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〈Review〉

Trends of Ecosystem Studies in the Eastern United States : A Review[1]

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美國 東部 地方에서의 生態系 硏究 動向[1]

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ABSTRACT**

The backgrounds, goals, and trends of interdisciplinary ecosystem studies carried out in the eastern United States are introduced to identify the importance for the initiation of ecosystem studies for wise use of forest resources and forest land in Korea.

要 約

韓國의 林業發展을 爲한 學際的인 生態系 硏究 推進의 重要性을 强調하기 爲하여, 美國의 東部地方에서 그 構造 및 機能에 對한 硏究가 活潑하게 進行되고 있는 代表的인 生態系를 選定하고 그 硏究의 目的, 業績 및 動向을 紹介하여, 韓國에서의 綜合的인 生態系硏究의 遂行이 林業發展에 寄與할 수 있는 可能性을 論議함.

INTRODUCTION

The necessity for sound understanding of the behavior of ecosystems has been increased as anthropogenic disturbances and environmental stresses have progressed beyond the limits of our imagination. The structure, functions, and development of ecosystems have been extensively investigated throughout different types of woodlands in the world (Reichle, 1981). However, no major interdisciplinary ecosystem studies were carried out in Korea. Here, an ecosystem is defined as a single experimental unit where the circulation, transformation, and accumulation of energy and matter through the medium of living things and their activities can be studied (Waring and Schlesinger, 1985).

As a participant of the Hubbard Brook Ecosystem Studies, one of the most intensively studied temperate forest ecosystems in the world, the reviewer had an opportunity to examine some details of ecosystem studies carried out at the Hubbard Brook Experimental Forest (HBEF). Therefore, he was motivated by the desire to review some activities and trends of ecosystem studies carried out in the eastern United States and to introduce some important findings of them to forest and ecosystem scientists in Korea.

The objective of this review is to identify and

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compare the backgrounds, goals, and trends of interdisciplinary ecosystem studies carried out in the eastern United States, and to propose the necessity for launching ecosystem studies for wise use of forest resources and forest land in Korea. Due to its wide range in subject and region of the ecosystem studies, emphasis is placed on the introduction of the perspectives of general importance of ecosystem studies at HBEF, New Hampshire, and the Coweeta Hydrological Laboratory (CHL), North Carolina, in the United States of America. For general review of up-to-date forest ecology and systems ecology, the readers are referred to Odum (1983) and Kimmins (1987).

REVIEW METHOD OF THE ECOSYSTEM STUDIES

Two intensively studied ecosystems in the eastern United States (HBEF and CHL) were selected and the trends of their accomplished and ongoing studies (more than 1,000 publications) from 1928 to 1984 were categorized into several groups and compared with each other. These ecosystems were selected not only because they are representative ecosystems of the world, but because the publications from them were most frequently cited in the papers on ecosystem studies. In addition, due to latitudinal similarity of the ecosystems to Korea, the study results could adequately be applied to the better understanding of the temperate forest ecosystems in Korea.

The categories of studies for this review were adopted after some modifications of those used to differentiate the studies carried out at CHL (Gaskin, *et al*., 1984) (Table 1).

GOALS, ACHIEVEMENTS, AND TRENDS OF THE ECOSYSTEM STUDIES

1. Goals

The major goal of the Coweeta research program initiated in 1934 was to define the characteristics of soil, water, and climate of forested land in the southern Appalachians and that of HBEF initiated in 1963 was to present an integrated picture of the structure, functions, and development over time of the hardwood ecosystem in the northern Appalachians. The studies were carried out to warrant a diagnostic approach linking a variety of processes with an idea that some mysteries will unravel with carefully designed experiments.

2. Achievements

Terrestrial ecology and water related studies are the major fields of study at both of the ecosystems, categorically. One-third and more than half of the studies were carried out on terrestrial ecology and water related studies of the ecosystems, respectively (Figure 1). The role of water as media for various processes of ecosystem functions was especially emphasized in investigations (Likens, 1985).

More than 500 publications were resulted from the works at CHL. These cover biogeochemical cycling, ecosystem responses to disturbances, soil-plant-atmosphere interactions on hydrological processes, as well as the characteristics of soil, water, and climate of forested land (Gaskin, *et al*., 1984) (Figure 2). Works at HBEF resulted in about 500 publications on similar topics (Likens, 1986) (Figure 3).

3. Trends

Due to the establishment of stable basis for further ecological studies, the numbers of studies carried out at the ecosystems are continuously increasing at both of the ecosystems. This trend is conspicuous more at HBEF than at CHL (Figure 4). After 1984, more than 30 and 70 papers, in number, are annually published from CHL and HBEF, respectively. It is interesting to note that the number of publications carried out by more than three authors was significantly increasing in recent years. Majority of the studies at HBEF in recent years were carried out by single author, however (Figure 5).

Categorically, more non-application oriented studies were carried out than applicaton oriented

Table 1. Categories of the Studies Adopted for This Review

MAIN CATEGORY	KEY SUBJECT
TERRESTRIAL ECOLOGY	Baseline Characteristics and Land Use Effects 1. Biomass and surface area 2. Growth and stand structure 3. Succession and physiology 4. Invertebrates 5. Soil biological processes 6. Nutrient cycling Theory and Modeling
STREAM ECOLOGY	Baseline Characteristics and Land Use Effects 1. Aquatic habitat 2. Invertebrates 3. Primary production Theory and Modeling
STREAMFLOW AND GROUND WATER	Water Quality Water Quantity Timing of Flow Modeling Ground Water
SOIL RELATIONSHIPS	Erosion and Its Control Geological Relationships Humus and Litter Moisture Relationships Physical and Chemical Properties
PLANT-WATER RELATIONSHIPS	Evapotranspiration Interception Internal Water Relationships
HYDROMETEOROLOGY	Climatic Patterns Evaporation and Precipitation Atmospheric Deposition Radiation and Temperature Water Vapor and Wind
WATERSHED MANAGEMENT	Managed Watersheds Forest Roads and Trails Water Resources and Policy
WILDLIFE	
LAKE AND SEA ECOLOGY	

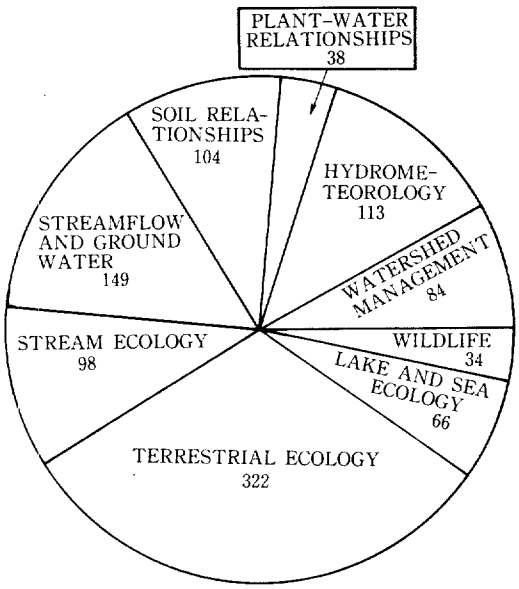

Fig. 1. Studies carried out at the Coweeta Hydrologic Laboratory and the Hubbard Brook Experimental Forest from 1928 to 1984 (1,008 publications in total). The number of publications is indicated for each category.

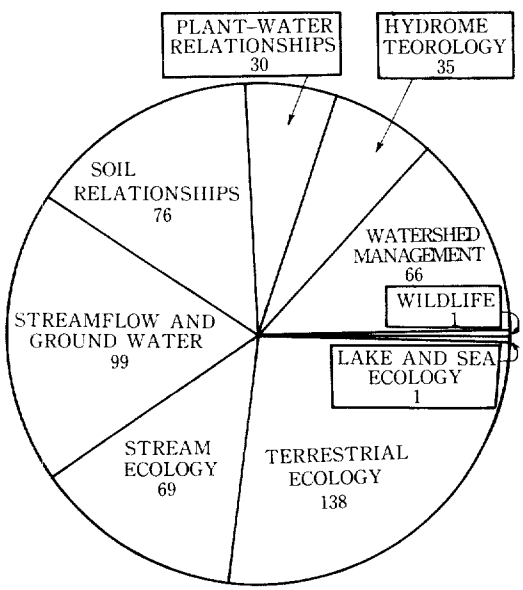

Fig. 2. Studies carried out at the Coweeta Hydrologic Laboratory from 1928 to 1984 (515 publications in total). The number of publications is indicated for each category.

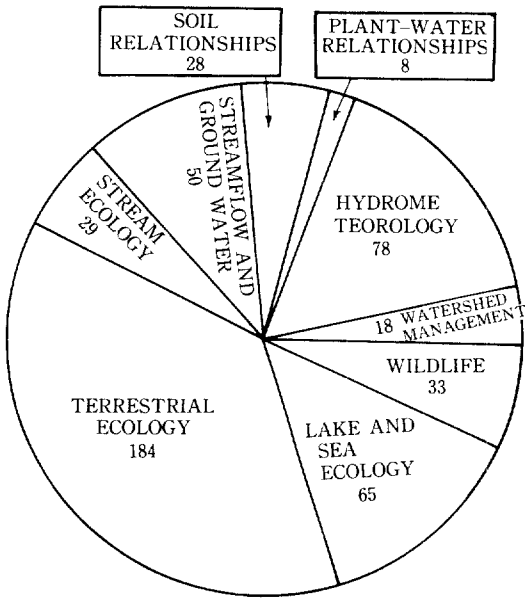

Fig. 3. Studies carried out at the Hubbard Brook Experimental Forest from 1956 to 1984 (493 publications in total). The number of publications is indicated for each category.

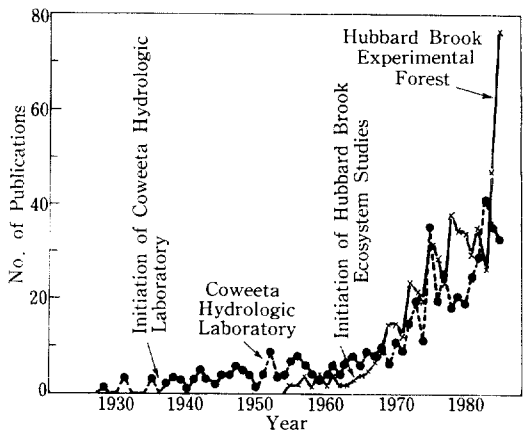

Fig. 4. The number of publications for the two ecosystems by year (papers, books, dissertations, and theses are included). Dotted line and solid line represent the number of publications at the Coweeta Hydrologic Laboratory and the Hubbard Brook Experimental Forest, respectively.

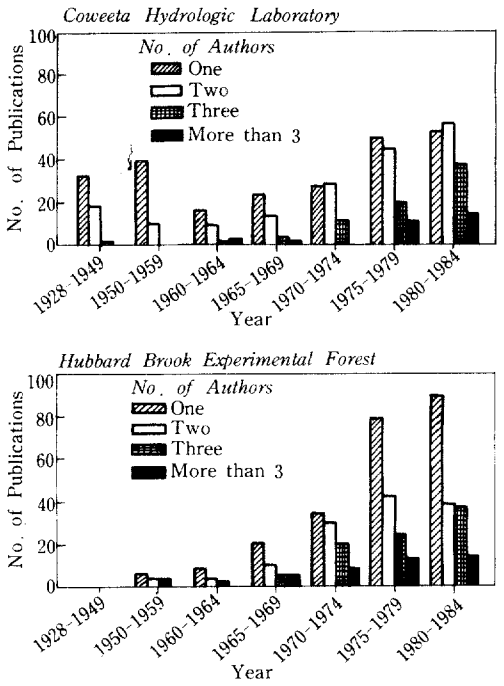

Fig. 5. The number of authors for the publications from the two ecosystems from 1928 to 1984.

studies at both of the ecosystems. Similarly, fewer studies deal with the subjects of ecosystem disturbances than those that deal with non-disturbance related subjects. These indicate that researchers are actually emphasizing studies on non-disturbance related pure sciences at both of the ecosystems (Table 2). In recent years, many studies covered the effects of artificial disturbances to the forest ecosystems and special attention was paid to the phenomena of tree growth decline (or dieback) in northeastern United States and to the role of anthropogenic stresses to forest ecosystems.

Table 2. Categorized number of studies carried out at the two ecosystems from 1928 to 1984.

	Coweeta Hydrologic Laboratory	Hubbard Brook Experimental Forest
Application Oriented Studies	183	147
Non-Application Oriented Studies	332	346
	Coweeta Hydrologic Laboratory	Hubbard Brook Experimental Forest
Disturbance Related Studies	132	61
Non-Disturbance Related Studies	383	432

4. Major contribution of the studies to the understanding of the patterns and processes of the forest land

The ecosystem studies provided significant contribution to the better understanding of the structure and functions of the ecosystems, which made it possible to share an emerging insight that there are key linkages between the processes that operate in forests, as well as important information for the long-term management of natural resources for sustained yields of water, wildlife, timber, and forest growth. They also provided baseline information on ecosystem responses to anthropogenic stresses in the regions. Based on measured and projected changes in total biomass, four model phases of ecosystem development after clear cutting were proposed, *i.e.*, reorganization, aggradation, transition, and steady state. The changes of biotic regulation, energetics (energy flow), biomass (productivity), hydrology, and biogeochemistry were investigated for the phases proposed above.

These were made possible with the use of small watershed technique, coupled with the measurement of internal features (nutrient uptake by living biomass, nutrient accretion in living and dead biomass, and the estimates of leaching, exudation, decomposition, nutrient input, and weathering, *etc.*) along with the measurement of input (meteorological vector) and output (meteorological and geological vectors) (Likens, *et al.*, 1977; Bormann and Likens, 1979), where an ecosystem is considered as a black box, whose boundaries are coincident with those of a small watershed underlain by tightly impermeable bed rock. This small watershed technique allows the better explanation of the structure, functions, and

development of natural ecosystem after disturbance. Once having established baseline biogeochemistry, it is possible to develop a program in experimental ecosystem ecology, wherein treatments are imposed on entire watershed-ecosystems and responses of the treated system are compared to undisturbed systems. This approach not only yields considerable information on the effects of the treatment but also allows quantification of some processes occurring in the undisturbed systems that are otherwise unmeasurable.

Because of the extensive and intensive studies performed on these ecosystems, they were selected as the sites for the Man and Biosphere (MAB) program of UNESCO, as well as the sites for the Long-Term Ecological Research (LTER) program sponsored by the National Science Foundation (NSF) of the country.

POTENTIALS OF THE ECOSYSTEM STUDIES

These ecosystem studies are supported by policy makers and managers of woodlands to answer some questions of current issue and to provide baseline information by which to judge subsequent changes in ecosystem structure and functions after ecosystem disturbance.

The combination of excellent study sites, long term goals, dedicated researchers with group harmony, and the policy that enabled the same personnel to remain at the same forest throughout the life has resulted in significant contributions to the understanding of natural processes as well as the responses of ecosystems to anthropogenic disturbances (Bormann, 1986). These long-term studies with initial concerns for integration are essential if we are to achieve a sustainable environment for future generations of people, animals, and plants.

CONCLUSION : A PROPOSITION FOR LAUNCHING INTERDISCIPLINARY ECOSYSTEM STUDIES IN KOREA

The reviewer acknowledges that it is high time for a forest organization in Korea to launch some cooperative and interdisciplinary ecosystem studies to have sound understanding of the structure, functions, and development of the ecosystems (part of the subjects are categorized in Table 1).

The results of these ecosystem studies can be much informative as guides for possible solutions for many questions in forestry in Korea, *e.g.*, the enhancement of productivity after different silvicultural and managerial treatments and the sound changes of ecosystems by the unexpected changes of biotic and abiotic factors. In addition, this will not only make it possible to advance the levels of ecosystem ecology but also set a basis for the exchange and integration of study results with other forest and ecosystem ecologists of the world.

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