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A study of bioindicator selection for long-term ecological monitoring

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Abstract
It is very useful and important to see the status and change of necessary parts in a short period through selecting and observing the bioindicator continually to forecast and prepare the future. Especially, living things are so closely related to the environment that the indicator between the environment and living things shows close interrelationship. Also, the indicator related to environment provides information about representative or decisive environmental phenomenon and is used to simplify complicated facts. Considering wide range of background and application including various indicators such as the change-, destruction-, pollution-, and restoration of habitats, climate change, and species diversity, the closest category includes "environmental indicator," "ecological indicator," and "biodiversity indicator." The selection and use of bioindicator is complicated and difficult. The necessary conditions for the indicator selection are flexible and greatly depend on the goals of investigation such as the indicator for biological diversity investigation of specific area, the indicator for habitat destruction, the indicator for climate change, and the indicator for polluted area. It should meet many various conditions to select a good indicator. In this study, eleven selection standards are established based on domestic and overseas studies on bioindicator selection: species with clear classification and ecology, species distributed in geographically widespread area, species that show clear habitat characteristics, species that can provide early warning for a change, species that are easy and economically benefited for the investigation, species that have many independent individual groups and that is not greatly affected by the size of individual groups, species that is thought to represent the response of other species, species that represent the ecology change caused by the pressure of human influence, species for which researches on climate change have been done, species that is easy to observe, appears for a long time and forms a group with many individuals, and species that are important socially, economically, and culturally.

Key words: bioindicator standards, ecosystem monitoring

NECESSITY AND BACKGROUND

Indicator is developed to meet the characteristics of variety of areas such as politics, economics, society, culture, environment, and health, and it is being widely used. The importance of using the indicator is spotlighted in many aspects. It is very useful and important to see the status and change of necessary parts in a short period through selecting and observing the indicator continually to forecast and prepare the future.

Especially, living things are so closely related to the environment that the indicator between the environment and living things shows close interrelationship. The indicator related to environment provides information about

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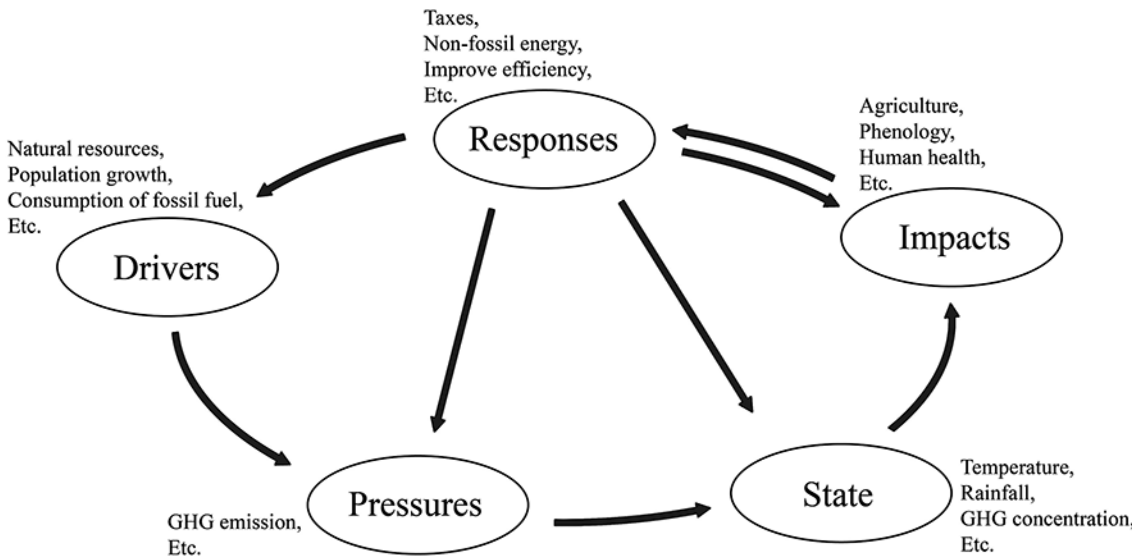

Fig. 1. The DPSIR framework for reporting on environmental change (EEA, 1999).

representative or decisive environmental phenomenon and is used to simplify complicated facts (Smeets and Weterings 1999). Organization for Economic Cooperation and Development (OECD) established pressure, state, and response (PSR) system (OECD 1993). European Environment Agency (EEA) improved the system to driver, pressure, state, impact and response (DPSIR) mentioning environmental indicator at its State of the Environment reports published by European Union (EEA 1999) (Fig. 1). PSR system is biased to social response such as the change of environmental policy rather than focusing on direct response of ecosystem that is related to living things. DPSIR system expanded the indicator that shows everything about the driver and impact of environmental change including fossil fuel consumption, climate elements change, change of ecosystem, phenological change, and health of mankind.

DEFINITION OF BIOINDICATOR

Bioindicator measures the change of biological or nonbiological factors in ecosystem focusing on a living thing in some circumstances. Bioindicator indicates a living thing or a group of living things. It is used as a representative to understand and estimate general status of ecosystem. But more specifically or generally, it means the impact of environmental change in habitats, community, or ecosystem as species or group of species representing the status of living things or inanimate objects in the environment. It could also indicate living things or group of living things that show the diversity of taxonomic group in an area or a subset in entire diversity (Gerhardt 2002).

BIOINDICATOR CATEGORY (TERRESTRIAL INSECT)

For example, terrestrial insects occupy the greatest ratio in the species richness and in biomass and play great roles in the function of ecosystem. This kind of recognition not only made a process to achieve evaluation and discussion to use them as bioindicator but also applied to many areas such as taxonomic group, habitats, and environment scenario (Holloway 1980, Rosenberg et al. 1986, Kremen et al. 1993). Even if there were variety of and wide range of indicator studies with terrestrial insects, the definition and goal of bioindicator on that has not been clear yet. Considering wide range of background and application including various indicators such as the change-, destruction-, pollution-, and restoration of habitats, climate change, and species diversity, the closest category includes “environmental indicator,” “ecological indicator,” and “biodiversity indicator” (McGeoch 1998) (Fig. 2). The indicators to be used to detect the change in environment are generally environmental indicator and ecological indicator. Biodiversity indicator shows general diversity of living things.

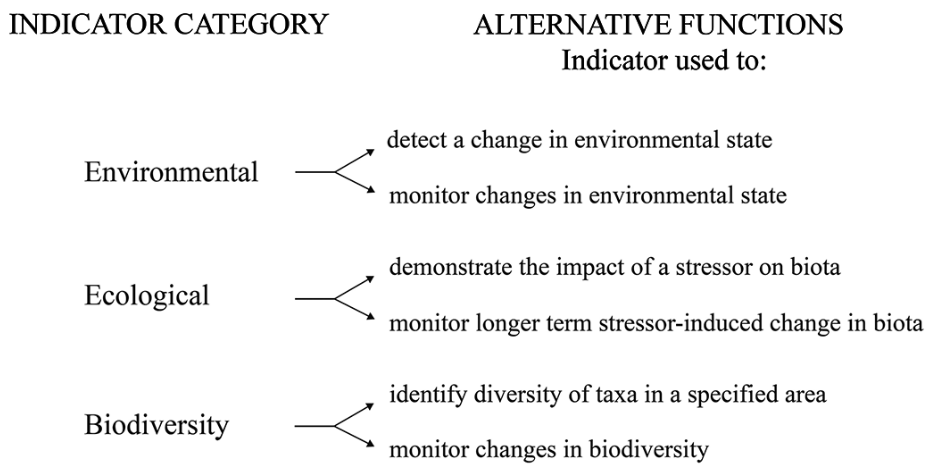

Fig. 2. The functions of bioindicators in each category of bioindication (McGeoch, 1998).

SELECTION STANDARDS

By using the bioindicator, it is possible to evaluate the impact on groups of living things by human activity instead of investigating all living things. The most important parts of bioindicator are to provide cost-efficiency and early warning on changes (Spellerberg 1993). In detail, the selection and use of bioindicator accompanies more complicated and difficult conditions. Some scholars defined necessary conditions that a useful indicator must have (Noss 1990, Pearson and Cassola 1992, Niemelä 2000). According to their ideas, a good indicator should include the following conditions. It should have well-known classification and ecology. It should cover wide geological area. It should have specialty as necessary condition of a habitat. It should provide early warning for a change. It should be cost efficient and easy to investigate. It should be independent from the sample size. It should think about the response of other species. It should find out the factor that is caused by the pressure of human influence in the circulation and direction of the nature. It should be important potentially and economically. As the required conditions are very wide, it is actually hard to find species or species groups that show the all characteristics mentioned above (Noss 1990, Pearson and Cassola 1992).

National Institute of Biological Resources (NIBR) of Ministry of Environment had 4 steps of selection procedures after many discussions to select “national climate change bioindicator 100 species” (NIBR 2010). Especially in the second step, it established standards for five academic conditions: 1) classification and ecology are known; 2) it has clear geological distribution; 3) it has clear habitat characteristics; 4) it has many independent individual groups; and 5) the species has research result on climate change. And, five factors of economic feasibility and availability were also established: 1) it is easy to observe; 2) it appears for a long time; 3) there are many individuals that form a group; 4) it doesn’t cost a lot for the investigation; and 5) the species is important socially, economically, and culturally. McGeoch (1998) also suggested step-by-step procedures of rejecting or accepting an indicator by improving and developing procedural steps for the selection of adequate environment, ecology and biological diversity indicator.

As described in the above, the selection and use of bioindicator is complicated and difficult. The necessary conditions for the indicator selection are flexible and greatly depend on the goals of investigation such as the indicator for biological diversity investigation of specific area, the indicator for habitat destruction, the indicator for climate change, and the indicator for polluted area. It should meet many various conditions to select a good indicator. This study established eleven selection standards based on domestic and overseas studies on bioindicator selection as shown in the below.

1. Species (or species groups) with clear classification and ecology.

Table 1. An example of bioindicator selection for Long-term ecological monitoring

	Selection standards										
	1	2	3	4	5	6	7	8	9	10	11
Pinus densiflora	◎	◎	◎	◎	◎	◎	◎	○	○	◎	◎
Quercus mongolica	◎	◎	◎	◎	◎	◎	◎	○	○	◎	○
Carabid beetles	○	◎	○	◎	◎	◎	◎	○	◎	◎	△
Libythea celtis	◎	◎	○	◎	◎	◎	◎	○	○	◎	△
Mosquitoes	○	◎	△	◎	◎	◎	◎	◎	◎	◎	◎

◎, very high in relationship; ○, high in relationship; △, medium in relationship.

2. Species (or species groups) distributed in geographically widespread area.
3. Species (or species groups) that show clear habitat characteristics.
4. Species (or species groups) that can provide early warning for a change.
5. Species (or species groups) that are easy and economically benefited for the investigation.
6. Species (or species groups) that have many independent individual groups and that is not greatly affected by the size of individual groups.
7. Species (or species groups) that is thought to represent the response of other species.
8. Species (or species groups) that represent the ecology change caused by the pressure of human influence.
9. Species (or species groups) for which researches on climate change have been done.
10. Species (or species groups) that is easy to observe, appears for a long time and forms a group with many individuals.
11. Species (or species groups) that are important socially, economically and culturally.

In addition, an example of bioindicator selection based on selection standards is shown in the Table 1.

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