Introduction to the Connectivity of Hills, Humans and Oceans (CoHHO*) Vol.5: Interaction between humans and nature II
*We call it “Mori-Sato-Umi Renkan-Gaku” in Japanese.

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6. Main subject of the CoHHO: Interaction cycle of humans and nature

In the previous article, I mentioned the interaction cycle of humans and nature, as shown in Fig. 1.

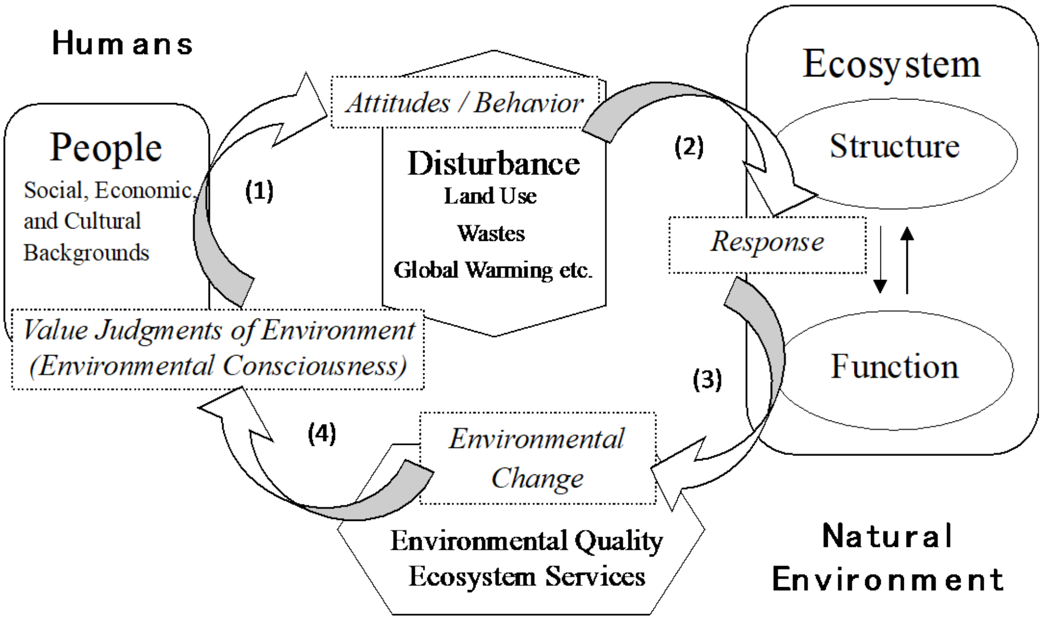


Fig. 1. Interaction cycle of humans and nature (Yoshioka 2020)

The repetitive exchange between humans and nature according to this interaction cycle is the basis of the linkage between forests, rivers, human habitations (Sato), and oceans. CoHHO is the academic field where such interactive exchanges are surveyed. Fig. 1, therefore, shows the conceptual framework of CoHHO. For natural scientists, processes (2) and (3) can be studied by the methodology of natural science, while for humanities and social sciences, processes (1) and (4) will be the subject of research. Therefore, if researchers in the natural sciences, humanities, and social sciences gather, then the CoHHO study can be done.

Do you think so?

No, I do not.

If yes, then a large amount of research would have been performed so far. However, few or no case actually exists. The main reason may be that environmental valuation, which is the process between (4) and (1), has not yet been investigated in depth, especially by natural science. The main target can thus be set at people's environmental consciousness.

7. Environmental consciousness and environmental value

Environmental consciousness is the basis of the value judgment of the environment when people decide their attitude toward the environment. People's valuations of the environment are different from one another, and their attitudes and behaviors toward the environment should be different accordingly. If people want to earn money from trees in the forest, then they will estimate the use value of the forest (tree) and may cut trees to produce timber. People who like birdwatching may conserve and preserve the forest environment by assessing the non-use value of wild birds in the forest.

In this way, it can be considered that people judge the value of the environment as one of the phenotypes of their own environmental consciousness (Fig. 2).

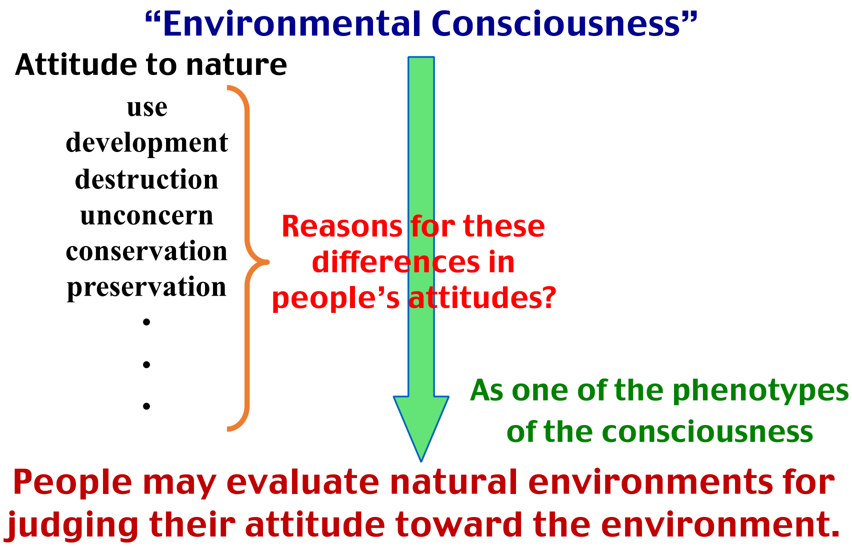


Fig. 2. Conceptual diagram of environmental consciousness and environmental valuation.

So, what are people evaluating?

What is the value of environment?

Various studies have been conducted about the value of environment in the fields of environmental philosophy, environmental ethics, and environmental economics, but the definition is difficult and ambiguous. Although defining this issue is very hard for me as a biogeochemist, I would like to take a quick look at it by referring to some articles (Kito 1996, Lockwood 1999, Washida 1999, Takada 2003). The terminology differs slightly depending on researchers, but two types of value are generally recognized: use value (instrumental value) and non-use value (Fig. 3).

Use value is divided into direct use value and indirect use value. People can derive some resources and benefits from direct use value of nature. For example, cutting timber and selling them is a direct use value of forest trees. Indirect use value does not contribute any types of resources but contributes some types of benefits to humans. For example, forests absorb CO_2 to produce oxygen and purify water, which allows us to breathe and secure drinking water. Thanks to these use values, humans can obtain resources and benefits from the environment.

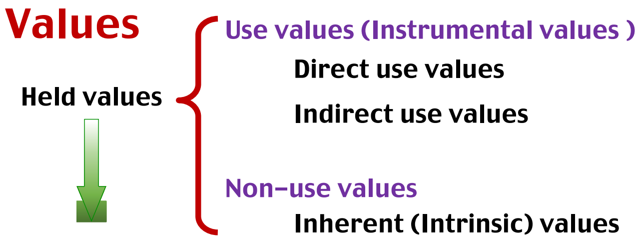


Fig. 3. Structure of value[#1]

Non-use value is the value that does not benefit humans as resources and intangible benefits. It means, for example, that a stone lying on the roadside may be valuable. Non-use value is also called inherent value, existence value, and intrinsic value. Some non-use values work on people's consciousness, and some of them are thought to bring benefits as indirect use values. For example, people keep out of the deep forest, where a god lives, to protect it, and worship the forest itself as a god. Thus, the deep forest brings profit to the human activity (emotion) of faith.

With the forest environment taken as an example, values of nature will be considered.

The forest has eight functions and is therefore considered multifunctional.

(1) Conservation of biodiversity
(2) Conservation of global environment
(3) Prevention of landslide disaster/soil conservation
(4) Conservation of water resources
(5) Creating comfortable environment
(6) Health and recreation
(7) Cultural function
(8) Material production

These functions are closely related to values of forest. For example, the material production function (8) supplies humans with resources such as timber, mushrooms, edible wild plants, and other forest products. It is the direct use value of the forest. Although functions (2) to (7) do not mean that humans consume forest materials as resources, they can use clear air and water, and enjoy hiking and forest therapy. Forests can benefit humans. These functions are related to indirect use values. Function (1) hardly contributes to human lives but provides habitat and nutrition to various organisms. This function would be related to the inherent value, which might not contribute the value assessment of nature.

All objects and phenomena in nature thus have aspects on more or less both use and non-use values. People construct their own sense of values (or beliefs), which are the so-called "held values," for objects and phenomena from these two types of value, and they assign the value according to their sense of values (Fig. 3). The "assigned values" are usually expressed in monetary amounts.

What is the sense of value producing the assigned value?

It may be one of the sensations and emotions that people have for objects and phenomena. People determine the value based on their sense of values, corresponding to the arrow from "Held values" to "Assigned values" in Fig. 3, the sensations and emotions may be important factors for judging the value of nature.

This sense of values can be broadly divided into two types depending on the position of human beings in the world (Takada 2003).

1) Anthropocentrism

Anthropocentrism is based on the dualistic idea of distinguishing between humans and others. From an anthropocentric standpoint, the value of the environment and natural objects is evaluated on the basis of benefits to humans. Depending on the period of interest, it is divided into the narrow (strict) anthropocentrism and the relaxed anthropocentrism. The narrow anthropocentric thinking measures the value of profits in a short period of time, whereas the relaxed anthropocentric thinking considers benefits for the next generation and human beings in the distant future.

2) Non-anthropocentrism

In non-anthropocentrism, which relativizes and thinks of humans holistically, humans do not occupy the center of the world, but something other than humans or something that includes humans is focused on. Several principles are presented according to what is at the center of the world, as follows:

Higher animals that are thought to have emotions: Pathocentrism, animal liberation

All living things: Biocentrism

Ecosystem, including inanimate objects: Ecocentrism

They may be further classified into different types. For example, globe totalitarianism centers on the Earth, deep ecology, and ecofeminism emphasize equality, bioregionalism emphasizes biodiversity, and social ecology emphasizes cultural diversity. Takada (2003) and Maruyama (2004) provide further information on these concepts.

8. Environmental consciousness

So far, we have seen the outline of the structure of environmental value, which seems to be a subject in fields such as environmental philosophy, environmental ethics, and environmental psychology. However, do people usually understand the values and functions of the surrounding nature and environment? Do you mow the bushes in the forest or wash clothes in the river, thinking of the concepts that researchers and scholars have come up with?

Recognizing the multifunction of the environment and the structure of values of environment mentioned above may be very difficult for people. To clarify this point, we surveyed whether people can identify the function and the value of nature by using a questionnaire (Matsukawa et al. 2009). Respondents were asked whether or not they are interested in wood production, habitats for animals and plants, the provision of water resources, and so on, which relate to direct use, indirect use, and non-use values of forests, rivers, and farmland.

Table 1 shows the list of values and functions of forest–lake ecosystem and human activities. We prepared a questionnaire according to Table 1 to survey the strength of people's interest in values and functions of forest, farmland, and water bodies and then to clarify people's recognition of the structure of environmental values.

Table 1. List of values and functions of forest, farmland, and water bodies, and human activities

		土地被覆（Land cover/Land use）						
		Forest	Grassland	Agriculture	Aquatic	Man-made	Atmosphere	Environmental complex
Use value	Direct use	Timber Fabric Food Fuel	Food, Feed Fabric Fertilizer Biomass	Food, Feed Fabric Biomass etc.	Water resource Fisheries etc.	Infrastructure Industry Residence etc.	O_2 supply Ventilation Absorb etc.	Agro-forestry Paddy-watershed etc.
	Indirect use	Water resource Land preserve Health, Culture Habitat etc.	Soil preserve Air purify Sightseeing Habitats etc.	Soil preserve Landscape Habitats etc.	Hydroelectric Purification Sightseeing Habitats etc.	Electric power Disaster control Landscape Sightseeing etc.	Wind power Aerosol etc.	National park Universal park etc.
	For future	Resources Plants, Animals Land use change etc.	Stockbreeding Plants, Animals Land use change etc.	Improvement of breed Land use change etc.	Landfill Water resource Fisheries etc.	Diversion Historical and cultural heritage etc.		Population increase
Non-use value	Inherent	History, Culture, Arts, Wilderness, Long for forest etc.	History, Culture, Arts, Long for grassland etc.	History, Culture, Arts, Long for agricultural land etc.	Culture, Long for aquatic environments etc.	History, Culture, Heritage, Long for architecture etc.		
	Intrinsic	Ecosystem Carbon sink Soil formation etc.	Ecosystem Material cyclings Soil formation etc.	Ecosystem Material cyclings Soil formation etc.	Ecosystem Watershed Water purification etc.	Artificial landscape etc.	Precipitation Wind disaster Temp. regulation etc.	Basis of life etc.
Others	Human activities	Maintenance Old paper use Employment	Maintenance Abandonment Culture	Abandonment Chemicals Irrigation	Management Heavy use Pollution	Culture Depopulation Dumping of wastes	Toxic gasses Emission control	Moral, Custom Law, Institution Sense of value
	Impacts	Pollinosis	Effects of chemicals	Effects of chemicals, Flooding	Drought, Flooding Pollution, Eutrophication	Waste, Groundwater pollution,	Air pollution Global warming	Sense of nature Ethics, Scientific civilization
	Others	…	…	…	…	…	…	…

Six factors were selected by using exploratory factor analysis (Table 2). Environmental functions found in the factor belonged to almost the same environmental value, such as direct use value, indirect use value, and non-use value. This finding suggests that people might partly distinguish the values and functions of the environment, and show their interest in the environment according to their distinctions (Matsukawa et al. 2009). Although the values and functions of the environment are difficult concepts, the conceptual framework may be always imaged in people's consciousness.

Table 2. Structure analysis of people's interests on forest, farmland, and water bodies

(Matsukawa et al. 2009)

Fuctions	I	II	III	IV	V	VI
F6: water purification	**0.84**	0.01	0.03	□0.04	0.06	−0.05
F5: conservation of land	**0.64**	−0.03	0.00	0.14	0.08	0.00
F4: maintaining water supply	**0.63**	0.03	0.03	0.21	0.04	0.00
F7: conservation of living environment	**0.60**	−0.05	0.13	0.03	−0.06	−0.07
F9: CO_2 absorption	**0.49**	−0.04	0.01	0.03	0.01	−0.30
A1: cereal production	−0.04	**−0.89**	−0.06	0.08	0.05	0.02
A2: vegetation and fruit production	0.05	**−0.88**	0.02	0.03	−0.01	0.04
A3: dairy production	−0.06	**−0.56**	0.14	0.01	−0.01	−0.15
A5: conservations of water and soil resources	0.38	**−0.38**	0.07	−0.03	0.24	−0.02
W4: landscape/recreation	−0.03	0.08	**0.78**	−0.01	0.18	−0.04
A4: landscape/recreation	0.06	−0.19	**0.71**	−0.02	−0.07	0.01
F3: landscape/recreation	0.21	0.01	**0.51**	0.21	−0.13	−0.04
F2: forest production except for wood	−0.05	−0.06	0.01	**0.90**	−0.03	0.02
F1: wood production	0.09	0.01	−0.01	**0.65**	0.07	−0.04
W2: water resource for industry and agriculture	0.19	−0.15	−0.03	0.12	**0.57**	−0.01
W3: fisheries	−0.10	−0.02	0.23	0.14	**0.49**	−0.12
W1: domestic water supply	0.29	−0.23	0.03	0.00	**0.43**	−0.03
W6: water purification	0.26	−0.10	0.10	0.01	**0.37**	−0.19
F8: habitats for animals and plants	0.28	0.03	−0.02	0.10	−0.13	**−0.68**
W5: habitats for animals and plants	−0.11	0.00	0.17	0.06	0.32	**−0.59**
A6: habitats for animals and plants	0.02	−0.25	0.07	0.02	0.08	**−0.56**

F: forest, A: farmland, W: water bodies.

With this result, we further considered environmental consciousness. The following is based on the project "Interaction between environmental quality of a watershed and environmental consciousness: With reference to environmental changes caused by the human use of land and water resources (Environmental Consciousness Project)" of the Research Institute for Humanity and Nature (RIHN) during 2004 and 2009. I would like to emphasize the importance of thinking about people's environmental consciousness to solve global environmental issues and also touch on the methodology for investigating people's environmental consciousness. A questionnaire survey mentioned above (Tables 1 and 2) was a part of the Environmental Consciousness Project.

The human consciousness–behavior model assumed in the Environmental Consciousness Project is that "when deciding the attitude/behavior toward the environment, people judge the value of the environment based on their environmental consciousness" and "the environmental quality may influence the value judgment of the environment." In this model, the interaction between humans and nature is represented by a "ring" between people's environmental consciousness and the quality of the environment (Fig. 4).

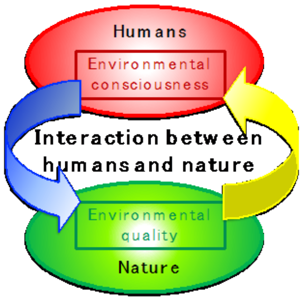


Fig. 4. Interaction between humans and nature envisioned by the Environmental Consciousness Project

The relationship between humans and nature in Fig. 4 is a simplification of the interaction cycle of humans and nature shown in Fig. 1. The relationship between environmental quality and value judgment would be clarified by analyzing how people's value judgments change when the quality of the environment changes in various ways due to human or natural conditions. In the Environmental Consciousness Project, we tried to clarify the relationship between environmental quality and environmental consciousness by creating a virtual scenario about environmental change and analyzing changes in people's value judgments.

The significance of the project is that it evaluated the effectiveness of a consciousness survey by using scenarios (scenario questionnaire) as one of the methods for public involvement (public participation) that is emphasized in environmental assessment (preliminary evaluation of environmental impact). Scenario-based consciousness surveys were already dealt with in the contingent valuation method and conjoint analysis in environmental economics, but the Environmental Consciousness Project included conceptual considerations of environmental consciousness and environmental quality (Yoshioka ed., 2009).

9. The Environmental consciousness project: Scenario questionnaire

In considering the structure of the scenario questionnaire and creating the questionnaire, researchers in humanities/social science and natural science had to collaborate. In the field of natural science, we developed a response prediction model that predicts how the watershed environment will change in response to anthropogenic environmental changes such as forest logging. In the fields of humanities and social science, we conducted a survey (people's interest survey) on what people are interested in among the forested watershed environment consisting of forests, rivers, lakes, and villages. However, in the Environmental Consciousness Project, these studies were not performed separately, but were always jointly conducted by natural science researchers and humanities and social science researchers, who exchanged their opinions (Fig. 5).

The development of the response prediction model and the investigation of people's interests were the basis for conducting the scenario questionnaires and were the first issues that must be addressed in the project. However, at this first stage, we realized that integrated research between humanities and natural sciences faced the most difficult and the most important issues. For example, when natural scientists, humanitarians, and social scientists were discussing the preparation of the questionnaire, it was difficult to proceed even after several hours of discussion. Natural scientists like me are completely unfamiliar with social survey, so at first, I thought it would take a long time to understand how to do it.

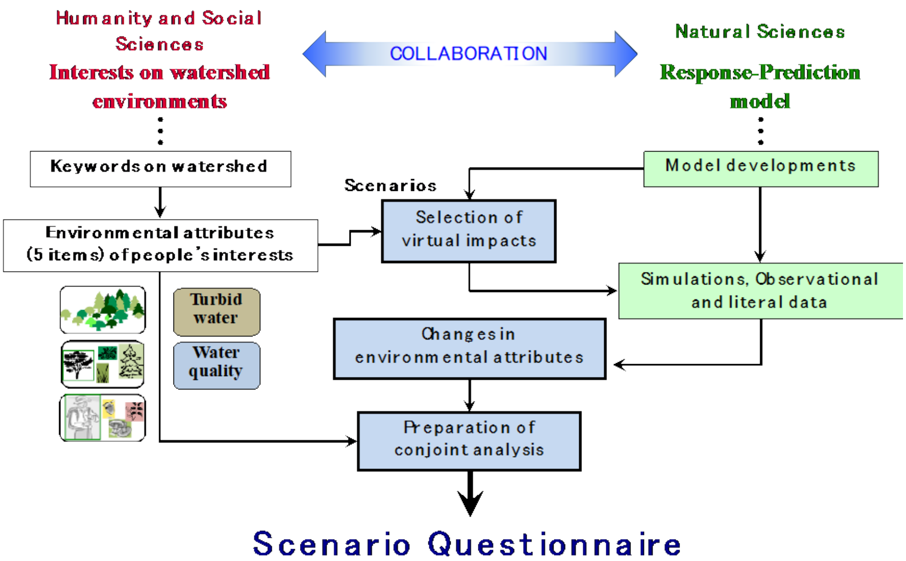


Fig. 5. Preparation procedure for scenario questionnaire

However, I observed something strange.

When I started to wonder why mutual understanding did not progress even after a long time, I realized that the definitions of each other's words were completely different.

We did not understand the real meaning of a word used in the other group!

It has also become clear that efforts to share a common definition of words are only a waste of time and effort. On the basis of the understanding that the definitions of each word and the thoughts contained in them are different, I understood that mutual patience to proceed with discussions is indispensable for research that integrates humanities and natural sciences[#2].

9-1. The Environmental consciousness project: Scenario questionnaire

At the starting point of the project, we conducted a questionnaire on a people's interest survey, as shown in the left part of Fig. 5. The project members needed to spend a long time to consider how to analyze the aggregated results from the questionnaire. Five items were selected as a result of the analysis: "forest landscape (forest area)," "quantity and type of vegetation," "recreation utilization," "turbid water," and "water quality" (Fig. 6).

Fig. 6. Five attributes of the forested watershed that are important for people's environmental consciousness as extracted from the interest survey (Yoshioka ed., 2009)

A scenario questionnaire was prepared using these five attributes and their environmental changes predicted by the simulation results from models. Choice experiment with virtual environmental changes was conducted on the basis of the conjoint analysis[#3]. Although the effects on forest logging plans were expected in detail, considerable simplification was needed to conduct the questionnaire, because respondents might not be able to understand complicated environmental changes. Then, the choice experiment with five attributes and two levels (large and small changes caused by logging) for each attribute was prepared.

9-2. Environmental change simulation model

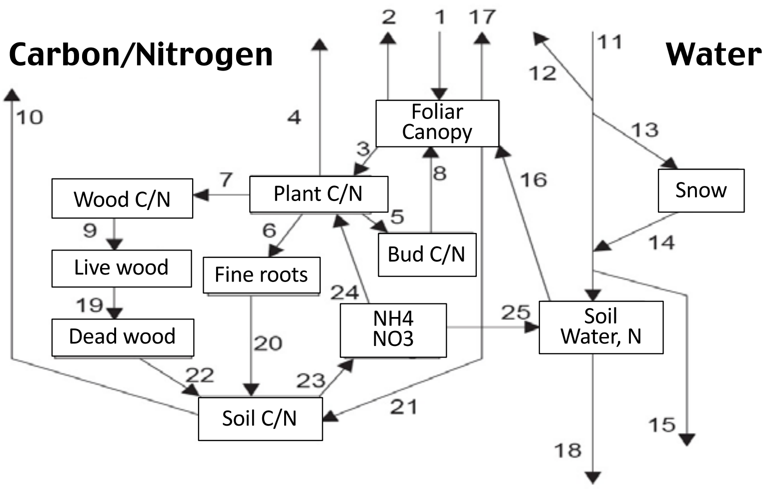


Fig. 7. PnET-CN (photosynthesis and evapotranspiration-carbon and nitrogen) model (Aber et al. 1997, modified by Shibata et al. 2006)

1: Gross photosynthesis, 2: Leaf respiration, 3: Transfer to mobile C, 4: Growth and maintenance respiration, 5: Allocation to buds, 6: Allocation to fine root, 7: Allocation to wood, 8: Foliar production, 9: Wood production, 10: Soil respiration, 11: Precipitation, 12: Interception, 13: Snow–rain partition, 14: Snowmelt, 15: Fast flow, 16: Water uptake, 17: Transpiration, 18: Drainage, 19: Wood litter, 20: Root litter, 21: Foliar litter, 22: Wood decay, 23: Mineralization, 24: Nitrogen uptake, and 25: Penetration into soil.

The environmental change simulation model was composed from several submodels. Nutrient concentrations such as NO_3^- are calculated by the PnET-CN model for forest environment (Fig. 7, Aber et al. 1997) and by observation for agricultural land. The study site for the scenario questionnaire was the Lake Shumarinai watershed in the northern part of Hokkaido Prefecture, Japan.

The PnET-CN model can simulate water, carbon, and nitrogen mass and flux in the forest ecosystem. Input data are air temperature and precipitation. The model calculated the forest biomass recovery after imaginary logging in 2000 (Fig. 8).

The period required for the recovery of forest biomass is different among types of forest logged (broad-leaf, coniferous and mixed forests), depending on the difference in the growth rate of trees. The recovery rate for the broad-leaf forest was estimated to be about 80% after 50 years, while that for the coniferous forest was about 60%. The recovery rate for mixed forest was estimated between the two.

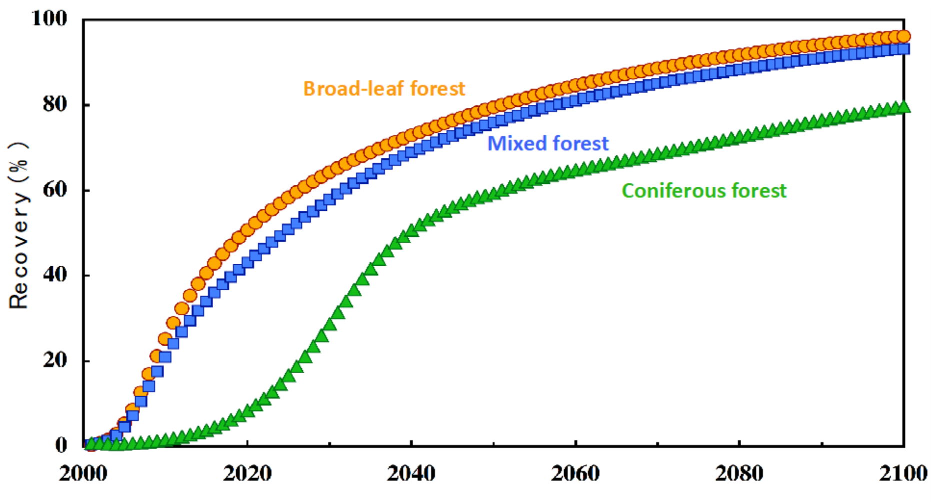
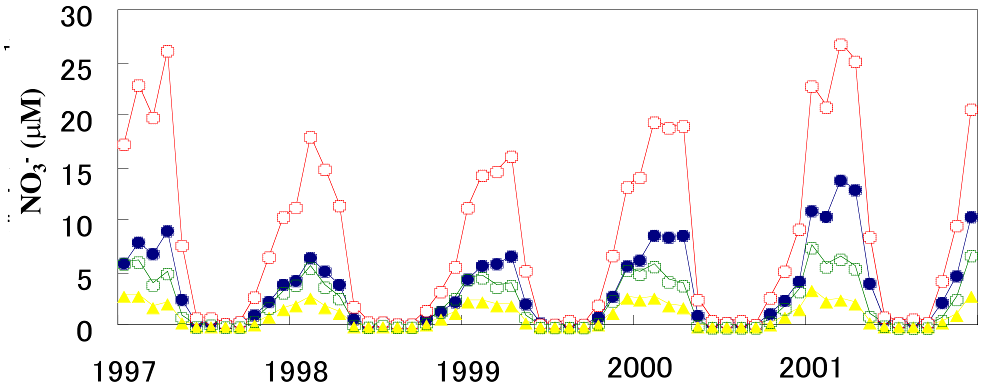


Fig. 8. Biomass changes in different forest types after logging using the PnET-CN model (unpublished data)
Circle: broad-leaf forest, triangle: coniferous forest, square: mixed forest (broad-leaf: 66% and coniferous: 34%)

Water is discharged from the forest through processes 15 and 18 in Fig. 7 as surface and ground water runoff. Various kinds of materials can outflow along with the discharge water from the forest. Stream NO_3^- concentration was preliminarily simulated with the PnET-CN model (Fig. 9). If the atmospheric nitrogen deposition (as NO_x and NH_3) increases by two times higher than present level, then the stream NO_3^- concentration may almost double (red circle) during winter and spring. If the atmospheric CO_2 concentration increases to 500 ppm, then the stream NO_3^- may decrease (yellow triangle). When both phenomena (increases in atmospheric N deposition and CO_2) occur, the spring increase in the stream NO_3^- will be diminished to less than the present level. The PnET-CN model may be a powerful tool for simulating the stream water chemistry.

Fig. 9. Simulation of the stream NO_3^- concentration assuming atmospheric N deposition and/or CO_2 increases



Solid blue circle: present situation, red circle: 2 × atmospheric N deposition, yellow triangle: CO_2 = 500 ppm, green circle: 2 × N deposition and CO_2 500 ppm.

However, the simulation results for the present situation (solid blue circle in Fig. 9) did not match well with the observations not only in the Lake Shumarinai watershed but also in almost all forested watersheds in Japan. The results in Fig. 9 show that in all cases, including the current simulation results, seasonal fluctuations commonly occur, in which the NO_3^- concentration in the stream water increases in early spring and decreases and is completely depleted in summer. The NO_3^- concentration in Japanese streams increases in early spring, but does not completely deplete in the summer, or rather, it increases. To apply the PnET-CN model to the scenario questionnaire, the cause of this discrepancy needed to be clarified.

The PnET-CN model incorporates a model of the hydrological process that expresses the movement of water in forests. However, the water regime (seasonal change in precipitation) in Japan is different from that in the US, where the model was developed. Therefore, the original PnET-CN model showed good agreement between the observed NO_3^- concentration (open circle) and the simulated one (solid circle) on the peak of NO_3^- concentration in the stream water in early spring, but showed a large difference in the summer (Fig. 10, *Katsuyama et al. 2009).

Thus, we applied the hydrological model HYCYMODEL (Fukushima and Suzuki 1986) developed in the Japanese forested watershed to adjust the stream flow and material concentrations (*Ohte 2009). The simulation result using the PnET-CN model and the HYCYMODEL showed relatively good agreement with the observation (Fig. 10). For the scenario questionnaire, we used this combined simulation model for forest and stream environments.

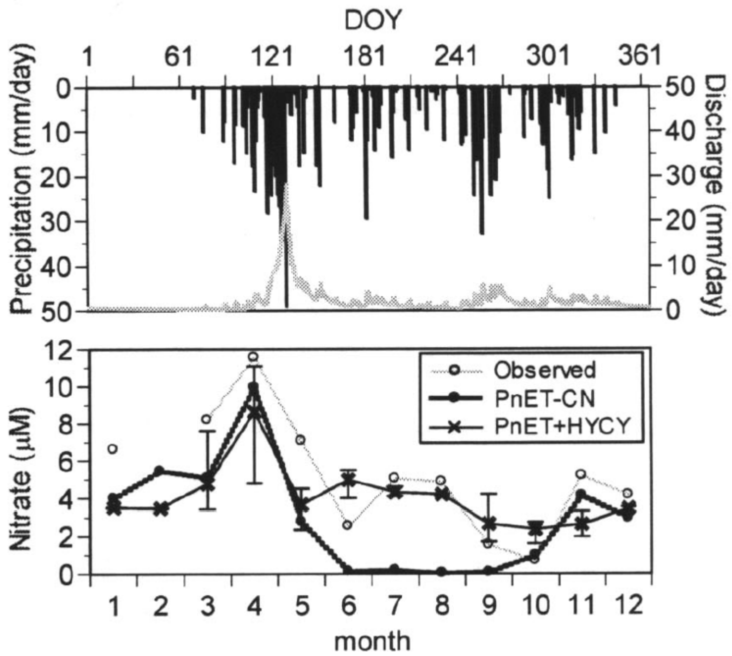


Fig. 10. Hydrological and hydrochemical data for the Lake Shumarinai watershed (*Katsuyama et al. 2009)

Upper panel: hyetograph (vertical bar) and discharge (gray line).

Lower panel: NO_3^- concentration for observed (open circle), simulated results by PnET-CN model (solid circle) and by the PnET-CN model and the HYCYMODEL (x).

The effect of forest logging on the stream chemistry is different among forest types, probably because of differences in the recovery process in the forests (Fig. 8). The recovery of broad-leaf forest from logging was faster than that of coniferous forest, which may reflect the quick and sharp response to the stream NO_3^- increase (upper panel in Fig. 11). The peak appeared at five years after logging and quickly decreased to the original level by almost 15 years. The broad peak of the stream NO_3^- for the coniferous forest logging (middle panel in Fig. 11) may result from the slow recovery of the biomass. Although the peak concentration was lower than that in the case of broad-leaf forest logging, the effect of logging was prolonged for more than 30 years. In the case of mixed forest logging, the result was the combination of broad-leaf and coniferous forest logging (lower panel in Fig. 11). Relatively high peak and prolonged increase in the stream NO_3^- concentration was found.

The stream NO_3^- level five years after logging is highest in the broad-leaf forest, while that 10 years after logging is highest in the coniferous forest (Fig. 12). After 50 years, the effect of forest logging is not found irrespective of forest types.

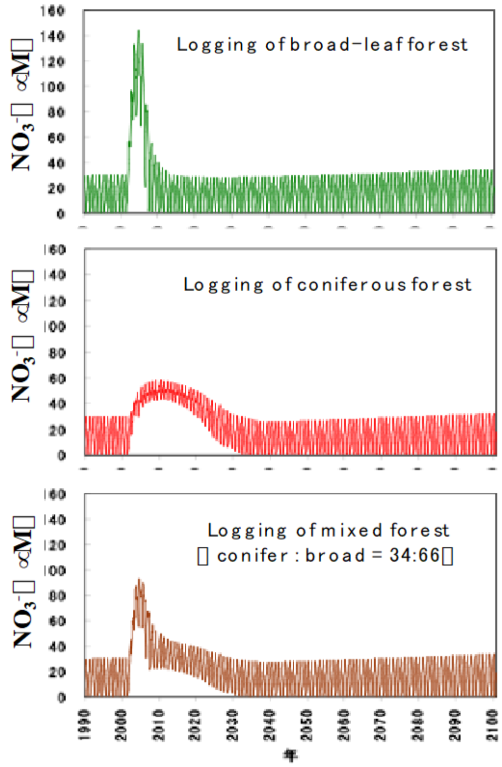


Fig. 11. Left panels: Simulation results of the stream NO_3^- concentration after logging (year of 2001) using the PnET-CN model (*Katsuyama et al. 2009)

Upper panel: broad-leaf forest logging, middle panel: coniferous forest logging, lower panel: mixed forest logging.

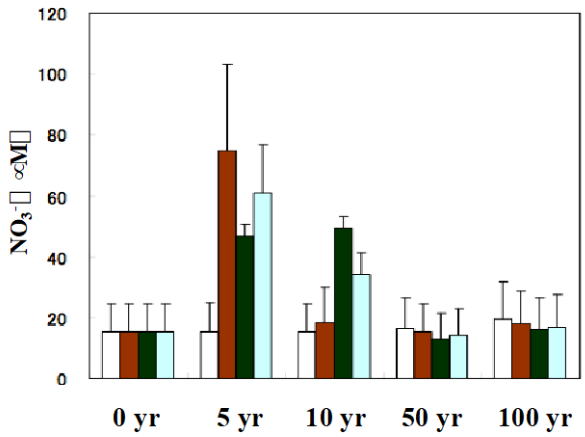


Fig. 12. Comparison of stream NO_3^- concentration among scenarios (*Katsuyama et al. 2009)

□: unlogged, ■: broad-leaf forest logging, ■: coniferous forest logging, ■: mixed forest logging

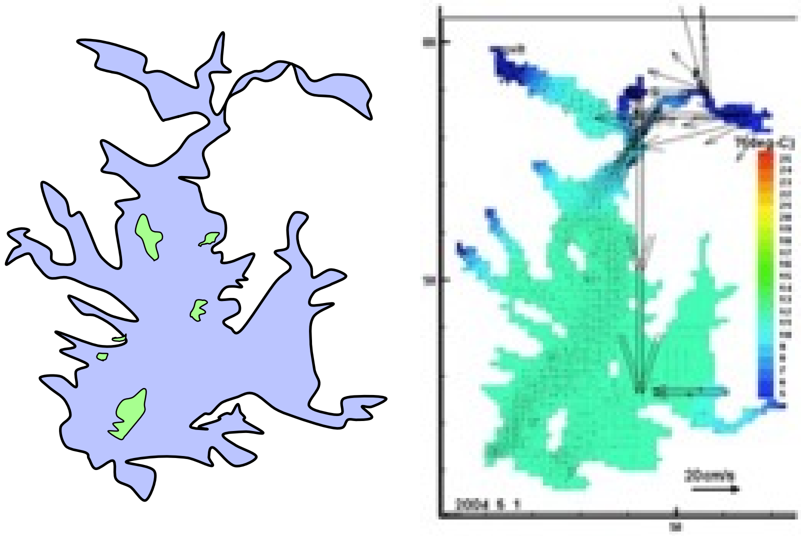


Fig. 13. Simulation results of lake water flow and surface temperature of Lake Shumarinai (after *Nakata and Kutsukake 2009a)

Left panel: shape of Lake Shumarinai, right panel: simulation results of the surface water temperature shown as changes in color from blue to red designated by color bar and the lake water flow direction and velocity indicated by arrows.

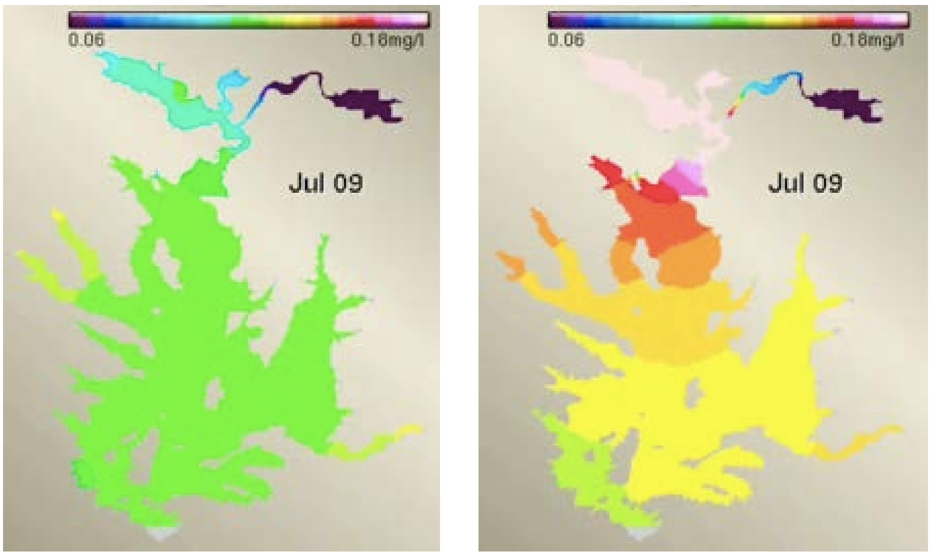


Fig. 14. Surface NO_3^- concentration simulated three years after logging (*Nakata and Kutsukake 2009b).

Left panel: forest is unlogged, right panel: forest (10 km^2) in the watershed is logged.

Water volume and material loads were introduced to the lake model to calculate the water movement and the distribution of nutrients in the lake (Figs. 13 and 14). Temporal change in the NO_3^- concentration was estimated using the biogeochemical simulation model that is newly developed for Lake Shumarinai (*Nakata and Kutsukake 2009). The left panel of Fig. 14 shows the temporal change in the surface NO_3^- concentration before logging. The right panel of Fig. 14 shows the temporal change three years after logging. The NO_3^- concentration increases from the Dorokawa inner lake (northwest branch of the Lake Shumarinai), where the stream discharges from the logged forest into the lake. The signal of the increase in the NO_3^- concentration expanded to the whole lake area.

We also developed a biogeochemical model for Lake Shumarinai to simulate growths of phytoplankton and zooplankton species in the lake. Unfortunately, Lake Shumarinai is a phosphorous-limited (P-limited) lake; the increase in NO_3^- loading by forest logging cannot cause the large change (increase) in the abundance of phytoplankton and also of zooplankton. However, the primary production by lacustrine phytoplankton in a part of the lake (northeast branch of Lake Shumarinai: Akaishi River mouth) was suggested to increase in some cases in forest logging plans (Fig. 15, *Nakata and Kutsukake 2009) probably because of phosphorus input from the surrounding dairy farm.

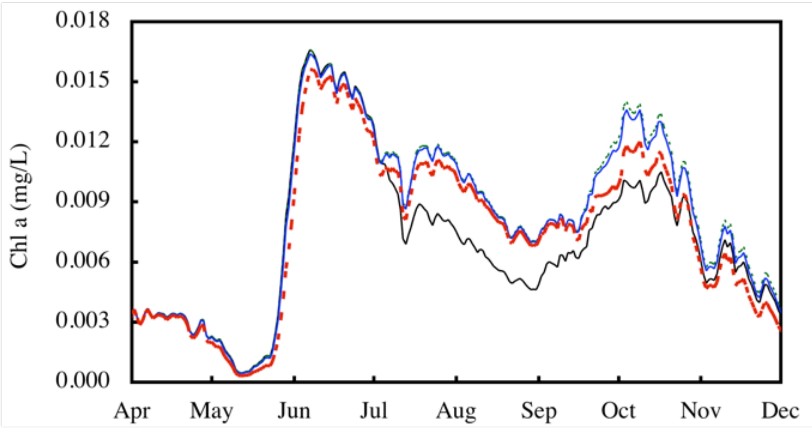


Fig. 15. Phytoplankton biomass (chlorophyll a concentration) changes at the mouth of an inflow river (Akaishi River) three years after forest logging (*Nakata and Kutsukake 2009b).Forest logging areas are as follows: green, 0.8 km^2; blue, 4 km^2; red, 20 km^2.

9-3. Scenario questionnaire using choice experiment method

A scenario questionnaire was prepared using five attributes (Fig. 6) and their changes as predicted by the simulation results from models and information from the literature. A choice experiment with imaginary questions based on the forest logging scenario was conducted. Although the effects on forest logging plans were expected in detail using the models, considerable simplification was needed to conduct the questionnaire, because the respondents might not understand complicated environmental changes and the meanings of figures of each component such as NO_3^- and chlorophyll concentrations. Thus, a choice experiment with five attributes and two levels (large and small effects caused by forest logging) for each attribute was prepared. Conjoint analysis would elucidate the important environmental attribute for people to consider environmental change.

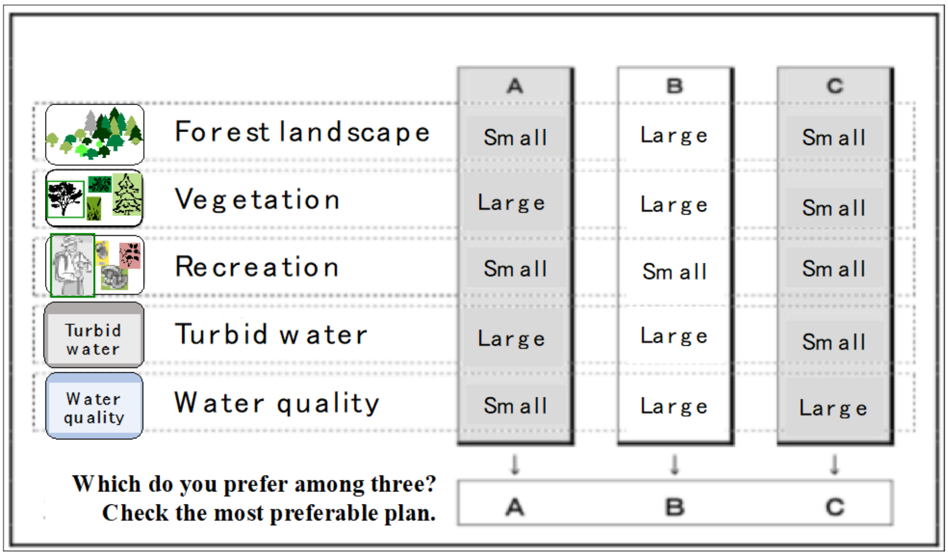


Fig. 16. Example of the scenario questionnaire (Yoshioka ed. 2009). Each question has three environmental scenarios prepared (A, B, and C). Respondents were asked to select their most preferred scenario.

Environ. Attributes	Partial Utility
Forest landscape	0.77**
Plant amount and diversity	−0.70**
Recreational uses	−0.29**
Turbid water	0.26**
Water quality	−1.00**

**: $p < 0.01$

Fig. 17. Results of the choice experiment (Yoshioka ed. 2009). Positive and negative partial utilities mean that people tend to prefer large and small changes of environmental attributes, respectively.

Theoretically, 32 (=2^5) scenarios exist. However, only seven scenarios were retained after biogeochemical simulation results. Eight combinations of the question, which was composed of three different scenarios (Fig. 16), were prepared with the use of these seven scenarios.

The survey was conducted for residents who live in eight river watersheds selected from 109 first-class water systems in Japan. In accordance with the population density, channel density, forest area ratio, and agricultural land area ratio of the watershed, 109 water systems were divided into four groups by cluster analysis. Two water systems were selected from each group. The eight selected water systems were Omono River, Kino River, Joganji River, Monobe River, Kiku River, Suzuka River, Tsurumi River, and Yamato River water systems. Each water system was divided into four equal parts by the length of the channel, and 400 residents were extracted from the Basic Resident Register from the most upstream and most downstream parts. On the basis of the size of the population, the number of people in the Kino and Monobe rivers was set at 300 individuals, and a total of 6,200 people were selected for the survey. As mentioned above, we also conducted a survey using 32 scenarios (called a control survey for the main survey; see Yoshioka ed. 2009). Therefore, 800 individuals for each water system (600 individuals for Kino and Monobe rivers) were extracted, bringing the total to 12,400 people. Recovery rates were about 38% for both main and control surveys.

As a result of the conjoint analysis for the main survey (Fig. 17), the partial utility for the water quality showed the largest negative value (−1.00), whereas that for the forest landscape showed the largest positive value (+0.77). Interestingly, it suggested that people preferred large changes in the forest landscape. In the control survey, the partial utility for the forest landscape was negative (−0.11), but that for the water quality was more negative (−0.29). This finding suggests that among the environmental changes caused by forest logging in the watershed consisting of forest, river, and lake, people were most concerned about the deterioration of water quality. If we were asking about changes in the forest environment only as a consciousness survey on deforestation, we might not have been able to find such environmental consciousness in people's minds.

I realized from the Environmental Consciousness Project that there must be an academic field composed from forests, humans, and lakes. A new academic study was started almost simultaneously, as well as allopatrically (at different spaces in FSERC, Kyoto University, and in RIHN). Perhaps it was the moment when "Mori Sato Umi Renkan-gaku" (Connectivity of the Hills, Humans, and Oceans, CoHHO) was established in my mind.

In the survey, we also prepared a questionnaire that includes 32 scenarios and compared the results of the choice. I cannot introduce in detail people's interesting environmental consciousness as elucidated from several questionnaires and the results of response prediction models. The book *Methodology on the Survey of Environmental Consciousness: Environmental Scenario and People's Preference* edited by Yoshioka (2009) can serve as a reference. The final report of the project was published in the repository of RIHN. Please refer to the list at the end of this article.

In the next article, "Introduction to the Connectivity of Hills, Humans, and Oceans (CoHHO) Vol. 6: Interaction Between Humans and Nature III," I will introduce the survey results obtained in "Research project of the CoHHO on the local society based on ecosystem services in the forested watershed environment (the Kibunka Project)" conducted in FSERC during 2009 and 2013. Professor Yamashita already showed the natural scientific results of this project in the previous article (Vol. 2). I would like to describe the social scientific aspects of the project. In addition, I will reconsider the conceptual framework of people's environmental consciousness and discuss the purpose of the CoHHO study.

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https://chikyu.repo.nii.ac.jp/index.php?action=pages_view_main&active_action=repository_view_main_item_snippet&index_id=327&pn=1&count=20&order=17&lang=japanese&page_id=34&block_id=108

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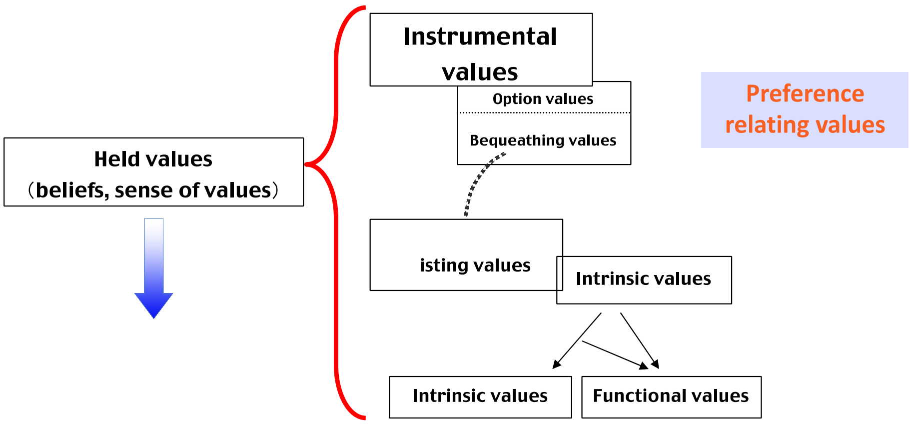
[Glossary] (soliloquy named glossary)

#1 Structure of value

The value of the environment and natural objects has been studied in the fields of environmental philosophy, environmental ethics, and environmental economics, but the terms do not appear to have been unified, and researchers in the field of natural science like myself find this issue a very difficult topic to understand. In Fig. 3, use value and non-use value are illustrated simply, but if the scope is expanded to the sense of the value examined later, then it seems that the diagram cannot fully explain the structure. Therefore, as part of the glossary, I referred to Kito (1996), Washida (1999), Lockwood (1999), and Takada (2003) to extract approximately common perspectives on the value of the environment and to create a schematic. The academic accuracy of the following figure has challenges, but it may be useful for you to think about the value of the environment.



Supplemental Fig. 1. Schematic of the structure of environmental value (original).

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#2 Integration of humanities and natural sciences

The academic idea of RIHN at the time of its establishment was that "the root of global environmental issues is the matter of the human culture." On the basis of this idea, the Environmental Consciousness Project aimed to propose a new research style that combines the methods of natural science and the methods of humanities and social science. However, along the way, I realized that wide and deep gaps exist among humanities experts, social scientists, and natural scientists that pose challenges to our collaborations.

The main purpose of humanities and social sciences is to precisely describe a specific individual, a specific village, or a group (hereinafter referred to as a community, including an individual), thereby understanding human beings and society, I supposed. Researchers in these academic fields are required to have the skill of obtaining information from a community. Some social scientists may strictly believe that the target community is not the original community because the researcher has entered the scenario. Therefore, objectively describing the society in detail may be impossible. However, in many cases, when the researcher is highly skilled, then more detailed characteristics of the community will be revealed. Another social scientist's investigation of the same community may reveal different aspects. A great source of the researcher's originality may exist. I think that the way humanities and social science progresses is to accumulate individual results.

In contrast, research by natural scientists must obtain the same results no matter who performs it. To guarantee the possibility of retesting, the analytical methods and equipment used in the study needs to be specified. If natural scientists do not describe the version of the software used for the analysis, then they will not be able to publish their paper. In this way, in natural science research, natural scientists tend to respect generality rather than individuality (individual case studies). They may aim to derive general rules from the results of their own research, or they may try to clarify the conditions that lead to individual results from general rules. Originality is required for discovering new phenomena, developing new analytical methods, and their unique combination. The accumulation of individual cases can be regarded as material for finding general rules.

Noie (2005) called humanities and social sciences "personal science." Questions would be "What did you do then?," "How did you feel at that time?," and so on. It is, therefore, called "personal science" because the information is mainly collected on "someone" (often "you"). Natural science, on the other hand, is called "impersonal science." Natural scientists often describe natural objects as the subject, and sentences in scientific papers are often expressed in passive voice—for example, "Nitrate concentration in river waters was analyzed colorimetrically."

Then, is it possible for a humanities researcher who focuses on personal science and a natural science researcher who focuses on impersonal science to collaborate toward one purpose? This issue was a severe difficulty I encountered while working on the Environmental Consciousness Project in RIHN. In short, it took a long time for me to realize that the former, which respects individuality, and the latter, which respects generality, have completely different attitudes toward things. The fact that the definitions of words are different among academic fields is also troublesome during collaboration, but it may be overcome if the participants take the time to explain the terms to each other. However, the difference in researcher's attitudes on individuality and generality is difficult to overcome. After giving up on the initial breakthrough and recognizing the differences among collaborators, we decided to proceed with the project by taking the advantages of each field.

I will not explain the details, but in the environmental interest survey, we applied morpheme analysis to analyze the free responses of people (respondents to the questionnaire) and to extract the people's interest in the use value and non-use value of forests, rivers, lakes, agricultural land, etc. We established a procedure for creating questionnaire sheets to comprehensively ask about people's interest in environmental values, as shown in Section 8. The procedure we adopted was also the result of repeated discussion among the specialists in humanities, social sciences, and natural science.

【References】
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#3 Conjoint analysis

This is one of the research methods used in the marketing field. Customers who want to buy products and services need to consider various factors. Conjoint analysis is a statistical method for deciding which factor should be emphasized when developing a new product or service. When automobile manufacturers want to develop a new car, they will select the items (called attributes) and their types (called levels) that customers expect and require in a new car. As an example, in the table below, we set three levels for five attributes, namely, body type, engine displacement, interior, body color, and price.

Supplemental Table 1. Example of the attributes and levels for a new car that is under development.

Attributes	Levels		
Type	Sedan	Coupe	Mini-van
Engine displacement	1100cc	1500cc	3000cc
Interior decoration	Leather	Synthetic leather	Plastics
Body color	Standard	Pastel	Pearl
Price	2 million yen	3 million yen	4 million yen

In this example, a total of $3^5 = 243$ new cars can be considered. However, asking people's preferences (judgment of whether or not to buy) for all these combinations is unrealistic. Therefore, conjoint analysis uses a small number of combinations that are appropriately selected by statistical methods. Through a statistical analysis of the responses, estimating which attributes and levels are most effective for the preferences of people, as well as how much each attribute level contributes to the price of the car, is possible. In this way, conjoint analysis enables new vehicle development policies (important attributes and their levels) to be determined. See the references below for more information.

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