BIODIVERSITY AS AN ESSENTIAL
- CONSERVATION AND SUSTAINABLE USE -

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Preface

What exactly is the study of living organisms and ecosystems in the environmental field? In the final analysis, it is the study of conserving biodiversity[1] and the sustainable use of biological resources.

Why is conserving biodiversity so important? Loss of biodiversity leads to simpler ecosystems and the less complicated systems are the more fragile. Entertaining the idea that perhaps some sort of partial destruction - while retaining that which is important for humans - could be permitted raises further questions regarding the extent of destruction, and the definition of what exactly is "important to humans", questions that cannot be answered. This working group has discussed these questions many times since its inception.

"Biodiversity" is a key phrase that permeates many corners of environmental research. For example, questions about the possible effects of global warming on biodiversity have quickly become regarded as problems. Eventually we decided that the task of this working group was not just to deal with these issues but to clearly establish what exactly is meant by the phrase "biodiversity". What is the relationship between biodiversity, ecosystems, and humankind? How should we adequately use biodiversity as a biological resource? We debated these and other questions at length.

We agreed that for the working group, the term "living organisms" means "biodiversity," and that biodiversity is a vital factor in the existence of mankind.

Living organisms tend to diverse by their nature. In other words, they have genes through which they leave descendents. The group of genes does not simply increase but, according to a certain probability, minute changes in it occur. Thus over the generations living organisms diversify without fail. Out of all these diversified organisms, it is the ones that happened to appear in the right environment which survive. And they will be closely followed by new organisms, which will prey on them - a pattern living organisms have followed since the Paleozoic era. *Homo sapiens* too, originated from out of this biodiversity. Considering the matter from the point that animals need to ingest nutrients from food in order to live, some evolved into carnivores, some into herbivores. They evolved bodies and digestive systems suited to each diet. Human beings, however, are neither one nor the other, appearing to have evolved as omnivores with rather diversified diet. So if the living organisms that they feed upon become less diverse, then humans will not be able to obtain the food they need to live healthily. Decreasing biodiversity manifested by malnutrition is, in other words, linked to a crisis in mankind's very existence.

At this point, conventional scientific thinking would no doubt point to the development and spread of nutritional supplements. But we really need to go back to basics, and be fully aware of the fact that for mankind, which evolved from omnivorous animals, the diversity of the organisms that are our food is key to whether we live or die.

The word "diversity" in biodiversity also refers to the diversity of strategies and the logics with which living organisms such as animals, plants and microorganisms have maintained their individuality and passed it on to their descendents. This is also true of human civilizations, and is a question of our perception of the world and of ourselves.

In line with this shared awareness, this report discusses many matters, and summarizes how research on living organisms and ecosystems in the environmental field should be developed in Japan, from a viewpoint of conserving biodiversity and the sustainable use of biological resources.

Toshitaka HIDAKA

Characterization of the report

The Working Group on Living Organisms and Ecosystems Research and Development (WG) was set up under the auspices of the Environmental Research and Development Promotion Project Team (PT) in June 2003, to examine how research on living organisms and ecosystems in the environmental field should be developed in Japan.

Bearing in mind the relationship with the five environmental research initiatives being implemented under the Promotional Strategies in Prioritized Fields drawn up by the Council for Science and Technology Policy, and taking into account the direction of the measures in the New National Biodiversity Strategy of Japan, the WG studied the current state of research development in Japan, and determined what issues and methods it should address in the future from the viewpoint of conserving biodiversity and the sustainable use of biological resources.

The report summarizes the results of these deliberations and makes some recommendations on the hierarchical structure of research and development in Japan to promote the study of living organisms and ecosystems.

We hope that the report will provide information that proves useful in the future formulation of plans for living organism and ecosystems research in Japan.

[1] The words 'biodiversity' and 'biological diversity' are used interchangeably in this report.

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1. Introduction

Living organisms tend to diversify by their nature, and humankind also emerged from the midst of that diversity. Living organisms form ecosystems made up of biological communities and the abiotic environment surrounding them, and obtain food among the food chain. The ecosystem provides the foundation for the existence of living organisms, and supports their diversity. It was precisely this diversity of living organisms that gave rise to human beings, which are neither purely carnivorous nor purely herbivorous, but omnivorous. That diversity has sustained the continuing existence of humankind. It is essential that biodiversity, and the ecosystems that support it, be maintained in a healthy condition for the existence of human beings.

At the same time, humankind has made use of diverse biological resources for its own survival and for the development of civilization. Biodiversity holds out significant possibilities for the future as a resource in itself. Consequently, it is considered necessary to utilize biological resources for the stable existence of humankind and the preservation of civilizations while at the same time showing the utmost respect, even under international frameworks, for the sovereignty of those countries where biological resources originate. Article 2 of the Convention on Biodiversity defines the term as follows:

"'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

According to the EICnet database of environmental terminology, which is operated by the National Institute for Environmental Studies, biodiversity is also defined as "a concept that points in a comprehensive manner to the variability observed among living organisms, which originate as single cells, evolve, and display a variety of appearances, forms, and modes of life." This working group has decided to define biodiversity as "a concept signifying the multifarious modes of existence of, and interactions among, living organisms that have arisen as the result of evolution and that occur at the genetic, species, and ecosystem levels."

According to DIVERSITAS Report No.1, 2002, the speed at which species have recently been extinct is estimated as being at least one thousand times worse than the decrease experienced during the worst periods of extinction in global history. What sort of effect this decrease will have on mankind is, however, far from understood. And it is difficult to make any sort of deterministic predictions as to how biodiversity and ecosystems interact with climate changes caused by human activity or with artificial ecosystem alterations or environmental pollution.

The issues surrounding biodiversity and ecosystems are shrouded in uncertainties, and difficult to predict. But if ecosystems are destroyed and biodiversity is further diminished, there is a danger that humankind could be left facing massive and irreversible damage in the form of food shortages or imbalances, or the proliferation of emerging infectious diseases, eventually leading to the extinction of human beings. Subsequently, from a prognostic and precautionary point of view we must do our utmost to predict the changes in biodiversity accompanying human activities, clarify the extent and severity of the effects they will have, and implement appropriate measures. This prognostic and precautionary approach can also be seen as a way of thinking in which we will choose a prudent lifestyle, one that is always concerned with sustainability, rather than seeking short-term economic gain or convenience.

The study of living organisms and ecosystems is thus one of the most important and compelling fields in the search for solutions to the uncertain issues modern people now face. However, we have not sufficiently grasped the state and direction of research and development, and to say that Japan has established a clear course for research into the conservation of biodiversity and the sustainable use of biological resources would be misleading. Articulating the direction of Japan's research on biodiversity and ecosystems - from perception of the current state of affairs through to taking appropriate measures - is an urgent task. This is why the Working Group researched and studied the current state of research development in Japan, the issues and methods it should address in the future from a viewpoint of conserving biodiversity and the sustainable use of biological resources, and compiled the results herein.

2. Background of the study

As mentioned in the preface, dealing with changes in biodiversity is of paramount importance to the existence of humankind and the future of civilizations. This is a view that is commonly held around the world, reflected in the Convention on Biological Diversity adopted at the 1992 Earth Summit and ratified by Japan the following year. In March 2002, the Council of Ministers for Global Environmental Conservation decided upon the New National Biodiversity Strategy of Japan. And in September of that year, participants at the World Summit on Sustainable Development (WSSD) agreed to achieve by 2010 a significant reduction in the current rate of loss of biodiversity and negotiate an international regime to promote and safeguard the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

In Japan, the environmental research was designated as a prioritized area under the Second S&T Basic Plan (2001-2005). As a result of this, five initiatives[2] on critical research issues were identified with research into living organisms and ecosystems being made an integral part of each.

Meeting in May 2003, the Expert Panel on Promotion Strategy of Prioritized Areas pointed out the "importance of a biological frame of reference" in Japan's environmental research. The Working Group on Living Organisms and Ecosystem Research and Development was then set up under the auspices of the Environmental Research and Development Promotion Project Team (Appendix 2) in order to study: 1) research and development of environmental conservation measures and techniques using living organisms, 2) research and development of biodiversity conservation and ecosystem management, and sort out how research into living organisms and ecosystems should best be conducted in Japan.

The Working Group researched and studied, from the perspective of conserving biodiversity and the sustainable use of biological resources, how living organisms and ecosystems react to climate change, the effects of environmental pollution on organisms, land management and use and biodiversity conservation, and environmental techniques for using living organisms, while bearing in mind the links between research into the five environmental initiatives currently underway. (cf. 4.1.2).

3. The conservation of biodiversity and the sustainable use of biological resources

The inherent uncertainty of the issues surrounding biodiversity and ecosystems makes it difficult to offer any deterministic predictions about their interactions with global-scale climate changes, artificial ecosystem alterations, or environmental pollution. Moreover, the issues surrounding biodiversity and ecosystems are wide-ranging environmental problems with their own intricately intertwining phenomena; there are limitations as to the ability with which each ministry can deal with them on the usual individual basis. Pursuing R&D clearly identifying overall goals and the paths toward achieving them is an effective way of solving environmental problems that require a comprehensive approach. We decided that the ultimate target that we had to meet was presenting methods to ensure the conservation of biodiversity and the sustainable use of biological resources, for the sake of humankind's survival. Seven research fields were established in order to reach this target (Fig.1).

3.1 Purpose of the research

The purposes of research into conserving biodiversity and the sustainable use of biological resources are as follows:

(i) To observe the actual state of biodiversity and the processes that create and maintain it, and, by analyzing these observations, bring certainty to our scientific knowledge of biodiversity. A particular aim is to clarify the mechanisms with which biodiversity supports all life and civilization on Earth.

(ii) To develop intellectual fundamentals for the conservation of biodiversity and the sustainable use of biological resources.

(iii) To elucidate both the natural and human causes of changes in biodiversity, and their combined modes of action. To predict changes in biodiversity and to establish the limitations of such predictions.

(iv) To evaluate the effects of changes in biodiversity on ecosystems and human society, and clarify the threat to humankind and ecosystems raised by the loss of biodiversity.

(v) To develop basic techniques and methods which will contribute to conservation policies for reducing loss of biodiversity and to avoid the risks envisioned.

(vi) To develop practical measures for the sustainable use of biological resources in "life" industries such as agriculture, forestry and fisheries, and for land management practices incorporating the conservation of biodiversity.

(vii) To present policy options for the realization of the sustainable use of biological resources, and develop safety biological methods and technologies for environmental conservation.

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[2] The Promotional Strategy in the Environment Field under the Basic S&T Plan (App.1) states that: "With regard to priority issues in the environmental field, the individual research carried out by each ministry should be consistently integrated and restructured, and promoted in the form of scenario-driven initiatives channeled towards the reaching of targets common to the government as a whole." The outlines of research initiatives are mentioned in 4.1.2.

3.2 Hierarchical structure of research and development

From an accurate perception of the state of affairs right through to taking appropriate measures, ensuring the conservation of biodiversity and sustainable use of biological resources requires the establishment of distinct R&D channels. We started by establishing a series of core questions linked to our ultimate research target of addressing how exactly we are to ensure the conservation of biodiversity and the sustainable use of biological resources for humankind's sake. We then established a second tier of questions key to addressing the core questions, and then by stages established a further series of questions to address the second tier of questions. We will call this R&D structure the "strategic research and development's hierarchical structure". The core questions in the strategic research and development hierarchical structure are outlined below.

a. How does biodiversity support life on Earth? : Basic research area.

b. How best should we achieve strategic and systematic development for intellectual fundamentals for biodiversity research? : Research area dealing with development of intellectual fundamentals.

c. How do human activities cause changes in biodiversity? : Research area dealing with prediction of biodiversity changes.

d. What kinds of biodiversity losses represent a threat to the survival of humankind and civilizations? : Research area dealing with impact assessments of biodiversity changes.

e. How can we conserve biodiversity? : Research area dealing with development of technologies and systems for conservation and restoration of biodiversity.

f. How can we plan for the conservation of biodiversity and the balanced use of natural resources and land? : Research area dealing with the sustainable use and management of land and natural resources.

g. How can we ensure the sustainable use of biological resources? : Research area dealing with sustainable use of biological resources, and policies for that goal.

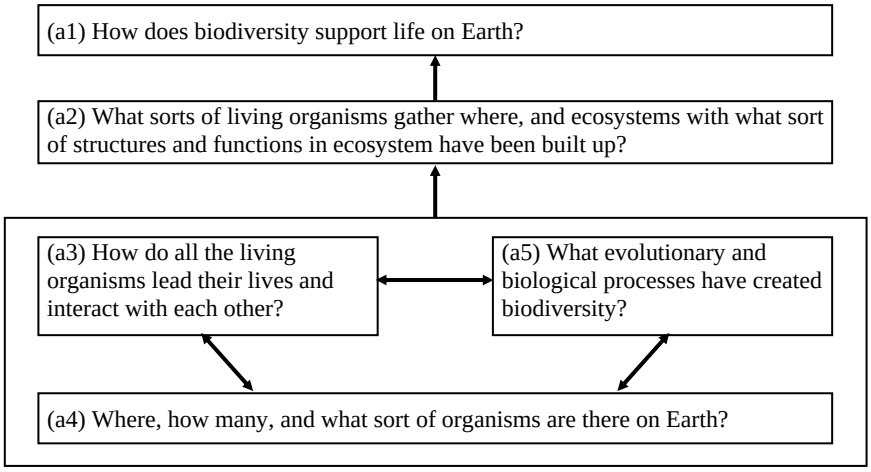
This is not a set of isolated research areas; rather, they are all interactively linked. All the research areas take the fruits of the other research areas as their basis, and these fruits in turn provide vital knowledge for each area. Furthermore, as several questions have been hierarchically placed in each research area, by threading the answers to each question to the question in the tier above, we will be able to achieve our overall objective (Fig.2).

The set of questions in each research area is shown in Table 1. The concrete details of each research area are as described below.

3.2.1 Basic research (a)

This research area deepens understanding about the question of how biodiversity supports life on Earth (a1). The results of research in this area are vital in providing the knowledge that will enable policy makers and citizens to gain a proper perception of the importance of biodiversity. The question that is a key to answering this question is configured in (a2), which asks what sorts of living organisms gather where, and what sort of structures and functions in ecosystem have been built up.

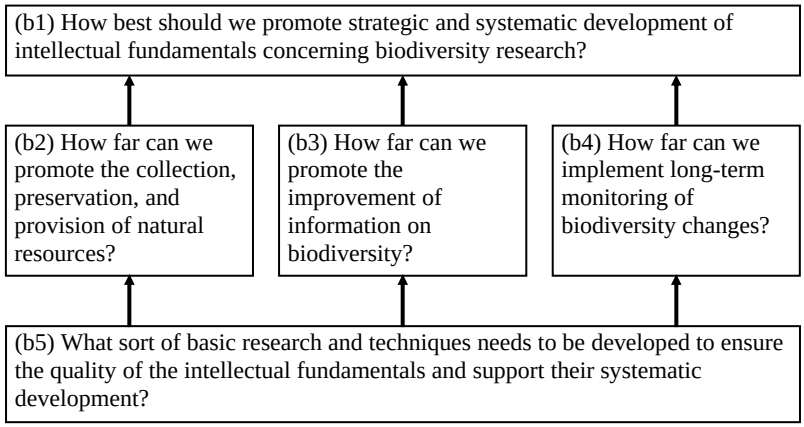
The keys to answering the second-tier question lie in the questions (a3) "how do all the living organisms lead their lives and interact with each other?"; (a4) "where, how many, and what sort of living organisms are there on Earth?"; and (a5) "what evolutionary and ecological processes have created biodiversity?". This research area necessitates the promotion of basic research centering on ecology, taxonomy, evolutionary phylogenetics, and paleontology - from the genetic level to the ecosystem level. When we examine the conservation of biodiversity and its sustainable use, it is evident that there are sizeable gaps in our knowledge about these questions. For example, it is thought that we only know around 10% of the Earth's living organisms. This is a result of the fact that we know only 5% or less of the planet's microorganisms, arthropods and insects. The theoretical, experimental and empirical knowledge we have of the ecological and evolutionary processes of biodiversity provides the most fundamental and important information we have for predicting and assessing the impact of changes in biodiversity.



3.2.2 Development of intellectual fundamentals (b)

Despite the fact that the research subjects concerning the conservation of biodiversity and sustainable use of biological resources are diverse and complex, the state of our current knowledge base is extremely precarious. In order to promote advanced, unique, or basic research into the conservation and sustainable use of biodiversity in Japan, and then utilize the results of such research effectively, development of intellectual fundamentals is an urgent task. We need to secure natural resources such as biological resources and environmental specimens; to conduct long-term monitoring of changes in biodiversity; and to encourage strategic and systematic improvements in our information about biodiversity.

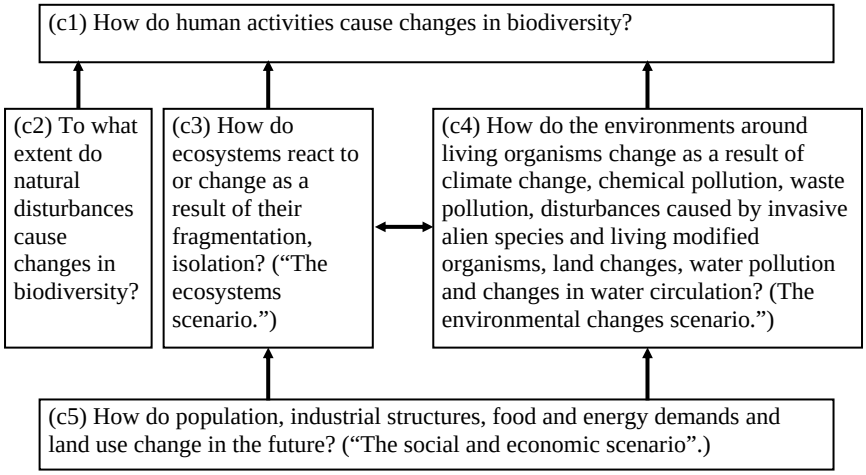
We put the first-tier question asking how best should we promote strategic and systematic development of intellectual fundamentals concerning biodiversity research, and showed the need for strategic and systematic improvements in the three fields of: (b2) **"**how far can we promote the collection, preservation, and provision of natural resources such as biological resources, cells and genes of endangered species and environmental specimens?"; (b3)"how far can we promote the improvement of biodiversity information by collecting and integrating decentralized information, environmental statistics and monitoring data on biodiversity?"; and (b4)"how far can we implement long-term monitoring of biodiversity changes in combination with inventory of biodiversity and monitoring of environmental changes?" The following question (b5) was configured in order to facilitate the above: "what sort of basic research and technologies needs to be developed to ensure the quality of the intellectual fundamentals and support their systematic development?".



3.2.3 Prediction of biodiversity changes (c)

In this research area, we need to answer the question of how human activities cause changes in biodiversity (c1). This in turn requires a clarification of biodiversity's response mechanisms as background data, by asking to what extent do natural disturbances cause changes in biodiversity (c2). Based on this, we then configured the following two questions. Regarding the major direct effects on biodiversity arising from human activities, we asked how ecosystems react to or change as a result of their fragmentation, isolation or alteration, which is particular question in biodiversity problems (c3); and, we asked how ecosystems change as a result of climate change, chemical pollution, waste pollution, disturbances caused by invasive alien species and living modified organisms, land changes, water pollution and changes in water circulation ("the environmental changes scenario") (c4). While the extent of the effect of much of these factors on biodiversity and ecosystems remains

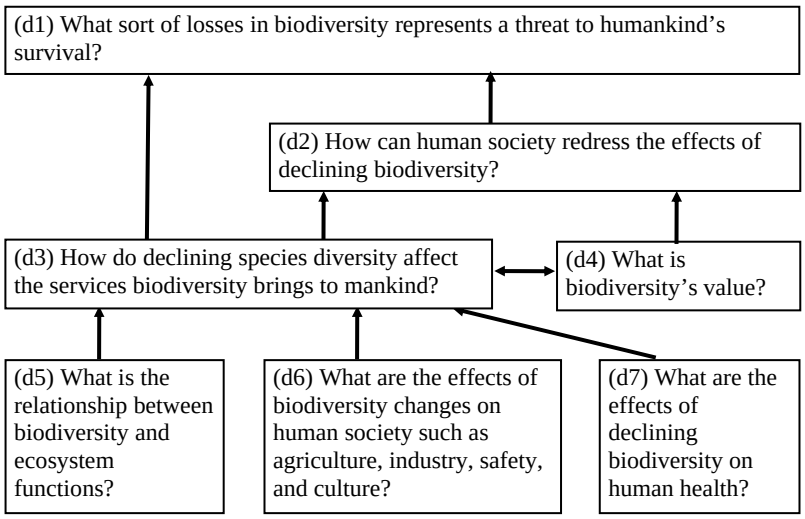
unknown, the following question, which looks at what brings about these factors, is a vital part of the background: what sorts of changes occur in ecosystems as a result of changes in population, industrial structures, food, energy demand and land use? ("the social and economic scenario") (c5). In order to answer these questions we need to understand the mechanism by which social and economic changes cause environmental changes, segmentation of ecosystems and invasive alien species problems, and based on this, to predict how these factors subsequently change biodiversity.



3.2.4 Impact assessments of biodiversity changes (d)

Based on the predictions of changes in biodiversity, we have to make an impact assessment by asking what sort of losses in biodiversity represents a threat to humankind's survival (d1), and how human society can redress the effects of declining biodiversity (d2). A decline in the number of species may alter the ecosystem functions and dramatically affect the services which biodiversity brings to human society. In order to predict and assess these factors, the relationship between biodiversity and the ecosystem functions must be elucidated. It is also possible that losses in biodiversity may have wide-ranging effects on agriculture, forestry and fisheries or other bio-industries, on food safety and pest control, even on our very culture and comfort. The questions configured for these issues were: how do declining species diversity affect the services biodiversity brings to humankind? (d3); what is the relationship between biodiversity and ecosystem functions? (d5); what are the effects of biodiversity changes on human society such as agriculture, industry, safety, and cultures? (d6); and, what are the effects of declining biodiversity on human health? (d7) .

It has been pointed out that there is a good chance that biodiversity possesses many values yet to be sufficiently evaluated; these need to be appraised. We must assess the effects on human society of the changes in biodiversity predicted under the environmental and social and economic scenarios, and also study how to redress the risks envisioned. The questions concerning these issues ask: how can human society redress the effects of declining biodiversity? (d2), and then, what is biodiversity's value? (d4).

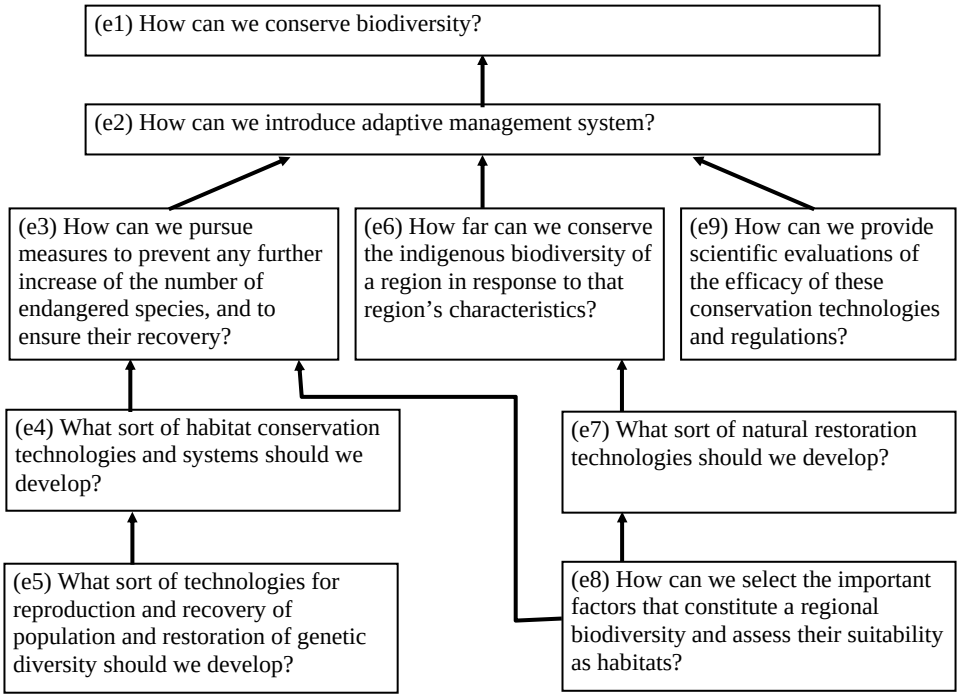


3.2.5 Conservation of biodiversity, and techniques and methods for its restoration (e)

This research area asks how can we conserve biodiversity (e1). However, since it is somewhat difficult to evaluate the efficacy of predictions of changes in biodiversity and of conservation measures, an adaptive management system[3] is necessary. We thus set this two-tier question: how can we introduce the adaptive management system? (e2). Answering this question requires the urgent establishment of ways to assess the efficacy of conservation technologies and regulations, and we thus need to consider the question of how we can provide scientific evaluations of the efficacy of these conservation technologies and regulations (e9).

With regard to endangered species, we need to develop technologies for the conservation and recovery of population and restoration of genetic diversity, and for the conservation and restoration of their habitats. The questions set to address these issues are: how can we pursue measures to prevent any further increase of the number of endangered species, and to ensure their recovery? (e3); what sort of habitat conservation technologies and systems should we develop? (e4); and what sort of technologies for reproduction and recovery of population and restoration of genetic diversity should we develop? (e5).

Though the stockpile of basic scientific knowledge in this research area is relatively shallow, it is also a field with an urgent need for the application of technologies. Thus there is a need for both wide-ranging basic and applied research. While we need to conserve indigenous biological species and ecosystems in order to pursue the conservation of global biodiversity, we must at the same time bear in mind the characteristics of each region. There are now many habitats which need to have their former natural environments restored. The following questions were posed to address these issues: how far can we conserve the indigenous biodiversity of a region in response to that region's characteristics? (e6); what sort of natural restoration technologies should we develop? (e7); and how can we select the important factors that constitute regional biodiversity, and assess their suitability as habitats? (e8).

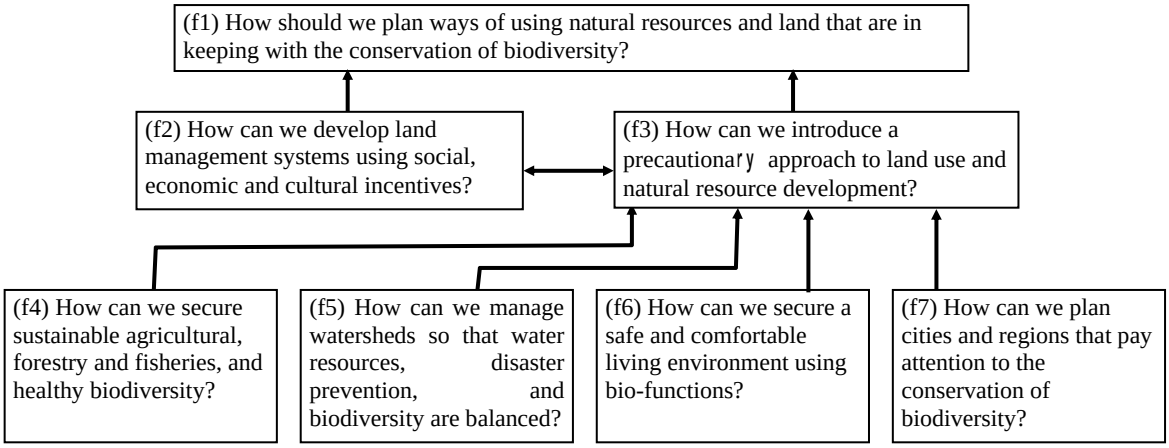


3.2.6 Sustainable use and management of land and natural resources (f)

Use of natural resources such as food, water and land needs to be balanced with the conservation of biodiversity. So while we need to develop technologies and methods for conserving biodiversity, we must also develop research to address the question of how we should plan ways of using natural resources and land that are in keeping with the conservation of biodiversity (f1). Maintaining production of safe food requires the use of many bio-functions and a balance with the conservation of biodiversity. The simple ecosystems growing around the vast areas occupied by a single crop or forest are highly susceptible to outbreaks of harmful insects or disease; environmental changes such as climate change etc can lead to

[3] The adaptive management system is a management tool that looks at regional development and ecosystem management plans as hypotheses and, through deliberations based on continuous monitoring assessments, repeatedly reviews the plans and policies and progressively revises them as and when necessary.

increased instability in production. These phenomena show the considerable influence exerted by biodiversity on the sustainability and stability of agricultural, forestry and fisheries systems. Consideration must also be given to biodiversity in the areas of water resources within watersheds, and the securing of disaster prevention. Biodiversity is also an essential part of amenable living environments in both urban and rural areas. Since deterministic predictions about the effects of the use of land and resources on these are difficult, and some changes are irreversible, a precautionary approach is essential. We must also at the same time research and develop the use of social and economic incentives and institutions which will make them feasible.

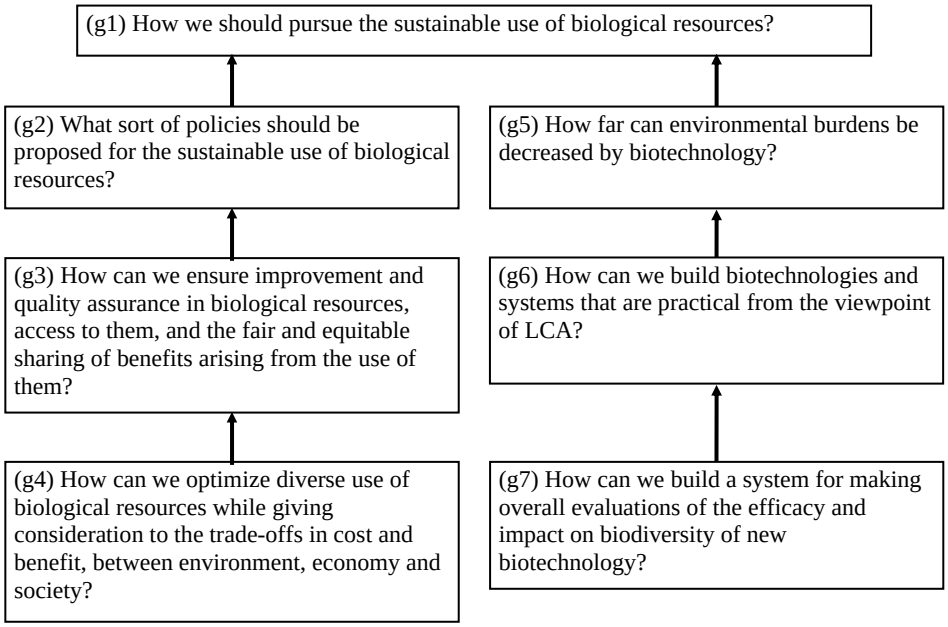


3.2.7 Sustainable use of biological resources, and policies for that goal (g)

With regard to the question of how we should pursue the sustainable use of biological resources (g1), we need to examine policies for the use of these resources without obstructing the development of research, promotion of the development of industry, environmental conservation and the facilitation of human health and welfare, while also respecting the sovereign rights of States over their natural resources and the concept of fair and equitable sharing of the benefits arising from the use of biological resources as enshrined in the Convention on Biological Diversity. In order to develop biotechnologies for environmental conservation such as biological energy conversion technology, biological treatment for decreasing environmental burdens, and bioremediation technologies, aimed at preventing global warming and achieving a recycling-oriented society, we must also develop a way of assessing the environmental impact of newly developed biotechnologies using biological resources. Thus the following second-tier questions were put: what sort of policies should be proposed for the sustainable use of biological resources? (g2); and how far can environmental burdens be decreased by biotechnology? (g5). In order to answer these second-tier questions we asked the following further questions: how can we ensure improvement and quality assurance in biological resources, access to them and the fair and equitable sharing of the benefits arising from the use of them? (g3); how can we optimize diverse use of biological resources while giving consideration to the trade-offs in cost and benefit between environment, economy and society? (g4); and, regarding the latter, how can we build biotechnologies and systems that are practical from the viewpoint of LCA?[4] (g6); and how can we build a system for making overall evaluations of the efficacy and impact on biodiversity of new biotechnologies? (g7).

All of these questions have been debated as matters of great importance at the Conference of Parties of the Convention on Biological Diversity and the OECD's Environmental Policy Committee. The question of the impact of biotechnology has been taken particularly seriously following the conclusion of the Cartagena Protocol on the effect of genetically modified organisms on ecosystems.

[4] LCA (life cycle assessments) are a tool for measuring the impacts on society and the environment of products and materials through their entire life cycle, from procurement of the raw materials through to their final disposal.



4. The current state of research and development in the field of living organisms and ecosystems

4.1 The state of research and development in Japan

4.1.1 Governmental ministry and agency activities, their state and their needs

Based on data provided by various governmental offices we compiled two tables showing the current state of R&D issues in each ministry (Table 2), and each ministry's R&D needs ("Future Issues", Table 3). We analyzed the state of living organisms and ecosystem-related R&D in the environmental field. The results of the analysis for each research area are presented below.

a. Basic research

The research issues that the ministries are dealing with (Table 2) include biodiversity and the mechanisms for maintaining it; basic research into marine (including deep-sea) and island ecosystems; and a social-scientific approach aiming at the rebuilding of concepts for ensuring the coexistence of human and nature. Research issues concerning the evolutionary and ecological processes involved in the creation of biodiversity and the species number of living organisms inhabiting the Earth are not mentioned above, but some of these are included in the 21st Century COE Program of Ministry of Education, Sports, Culture, Science and Technology, unveiled in 2003.

As basic scientific research into biodiversity is on the whole somewhat lacking, there is also very little basic knowledge about the state and the role of biodiversity as a life support system. Research limitations here provide the largest single reason why little progress is being made in understanding how biodiversity supports life on Earth.

b. Development of intellectual fundamentals

Monitoring and information studies and other research to support a systematic development of intellectual fundamentals, such as "The Agriculture, Forestry and Fisheries Environmental Database", "the National Census on Marine Coastal Organisms", "the National Census on River Coastal Environments" and "Data File of Toxicity Test of Harmful Chemicals for Aquatic Organisms" are being carried out. There are many efforts to acquire data about long-term changes in biodiversity, in the form of government undertakings conducted by ministries and research institutions, and in the form of individual projects such as environmental impact assessments. However, it cannot be denied that the way the material deriving from these endeavors ties in with R&D issues is somewhat tenuous; a positive attempt to put it to good use must be made. Although there are several research institutes involved with intellectual fundamentals such as preservation of natural resources including biological resources, endangered species and environmental specimens, many of these organizations typically lack the staff, finances and infrastructure to ensure that these projects are continuous. A concerted effort to strengthen and reinforce the system for supporting the conservation of natural resources is thus required. And with moves afoot to integrate data on biodiversity through international collaboration, building up a support system that can flexibly address this trend is desirable.

c. Prediction of biodiversity changes

While the effects on biodiversity of global warming, fluctuations in water cycles, chemical substances, invasive alien species, living modified organisms (LMOs[5]) and so on account for the lion's share of the issues being examined, other critically connected areas have received considerably less attention. For example, there is relatively little biodiversity research that considers socioeconomic scenarios; there is very little comprehensive research on prediction linked to the monitoring of entire watersheds, including forests and oceans. The efforts being made to develop models to address the inaccuracy of predictions about changes in biodiversity are also inadequate. On the other hand, most projects related to land use and construction are now accompanied by an environmental impact assessment upon which practical decisions are made about environmental conservation with respect to various elements of environments including animals, plants and ecosystems. Dramatic improvements to the systemization and quality of these methods are urgently required.

d. Impact assessments of biodiversity changes

Japan's efforts regarding the assessment of biodiversity are woefully underdeveloped. Despite the prediction that changes in biodiversity have multifaceted effects, the issues being dealt with by government ministries are few, and their evaluations one-sided. Considering the advanced nature of the evaluations of functions and services of biodiversity carried out in developed countries in recent years, and considering the way that these nations have also eagerly initiated academic research into the socioeconomic impact of losses in biodiversity, it is clear that Japan must redouble its efforts in this research area.

e. Development of technologies and systems for conservation and restoration of biodiversity

The issues that we are looking at here are how we can conserve indigenous biodiversity and endangered species according to their regional characteristics. Various research projects dealing mainly with the conservation of ecosystems in tropical forests, rivers, lakes, and coastal wetlands are underway, but they are neither systematic nor coordinated. Projects involving the protection and reproduction of endangered species are being carried out under the auspices of the Ministry of the Environment, for example, but these projects need to be given longer time spans and to be more closely tied to research and development issues. Meanwhile, a number of attempts to restore natural environments and conserve precious species in the management of rivers, lakes, grasslands and forest areas are underway; again, the way these are tied to research and development also needs to be strengthened.

f. Sustainable use and management of land and natural resources

Research into the development of basic technologies ensuring coexistence with nature on national lands, coexistence with nature in agriculture, and coexistence with nature and the restoration of watersheds is underway in the "Eco-harmonious River Basin and Urban Area Restoration" research initiative being carried out under the auspices of CSTP (see 4.1.2). Weaknesses exist in the socioeconomic research efforts to address the questions of land use, of how agriculture, forestry and fisheries should be pursued, and of how to deal with natural disasters. Answering these questions is indispensable for implementing a balance between biodiversity and extractive industries.

g. Sustainable use of biological resources, and policies for that goal

The main issues of sustainable use of biological resources concern technologies for using biomass (energy generation and recycling), mainly centering on matters that are closely linked to research initiatives to develop technologies for preventing global warming or for waste free (see 4.1.2). Policy-wise, these are inextricably linked to the Biomass Nippon Strategy and the Strategies for Development of Biotechnology (BT Strategy). The field includes environmentally sound biomanufacturing processes, bioremediation, and bio- and eco-sequestrations of carbon dioxide, some of which are the issues raised by government ministries. Policy research for the sustainable use of biological resources, and research on evaluating the safe use of living modified organisms are also underway, in response to both Article 15 of the Convention on Biological Diversity and the Cartagena Protocol on Biosafty.

4.1.2 Living organisms and ecosystems R&D in research initiatives being implemented under the auspice of CSTP

We have compiled a list (Table 4) of biodiversity-related projects which were selected from all the research projects registered by the government ministries in 2003 to the five research initiatives being implemented under the auspice of CSTP since 2002. Their main characteristics and relationship to the research areas discussed in Chapter 3 are presented below.

- Research initiative on global warming (climate change research area)

Research related to living organisms and ecosystems includes the impact of climate change on material cycles in terrestrial

5 LMO (living modified organisms) means any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology (Cartagena Protocol on Biosafety to the Convention on Biological Diversity, text and annexes, p.4, 2000.)

and marine ecosystems, predictions in that field, and research into the reaction of ecosystems to climate change. Most of this research has deeply rooted links to research areas (c) (prediction of biodiversity changes), and (d) (impact of biodiversity changes).

- Research initiative on global warming (prevention techniques research area)

Biodiversity-related research is being implemented in areas such as the application of bioprocess technologies to manufacturing process, technologies and systems for proper utilization of biomass energy and for fixing and accumulation of carbon dioxide by photosynthetic organisms, and impact assessments into the effects of deep-sea sequestration of carbon dioxide on marine ecosystems. All this research is relevant to area (g) (sustainable use of biological resources, and policies for that goal).

- Research initiative on waste-free and resource recycling technologies

There are many studies of technologies for the biological conversion of untapped organic resources (wastes) into methane, biotreatment of waste water, and bioremediation, and bioassaying harmful wastes. We can classify them as being part of area (g) (sustainable use of biological resources, and policies for that goal).

- Research initiative on eco-harmonious river basin and urban area regeneration

Research areas integrating ecology and civil engineering such as watershed management and coastal wetland restoration are dominant in this initiative. They fall into the research areas (e) (development of technologies and systems for conservation and restoration of biodiversity), and (f) (sustainable use and management of land and natural resources).

- Research initiative on chemical substance risk management

The main issues in chemical substance risk management are endocrine disrupting chemicals (“environmental hormones”) and related bioassay and experimental technology studies. These topics come under our research area (b) (development of intellectual fundamentals) and also include research into biological restoration techniques to clean up pollution caused by environmental hormones and cadmium. These research efforts are closely linked to research areas (e) and (g).

- Research initiative on global water cycle

Research includes comprehensive research into the regional eco-history of Asia and tropical monsoon regions, and research into the impact on ecosystems of fluctuations in water cycles. They are closely related to our research areas (c) and (d).

4.2 The international direction of biodiversity R & D

R&D related to living organisms and ecosystems is carried out under the auspices of many international cooperation mechanisms. Individual nations are also following their own autonomous research strategies as a result of the Convention on Biological Diversity. We will now take a look at the main international frameworks concerning research in the field, and make some remarks about the state of R&D in Europe and America.

4.2.1 International frameworks

An array of international frameworks aiming to conserve biodiversity and realize the sustainable use of resources has come into existence. Under the Convention on Biological Diversity (CBD) adopted at the 1992 Earth Summit, United Nations Conference on Environment and Development (UNCED), seven thematic work programs have been initiated to address marine and coastal biodiversity, agricultural biodiversity, forest biodiversity, island biodiversity, the biodiversity of inland waters, dry and sub-humid lands and mountain biodiversity. Over and above the thematic programs there are a number of key cross-cutting issues of relevance to all thematic areas. For example, work has been initiated on invasive alien species, the Global Taxonomy Initiative (GTI), which advocates the promotion of taxonomy, and the 12 ecosystem approach principles. Activities are also underway concerning access to genetic resources, the fair and equitable sharing of benefits arising from the use of genetic resources, and the effective implementation of the Cartagena Protocol on Biosecurity.

Another undertaking closely linked to the CBD is the International Treaty on Plant Genetic Resources for Food and Agriculture, approved in 2001 by the Food and Agriculture Organization of the United Nations (FAO). The treaty stipulates the conservation, collection and investigation of plant genetic resources required in each country in order to achieve the conservation and sustainable use of plant genetic resources used in food and agriculture. It also stipulates mechanisms to ensure the fair and equitable sharing of the benefits arising from the use of these resources, and the smooth supply of them from their country of origin to overseas.

In addition to such international treaties, there are international programs based on other international agreements. One of these is the Global Biodiversity Information Facility (GBIF), which was launched in March 2001 as a result of discussions at

the OECD's Committee for Scientific and Technological Policy. With the goal of collecting and integrating the diffuse information on biodiversity and arranging it in a manner so that it can be used anywhere in the world, the GBIF is attempting to build a system that will enable the public to view about 90% of the scientific names of the 1.75 million known species by 2010. The OECD's Environmental Policy Committee (2004) made some recommendations concerning international efforts aimed at developing economic methods to encourage the long-term conservation of biodiversity and the sustainable use of biological resources. In June 2002, the Millennium Ecosystem Assessment (MA) was also launched. Jointly funded by the Global Environment Facility (GEF), the UN Foundation, the Packard Foundation, the World Bank and others, MA seeks to improve ecosystem management by carrying out scientific assessments of ecosystems and providing comprehensive ecosystem data that is useful in policy making.

DIVERSITAS is an international research project jointly initiated by the International Council for Science's Special Committee on Problems of the Environment (ICSU-SCOPE), the International Union of Biological Sciences (IUBS), and the United Nations Educational, Scientific and Cultural Organization (UNESCO). DIVERSITAS promotes research into the formation processes of biodiversity, and its structure, function, maintenance and conservation. It also offers scientific support to the CBD. The Global Invasive Species Programme (GISP) was jointly devised by ICSU-SCOPE, the World Conservation Union (IUCN) and CAB-International (CABI), and was launched with the cooperation of UNEP, GEF, UNESCO and NASA. GISP's target is to collate case stories about invasive alien species around the world, examine the best ways to prevent such occurrences and plan for their management, and produce a list of methods for doing so. The International Geosphere-Biosphere Programme (IGBP), established by the ICSU, seeks, by understanding the physical, chemical and biological processes ruling the world and how they interact, to elucidate the state of the global environment in the past, present and future, as well as how it has changed, and what effects the activities of humankind have had on it. UNESCO's Man and the Biosphere Program (MAB), aiming to encourage the activities of an international network trying to protect diversity, maintain development and cultural values, designates biosphere reserves across the world. In response to calls from the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), the Intergovernmental Panel on Climate Change (IPCC) is compiling technical reports on climate change and biodiversity. There are also a number of joint global science research programmes planned between IGBP, WCRP, IHDP, and DIVERSITAS, such as the Earth System Science Partnerships on the carbon cycle, water, food, and human health.

As all the above testifies, many international activities are underway. Japan's contribution to these efforts tends to be reliant on the talents of individual researchers, and not enough is being done in terms of government-level responses. This is why Japan's scientific contribution to the international community is somewhat stunted.

4.2.2 The state of R&D of biodiversity outside of Japan

America's National Science Foundation (NSF) has launched its "Biocomplexity in the Environment" project as a multi-year research program in the field of environmental research & education. Its investigations intend to provide a more complete understanding of natural processes and cycles, of human behavior and decision making in the natural world, and of ways to use new technology effectively to observe the environment and sustain the diversity of life on Earth. The five interdisciplinary areas in the program are:

1) Dynamics of coupled natural and human systems, focusing on the complex interactions among human and natural system at diverse spatial, temporal, and organizational scales,

2) Coupled biogeochemical cycles, focusing on the interrelation of biological, geochemical, geological, and physical processes at all temporal and spatial scales,

3) Genome-enabled environmental science and engineering, encouraging the integrated use of genomic and computational approaches to gain novel insight into environmental questions and problems,,

4) Instrumentation development for environmental activities, supporting the development of robust instrumentation and associated software for observing, modeling and analyzing a wide range of complex environmental materials or compounds, life forms and processes, and,

5) Material use: science, engineering and society, reducing adverse human impact on the total, interactive system of resource use, as well as maximizing the efficient use of individual materials throughout their life cycles.

The annual budget for these efforts in 2004 was $99.8 million, making it the largest project of its kind in the world.

Elsewhere in the US, the Environmental Protection Agency (USEPA), National Fish and Wildlife Foundation (NFWF), US Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA), the US Department of Agriculture (USDA), and the US Department of the Interior (USDOI) all promote biodiversity-related research projects concerning wildlife protection and the conservation, management and restoration of coastal, wetland, forest and agricultural ecosystems. Meanwhile, the Department of Energy (USDOE) is devoting part of its budget for energy saving, new energy and energy efficiency technologies to biomass and biorefining R&D.

In 2002 the European Parliament and the Council of the European Union adopted the 6th Environmental Action Programme (EAP) drawing up guidelines for environmental strategy from 2002 to 2010. The programme identifies climate change, natural and biodiversity, environment and health and quality of life, and natural resources and waste as the priority

environmental issues, and sets objectives and priority areas for action on each issue; it aims to produce targets and strategies to address each issue by 2005. The priority areas in the issue of natural and biodiversity are as follows:

1) Monitoring and assessment of the EC's biodiversity strategy and the relevant action plans; research into biodiversity, genetic resources, the relationship between ecosystems and human activities; sustainable use, sustainable production and sustainable investments in relation to biodiversity; coherent assessment, further research and cooperation on threatened species; a fair and equitable sharing of benefits arising from the use of genetic resources; the prevention and control of invasive alien species;

2) Countermeasures for accidents and natural disasters;

3) Soil conservation;

4) Sustainable management of extractive industries with a view to reduce their environmental impact;

5) Promoting the integration of restoration and conservation of landscapes;

6) Promoting the integration of biodiversity considerations in agricultural policies, and encouraging sustainable rural development, multifunctional and sustainable agriculture;

7) Promoting sustainable use of the seas and conservation of marine ecosystems;

8) Sustainable forestry management; and,

9) The safety of genetically modified organisms.

5. R&D issues of biodiversity that Japan will have to deal with in the future

The working group analysed the disparity between the hierarchical structure of strategic R&D covered in Chapter 3 and the results of analysis of the current state of R & D in Chapter 4, and discussed what research issues will need to be addressed in the future. The issues that government ministries are dealing with now, and those which they will have to tackle in the future have been compiled in the research map in Fig.3. The issues, which should be dealt with in the future by the working group, are shown in Table 5. This chapter shows the disparity between the hierarchical structure for research in each area and the actual state of the issues, and describes what R&D issues Japan will have to deal with in the future.

a. Basic research

Since there is a widespread lack of basic scientific research on biodiversity there has been no sort of systematic accumulation of basic knowledge concerning its actual state and the role that it performs. Issues that could become the bedrock of future biodiversity research such as evolutionary processes, the interaction between species and an inventory of species are all essential areas. Most of the research hitherto conducted in theses areas has been propped up by small-scale individual efforts; support for such research should be expanded and systemized. Some of the vital issues to be addressed include: applying genome analysis, remote sensing and other advanced technologies to the elucidation of phenomena and evaluation methods at population, species and ecosystem levels; linking taxonomic data at the species level with phylogenetic and evolutionary theories, and with topographical and ecosystem function data; and improving our knowledge of the taxonomy, distribution, ecology, evolution and genetics of microorganisms (including viruses) and arthropods, all of which play vital roles in the Earth's biogeochemical cycles. Government support should be considered for efforts such as the tentatively named Eco-genome Project, which seeks to make a cross-structural elucidation of genetic behavior at cell, individual, population and ecosystem levels. Deepening our understanding of the biodiversity maintenance mechanisms through such projects is an important foundation for establishing ways to conserve and restore biodiversity. Moreover, eco-genome research to elucidate the behavior and evolution of microorganisms and micro-parasites is an essential basis for safeguarding against emerging infectious diseases and imported diseases, and enabling the safe use of genetic modification technologies.

b. Development of intellectual fundamentals

The state of the development of the intellectual fundamentals in Japan - for example, monitoring, data development, preservation and provision of biological resources and environmental specimens - is well behind that of Europe and America. A thorough overhaul and strengthening are needed in all these projects: the GBIF Japan being pursued as an inter-ministry project, the National BioResource Project that the Ministry of Education, Culture, Sports, Science and Technology is involved in; the Ministry of the Environment's Environmental Specimen Time Capsule project, and the ministry's National Survey on Natural Environment for biodiversity monitoring; and work on the preservation and provision of biological resources that is currently underway at Japan's universities and research institutes.

We need to ensure the constant development, under a domestic and international network, of methods to improve the quality of these projects - methods for long-term preservation, taxonomy and identification. We also need to make the data more user-friendly, provide the existent information so that intellectual fundamentals can be managed in an integrated manner, and create a structure in which the facilities match users' needs.

Information about biodiversity is highly varied, ever expanding, and becoming more diffuse. In particular, the bulk of the

colossal volume of data arising from administrative surveys conducted by governments and research institutes, and the results of environmental assessments and other related projects, lies dormant without being put to any good use. This data should be rescued from its slumber. Integrated data processing and management methods, methods of expressing data in GIS format, and effective ways of using the data - including making it more public-oriented - should be developed. The links between this data and R&D should also be reinforced.

c. Prediction of biodiversity changes

While various research efforts are underway in the field of predicting changes in biodiversity arising from environmental changes, we lack the knowledge to make adequate predictions about issues such as invasive alien species, LMOs and ecosystem segmentation. Moreover, since the various predictive research projects underway are all following their own different courses it is impossible to grasp an overall picture of what exactly their targets are. In order to redress this situation we need to strengthen research into comprehensive prediction models. In doing so, it is vital that we try to merge a comprehensive model containing a ecological model with several socioeconomic scenarios (as is the case in global warming research). It is also vital that we refine our prediction models and improve their certainty, while at the same time involving ecosystem monitoring in certain specified regions. The status of individual research activities will also have to be re-thought in line with the prediction models. For example, research issues such as exploring the effects that changes in the use of land and water resources have on terrestrial and marine ecosystems in Asia are issues that demand immediate attention, and conducting them in tandem with research initiatives already underway (see 4.1.2) should be looked at.

d. Impact assessment of biodiversity changes

Though the past decade has seen a boom in research into the relationships between biodiversity and ecosystem functions such as production and material cycles, Japan's efforts in this field are woefully inadequate. While we have seen that ecosystems with a high degree of species diversity also have high production, this is largely based on the results of research into grassland ecosystems. Obviously we need to explore this relationship in other types of ecosystems. As production is directly related to ecosystem services such as the absorption and discharge of carbon dioxide and other greenhouse gases, climate adjustments and the supply of water resources, there is a need to understand what sort of contribution biodiversity makes for production. The hypothesis is that biodiversity makes a considerable contribution to the stability and sustainability of ecosystem functions. However, empirically supporting this relationship remains a challenge for the future. In this sense, a tie-up with the research initiatives currently underway is obviously important.

The occurrence of disease-bearing or harmful organisms in human or industrial organisms is the result of interaction among organisms; the elucidation of these mechanisms, their quantitative analysis, and predictions of their outbreak are needed. It is thought that the genetic diversity of industrial organisms, homogeneity of culture and captivity environments, and the evolution of harmful microorganisms are all background factors in these mechanisms, and these deserve to be treated as important aspects of biodiversity in the future. There is also research underway in the US and Europe that emphasizes the cultural, social and economic value of biodiversity to local communities. This research area is vital from the point of getting across the message that biodiversity needs to be conserved and used, and urgent efforts are needed to develop methods for making qualitative and quantitative assessments of the value of biodiversity.

e. Development of technologies and systems for conserving and restoring biodiversity

Methods of conservation and restoration of biodiversity are nationally important if Japan is to contribute to clearing the target set at the 2002 WSSD, i.e. to significantly reduce the current rate of loss of biodiversity by 2010. There has to be a strengthening of research into methods to conserve biodiversity appropriate to the peculiarities of individual regions, and research into conservation of endangered species and the reproduction of populations. Regarding the former, research is needed that will enable the identification of the important elements that make up the biodiversity of a region and the elucidation and appraisal of the appropriate growth conditions. The latter will require research into the physiology, evolution, ecology, and genetics of endangered species. And policy-related research into exactly how effective the existing regulations and systems have been is also necessary. This is an area in which individual research is small-scale and pursued with little linkage to the others; the impact of its results on the public tends to be somewhat weak. The results of research and their significance must be conveyed to society, and the essential individual research needs to be re-formatted to fit in with the R&D hierarchical structure and system and systematically promoted.

f. Sustainable use and management of land and natural resources

Since this area seeks to put forward suitable proposals for ways of using land and water resources and structures for extractive industries that will enable the conservation and sustainable use of biodiversity in the lands of 21st century Japan,

hopefully it can be put to work in tandem with the research initiative on Eco-harmonious River Basin and Urban Area Restoration. One way of doing this would be to integrate all the results of the studies that have accumulated much knowledge over the years, and create a system to use these results - not merely as accumulated data but converted into the form of useful information for sustainable development. Then, based on the results of section (e) above, social experiments in land use that balance biodiversity, in agriculture, forestry and fisheries, and in natural disaster responses should be conducted, in accordance with the principles of adaptive management. In doing so, due attention should be paid to regional cultures, social equity, natural characteristics, and the industrial make-up.

g. The sustainable use of biological resources, and policies for that goal

In order to prevent global warming and achieve a recycling-oriented society, support is needed for the development of environmental conservation technologies using biological functions, such as energy-conversion technologies using living organisms, biotreatment technologies to reduce environmental burdens, and bioremediation technologies. This in turn will require the development of methods to evaluate accurately the efficacy of such technologies and their impact on biodiversity and ecosystems, with due reference to the Strategies for Development of Biotechnology. With regard to the Convention on Biological Diversity, research is needed into the design of systems to use biological resources from overseas (such as sustainable use of biological resources and the fair and equitable sharing of the benefits arising from the use of them). This is an issue that cannot be avoided if we are to achieve the sustainable use of biological resources. Finally, reflecting "the recommendation of the Council on the use of economic instruments in promoting the conservation and sustainable use of biodiversity" adopted at the ministerial level meeting of the OECD's Environment Policy Committee, we must develop economic technologies for the sustainable use of biological resources that maximize environmental, economic and social benefits.

6. Important related matters

6.1 The promotion system of R & D of biodiversity

Research into living organisms and ecosystems in the environmental field provides the scientific knowledge and technological basis for achieving the conservation of biodiversity and the sustainable use of biological resources. When we think about the promotion system for research into living organisms and ecosystems, we must do so while properly appreciating the peculiarities of the environmental fields, and it is important to bear the following points in mind.

- Reaching targets requires that the results of research are compiled as comprehensive, consistent and concrete knowledge, and that the proposals of policymakers and the actions of private citizens are given a firm scientific platform.
- Since research into living organisms and ecosystems is varied and the targets of the various government ministries differ, it is extremely difficult for individual autonomous researchers to produce comprehensive, consistent and concrete knowledge and then have that knowledge reflected in national policy.

Considering the inherently different nature of these areas, research into living organisms and ecosystems in the environmental field would be best pursued by being carried out by ministries, institutions and universities under the framework of a consistently integrated initiative, in line with the hierarchical structure of strategic R&D proposed. The Council for Science and Technology Policy, which is in a position to oversee all the research carried out in Japan, must exercise its leadership. The Council for Science and Technology Policy should establish a promotion system and take the lead with the following steps.

1) Integrate and restructure the individual projects of ministries and agencies so they do not descend into random research structures, and coordinate them with the overall targets of the strategic R&D hierarchical structure and the targets of each research area,

2) Conduct appropriate evaluations and studies to ensure that the restructured products are reaching their targets,

3) Provide advice to the government on the results of these evaluations and studies,

4) Provide its opinion on the progress of each project when necessary, and

5) Designate priority issues at all levels.

And, under the auspices of the Council for Science and Technology Policy, while flexibly treating the characteristics of each research area, an implementation plan needs to be drawn up clearly stating a timetable for the hierarchical structure of the strategic R&D proposed in this report and showing what needs to be done, by when and to what extent, in order to achieve effectively the promotion of living organism and ecosystems R&D.

6.2 Improvement of legal and institutional issues in living organism and ecosystems research

Legal and institutional mechanisms are vital in solving biodiversity and ecosystem issues. For example, an analysis of the state of and results of regionally designated systems related to conserving the natural environment is essential. The laws and

institutions surrounding Japan's sovereignty and access to its biological resources are underdeveloped, and suitable laws or institutions needs to be designed by learning from the situation overseas.

In June 2004, the Invasive Alien Species Act was enacted to redress invasive alien species. Social mechanisms will have to be put in place in order to ensure that the provisions of the act are effective when brought into force. Moreover, as the keystone of an effective policy, prior assessment and inspection based on basic knowledge about the invasion, colonization and expansion of invasive alien species, and the establishment of a decision-making system based on this need to be enhanced. Support needs to be given to research in cases in which the taxonomy and distribution information about biological communities is scarce, especially in microorganisms.

Regarding LMOs, efforts must be made to promote the accumulation of basic knowledge and the provision of information for impacts of LMOs on biodiversity, in line with the Cartagena Protocol and other related domestic legislation. Though information on biodiversity and ecosystems is being collected from various projects and assessment activities, this information tends to be disparate and kept idle; a system to put this information into a database and make it publicly accessible is needed.

6.3 International cooperation

Because research into the conservation of biodiversity and the sustainable use of biological resources involves looking at the complex relationships among a variety of living organisms, it is a laborious task, and one which would be impossible for a single nation to complete by itself. Thus the majority of biodiversity research is the result of international cooperation, much of which Japanese researchers take part in. However, the vast majority of this international cooperation relies entirely on the efforts of individual researchers: it is not coordinated at a national governmental level. The result of this is that Japan's scientific contribution to international society is restricted. Japan should make its position clear, and take up an international leadership role while pursuing its own biodiversity and ecosystem research programs. This will require a government-led initiative that seeks to make Japan a country that contributes to the world by creating and using knowledge.

Most of the regions where there are particular fears about biodiversity loss are developing countries in tropical zones, typically rich in biodiversity. The Asian-Pacific region's relationship with Japan's biota is not only close biogeographically but also interacts powerfully through the movement of migratory birds and other living organisms. At the same time the region is an area of sudden economic growth, booming populations, and plummeting biodiversity. There is thus a very real need for international cooperation in the conservation of biodiversity and its sustainable use in the region. But since the way that Japan's ODA is structured makes the promotion of such international cooperation difficult, a new system is needed between Japan and developing countries, one that includes improving the capacity of science and technology in developing countries.

6.4 Industry, academia, government - their roles

Scientific knowledge and technologies from various research fields, e.g. life science, information technology, and nanotechnology, should be integrated into research on living organisms and ecosystems in response to social needs including the conservation of biodiversity and its sustainable use and the fair and equitable sharing of the benefits arising from the use of them.

If one particular sector becomes involved in every single aspect, as well as being inefficient, it is unlikely that they will achieve satisfactory results. Issues extraneous to market principles, issues accompanied by high costs or high risks, basic research and the development of intellectual fundamentals should ideally be carried out at universities, public research institutes, and academic research bodies. The grooming of personnel too should ideally be carried out at universities, and research aiming at practical use should be encouraged within the private sector. As there is a shortage of taxonomists specializing in living organisms, parataxonomists and specialists dealing in the conservation of living organisms, it is important that industry, academia and government join together to establish mechanisms to ensure an adequate supply of professional specialists. It is with such a philosophy that industry, academia and government should suitably collaborate and promote R&D.

6.5 Linking regional efforts, and providing a platform for interdisciplinary exchanges

Apart from being an environmental field, research into living organisms and ecosystems also enjoys many common themes with research about how humans behave. If one traces back the vertical strands of each field of research, one finds that living organism and ecosystems research is a horizontally intersecting strand. Rather than existing alone, this research is even more significant in the context of research dealing with human activities. Subsequently, it is important to fortify the organic connections between living organisms and ecosystem research and social science. In doing so, it is also vital that local characteristics of biodiversity are borne in mind and a type of conservation that adapts to the special features of local history, social organization and the environment is considered.

In order to achieve this, it is highly desirable to foster platforms for interdisciplinary exchange and stimulation between researchers in the discipline of living organisms and ecosystems and researchers in other disciplines. We must also strengthen the system for supporting wide-ranging research aimed at interdisciplinary and practical output within the same field.

As social and economic aspects become increasingly important, the trend is for NGOs and others to play a more central role in local efforts to conserve biodiversity and achieve the sustainable use of biological resources, (the *Nymphoides peltata* Project at Lake Kasumigaura being one example). And while these attempts are not yet scientifically structured, exchange and collaboration between scientific researchers and field managers are also taking place. For instance in the management of rivers, lakes and agricultural land, all sorts of practical efforts are being made to try to reach a balance between the conservation of biodiversity and human activities, based on the conditions in each individual location. The knowledge and experiences gained from such interaction with human society are important in the sense that they lend new value to biodiversity. But it is hard to turn this into a concrete R&D issue through tacit understanding alone; these sort of experiences need to be enthusiastically endowed with their own vocabulary, and to be properly structured. In other words, the results of research into biodiversity need to be comprehensively, locally and concretely compiled so that they may be adequately put to use at the local level. And by participating in such local activities and gaining feedback on the practical application of research results, new efforts aimed at R&D will be precipitated.

6.6 Building up of human resources and distribution of research funds

Research into living organisms and ecosystems is a new field integrating a myriad of disciplines. Therefore, the government should realize that current research has to be conducted along with training and capacity building, which requires financial investment, improvement of infrastructure and organizational enhancements and developments.

Achieving conservation and the sustainable use of biodiversity requires specialized, advanced knowledge in the fields of human science (in particular, environmental ethics), geography, sociological theory, economics, engineering and chemistry, in addition to the various fields of biology such as taxonomy, ecology, physiology, embryology and genetics. Learning from past mistakes like the way that research training became stultified at the graduate school of environmental science set up in several universities during the pollution research era, we must ensure that research training efforts at environmental universities recently established or restructured are genuinely enhanced, innovative and interdisciplinary. We need to create an original research-training curriculum so that the substance of environmental problems can be sought out and discovered before they become obvious in society, while continuing to systematically provide scientific knowledge and technologies for solving environmental problems.

The number of specialists in increasingly “endangered” areas such as natural history, including taxonomy and topography, is declining, despite a very real need for them. There is an urgent need to foster a new generation of experts in these fields as well as in those areas at the cutting edge of science and technology. In concrete terms, this means enhancing natural history museums and biological resource centers, and building - through collaboration between industry, academia and government - social frameworks in which the specialists can be put to good use.

Japan’s budget for research into living organisms and ecosystems is roughly estimated at around ¥13 billion[6]. In comparison, the budget of the US (which is not a signatory of the Biodiversity Treaty) for the NSF Biocomplexity Project[7] alone is a similar figure. When the various biodiversity-related agency-led projects for watershed protection[8], and the Department of Energy’s biomass and bio-refinement projects[9] are factored in, the sum is estimated at several times the figure allocated for research in Japan. Faced with such a situation, the government must provide a special budget to support research into living organisms and ecosystems and consider proactive efforts such as integrating the activities of the various ministries and conducting research initiative using enhanced budget.

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6 The FY 2003 budget for issues in Table 2. The table presents the approximate figure devoted to living organism and ecosystems research for issues registered as receiving subsidies at research institutions. Since Tab. 2 does not necessarily contain every single research issue, the total budget for research into living organisms and ecosystems is estimated at ¥13 billion, and the actual figure is thought to be somewhere in this range. Please refer to Fig.4 for details of the estimated figure for each research area.

7 The sum was $99.8 million in fiscal year 2004. (President Bush’s Annual Budget, 2005, Overview (Pt.3), Matsuyama, Kiyoko, http://www.nedodcweb.org/report/2004-2-20.html

8 The sum was $4.74 billion in fiscal year 2004. The amount is the total sum of the budgets obtained from the Catalog of Federal Funding Sources for Watershed Protection using the following keywords: grant, agriculture, fisheries, forest, invasive species, restoration, wetland, and wildlife habitat. These may have been budgeted as public works and such cannot be regarded as purely being for research into living organisms and ecosystems.

9 The sum is approximately $93.9 million. (Outline of President Bush’s Presidential Budget Address, 2005, (1/3)), Matsuyama, Kiyoko, from NEDO Overseas Report No.925, February 18th 2004.