soil-formation materials and nutrients, and obtain nutrients from the air (Lugo 1992).

The initial stage of forest restoration requires active human intervention, and cannot rely on abiotic and biotic forces alone (Burke and Mitchell 2007). During the forest promotion project in South Korea, local people were restricted from gathering fuel from forest land. The energy revolution, which promoted the use of briquettes and gas at that time, contributed to the success of the prohibition policy. The lowland areas around the mountains had traditionally been utilized for residential and agricultural uses and were a source of fuel, timber, non-timber products, and more. These cultural and historical practices hindered initial restoration efforts. The challenges were overcome partly by providing an income subsidy to local people who participated in field activities and helped with seedling production in nurseries (Gyeongsangbuk-do 1999).

Biological context and emergence of a novel ecosystem

During the early 20th century, the vegetation of South Korea gradually changed from the agricultural crops emphasized in the Joseon Dynasty (1392–1896), due to population growth (Kim 2017). In the past, the landscape was severely degraded and disturbed due to the Korean War (1950–1953). However, early seral vegetation that was part of herbaceous and shrub ecosystems in mountainous areas was sustained by human activities for a hundred years. A diversity of habitats is very important in order to support a complete food web and species interactions within the ecosystem (Estes et al. 2011; Ripple et al. 2014). Until the middle of the 20th century, large carnivores such as tiger, wolf, and leopard were still present as apex consumers and were exercising a regulatory effect on other species, although their populations were very small and there were areas in which they were locally extinct (NIBR 2013; Ulsan Daegok Museum 2016; Kim 2017). The local extinction of apex consumers due to hunting to enable agricultural expansion in the Joseon Dynasty period and the consequent shrinking of wildlife populations, including those of herbivores, in the mid- and late 20th century, were likely the hidden biological factors that allowed rapid establishment of the forest-dominated landscape in South Korea. Reduced herbivore presence can facilitate vegetation succession by allowing vegetation to become abundant (see Estes et al. 2011). Thus, human influences were responsible for changed and newly emerging vegetation–animal interactions and species assemblages in South Korea. In order to understand the history of this landscape, it is important to consider the local extinction of species as well as, more importantly, the complete extinction of species from the assemblage and subsequent loss of their interactions in the region.

A change in ecosystem management policy brought a complex and significantly altered spatial arrangement and biological interactions to the landscape. Most of the restored forest area in South Korea was not historically forest land. The present plantation forest in South Korea was shrub and herbaceous vegetation for a hundred years, due to historical policy and land utilization, until the policy change. The present landscape structure (Table 1) and landscape-level diversity (Fig. 6) as revealed by our analysis show the alteration to the historical Korean ecosystem. This altered landscape and related biotic composition as a result of human activities in ecosystems is a global phenomenon (Hobbs et al. 2006).

Figure 8 shows simple and long-term changes in the ecosystem state, correlated with the strength of human intervention in South Korea. The ecosystem state (y-axis) indicates the changing nature of a given ecosystem, due to the historical environmental context, rather than any good or bad status of the ecosystem. The first tipping point of the ecosystem in South Korea was associated with the promotion of agriculture by the Joseon Dynasty. During that period, there was a large expansion

of agricultural fields, along with human population growth, and animal species such as tiger and wolf were hunted to local extinction. The second tipping point was related to execution of a strong new environmental policy on forest promotion and nature protection in the 1970s. At this time, human intervention in the ecosystem was greater than ever before. After the second tipping point, the human influence on the ecosystem state continued to increase. In a changing global environment, it is important to observe the present state of ecosystems and to be aware of tipping points that affect them. It is clear that human environmental policy has determined the changes to the ecosystem in South Korea over the past century.

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