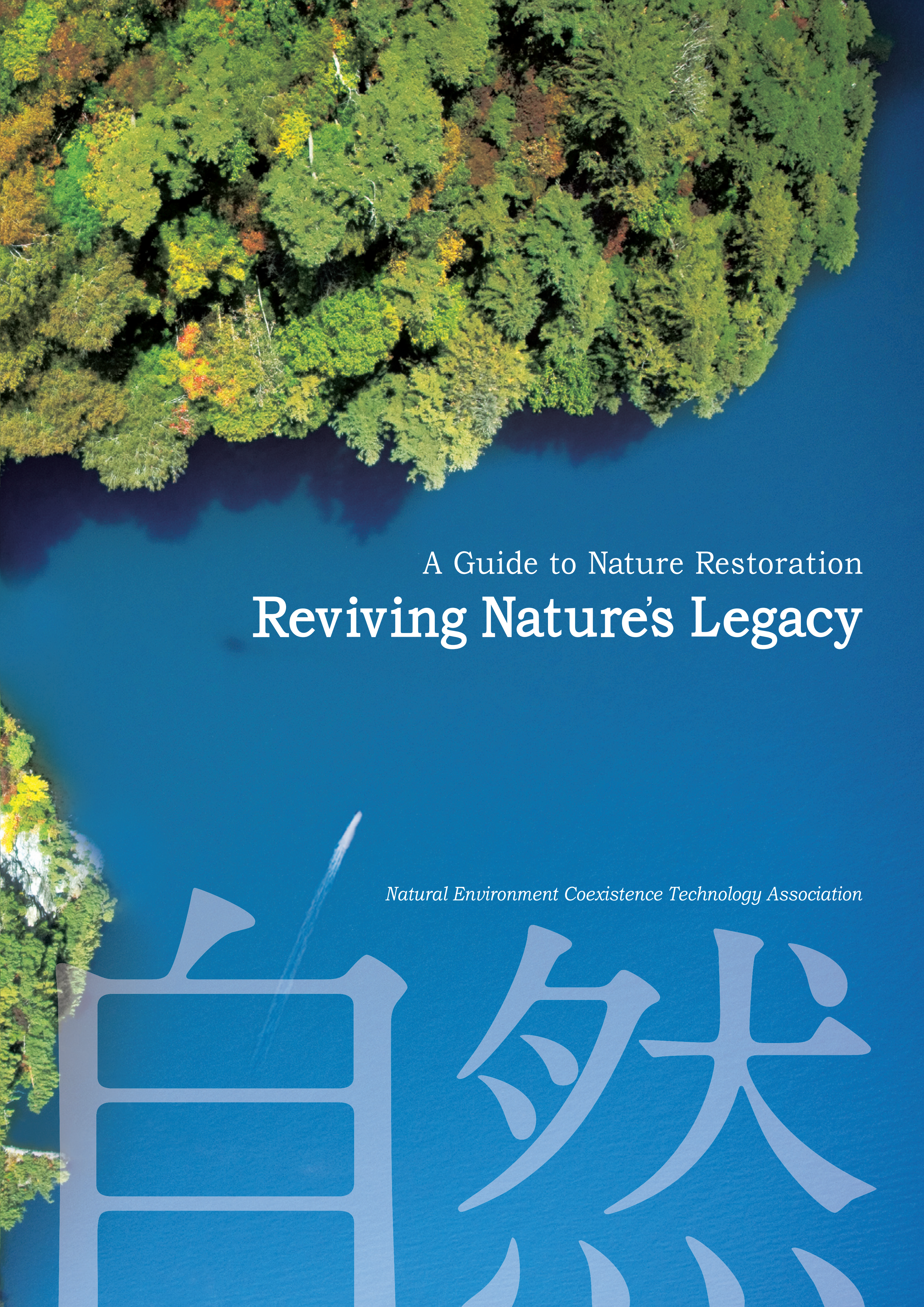

A Guide to Nature Restoration

Reviving Nature's Legacy

Natural Environment Coexistence Technology Association

A Guide to Nature Restoration

Reviving Nature's Legacy

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Natural Environment Coexistence Technology Association

Preface

The rehabilitation and restoration of many ecosystems, including forests, farmland, rivers, wetlands and tidal flats, have been implemented under the Law for the Promotion of Nature Restoration, enacted in 2003. At present, eighteen nature restoration projects have been conducted by a Committee established under this Law. On the other hand, once a Committee has been launched, we have heard many calls for help at the working-level regarding how to formulate an Overall Plan and Implementation Plan. In an attempt to answer these questions, this guide has been compiled by consultants who have actually been involved with project implementation to present an overall framework of nature restoration projects to local governments, NGOs and consultants who are interested in planning or implementing them.

Part 1 discusses the philosophy and concept of nature restoration and describes the necessity for nature restoration projects as measures to achieve the goals of the Convention on Biological Diversity adopted at the Earth Summit and the New National Biodiversity Strategy of Japan and realize a society in harmony with nature. Then, the principles for implementing projects in line with Law for the Promotion of Nature Restoration are provided along with an image of the direction that projects should be headed. The structure of the Committee, the decision-making body for nature restoration projects, and important notes regarding its establishment are also explained.

Part 2 focuses on the technical aspects of implementing a nature restoration project. The entire project process beginning with drafting the Overall Plan and formulating the Implementation Plan, through design, construction and maintenance is explained from a viewpoint different from conventional construction works. Therefore, important points specific to nature restoration projects, such as adopting adaptive management and formulating monitoring plans in line with an adaptive approach, are described.

Part 3 discusses how to implement project evaluation. Nature restoration projects may appear to require just ecological evaluation, but actual project implementation is not so simple. Projects can be greatly mobilized when they have social and economic benefits on local society. This is an important perspective in the context of incorporating the philosophy of nature restoration into various public works instead of separately implementing individual restoration projects. Therefore, this part introduces not only biological evaluation methods but also evaluation and analysis methods from social and economic dimensions.

Part 4 introduces how nature restoration should be implemented in different ecosystems and discusses goal-setting and survey methods through detailed case studies. As the New National Biodiversity Strategy of Japan elaborates, Japan is faced not only with restoration needs in primitive natural ecosystems like those in Hokkaido and Okinawa, but also with the rehabilitation of ecosystems that have been managed and maintained through human production activities, such as *Satoyama* and grass lands. In these areas, proposals of nature restoration projects must be harmonized with local socioeconomic systems that have been maintained to present.

Many nature restoration projects which have been initiated nationwide are at a standstill at the Implementation Plan phase. One of the reasons for this is that the perspectives required differ from those of conventional technologies. If a nature restoration project is to "assist nature in its recovery with minimal human interference, leaving the rest to nature's resilience," existing detailed blueprints are unnecessary. What is important is to restore and maintain the necessary ecosystem processes so that nature can change on its own. Unfortunately, such technologies have yet to be developed. Furthermore, when nature restoration projects are proposed by local residents instead of by the government, the procurement of funds, including seeking administrative support, must be deliberated. The reference ecosystem (or the ideal ecosystem) is determined not through scientific discussion but through sharing values. It is hard to imagine that all actors would share the same views; and therefore, consensus-building is a challenge to find a point of compromise, acknowledging that members have diversified values. This is extremely difficult in a Committee of over 100 members.

As abovementioned, nature restoration projects have just been launched and this guide is only a summary of its overall framework. It is also not meant to be a manual, which should not be prepared for nature restoration projects. What is required is the wisdom to implement projects based on a collaboration of scientific expertise and the local community. This guide has not been contrived to resolve the various issues to be faced on site in the course of project implementation. We welcome guidance and criticism from many people for the further development and improvement this introductory guide.

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PHOTO
Humpback Salmon
Kushiro Shitsugen National Park, Japan
Snow Monkey
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Great purple emperor
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Towada-Hachimantai National Park, Japan
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Part 1

Biodiversity and Nature Restoration

1.The Concept and Philosophy of Nature Restoration

(1) The significance and necessity of nature restoration

Our Earth has many different ecosystems which are home to a diversity of living things. We enjoy the blessings and services that diverse ecosystems and species provide us.However, development and the changing environment have caused ecosystems to deteriorate - forests and tidal flats are disappearing, wetlands are drying up, and plants and animals that we could find in great numbers until just recently are being threatened with extinction.

Now, there is an ever stronger call for biodiversity conservation.Therefore, we must not only make efforts to conserve our remaining ecosystems but also proactively restore and rehabilitate deteriorating ecosystems to recover their healthy state.

Leaving nature to recover on its own is often not an efficient solution to reviving a deteriorating ecosystem, and we must work to eliminate the human activities that have impacted ecosystems, or introduce some human influence intended for their restoration. It is therefore important that we actively carry out nature restoration to recover the lost natural environment so that deteriorating local ecosystems can recover theirresilience.

(2) Creating a society in harmony with nature

Biodiversity conservation issues are indications of excessively developed human activities affecting the survival of living species.

Against the backdrop of increased international discussion on the rapid decrease of tropical rainforests and the risks of species threatened with extinction,the United Nations Convention on Biological Diversity was adopted at the Earth Summit (United Nations Conference on Environment and Development) for the purpose of conserving biological diversity.

Based on the Convention, Japan adopted the National Biodiversity Strategy, which has been revised to accommodate stronger measures, in line with the changes that have occurred to the natural environment and socio-economic circumstances after its first version in 1995.

The Strategy identifies the crises faced by biodiversity, including the destruction of habitats resulting from development and other impacts that human activities have had on living things and ecosystems, changes in human lifestyles and production modes, the degradation of production landscapes such as farmland and forests, and pollution caused by alien species and chemical substances.

The basic measures presented in response to such crises are: “enhancing biodiversity conservation,” or enhancing the conservation of an ecosystem faced with drastic decrease and degradation and preventing the extinction of species; “nature restoration,” a method to proactively restore and rehabilitate the functions of an ecosystem by learning from its past state; and “sustainable use” to preserve secondary natural environments, such as *Satoyama*, which are familiar productive landscapes (managed through human influence).

Hence, Japan’s strategy is a comprehensive plan to conserve and restore nature with the aim to realize a society where people live in harmony with the natural environment and nature restoration is promoted as one of its

major measures.

Based on this newly introduced concept of environmental restoration, the Law for the Promotion of Nature Restoration was adopted in 2002 for the implementation of nature restoration projects.

2.What are nature restoration projects?

(1) The purpose of nature restoration projects

Under the Law for the Promotion of Nature Restoration, nature restoration is defined to be "the conservation, restoration or creation and the maintenance of the conditions of the natural environments with the participation of various actors in the local community, including concerned government agencies and municipal governments, local residents, NPOs and experts, with the objective of recovering the ecosystems and other natural environments that have been damaged or destroyed in the past."

"Conservation" refers to proactive efforts to maintain the conditions of an existing healthy natural environment.

"Restoration" refers to the activity of recovering the natural environment in areas where it has been damaged or destroyed.

"Creation" is an activity to recover native ecosystems by constructing large green spaces in areas where most of the natural environment has been lost - for example, in large cities.

"Maintenance" refers to the activity of monitoring the condition of the restored natural environments and providing the necessary management in order to maintain the condition for a long time.

However, the term "nature restoration" has come to be widely used with a broader meaning, including not only projects based on the Law for the Promotion of Nature Restoration but also the conservation of specific species and creating biotopes.

In this guide, "nature restoration" will cover a wide range of activities, including efforts, consistent with local characteristics, which are made to enhance the quality of ecosystems.

(2) Nature restoration efforts

Nature restoration efforts should be determined in line with three important perspectives: 1) realizing a society in harmony with nature through the protection of biodiversity (setting the goals); 2) adopting an adaptive approach based on scientific knowledge from a long-term perspective (adaptive management); and 3) promoting the participation and cooperation of various local actors (consensus-building). Therefore, a nature restoration project requires a Technical approach based upon scientific knowledge and taking into account the characteristics of the local natural environment, as well as a procedural approach respecting local autonomy and initiative efforts. The process followed in each approach is exhibited in Figure 1.

The concept of the perspectives which characterize nature restoration projects can be summarized as follows:

1) Realizing a society in harmony with nature through the protection of biodiversity (setting the goals of nature restoration)

Project goals should be determined from a broad perspective, such as that of a river basin-wide initiative or considering the ecosystem's relationship with surrounding areas, because an ecosystem is intricately interrelated with the water and material cycles of a river basin and wild species move in a wide area as an ecological characteristic.

Efforts should be made to compile sufficient scientific knowledge to explain the structure and functions of an ecosystem, which is complex and ever-changing, and therefore accompanied by uncertainty.

Nature restoration includes not only primitive nature, but also secondary nature, such as grasslands and *Satoyama*, which are established upon human influence. Therefore, feasible goals should be set based on changes in the ecosystem from the past to present as well as objectives and scientific data.

Feasible goals should be determined based on consensus among concerned

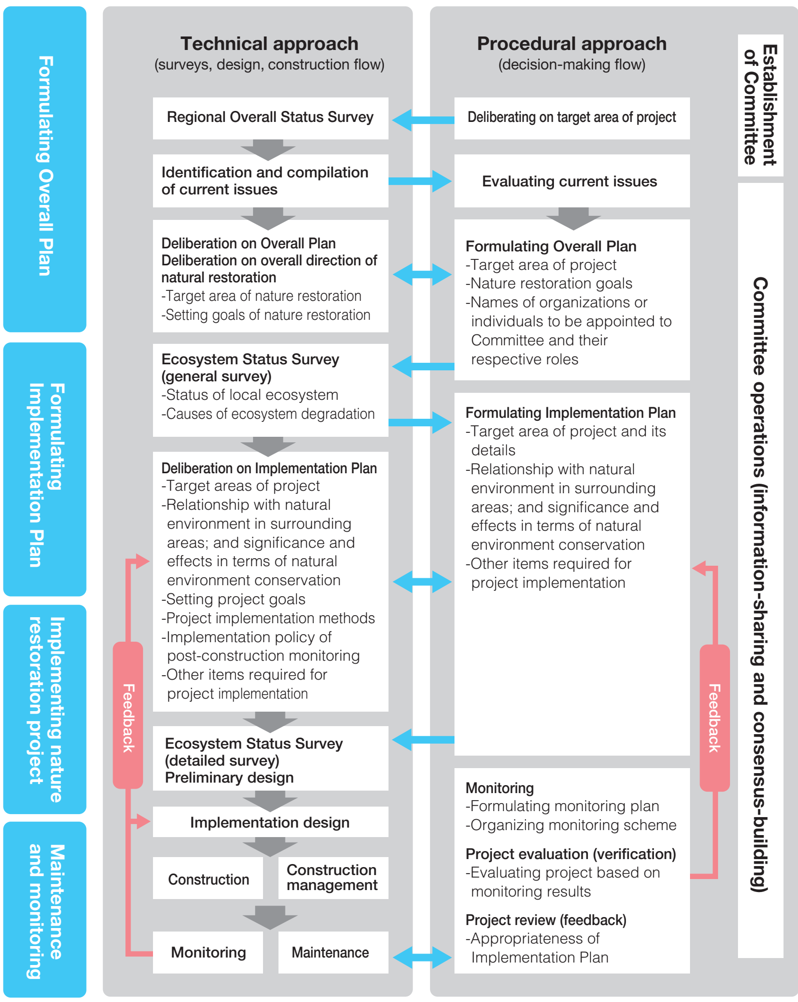


Figure 1 Nature restoration project flow and decision-making

actors, in line with the status of local socioeconomic activities, among other local circumstances.

2) Adaptive approach based on scientific knowledge and a long-term perspective (adaptive management)

Forecasts of ecosystems are always accompanied by uncertainty; and therefore, an adaptive management approach should be applied (Figure 2).

Adaptive management involves thorough preliminary studies on the ecosystem in order to avoid uncertainties, implementing projects based on a hypothesis, monitoring restoration progress once the project is launched, scientifically evaluating monitoring results and incorporating the evaluation results into the ongoing project.

Nature restoration calls for a long-term perspective based on an understanding that nature restoration requires considerable time and that early progress should not be expected.

It is important that nature restoration is continually monitored in the long term and that appropriate management is conducted, and that uncertainties are addressed with an adaptive approach, or “the flexibility of being ready to learn from acceptable mistakes.”

3) Participation and cooperation of various local actors (consensus-building)

Ecological changes are associated with both ecological and social factors.

Therefore, given the complex character of a nature restoration project, consensus-building and partnership among the array of actors in the local community associated with the project is essential.

It is important that a forum for liaison and coordination among various participating and cooperation local actors should be established to facilitate project implementation.

In Japan, such roles are assumed by a Committee.

The Committee is a forum for information-sharing and consensus-building among various concerned actors.

Each stage of a nature restoration project, namely, formulating the Overall Plan for the restoration project, formulating the Implementation Plan, maintenance and monitoring, encompasses enormous volumes of information, which should importantly be shared among concerned actors on a real-time basis

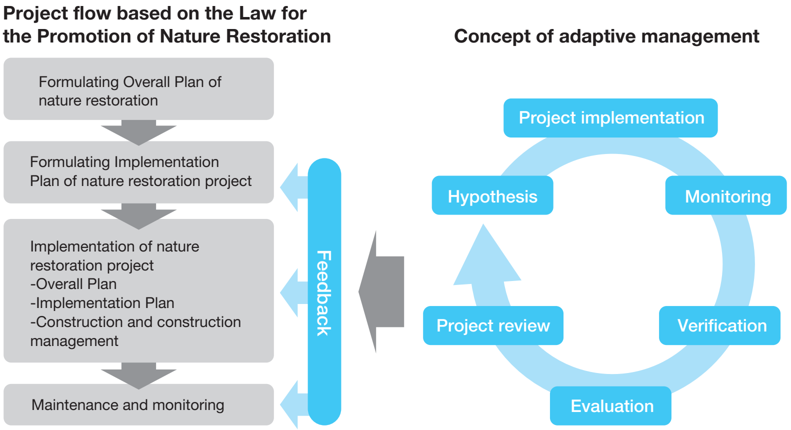


Figure 2 Nature restoration project flow and adaptive management concept

Table 1 Items for information-sharing and consensus-building

Item	Contents
Purpose	Goals of nature restoration, purpose of establishing implementing organization
Project schedule	Overall project schedule Consensus-building schedule (what should be decided at which stage)
Meeting frequency	Regular meetings or voluntary meetings
Participants	Participants are basically fixed. Spontaneous participants should also be welcome if efforts are be made to close the information gap with established participants.
Decision-making process	Committee meetings and other occasions of group discussions may serve as forums for reviewing the consensus-building process and building trust among actors as the project is taken forward.
Basic rules	Basic operation rules, including dispute settlement methods, should be determined among participants to prepare for possible internal conflict.
Appointment of chairman, moderator and coordinator	Appropriate human resources should be appointed based on their human quality and capacity to reflect and coordinate opinions presented by local residents and NPOs.

(3) Cooperation among concerned actors

1) Information-sharing and consensus-building among concerned actors

Given the complex nature of a nature restoration project in terms of the technical and procedural approaches taken, the participation and cooperation of various local actors is essential.

Various concerned actors must organize an implementing organization for the formulation of the Overall Plan and Implementation Plan, which will serve as the basis of a nature restoration project, through information-sharing and consensus-building.

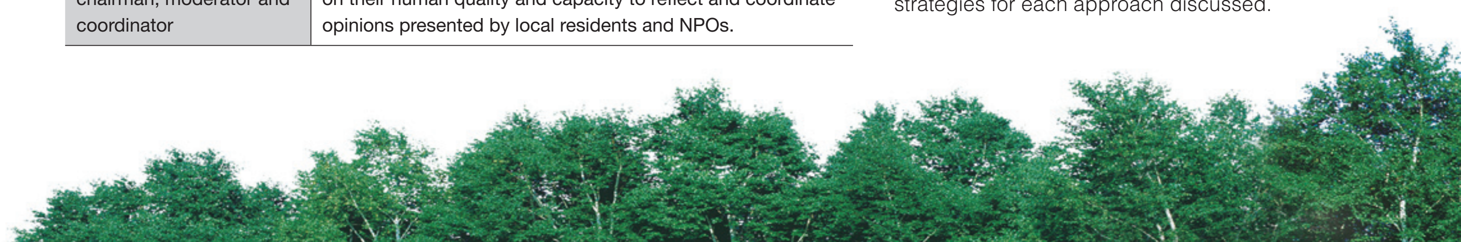
The details that should be shared and mutually agreed upon are provided in the chart below.

2) Structure of implementing organization

The implementing organization should comprise actors of societies which are associated with the area covered by the project.

The organization should be led by a local university researcher with scientific knowledge that can speak his/her opinion from a socially neutral standpoint.

Neutral NPOs should be employed as coordinators in order to gather and organize information and present strategies for each approach discussed.



3) Scale of implementing organization

The scale of an implementing organization is determined according to the project scale and local characteristics.

Given the need for an integrated understanding of project details, the Committee should basically operate under a fixed membership, but also requires the flexibility of being prepared to welcome new members or renewing members when problems occur (Figure 3).

Larger organizations generally experience more difficulties in gathering and coordinating different views among local residents, etc., and therefore require creative management, for example organizing smaller subcommittees and group meetings.

4) Concept of consensus-building

Although unanimous consensus is preferred regarding conflicting interests associated with a project, actors will often trade off in a nature restoration project, which encompasses actors with diverse opinions.

Perfect consensus should not be pursued in consensus-building, but instead, actors are required to “equally share burdens” and mutually seek benefits for the project or for the entire region.

5) Operating the organization

In order to promote a nature restoration project, regular meetings should be held to facilitate the operation of the implementing organization, but voluntary meetings may also be held in light of the complex nature of such projects.

Furthermore, because the implementing organization of a nature restoration project is inherently in being for a long period of time, careful deliberation should be made on how the organization should operate, with due consideration of liaison, coordination and information-sharing.

Time restriction and lack of information is likely to discourage participants; and therefore, careful though should be given to what information is required by actors and meeting schedules; and for example, organize theme-oriented committees (Table 3).

- It is especially important that the participation of parties with expertise is ensured for deliberations based on scientific knowledge
- Concerned government agencies and municipal governments promote nature restoration through providing the support required in organizing the Committee and must be on the Committee membership
- The membership of concerned actors, such as land-owners, is important in terms of gaining their understanding of the necessity of a nature restoration project and also their consent on land provision may be gained.

The Committee is principally open to the public, except for cases in which public disclosure may impede the conservation of rare animal and plant species or the protection of personal information.

Figure 3 Image of Committee

Table 2 Membership of Committee

Members	Main role
Experts	Has expert knowledge and can present opinions based on scientific knowledge
Local residents	Lives in areas that might be affected by project and neighboring municipalities Members may be appointed through open application when necessary.
Relevant government agencies and municipal governments	Offers the implementing organization necessary support
NPOs/NGOs	Preferably a concerned local group. Members may be appointed through open application when necessary.
Stakeholders	Land-owners and other actors whose consent is required for land provision, etc.
Other	Coordinates meetings and expertise Organizations such as NPOs should be employed

Table 3 Ideas for effective consensus-building

Project Stage	Ideas for effective consensus-building
Establishing the implementing organization	- A wide variety of local actors should be invited to the membership. - Some flexibility is also required, including being prepared to add new members according to the project’s progress.
Organizing meetings	- Meetings should be held regularly, but their frequency should be determined according to the project details, etc. - For large-scale projects, subcommittees should be organized to discuss individual measures to gather opinions from a wide range of actors. - Efforts should be made towards information-sharing by employing the internet and newsletters. - Members should share the understanding that the implementing organization is a forum for mutual cooperation.
Setting goals Implementing project Maintenance	- Conferences and committee meetings should be held at every stage of deliberation, and the opinions presented should be disclosed, reflected on decisions and coordinated. - Activities should be incorporated into the local community as an established social system, where role of each member is clearly defined so that members can be conscious of their participation in the project.
Environmental learning	- Project information should be outreached to local residents and schools, etc. - The project should be utilized as a venue for environmental learning at each stage, such as project implementation and monitoring. - Questions and opinions presented through environmental learning opportunities should be inputted into the project.
Monitoring	- The monitoring system should be designed to accommodate the participation of various actors. - The project should be evaluated based on analyses of an array of information.

Part 2

Technical Approach of Nature Restoration

1.Nature restoration procedures

The implementation of nature restoration projects involves excavation, land development, and planting, which are similar to the procedures of construction works and afforestation projects. However, a significant characteristic of nature restoration projects is that there is much uncertainty between the action and results.

Therefore, a nature restoration project must be based on an adaptive approach - several construction works are implemented with the aim of achieving the larger Overall Plan and the outcomes are reflected in the plan and design. The following procedures are called for:

i. Based on sufficient preliminary studies on the ecosystem, post-construction monitoring should be conducted. Findings should be flexibly dealt with, for example, providing it as feedback based on scientific evaluation.

ii. In order to avoid the uncertainties of the ecosystem, a project should be carefully promoted, from the standpoint of minimizing experimental-work-based verification and construction and lending nature a hand in the restoration process.

2. Overall Plan

(1) Deliberating on the Overall Plan

An Overall Plan determines the direction of a nature restoration project, such as its area coverage and goals, by studying the status quo of the target area and identifying the issues at hand. Therefore, the plan should comprehensively consider where and how the local ecosystem has become degraded, as well as the direction in which the project will take it, based on data on the local natural environment and social situation.

(2) Regional Overall Status Survey

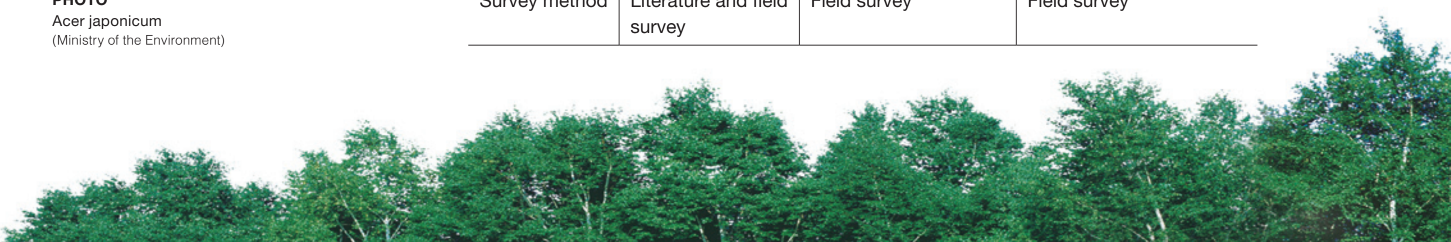
1) Scope of Regional Overall Status Survey

It is important that an Overall Plan embodies not only the target area but also areas and river basins that are mutually associated with the ecosystem.

Table 4 Purpose and accuracy of status surveys in each stage

	Overall status survey (Overall Plan)	Ecosystem status survey	
		General survey (Implementation Plan)	Detailed survey (Design)
Purpose	Regional perspective	Project site-level	Point-level
	Grasping regional environmental characteristics	Collecting data to formulate plan (hard & soft)	Collecting data to design project
	Selection of project site	Zoning plan	Preliminary design, implementation design
Survey boundaries	Potential locations for project site	Coverage required for project plan	Coverage required for project design
Degree of accuracy	1/50,000 -1/10,000 Scale	1/5,000 -1/1,000 Scale	1/500 -1/100 Scale
Survey method	Literature and field survey	Field survey	Field survey

PHOTO
Acer japonicum
(Ministry of the Environment)



For example, the Kushiro Wetland nature restoration project covers the Kushiro Wetlands and adjacent areas, and the entire Kushiro River Catchment as well. This is because the natural environment and land use around the Kushiro Wetland and in the Kushiro River Catchment are closely related to the wetland ecosystem.

2) Methodology of Regional Overall Status Surveys

In order to gain understanding of an ecosystem, both environmental and social characteristics of the area must be grasped. A 1:50,000 to 1:10,000 scale survey is conducted to capture ecosystem elements, such as geographical and geological features, fauna and flora, and the water environment to comprehensively identify how the local ecosystem interacts, how it has evolved and what has caused the changes (Table 4).

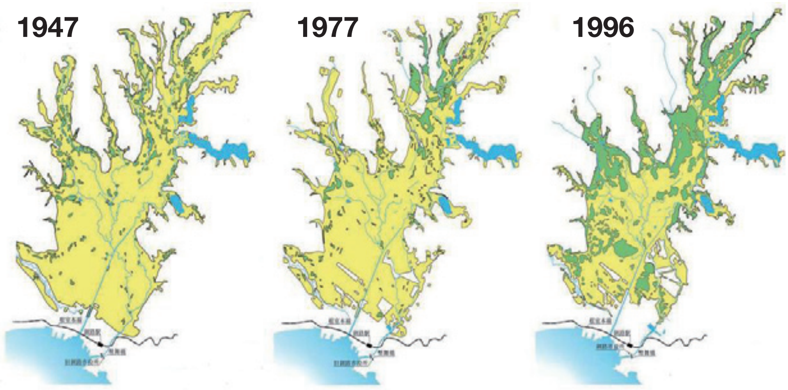
Therefore, not only current environmental characteristics but also historical conditions should be grasped and compiled to the fullest extent possible for better understanding.

3) Compiling a Regional Overall Survey

The outcomes of a regional survey should be comprehensively diagnosed and compiled into a database by employing systems such as Geographic Information Systems (GIS) so that they may be referred to when the Committee is launched or in consensus-building (Table 5). It is also important that the data be organized in a clear and simple manner so that it may be shared among actors. (Figure 4)

(3) Setting goals for an Overall Plan

Once the current status and challenges faced by the target region are identified, the general direction of the natural restoration project can be determined. Then, the target area of a



	1947	1977	1996
Alder forest	21.0	29.4	71.3
Reed community	224.8	195.9	123.0
Total wetland area	245.7	225.3	194.3

Alder forest
Reed community
Unit : km^2

Figure 4 Wetland area changes in Kushiro Wetland
(Source: Ministry of the Environment (2005) *Kushiro Wetland Nature Restoration Project*)

Table 5 Examples of data compilation

Environment type	Data categories	Examples of study methods	Examples of output compiled
Natural environment	Geographical and geological features, soil, hydrological phenomena, fauna and flora, ecosystem, landscape, etc.	Literature surveys Field surveys Aerial photo analysis Remote-sensing Interviews	Review of natural environment conservation issues Illustration of conservation challenges Natural history timeline Review of natural history and natural environmental characteristics Research history timeline Review of research history timeline Database of literature on abovementioned themes Geographical information maps on abovementioned themes -Distribution maps of rare animal and plant species -Habitat potential maps -Maps of existing flora -Other natural environmental assessment maps
Pollution	Water quality, atmosphere, noise, vibration, soil contamination	Literature surveys Field surveys Interviews	Review of living environment conservation issues Review of status and characteristics of living environment Database of literature Geographical information maps on abovementioned themes
Social environment	Development (public and private projects, etc.) Industry Policies and measures Public movement for environmental conservation	Literature surveys Interviews	Timeline of agricultural and industrial development history Review of development history Material on river improvements and road construction projects Timeline of industry, policies and measures Review of social characteristics Database of literature Geographical information maps on abovementioned themes -Public works location maps -Land use maps -Regulations maps

nature restoration project and its goals can be established. It is important that the goals of an Overall Plan provide a general image of how local people can live in harmony with nature instead of being partial to specific phenomena and figures.

3.Implementation Plan

(1) Contents of an Implementation Plan

An Implementation Plan identifies the project site for the nature restoration project, the project details, its relationship with the ecosystem of the surrounding area, the significance and effects of ecosystem conservation, and other items that need to be determined to implement the nature restoration project. When there are more than one project site, the Implementation Plan individually reveals the details for each site, in line with the Overall Plan.

(2) Important notes for Implementation Plan deliberations

1) Formulating the Plan from design to monitoring

The process of a nature restoration project begins with formulating the plan, and continues through the phases of project design, construction, and maintenance. These are series of actions which will be addressed in the Implementation Plan in a comprehensive and integrated manner. Furthermore, the Implementation Plan will be flexibly reviewed according to monitoring results derived during and after project implementation (adaptive management).

2) Deliberations based on Overall Plan

The most important essence of an Implementation Plan is that it lays out the details for a project based on the Overall Plan and provides an understanding of where the ecosystem recovery is headed for each individual project site. The direction of a project should not be misjudged as a result of being preoccupied with site-specific challenges.

3) Status survey and analysis

The outcome of the status survey (general survey) and analysis will determine the direction in which the project should be taken. A precise survey should be conducted to reveal which part of the ecosystem is deteriorating and what will happen if such trends continue. Then, the Implementation Plan should be proposed.

In the event that the direction of ecosystem recovery or the effectiveness of construction methods is uncertain, experimental work should be conducted and test results should be reflected in the Implementation Plan.

4) The perspective of “helping nature self-create”

An ecosystem develops as a result of spatial circumstances and in the passing of time. From the perspective that nature restoration projects “help nature self-create,” minimal construction works should be implemented.

5) Efforts to share the project image

It is difficult to explicitly and accurately explain the project goals. Therefore, a Design Description Document, conceptual figures and sketches should be used to effectively gain mutual understanding of the project goals and details.

6) Significance of process planning

Simultaneously implementing a series of construction works may invite unexpected results due to the inherent uncertainties of ecosystems. A process plan should be carefully structured, based on full consideration of the project site and the surrounding environment which collectively form the ecosystem, and also from the concept of adaptive management.

(3) Status survey for the Implementation Plan (general survey)

In order to gain understanding of the ecosystem of the project site, the environmental characteristics of the site and surrounding areas should be captured. A 1/5,000 to 1/1,000 survey is conducted to grasp ecosystem elements, such as geographical and geological features, fauna and flora, and the water environment, to identify current environmental characteristics.

The survey should be conducted from the following perspectives, which are focused on the project site’s ecosystem.

1) Seeking the causes for regional ecosystem degradation

In order to grasp the status of the project site, not only status surveys on fauna and flora and the ecosystem but also studies from both spatial and temporal viewpoints should be conducted to seek the historical background against which the ecosystem developed and the causes for its current degraded state.

The survey should broadly collect environmental information for a certain area that constitutes the project site’s ecosystem and identify the ecosystem’s internal factors, such as plant and animal species, food chain, the plant succession (time series), external factors (social environment) and changes in the atmosphere, water, soil and human influence.

2) The project site’s relationship in the regional ecosystem (ecological network)

A regional ecosystem is founded on the continuity and integrity of the habitat of living things (ecological network). Therefore, it is important that the project site’s ecological position is made clear and the widest possible area is secured. In the case of a small project area, in particular, the outcomes of the regional overall survey and the geographic characteristics and

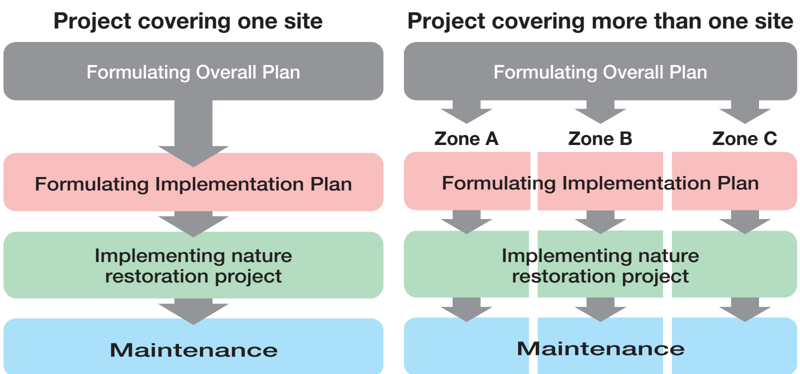
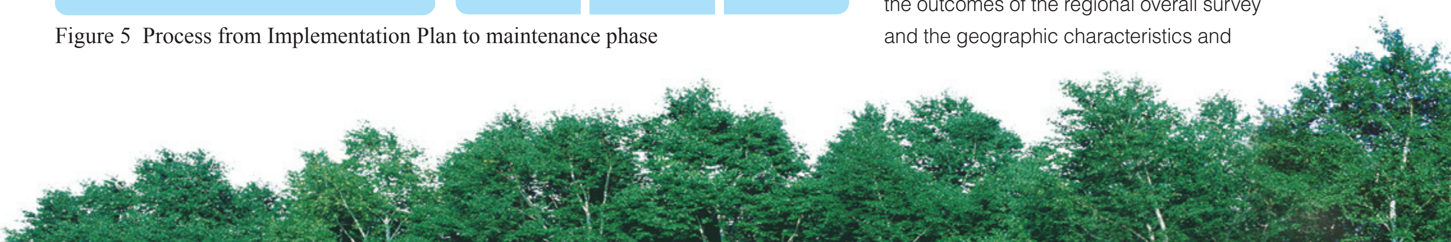


Figure 5 Process from Implementation Plan to maintenance phase



area should be taken into account – for example, the continuity and integrity with other areas should be secured –when deliberating on the direction of ecological restoration (Figure 6).

i. Large habitats (two-dimension space)

Large habitats are continuous and stable habitats for fauna and flora and allow the inhabitance of species requiring large-sized ranges.

Bearing the functions of providing temporary breeding and resting sites to animals, they take the form of stepping-stone habitats which connect elements and facilitate the passage of wild fauna and flora migrating between large-scale habitat spaces.

ii. Corridors (linear space)

Corridors mainly bear the role of ecologically connecting habitat spaces. Diamond's six principles should be referred to when determining the configuration of habitats (Figure 7).

3) Deliberating on temporal and spatial project goals and forecasting the restoration process

An ecosystem's development process and its time course are also important elements to consider. A mature ecosystem has developed over a long period of time; and therefore, humans cannot accelerate or slow down its evolution.

The goals and restoration process of a nature restoration project must always be considered from a long-term perspective (Figure 8).

(4)Experimental work (Test construction)

The experimental work phase of nature restoration projects refers to "surveys, measurements and tests required for construction." The purpose of experimental work is to verify the direction of the nature restoration project, confirm the appropriateness and effectiveness of the construction method, and check for and rediscover unpredictable impacts on the ecosystem (uncertainties).

The purpose of implementing experimental work and monitoring details should be clarified before deliberating the details of survey,

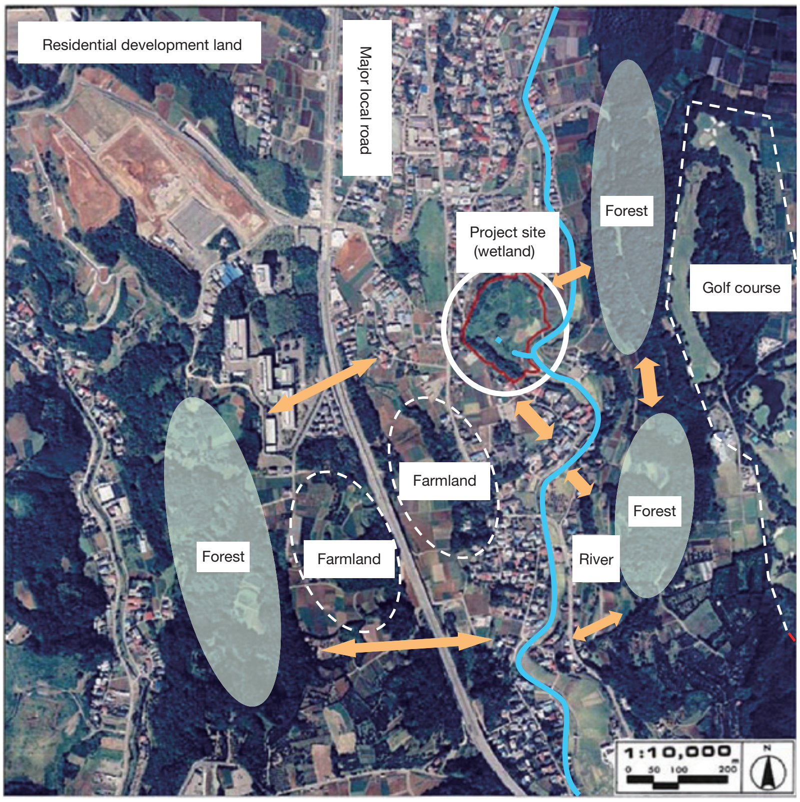


Figure 6 Case study of continuity and integrity of local biotopes(ecosystem network)
(Source: Asia Air Survey Co.,Ltd.)

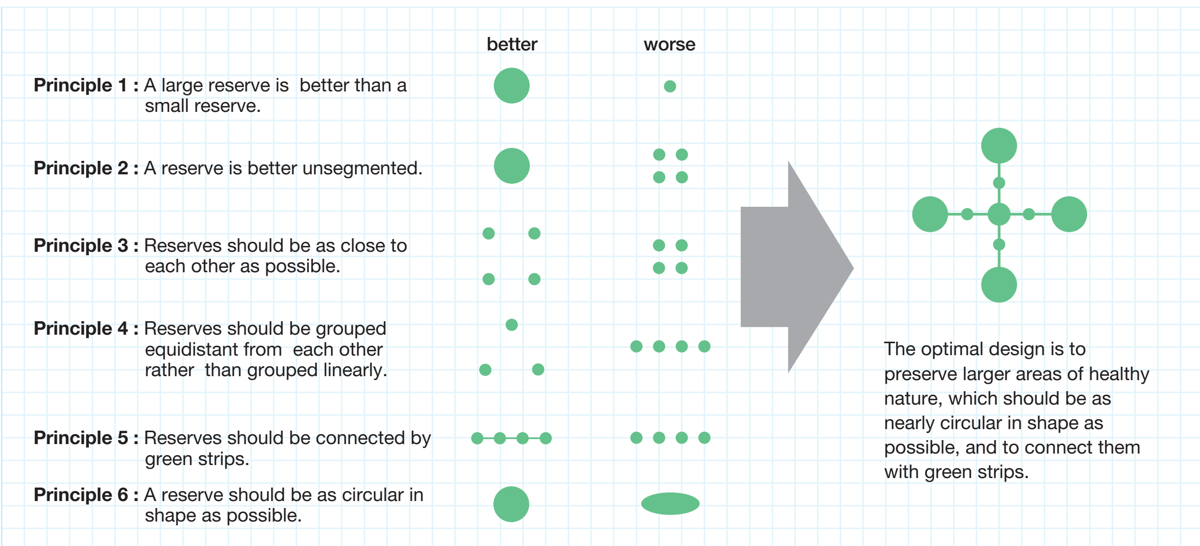


Figure 7 Diamond's six principles
(Source: Diamond JM (1975) The island dilemma: Lessons of modern biogeographic studies for the design of nature reserves. Biol. Conserv. 7 : 129-146)

design and construction according to procedure.

(5) Formulating the Implementation Plan

1) Setting project goals

Project goals should be set individually for each project site, based on the nature restoration goals and Overall Plan and taking into consideration the causes of ecosystem degradation that were revealed in the status survey.

A project goal should satisfy the following conditions:

-objective and detailed
-based on consideration for the acceptable range of variation
-based on consensus among stakeholders

2) Procedures for formulating the Implementation Plan

i. Identifying the overall picture of project

Based on the Overall Plan and project goals, the Implementation Plan identifies the full picture of the project.

ii. Zoning and implementation details

Based on the outcomes of the status survey (general survey), the Implementation Plan divides the project site into zones for conservation, restoration, creation and maintenance and identifies the implementation details for each zone.

iii. Identifying project contents

The contents of the project are determined based on the concept that the ecosystem of the project site should not be affected and that nature's ability to maintain and recover its natural environment should be allowed to take full control. Envisaging what kind of response can be expected (project goals) as a result of what kind of impact (construction) imposed upon the wildlife

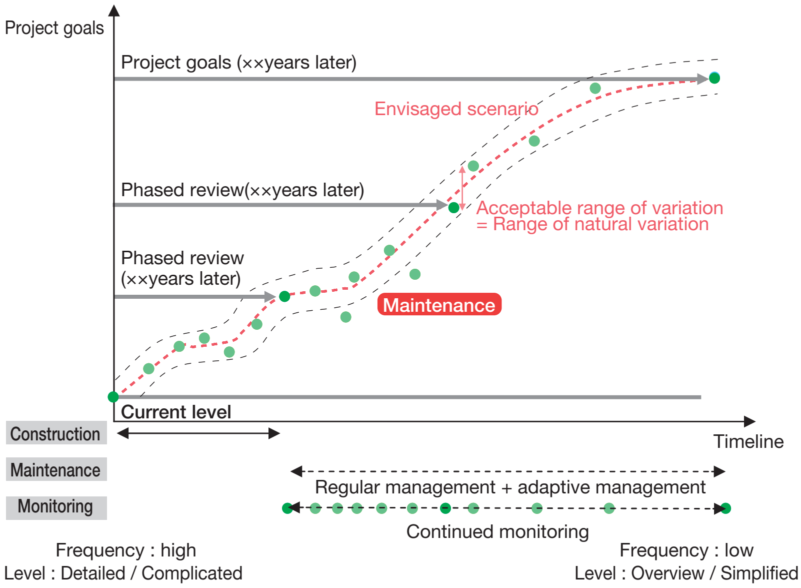


Figure 8 Project goals and procedures

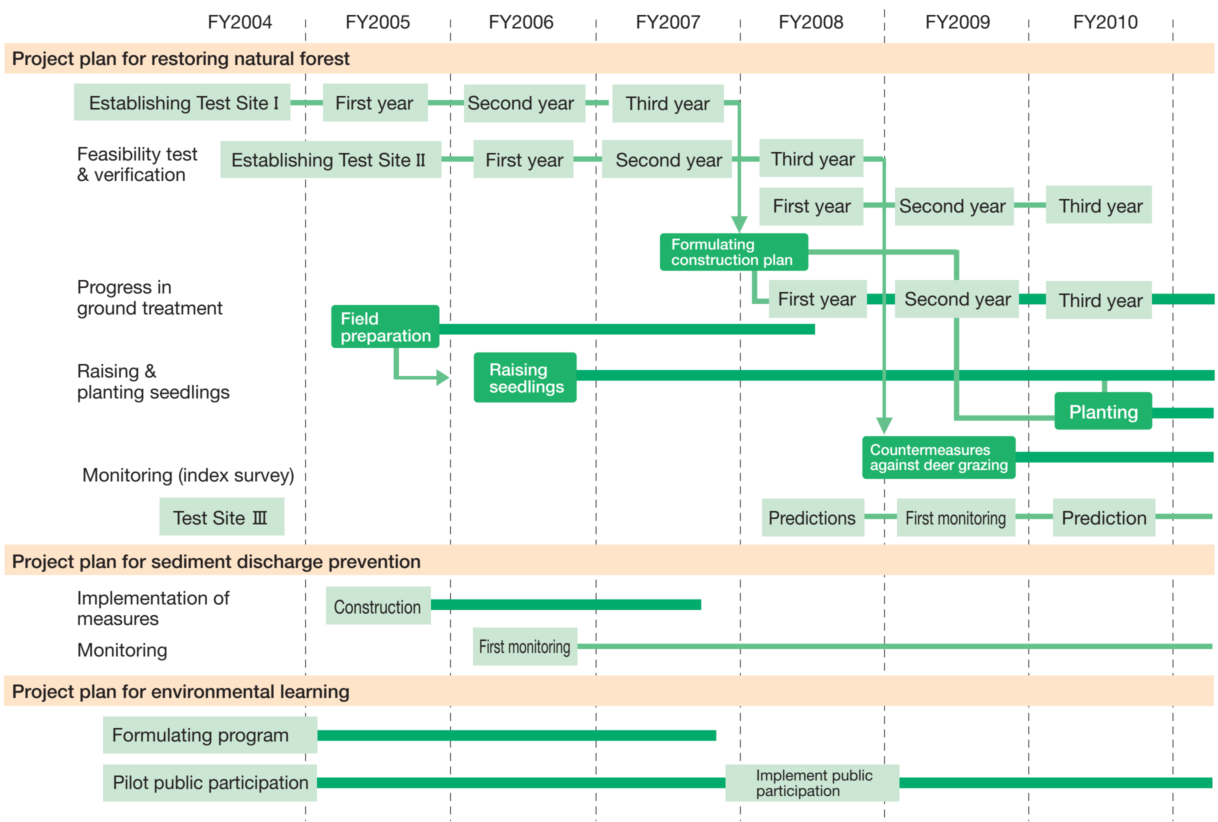


Figure 9 Pilot construction project in Takkobu Native Forest Restoration in Kushiro Wetland and Monitoring Plan
(Source: Ministry of the Environment (2005) *Kushiro Wetland Nature Restoration Project*)

habitat, the principles (overall concept) and the schedule of the entire project, from the Implementation Plan through design, construction, and maintenance, should be set out.

iv. Formulating an Implementation Plan Diagram

A diagram of the Implementation Plan is drawn out to illustrate the methodology, construction methods and major construction types that will be applied for goal attainment.

v. Deliberating on the construction plan

Based on the local climate and ecological characteristics of the project site, a construction plan covering timing, locations, methods and contents, etc. is discussed in detail.

vi. Deliberating on the maintenance plan and monitoring plan

Maintenance refers to the monitoring of the ecosystem in the project site and helping the project progress according to its plan. Based on the Implementation Plan, the monitoring site, monitoring items, methods, persons in charge, schedule, etc are discussed to draft a monitoring plan. Other issues to be discussed in advance include the establishment of a database to compile monitoring data and the evaluation method to be applied to monitoring results. A maintenance and monitoring framework should be established among actors.

vii. Working out the schedule and estimated project costs

In order to facilitate the implementation of a project, the overall schedule from Implementation Plan to maintenance should be organized, and the project costs should be estimated. This information should be shared among actors.

4.Design

(1) Working with the design

1) Basic concept

The design of a nature restoration project is determined through careful and detailed discussion on the methods to be applied, including the use of local natural material and human power (human-powered engineering).

i. Acknowledging that the project's aim is to restore the ecosystem and secure biodiversity, the design should be based on scientific expertise, such as records and data of similar cases.

ii. The design should be in line with the goals of the Overall Plan and Implementation Plan.

iii. The construction types and methods selected should reduce burden inflicted upon ecosystems.

iv. Post-construction maintenance should be included.

2) Status survey for design (detailed survey)

A detailed survey of the project site is conducted using a detailed survey map (1/1,000 – 1/500 – 1/100 scale) of the site and from the following perspectives:

i. Elements of the project site's ecosystem, such as special phenomena (microtopography, water systems and springs), as well as the distribution and status of the vegetation, endemic and rare animal and plant species should be captured in detail and organized into data, which are required in the project design. A detailed survey should also be conducted on human impacts, soil, hydrological changes, and the introduction of alien species, which contribute to the degradation of the ecosystem.

ii. Sites where structures will be constructed should be carefully surveyed in order to assure functions and durability.

iii. Surveys should be conducted on temporary construction roads and construction yards, etc to reduce any impact on the ecosystem. Possibilities of using facilities for post-construction monitoring and maintenance as environmental learning facilities should be sought.

iv. Surveys should be conducted on the timing and duration of construction, and the climate conditions (rain, snow, frost) of the project site in order to determine the construction method to be applied, the timing that plants and animals appear, breeding time, changes according to the of day, and changes in the water level according to season and climate.

3) Design process and important notes

Ecosystems being diversified, different restoration methods are applied to different project sites. Therefore, the design process is also varied among ecosystems. Furthermore, project design not only requires not only understanding of the local ecosystem but also of the current status and future forecasts of the project site's social environment - for example historical land use changes and presumed future changes. Once the design is complete, it is important to check its consistency with the site.

The design process can be divided into two stages, namely preliminary design and implementation design, the goals of which are provided below:

i. Preliminary design

The preliminary design involves organizing the preconditions and Implementation Plan, and thoroughly studying aerial photos, existing material, survey maps and the outcomes of the status survey. Field surveys are then conducted in order to gain understanding of the status quo. The preliminary design document will include organized information on the ecosystem to be conserved and restored, zoning and project principles in the context of conservation, restoration, creation and maintenance, the facilities required for restoration, the selection of construction types and methods, the timeline and spatial conditions in which the target ecosystem can be established, and the requirements for maintenance.

ii. Implementation design

The implementation design involves reviewing the given conditions in the preliminary design and drawing out a detailed design document based on the field survey, and survey data, etc. In order to obtain accurate information of the habitat distribution and status of important wildlife in the project site's ecosystem, the facility site along with construction types and methods should be determined based on field observations.

The design document should include sketches and figures as well as creative presentations of the design and detailed specifications.

(2) Preliminary design

1) Checking Overall Plan, project goals, Implementation Plan, status of

project site

i. Higher order plans, such as the Overall Plan and Implementation Plan should be checked and organized.

ii. Land use and environment conservation laws should be checked and organized.

iii. Based on the status survey, the habitats of important fauna and flora which compose the project site's ecosystem and other important notes in terms of preservation and conservation should be confirmed.

2) Checking the construction location and methods

i. Checking the construction location

A field survey is conducted based on the Implementation Plan document to check the location and details of the construction, and the construction types and methods.

ii. Selecting the construction method

The preliminary design should be focused on securing the region's fauna and flora's diverse habitats. It is important that construction types and methods required for the recovery of the ecosystem are determined.

The construction methods selected for a nature restoration project should be one that is the most appropriate for fostering habitats for fauna and flora, consistent with the characteristics of the project site and expected functions and based on comprehensive consideration of the scale, structure and materials. When selecting the structures required for nature restoration and the construction methods to build them, their functions and durability should be considered along with environmental soundness.

iii. Considering the construction methods to secure habitats of fauna and flora

a. Creating a biotope

"Biotope" is an English loanword derived from the German *biotop*, which in turn came from the Greek *bios* for organism and *topos* for place. It refers to an area with a certain amount of space in which living organisms can live and grow. The general idea is to protect and foster the nature that originally covered the area.

The purpose of creating a biotope is to make ponds and wetlands in open land, therefore conserving and creating space for various organisms that originally inhabited the region to live. The basic elements of a biotope, namely the local climate, water environment and soil environment, as well as fauna and flora and other elements that compose the local ecosystem should be considered in order to secure an environment in which a healthy ecosystem can be established and sustained.

b. Ecotones

An ecotone is a transition zone between two different ecosystems, such as a field of reed along a lake, a mangrove forest lining the seashore, brackish waters in the mouth of a river, mantle vegetation on the forest fringe, and borders between land and water (side pools, tidal flats, and macroalgae beds) or forest and grassland. Diverse fauna and flora live and grow in an ecotone, which is also an important breeding site. An ecotone should be designed to be of an appropriate scale and structure in line with its purpose and based on an understanding of the status of the location, the local animal and plant species, and their life history.

- Side pools

A side pool which is a back water area separated from the main channel, or riverside pool, is an important biotope, functioning as a spawning site for fish and a habitat for young fish that cannot swim. A side pool should be designed to create a healthy biotope, with consideration for how it connects with the main flow, and appropriate spur dikes, sediment accumulation, luxuriance of watergrass, and its basic environment, such as the water depth, water quality and bottom sediment.

- Tidal flats

A tidal flat is a flat stretch of sand or mud that occurs at low tide and is inhabited by various organisms due to its diverse environment. A tidal flat should be designed with consideration for not only the inter tidal zone in which they occur but also surrounding elements such as tide pools, creeks and reed colonies. The status of the site should be fully understood as the ebb and flow of tides can cause drastic geographic changes.

- Macroalgae beds

A rocky seagrass bed should be designed so that the bed is not homogenized, therefore maintaining a diverse macroalgae bed ecosystem where annual and perennate macroalgae can grow. In order to secure sunlight the water depth can be adjusted by raising the ocean floor. Tidal flume can be established and high waves can be controlled to adjust wave conditions. Beds can be shaped in a way that the invasion of other macroalgae seeds and seedlings can be prevented. Eelgrass beds on sandy-mud bottoms should be designed to control waves and secure sunlight by setting limits on the grain size of bottom sediments, water permeability, competing species such as shellfish that cover the ocean floor, and disturbances of the ocean floor by trawl fishing.

c. Fishways

Constructing fishways is a solution to the segmentation of rivers. A fishway should be designed based on the target fish species' behavior and life history. The selected structure type (pool-type, channel-type, lock fishway, etc) should match the river channel conditions and stream regime and be designed with consideration for its continuity with the river or channel, its location,

Side pools in Yodogawa river (Photo: Akira Kitayama, Kankyo Kagaku Co., Ltd.)

Tidal flat tillage (Photo: Tokyo Kyuei Co., Ltd.)

the location of its inlet and outlet, and whether or not priming water is needed.

d. Traditional construction methods

Many traditional construction methods are based on the local environment and natural material unique to the region, are highly adaptable and often contribute to the conservation of ecosystems and landscape.

Japan's rivers, *Satoyama* and farmland have been conserved using traditional construction methods, including gabion works, krippen groin, fascine mattresses, fascine hurdles, and managed through coppicing and raking. In the oceans, stone beds are placed and rock surfaces are cleared of weeds to create fishing spots and the ocean floor is tilled to improve the habitat for clams.

3) Procuring material

Natural materials unique to the region and native species should be considered for use, as well as waste material from the construction site. Procurability, marketability and economic efficiency should also be considered. Material procured from outside the region and artificial material should not be fully rejected, and may be selected with flexibility, according to the required functions or durability and other purposes of use.

Furthermore, when using artificial material with high biodegradability or biocompatibility, any impacts on the ecosystem should be checked for.

i. Using natural materials (wood, stone, thatch, fascine)

By using wood, stone, thatch, fascine and other natural material collected from the project site or surrounding areas, an ecosystem can be restored in a locally consistent manner.

It should be noted that natural materials are not uniformly shaped and are therefore not as strong or durable as artificial materials.

ii. Using native species (seed banks, transplanting, growing)

In order to prevent disturbing the ecosystem, native species should be used when plant materials are needed. Native species can be used in the following ways:

-Growing seeds and seedlings (Seeds or cuttings are collected on the project site and grown into seedlings and rooted cuttings in pots, etc.)

-Using seed banks

-Transplanting rare species and endemic species

-Transplanting tree stumps (Trees with

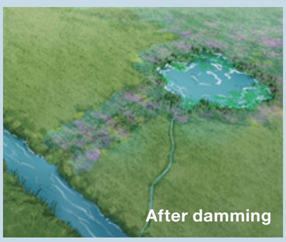
Nature restoration technologies in Sarobetsu Mire

Located in Hokkaido, the Sarobetsu Mire is one of Japan's largest raised bogs. It was formed in the downstream area of the Sarobetsu River over a period of 4,000 to 5,000 years. Once covering a vast area of 14,600ha stretching approximately 27 km in the north-south direction and about 8km in the east-west direction, the wetland area decreased drastically as a result of large development projects launched in the 1960s. The remaining wetland became desiccated with these land use changes in surrounding areas. The Sarobetsu Nature Restoration Project is being implemented by the Ministry of the Environment for its restoration. Various efforts are being made under the proejt, which seeks to restore the wetland vegetation to its state in 1974, when it was designated a national park.

A distinctive approach taken in Sarobetsu Mire is the conservation of wetland along the drainage canal. Beginning in fiscal 1961, a drainage canal was excavated in an important part of the Sarobetsu Mire to prevent floods in the Sarobetsu River. The removed soil was pumped out using a boat and then laid on the banks of the canal. Drainage ditches were also constructed to remove the moisture from the excavated soil. As a result, the groundwater flowed out to the drainage canal and caused desiccation, thereby changing the vegetation along the canal from raised bog vegetation dominantly covered with sphagnum and wild cranberry (*Vaccinium oxycoccus*), to *Moliniopsis japonica* community. Ochiai-numa Pond also dried up.

In order to prevent the deterioration of the remaining raised bog vegetation, efforts are being made to dam drainage ditches to prevent the lowering of groundwater table in surrounding areas. This has been highly effective in Ochiai-numa Pond, these operations will restore the water level and thereby reduce the lowering of groundwater in a wider area. There are high expectations that the raised bog vegetation will be maintained in surrounding areas and recovered in areas that have turned into *Moliniopsis japonica* community as a result of desiccation. The progress of wetland vegetation restoration is currently being monitored.

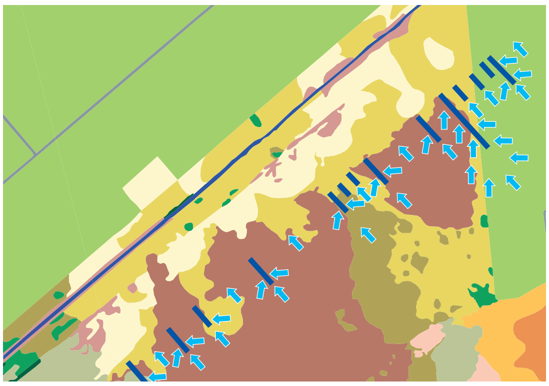
Image of projected effects of damming the drainage ditch



By damming the drainage ditch, the water level of Ochiai-numa Pond is recovered, thereby increasing the groundwater table of surrounding areas. *Moliniopsis japonica* community in the surrounding area will also come closer to raised bog vegetation.

Current status of groundwater flow

Desiccation is progressing due to the outflow of water to the drainage canal and ditches. Therefore raised bog vegetation changes into *Moliniopsis japonica* community.



Legend

- raised bogs vegetation (white beak sedge (Rhynchospora alba (L.) Vahl) -papillose sphagnum (*Sphagnum papillosum*) etc.)
- *Moliniopsis japonica* community
- Transitional mire (mixed community of dwarf bamboo) (*Sasa palmata* – *Moliniopsis japonica* community)
- Fen vegetation (reed (*Phragmites australis*)- *Calamagrostis langsdorffii*, etc.)
- Fen vegetation (mixed community of dwarf bamboo) (*Sasa palmata* – reed (*Phragmites australis*) community)
- Low-growing dwarf bamboo community
- High-growing dwarf bamboo community
- Sakhalin fir (*Abies sachalinensis*) community
- *Quercus crispula* Blume community
- Alder (*Alnus japonica*) community
- Willow community
- Drainage canal
- Pasture
- Drainage ditch
- Direction of groundwater outflow

Technical Approach of Nature Restoration

high reproductive capacity are cut near the ground and their roots are dug out for transplanting. Soon after transplanting, each stump sprouts 3 to 20 shoots.)
-Planting seeds (planting seeds collected on project site)
-Transplanting topsoil layer blocks (A method to restore vegetation by cutting out a block of topsoil, which includes plant seeds, small animals and microorganisms. Heavy equipment is used and the topsoil is set on the new site.)
-Collecting topsoil (Topsoil, which has been accumulated as a result of activities of plants, soil organisms and microorganisms, is collected and evenly laid out on the project site.
iii. Reusing on-site construction waste

Timber, rocks and other waste material generated in the course of construction are important local resources and should be reused on the project site as much as possible. When a large amount of construction waste is presumed, its use should be included in the design.
-Using cutted trees as wooden piles and earth retainer boards
-Using branches and twigs as a fascine fence. Other uses include making wooden chips for paving observatory paths or as mulch material.
-Using stones as garden rocks, masonry and recycled crushed stones

4) Minimizing changes to the natural environment

Methods to minimize changes made to the project site's natural environment should be deliberated by focusing not only on the scale, location and details of individual construction projects, but also on the scale of the entire construction work and the construction process, from a comprehensive perspective based on the project site's environmental capacity.

Topsoil layer block (Photo: Seibu Landscape Co., Ltd.)

Fascine fence (Photo: Seibu Landscape Co.,Ltd.)

(3) Implementation Design

1) Contents of an Implementation Design Document

An Implementation Design Document is formulated with due consideration of the elements of a project site's ecosystem, including the status of its environmental settings in detail –the local climate, geographic and geological features and water environment. Construction types and methods, materials, the scale and structure of the facility, and the structural resistance required of the facility are determined based on a thorough exploration of the details laid out in the Preliminary Design, including the basic principles for ecosystem restoration, zoning, scale

Nature restoration of wetland

1. The status of Kushiro Wetland and its challenges

Kushiro Wetland is a wetland located in the northern part of Japan, encompassing a national park and a Ramsar site. The largest wetland in Japan, it lost 20 percent of its area in the fifty years since 1947, due mainly to agricultural expansion, the straightening of the river, and logging in surrounding forests. Alder forests increased by 40 percent during the thirty years from 1947 through 1977 and 2.4 times in the following twenty years to 1996, drastically changing the local vegetation, especially that of the area where the river flows into the wetland. The Kushiro Wetland is a major habitat for the Japanese crane (*Grus japonensis*), a species protected as national natural treasure, and is also an important source of ecosystem services such as flood control and tourism resources. Therefore, its value is being reappreciated.

2. Taking the Kushiro approach in nature restoration efforts

Nature restoration in Kushiro Wetland is being implemented with the goal of simultaneously achieving the following three objectives: “conservation and restoration of the natural environment,” "compatibility of restoration and agriculture," and "contribution to the local society."

3. An introduction to major restoration projects

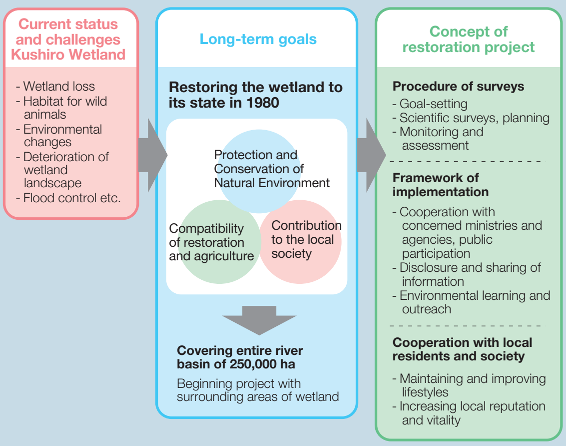
1) Restoring the wetland vegetation

A method of restoring wetland vegetation by removing the surface soil that had covered the wetland area for agricultural use is being tested to restore an environment suitable as a habitat for reed. New restoration methods consistent with agriculture will be sought in the future.

2) Restoring a meandering channel

Several parts of the Kushiro River and its tributaries have been artificially straightened. In the Kayanuma district along the Kushiro River, the river flow was redirected to the old meandering river channel. The restored section is now being used as new course for canoeing, contributing to making the region a more attractive destination.

Kushiro Approach in Nature Restoration



Sources

1. Extracts from Ministry of the Environment The Kushiro Approach in Nature Conservation: A Beginning in Kushiro, project pamphlet
2. www.kushiro.env.gr.jp/saisei/english/2_restoration/02kushiro/kushiro_01_e.html

of construction, the basic concept for construction types and methods, facility details, and the concept for post-construction maintenance. Design data, including structural calculations done to determine the construction type, should also be compiled into a Design Description Document.

2) Determining the construction type and method

i. Determining the construction method

Based on the Preliminary Design, a field survey is conducted to predict possible impacts on the ecosystem and determine whether or not the selected construction method is adequate in terms of minimizing impacts. Then decisions are made on the details of the construction method and construction process.

ii. Designing the construction type

The construction type is reviewed based on the Preliminary Design as well as the procurability of natural materials and field surveys. Ecosystem restoration should be prioritized when deciding on the construction type to apply, and therefore, it should be deliberated in terms of working efficiency, economic efficiency and maintenance in light of the characteristics of the project site's ecosystem, etc. When a structure requires a certain degree of structural resistance or durability, the structural calculations and historical data should also be reviewed.

iii. Determining the materials

Natural material and native species should be employed, and locally generated construction waste should be reused. Procurability, marketability and economic efficiency should also be considered.

3) Temporary construction design

Temporary construction works, such as temporary roads and stock yards, may largely impact the project site's ecosystem. Therefore, construction outside the project site should be prioritized. In the event that the construction of temporary facilities on site is inevitable, efforts should be made to minimize the construction scale and to apply better construction methods in order to reduce the impacts. Post-construction monitoring should be sought for temporary roads, along with ways to utilize them in environmental learning.

4) Timing and period of construction

The appropriate timing and period of construction should be determined in light of the target fauna and flora's growth. It should be noted that construction methods, temporary construction works and procurement of material may be more complicated in some areas due to climate condition differences.

5.Construction

(1) Basic Concept

Keeping in mind that an ecosystem is accompanied by uncertainties, a project must be prepared to quickly and properly address climate circumstances and changes in the situation on-site. It is important that the builder especially fully understands the project goals and design intentions, and proceeds in conjunction with the responsible organization.

The concept of the construction method is as abovementioned in the "Design" section.

(2) Construction Plan

The construction plan is compiled based on a field survey. The plan should include a lucid description of the construction details, construction procedures, implementation process, material procurement, equipment plan, temporary construction plan, management standards, etc.

1)Project goals

Perception gaps regarding project goals are the primary reason for misdirected construction, and therefore, goals should be fully understood through meetings with the responsible organization, order documents, and field surveys.

2)Design details

The location and scale are often adjusted on-site. When the location is difficult to find, when perceptions on construction methods and details differ on-site, or when more efficient construction methods can be applied, deliberations should be held with the responsible organization, etc.

3)Process Plan

The process plan is formulated with due consideration of the climate, changes in the vegetation, when plants germinate or enter a period of dormancy of plants, when animals breed or migrate, etc.

4)Material procurement

Based on the specifications presented in the design document, the contractor should make an effort to procure better material. Natural material, in particular, should be sought for as close to the project site as possible. Materials should be checked for preservative agents and other possible impacts on the ecosystem.

5) Temporary construction plan

Temporary construction roads which are used to provide equipment and materials, construction yards and temporary stock yards for material are often new causes of ecosystem degradation and should be built in locations that will not impose burdens on the ecosystem. Temporary construction roads must be creatively designed so that it overlaps the flow of management practices, such as monitoring.

(3) Preliminary construction

1) Conserving topsoil

The topsoil is a valuable resource, which is rich in buried seeds, roots and stems, insect eggs and larvae, microorganisms, fungi, etc and should proactively be conserved and reused. On the other hand, the introduction of soil from other areas can disturb the ecosystem and should be avoided.

2) Conserving and transplanting fauna and flora

Animal and plant species which are not specified in the Design Document should generally be conserved, but may be transplanted depending on the circumstances.

(4) Construction management

It is often difficult to gather accurate data in wetlands, oceans and lakes because field surveys are limited at the planning or design stage. Therefore, adjustments must be made at the construction stage by checking the project site and thoroughly understanding the blueprint. Both the responsible organization and the contractor should be prepared to conduct careful scrutiny of the site and need for changes in design.

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6.Maintenance

(1) Implementing maintenance and monitoring

1) Tool for adaptive management

Maintenance in nature restoration projects is not simply “management” but “adaptive management,” which includes monitoring.

A nature restoration project is not complete at the end of construction works are finished, but is enhanced and revised in the maintenance phase. Monitoring involves not only collection of data but also bears the role of employing indices for verification and assessment, maintenance and reviewing the effectiveness of a project, and reflecting findings in later reviews. Monitoring and maintenance are inextricably linked.

Furthermore, maintenance is founded on the concept of “passive restoration” and seeks to help nature self-create. For example, in *Satoyama* restoration, maintenance includes the management activities conducted to maintain its state over the long term. In restoring secondary nature -such as *Satoyama* and grasslands - which rely on management activities, it will be important to discuss social structures and tools to continue such activities.

2) Items to be noted

The following points should be noted upon implementation:

i. Checking the project’s effectiveness based on monitoring results and reflecting outcomes on maintenance activities

The purpose of monitoring is to check the effectiveness of the project. An ecosystem encompasses uncertainties; and therefore, outcomes should be analyzed based on the concept that a certain degree of change or disturbance is a necessary phenomenon in an ecosystem’s structure. This should be incorporated into the maintenance plan.

ii. Managing feedback

The structure of feedback and its uses, including employing monitoring results in future management, should be determined in Implementation Plan deliberations.

iii. Risk management

Ecosystem restoration entails unexpected changes; and therefore project actors must be ready to conduct emergency protection, rehabilitation and explanation.

iv. Consensus-building and organizing a implementation system

It is important that local residents and NPOs work together to engage in monitoring provide feedback and conduct maintenance practices. Therefore, an implementation system should be organized based on consensus among concerned actors.

v. Dealing with alien species

Unexpected events such as invasions by alien species should be immediately addressed. Alien species can disturb an ecosystem that is evolving towards goals and invasive alien species require special caution. Some examples include the germination of buried seeds in topsoil, the introduction of biological material, seed dispersion from nearby communities. Although such events cannot be completely prevented, alien species should be thoroughly exterminated by pulling them out or capturing them.

(2) Cooperation for maintenance and monitoring

1) Fostering a cooperation framework

It should be noted that maintenance and monitoring requires the diligent work of human hands and a long-term perspective that matches nature’s evolutionary cycle. Therefore, it is important that the cooperation of concerned NPOs and volunteers are sought to establish a locally rooted framework that will last in the long-term.

Furthermore, maintenance should be conducted in light of scientific verifications of the outcomes; and therefore, expert cooperation must also be sought.

2) Framework for scientific verification

Projects must be promoted based on scientific expertise and led by local initiative. Therefore, experts, including academics and researchers play a significant role and must join hands to form a comprehensive team of specialists representing both the natural sciences, such as ecosystems, plants, animals, geography and geology, and the social sciences.

On the other hand, when a team is diversified and complex, disparities occur among different perceptions and knowledge levels; and therefore, the respective role and expected output of each member should be made explicit. It is also important that assessment results be deliberated from various viewpoints. Hence, leadership is also significant.

3) Disclosure and sharing of monitoring results, consensus-building

In order to build consensus among stakeholders, monitoring and maintenance must be deliberated and discussed on a timely basis based on the confirmation and sharing of information and photos on maps, etc.

Even with common goals, actors have different interests regarding a project. Therefore, it is important that stakeholders make efforts to discuss the appropriateness of the project by constantly sharing information and seeking consensus on monitoring and maintenance procedures.

(3) Drafting a monitoring plan and maintenance plan

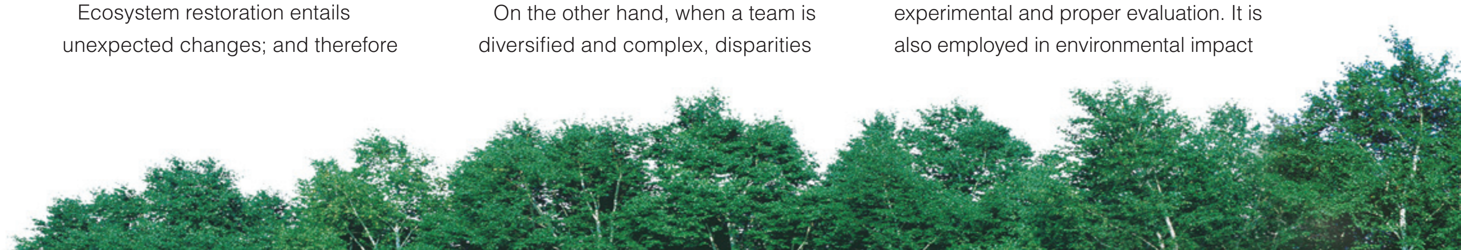
1) Important notes

Monitoring items cover a diversity of fields, including biology and physics. Therefore, in order to incorporate monitoring results into maintenance, it is important that specific indices related to the nature restoration goals be set so that success and progress can be clearly indicated objectively.

Specific indices related to nature restoration goals should be selected in light of local features which are revealed in survey results and the Implementation Plan, the ecosystem recovery and restoration process and construction details. The density, period and method of monitoring are also determined.

2) Monitoring design

When a nature restoration project is evaluated through monitoring, the survey design is important. Many nature restoration projects that have been implemented worldwide have been assessed through observation. A sampling design that can properly and experimentally evaluate correlation is required. The Before-After-Control-Impact (BACI) design is known to be a method which is capable of experimental and proper evaluation. It is also employed in environmental impact



assessment. The design attempts to scientifically evaluate the impacts of a nature restoration project using temporal variation (preliminary surveys (="before") and follow-up surveys (="after")) and spatial variation (control site (="control") and treatment (restoration) site (="impact")).In order to detect statistical discrepancies, replication at both temporal and spatial scales is recommended, but the larger the nature restoration project, the more impossible it is to set spatial replicates. Therefore, sampling from one each of treatment and control sites on multiple occasions both before and after restoration (Figure 11).

The BACI design does not incorporate project goals. Setting a reference is highly important in nature restoration and the progress made towards project goals should be assessed in the monitoring process. Therefore, it is better to formulate a monitoring plan using the Before-After-Reference-Control-Impact (BARCI) design, which incorporates a reference case. This allows the scientific verification of whether the ecosystem has recovered as a result of the nature restoration project (upward change exhibited in Figure 10) and of the extent to which the project has progressed towards its goals (approximation to goals).

1) Monitoring period and frequency

The time required to attain project goals varies according to project scale and organisms. Whereas the restoration of small individual wetlands require only a few years, the restoration of an entire floodplain takes tens of years. In the Kissimmee River restoration project implemented in Florida State in

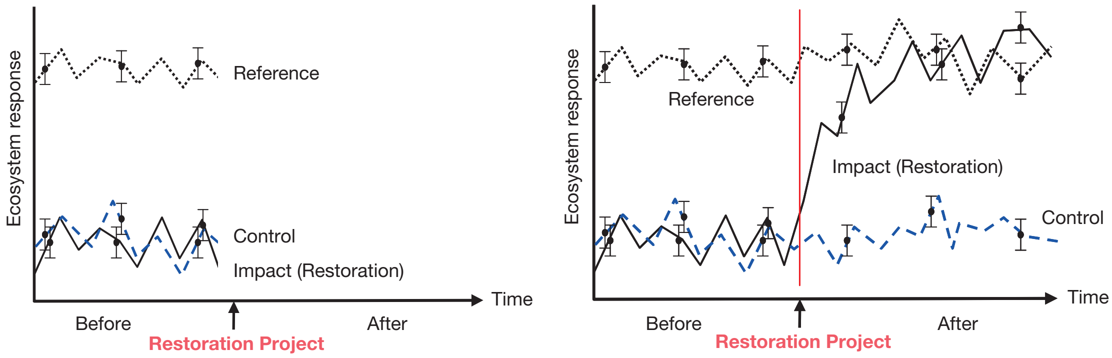


Figure 10 Evaluation of project using BARCI design
(Source: Futoshi Nakamura (2005) "Promotion and social evaluation of nature restoration projects based on an adaptive approach")

Vegetation recovery after surface excavation in a test area

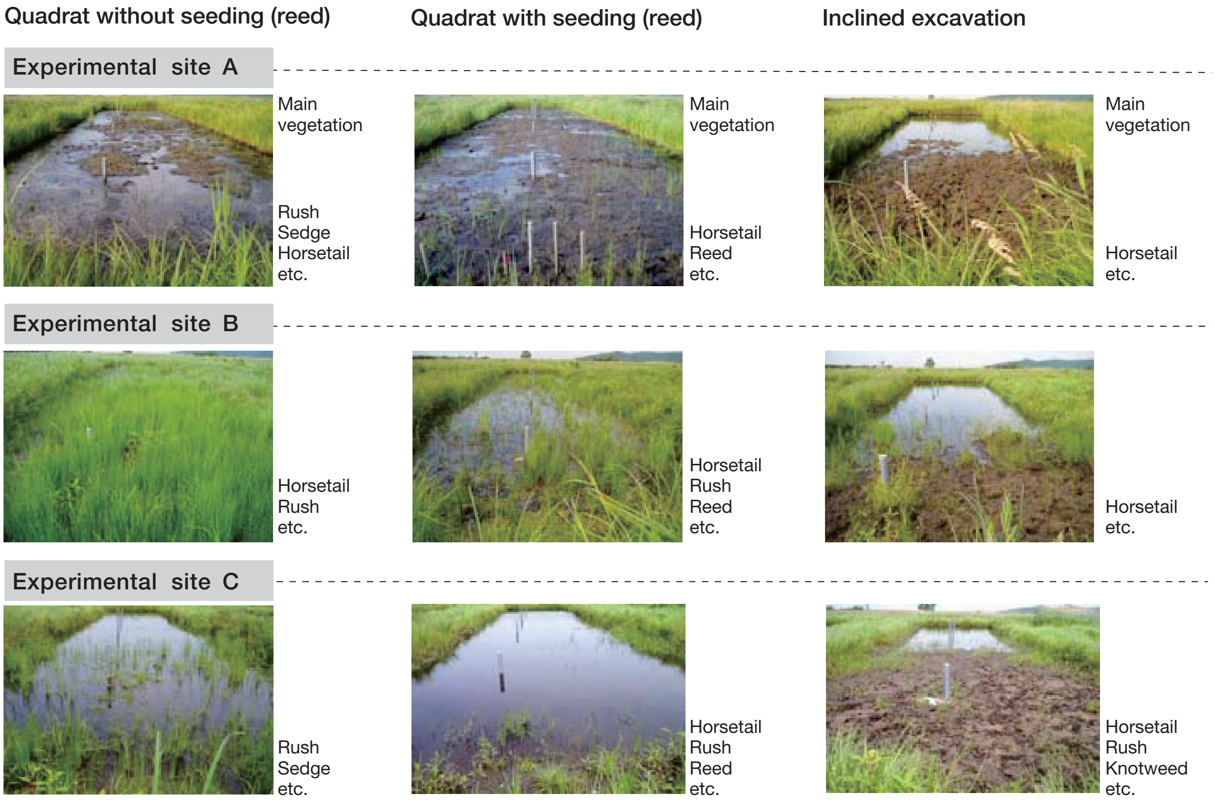


Figure 11 Monitoring survey on experimental work in the Hirosato area of Kushiro Wetland
(Source: Ministry of the Environment (2007) *Kushiro Wetland Nature Restoration Project*)

Technical Approach of Nature Restoration

the United States from 1997, forecasts hold that hydrophytes will be restored in only three to eight years, whereas it will take ten to twelve years for aquatic insects, and twelve to twenty years for fish to return. This should be given due consideration when determining the monitoring period. As aforementioned in Part 2 Section 3(3)3), spatial and temporal perspectives, including the formulation process and evolution of an ecosystem, are important.

The frequency of monitoring also differs depending on the target organism or physical environment. Significant changes are generally likely to occur once the construction is finished; and therefore, monitoring should be implemented frequently during the period directly after construction and at wider intervals as time passes by.

2) Monitoring items

Monitoring items can be categorized into biological and physical items. Many nature restoration projects are primarily focused on setting the physical environment; and therefore it is important to verify whether the physical environment has been changing as originally envisioned. Therefore, physical environmental elements that are important to the biota must be included in the monitoring item. It is important that species representative of the target ecosystem be selected in monitoring biota, but entire biotic community structures which are associated with the ecosystem process must also be looked into as a monitoring item.

If the physical environment cannot be rehabilitated, or if the target biota cannot be restored, monitoring items should be deliberated for project reviews to identify the reasons for gap between target and actual condition from the view point of adaptive management.

Comprehensive ecosystem management based on species interaction in the Ogasawara Islands

Threats by introduced species are the largest challenge faced in terms of nature conservation in the Ogasawara Islands, which was designated a World Natural Heritage site in June 2011. Actors have proactively engaged in efforts to exterminate alien species, but new issues have also come to light as efforts proceed.

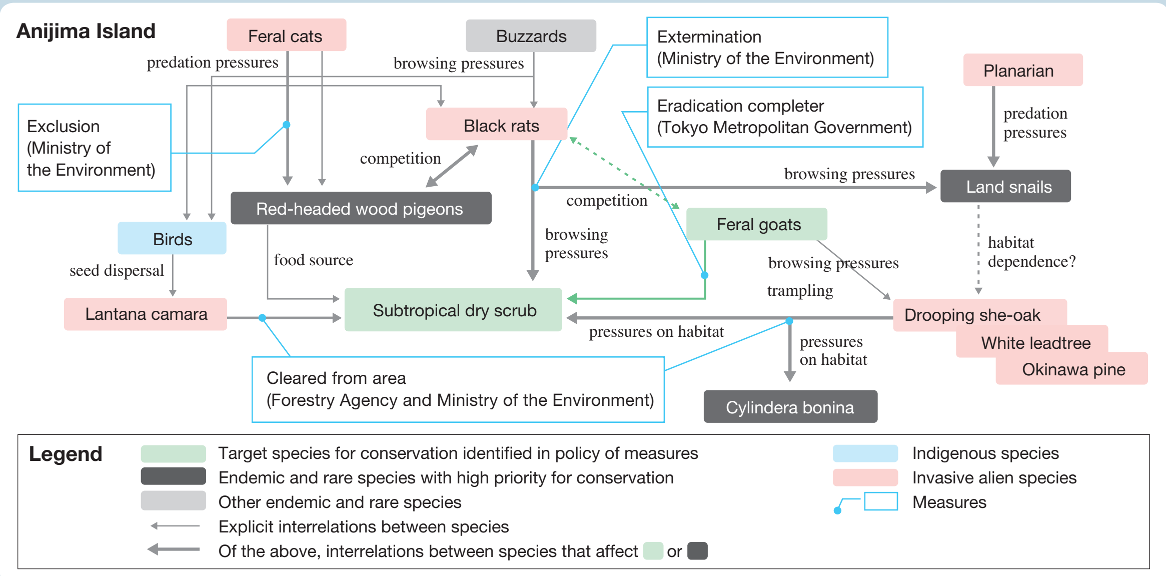
For example, having successfully eradicated feral goats, the island has enjoyed the restoration of endemic species that had drastically decreased in number. However, alien species such as the white leadtree are on the rapid increase and have aroused fears of competition with indigenous species. The extermination of one alien species can expose indigenous species to new dangers caused by invasions by other alien species and sudden environmental changes.

In order to address such issues, it is important to adopt an adaptive approach in implementing measures by understanding the significance of exterminating alien species in the context of the entire ecosystem, predicting its direct and indirect impacts, and monitoring progress. Every ecological interaction between species should be drawn into a diagram to make efficient predictions.

The Ogasawara Islands comprise many islands and the urgency of exterminating alien species vary significantly among the islands, depending on the characteristics of their respective ecosystems and their history and current status of human activities. Therefore, in the Ecosystem Conservation Action Plan, which was formulated upon the islands' nomination as a World Heritage site, individual goals and measures were determined for each island. The plan also included island-specific diagrams drawing out the ecological relationships between species, and laid out the progress made in exterminating alien species and conserving endemic species along with short-term goals. In the Ogasawara Islands, ecosystem management, including the extermination of alien species, is being conducted strategically by island, based on predictions and assessments in line with the Action Plan.

This strategic ecosystem management approach, the Ogasawara method, was highly evaluated in the judging process prior to the islands' registration as a World Natural Heritage site. The islands will strategically and adaptively continue their ecosystem management efforts through reviews of the Action Plan based on further case studies and accumulation of expertise.

Policy of measures	Measures	Progress (-end of FY2009)	Short-term goals (-end of FY2012)
Conservation Subtropical dry scrub	Extermination of feral goats	Eradication completed	—
	Extermination of black rats	Extermination initiated	Eradication completed
	Extermination of drooping she-oaks	Area exclusion completed, expanded	Completely cleared from area, expansion of area
	Extermination of white leadtrees	Exclusion method established Status survey initiated	Completely cleared from area
	...	...	...



Technical Approach of Nature Restoration

Part 3

Evaluation of Nature Restoration Projects

1. Project efficiency and evaluation

(1) What is project evaluation?

Project evaluation is the multi-dimensional evaluation of how a nature restoration project has developed towards its goals and what effects it has had. A project must be evaluated from biological, social and economic dimensions and also from the viewpoint of how to integrate its ecological health, social health and economic health. Therefore, multidisciplinary perspectives are called for (Figure 12). However, because the three fields are closely interrelated, projects should be comprehensively evaluated by mutually checking how the project is evaluated from each perspective.

(2) When should project evaluation be implemented?

A nature restoration project follows the same procedures as those taken when drawing up the Plan, which involve evaluating the plan for goal attainment from diverse perspectives, selecting and implementing measures, verifying the results and setting goals for the next stage (c.f. Figures 2 & 8). Project evaluation refers to the "verification" and "assessment" phases of the project cycle.

In the early phases of a nature restoration project, an Overall Plan is formulated, followed by deliberations among actors to gradually develop a more detailed plan. This process is based on an adaptive approach. The project is evaluated as necessary, its problems are identified and analyzed through comparing its progress against its goals, and the construction work is reviewed accordingly. Depending on the outcome of the assessment, not only the construction works but also the design, Implementation Plan and even the natural restoration goals provided in the Overall Plan may have to be reconsidered.

Therefore, there is no given timing of project evaluation that can be uniformly applied to all projects. However, the project evaluation process being an essential phase of a nature restoration project, the Implementation Plan and monitoring plan should provide a schedule of what should be reviewed to what extent (back to which phase) at which point.

(3) Who conducts the evaluations and reviews?

A nature restoration project should be evaluated employing a method that the responsible organization and Committee members can all agree on. The responsible organization is required to disclose the evaluation process and results, and to establish a system which gives all actors access to such information. Reviews must be conducted based on consensus among Committee members. The plans should not only include a schedule for evaluation and review but also preliminary decisions on who will conduct the evaluation and review and on which method will be employed.

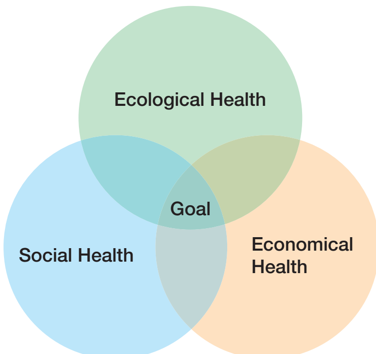


Figure 12 Evaluation of project using BARCI design

(Source: Futoshi Nakamura (2005) "Promotion and social evaluation of nature restoration projects based on an adaptive approach")

PHOTO
Daisetsuzan National Park, Japan
(Ministry of the Environment)

2.Evaluating biological health

(1) Perspective of evaluation

Projects should be evaluated from the following biologic perspective.

i Structure of ecosystem is composed with temporal and spatial scale of the ecosystem, hierarchical structure of biological community, and dynamic mutual relation ship between biotic and abiotic elements.

ii Function of ecosystem means the role of each element in the ecosystem.

An ecosystem is composed of close interrelationships between the physical environment, including the atmosphere, water, soil, etc., and community elements, such as animals, plants and microorganisms. Communities comprise species that create balance through various interrelationships, such as the food chain, habitat segregation, and competition within or between species.

A project's effectiveness is evaluated by employing the appropriate methods matching the ecosystem's structure and functions, with consideration for the biological hierarchy (populations, communities, ecosystems) in the target temporal and spatial scale. The concept of the Ecological Unit[1] should be helpful in understanding the structure and functions of an ecosystem in light of various spatial scales and biological hierarchy.

(2) Contents of Evaluation

i. Essential structure and functions of an ecosystem

Project evaluation seeks to check a project's consistency with its goals, but should not be confined to a comparison of figures. Evaluations should also consider interactions within an ecosystem. For example, to "restore" an ecosystem means to return it exactly to its past state, whereas to "rehabilitate" an ecosystem is to improve it so that it returns to the good condition it was in before, although its structure and functions cannot be restored to the very state they were in in the past. Therefore, it is important to determine whether the "rehabilitation" of a certain structure or function is directed towards "restoration". This is why evaluating progress against structure or function-specific quantitative "targets" does not provide the complete picture. Goals must be set with consideration of the acceptable range of variation (range of natural variation). Furthermore, even when monitoring results indicate consistency with targets, judgment must be made whether it was a necessary consequence of the restoration project or whether it was coincidental; and therefore, a statistical method must be employed to the extent possible.

ii. Trade-off between living species

Sometimes ecologically valuable native species may reduce in number or disappear as a project progresses. Acknowledging that such trade-offs can occur in a project, information on the status of the ecosystem prior to the project should be compiled and evaluated.

(3) Requirements in evaluation methods

A project is evaluated in its middle and final stages. The evaluation method should be presented and thoroughly understood when the project goals are determined.

In the ecosystem evaluation of a natural restoration project, it is important that the most appropriate method is selected by setting the temporal and spatial scale, and deliberating on defining indices in line with project goals and local characteristics.

Major methods that are used in quantitative evaluation of the ecosystem in Japan are introduced in Table 6.

Evaluation of Nature Restoration Projects

A Coastal mangrove vegetation saved people suffering from cyclone in Myanmar

On May 2 2008, Cyclone "NARGIS" struck Ayewaywady Delta, Myanmar. At that time, "Integrated Mangrove Rehabilitation and Management Project through Community Participation in the Ayeyawady Delta", supported by Japan International Cooperation Agency (JICA), was on-going in the delta.

Location map

JICA and Myanmar government conducted a rapid damage survey as a work to determine damages of the project area in June 2008. According to the field survey, many houses and basic infrastructures were completely destroyed in and around the course of the cyclone. Mangrove vegetation was also damaged and deteriorated.


Damaged village and mangrove vegetation in the delta

Through interviewing survivors of the project area, many villagers mentioned that they were saved by hanging or grabbing mangrove trees. Based on such experience, quite a few villagers started to realize importance of mangroves for disaster prevention and keen needs toward riverbank/coastal plantation for reducing serious threats by natural disasters. Actually, causalities were less in villages surrounded by mangrove vegetation based on preliminary analysis of mangrove function in the survey.


Damage distribution map in the delta

Based on findings of the survey, JICA has supported local communities in the area to increase awareness of function of mangrove vegetation for future generation. Through implementation of project activities, applicable procedure of community based mangrove management and practical silviculture techniques with land condition assessment have been discussed with local communities and the governmental staff to proceed long-term management of mangrove vegetation in the delta.


Mangrove nursery and meeting with local community in the delta

[1] An Ecological Unit is a unit that explains 1) potential biological colonies, 2) soil, 3) hydrological functions, 4) geographical and topographical features, 5) petrology, 6) climate, 7) atmospheric quality, and 8) natural cycle process of biomass and nutrient salts through the detection and categorization of similar patterns at various spatial scales.

3.Evaluating social health

The effectiveness of a nature restoration project must be judged from the viewpoint of “evaluation by the local residents” and “phased evaluation based on the satisfaction of actors”.

(1) Evaluation by local residents

i. Perspectives of evaluation

Local residents should evaluate a project’s significance and its contribution to the local community. This perspective seeks to explain the social benefits that can be obtained from the project in addition to the environmental and economic benefits, so that the project itself may gain approval from local residents. The projects’ effectiveness and losses and the significance of its presence are mainly evaluated.

In addition to the residents’ evaluation of the project itself, it contribution in improving the local community, direct interests in relation to the project and its ramifications must also be identified by referring to case studies.

ii. Evaluating a nature restoration project

The goals and necessity of the nature restoration project itself should be appropriately evaluated. It is important that symbolic goals (representative species and sites) in each project area are socially acknowledged for the project to be recognized not only locally but nationwide.

iii. Evaluating a project’s contribution to improving the quality of the local community

a. Evaluating a project from a social benefits perspective

Benefit incidence analysis (a method in which project effects are identified and listed along with their respective benefit incidence, or availability of benefits, in order to exhaustively grasp both positive and negative benefits) should be explored to determine what benefits a nature restoration project generates for society. Although it is difficult to forecast where the project effects will appear prior to implementation, as is the case with ecological assessment, predictive methods based on socioeconomics are available.

b. Evaluating a project using social indices

Indices and calculation tools to measure project effectiveness are provided in Figure 13. When employing social indices in project assessment, a combination of different indices should be deliberated. Indices should be combined based on the value of what an index represents (for example, how much a project has contributed to social satisfaction) and determined through discussion among a wide array of actors, as required.

c. Proposal of an evaluation method employing social indices

The social backgrounds of nature restoration projects are diversified by region; and therefore, no one set of social indices will match all projects. A combination of evaluation items, indices, and calculation methods based on social indices are proposed for a hypothetical conservation and restoration project in a *Satoyama* thicket close to a city in Table 7.

4.Evaluating economic health

Various ecosystem services are generated by rehabilitating the ecosystem through nature restoration. Many ecosystem services, such as produce and employment, are directly linked with economics benefits. The existence of an ecosystem has also been widely considered to have economic value. Under the Japanese government’s project evaluation program, methods including CVM and TCM are employed to estimate the economic value of ecosystems generated by nature restoration projects. These estimates are used in B/C analysis.

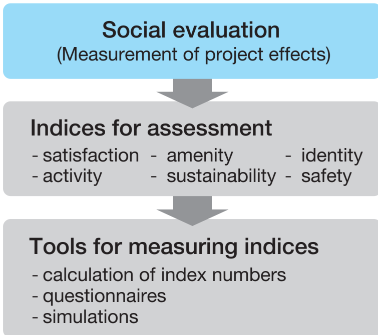


Figure 13 Evaluation method employing social indices

Table 6 Major quantitative evaluation methods for ecosystems

Name	Contents	Notes
Degree of Vegetation Naturalness	Based on the concept that nature exists in various levels, according to the degree of human influence, from those wholly in their natural state to those with a low level of naturalness An index indicating the degree of naturalness remaining on the land Plant communities are evaluated on a scale of 5 -10 according to their degree of discrepancy from natural vegetation.	Status evaluation
Index of Biodiversity	Biologically, ecosystems with more biodiversity are more stable. A method devised to conveniently express comparisons of biodiversity among different regions using a one-dimensional criterion which allows a simple comparison of magnitude.	Status evaluation
Target Species	Assesses an ecosystem representative of a region by selecting target species generally from the high order consumers, typical species and unique-environment-dependent species Keystone and umbrella species are sometimes selected to focus on the mutual relationship among species in a food chain.	Status evaluation
	Important species from an academic or scarcity perspective are selected as target species to evaluate the ecosystem. Target species are sometimes chosen based on familiarity, regional representativeness, or biological significance.	
	Symbol species that will attract the attention of local people and actors to evaluate the ecosystem. Some methods select biological indicator species which are believed to represent a species group that inhabits similar habitats or demands similar environmental conditions	

Evaluation of Nature Restoration Projects

Evaluation of Nature Restoration Projects

Name	Contents	Notes
Biological Water Quality Index	Conducts water quality evaluation using benthic animals and applying biological indices from the dominant species method and Beck-Tsuda method (Tsuda, 1960) and Buck's pollution index	Status evaluation
BEST: Biological Evaluation Standardized Technique	The population density and food consumption of several species are non-dimensionalized. An area's biological value is represented by the sum. Mainly applied in compensation measures in ocean areas. An evaluation area and reference area are chosen and comparative assessments are conducted between the areas.	Status evaluation
HEP: Habitat Evaluation Procedure	Conducts assessments by multiplying HU by the number of years. HU is calculated by using the formula: HSI (index representing a habitat's qualitative suitability) × habitat area =HU.	Habitat evaluation
HSI Habitat Suitability Index	HSI shows the suitability of a habitat with a relative value against the reference value (1), representing the optimum habitat, defined based on the habitat conditions required by the target species (SI: suitability index).	
WET: Wetland Evaluation Technique	Eleven wetland functions are evaluated from four dimensions - social importance, opportunity, effectiveness and habitat – by filling out a questionnaire. Wetland functions are evaluated qualitatively on a three-grade scale (high, moderate, low). Includes physical functions such as flood adjustment and social functions such as recreation, which are not included in HEP. Environmental scores and individual evaluations of functions are not aggregated to conduct a comprehensive evaluation of an entire wetland from the viewpoint that it would be lacking in scientific validity.	Status evaluation of wetland functions embodying social importance
IBI: Index of Biotic Integrity	Indices measuring living species, water quality and habitat structure are surveyed and scored against a reference site (biotic colonies in a healthy habitat). The total score is the evaluation value (IBI value). In rivers, it is defined as an index of impact assessment that measures the impact of human activity on fish colonies. Reference sites vary among regions, and therefore, a "regional version" is often formulated in line with the local circumstances.	Status evaluation of environmental situation
PHABSIM: Physical Habitat Simulation System	Changes in WUA (weighted usable area) incurred by flow alterations are forecasted for fish, based on preference curves obtained for fish in various physical environments and predictions of physical environmental change by flow alterations, etc. Method developed for the management of water volume discharged by dams. Attempts to assess impacts that flow alterations due to water source development have on aquatic species.	Future forecasts
IFIM: Instream Flow Incremental Methodology	Comprehensive evaluation method developed for the resolution and prevention of disputes related to water source development. Using PHABSIM, the relationship between flow and WUA is determined for each fish species and utilized with the hydrograph for the target river.	Future forecasts
PVA: Population Viability Analysis	Method used in the drafting of management / restoration plans for environmental impact assessment or conservation of animals, plants and the ecosystem, to predict the extinction probability or survival probability of populations of the target species under a series of conservation measures.	Future forecasts
RHS: River Habitat Survey	Outcomes of a simple questionnaire on the river environment is organized into a database and used for comparisons with the reference site (physical environment only).	Status evaluation

Table 7 Proposed examples of project evaluation employing social indices

Evaluation item			Index	Calculation method
Cultural and spiritual items	Revitalization of humanity	Revitalizing humanity through encounters with nature, refreshing effect	Amenity Satisfaction	Interviews, questionnaires, etc.
	Image-building and identity -building	Image-building effects: rebranding thickets & designating "environmentally advanced areas" Identity-building effects	Satisfaction	Interviews, questionnaires, etc.
	Conservation and succession of history and culture	Conserving and succeeding the agricultural history beginning with the development of new fields 300 years ago, and the local culture fostered against such historical background	Satisfaction	Interviews, questionnaires, etc.

Environmental learning & acquiring new expertise		Environmental learning among administration and local residents Acquisition of new expertise for researchers	Satisfaction	Interviews, questionnaires, etc.
Consensus-building		Forum for project participants with various standpoints to train in consensus-building Contribution to establishing a consensus-building system	Satisfaction	Interviews, questionnaires, etc.
Items related to land use	Guidance to make private development projects sustainable	Guiding private development projects that are difficult to legally reject towards reviewing their development plans for harmonization with the restoration project	Number of projects guided, scale, etc.	Interviews, questionnaires, etc.
	Promotion of application of conservation-related laws & creation of new programs	Promoting the application of existing conservation laws and programs, such as designating green spaces according to local ordinance and promoting the development of city parks Creating and applying new conservation programs, including adopting a special zone program, formulating new laws, establishing funds for the conservation of thickets and introducing an environmental tax	Application of existing legal system, proposal and application of new legal system	Literature surveys, interviews, questionnaires, etc.
	Building green space system	Developing a green space program embodying various functions – for example, environmental conservation, landscape-building, recreation, disaster prevention, and habitat conservation -by incorporating the project into a regional or local green space development plan	Ratio of green space Consistency with urban planning and Basic Plan for Greenery	Literature surveys, interviews, questionnaires, etc.
Industrial promotion		Developing sustainable agriculture by drawing on the resilience of nature, biomass energy, promoting industry, local revitalization through the promotion of a nature- experience-based tourism industry	Shipment value, sales total, Ratio of material cycle Number of tourists	Industrial statistics survey, interview, questionnaires, etc.
Disasters, accidents, etc.	Disasters	Preventing floods, landslides, etc.; or on the contrary, triggering such disasters	Safety	Literature surveys, interviews, questionnaires, etc.
	Accidents, diseases	Water-related accidents, animal-induced accidents, diseases occurring in nature	Safety	Healthcare center statistics surveys, interviews, questionnaires, etc.

Nature restoration in Odaigahara

1. The current status and issues of Odaigahara

Odaigahara is located in the Daiko Mountains, stretching along the border of Nara and Mie Prefectures. It is a non-volcanic elevated peneplain of approximately 700 ha at altitudes of 1,300 to 1,695 meters. It is home to valuable primitive nature, such as spruce (*Picea jezoensis* var. *hondoensis*) communities, which have become scarce in the Kinki region. Odaigahara welcomes 200,000 tourists annually and provides natural and tourism resources that are important features of the Yoshino-Kumano National Park.

However, multiple disturbances, such as windthrow caused by the Ise Bay typhoon in the 1950s, increasing Sika deer populations, and a growing number of visitors to the park, have inflicted the deterioration of the forest vegetation, such as spruce communities, thereby threatening the biodiversity of Odaigahara's with risks of degradation.

2. Nature restoration efforts

Given these circumstances, the Ministry of the Environment launched the "Spruce Forest Conservation Project" in 1986. In 2001, the "Sika Deer Conservation and Management Plan" was formulated and in 2002, the Evaluation Committee for Odaigahara Nature Restoration Promotion Plan was established. In 2009, the "Odaigahara Nature Restoration Promotion Plan: Phase 2" was developed and nature restoration efforts have been implemented based on this plan.

3. An introduction to major restoration projects

1) Conserving and restoring the forest ecosystem

Some of the activities implemented in Odaigahara to restore a vanishing healthy environment where forest succession occurs include, constructing fencing for deer exclosures to eliminate feeding damage by Sika deer and wrapping individual trees with wire nets to protect them from bark stripping. Furthermore, bamboo-grass cover is mowed to control *Sasa nipponica* growth and habitats are being conserved and created for seedlings, including fallen trees and stumps, to develop.

2) Conserving and managing Sika deer populations

Adjustments in excessive deer populations and measures to conserve the vegetation have been implemented in order to ameliorate their impact on the natural vegetation of Odaigahara. The program aims to reduce the Sika deer population from 36.8 deer per square kilometer in fiscal 2006 to 10 deer per square kilometer.

3) Efforts to promote new approaches to park use

Improvements are being made in the quality of park use to reduce the impact of tourists on the natural vegetation and to encourage wiser use. Examples of efforts include encouraging mass transit use, limiting access to particular areas and promoting environmental learning.

Masaki pass in 1963 Masaki pass in 2004

Changes in the forest environment of Odaigahara (Masaki pass)

Sources

Ministry of the Environment Odaigahara Nature Restoration Project: Envisioning moss-covered forest floors, once again, 100 years later

Photos: Takayuki Suganuma (1963, 1997)

Part 4

Important Notes for Nature Restoration

1. Important notes for nature restoration in terrestrial ecosystems

This section discusses the characteristics of terrestrial ecosystems, and important notes to be considered in goal setting and in conducting surveys for nature conservation projects in such ecosystems.

(1) Forests

1) The characteristics of forests from nature restoration dimensions

A forest is characterized by its layered structure and its mosaic structure, embodying gaps and patches which have formed as a result of repeated disturbance. It takes an extremely long time for a forest to be established and its variation patterns and process are varied depending on environmental factors and human influence.

A nature restoration project addressing a forest ecosystem is required to give the characteristics of a forest's temporal and spatial variation due consideration.

Forests that may be addressed in a nature restoration project include:

- Forests damaged by pests, disease and animals (grazing deer, weevils)
- Weather-damaged forests (wind, snow, floods, fires)
- Forests affected by alien species (afforestation tree species, garden tree species)
- Reduction, fragmentation and isolation of important habitats of rare species
- Deterioration of secondary forests (*Satoyama*) due to succession
- Deterioration of unmanaged artificial forests, abandoned bamboo forests
- Land left bare by quarrying, mining, logging, smoke damage and other human influences

2) Important notes for goal-setting

It takes tens of years, and sometimes an even longer period of more than one hundred years to establish a forest by afforestation. The same perspective is required in implementing nature restoration projects in degraded forests to direct the forest ecosystem towards a healthy state. Nature restoration goals should always be founded on a long-term perspective. Phasing goals should also be considered. Forests are closely interrelated with the surrounding environment, including rivers, wetlands, paddy fields and dry fields. Therefore, it should be noted that nature restoration projects implemented in forests may have a large impact on the surrounding environment.

3) Important notes for conducting surveys

When formulating forest ecosystem restoration goals and implementation methods, surveys must be conducted to evaluate the current and historical status of the forest, the causes of forest deterioration, the factors hindering its resilience, and its potential for recovery.

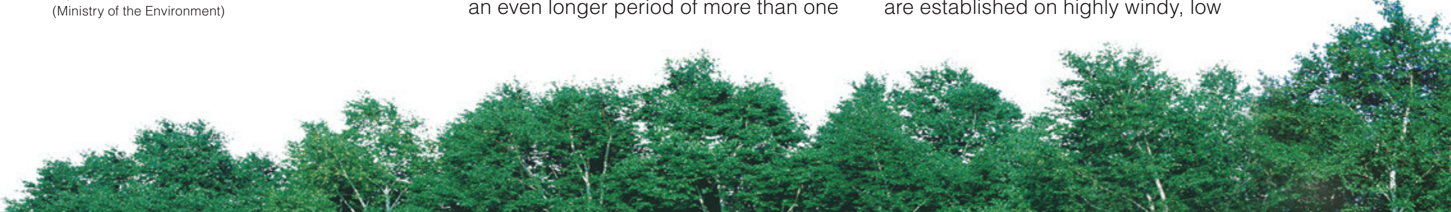
Survey methods include analysis of past and present aerial photographs and satellite images, collection and analysis of silviculture records and forestry plan drawings, surveys on tree species, population, size, and density, surveys on the structure and species composition of plant communities (vegetation survey), surveys on buried seeds, habitat surveys (climate conditions, soil survey), literature survey (local history, local flora, etc.) and interviews to local residents.

(2) Grasslands

1) The characteristics of grasslands from nature restoration dimensions

Grasslands can be largely divided into natural grasslands and secondary grasslands (semi-natural grasslands). In the temperate zone, natural grasslands are established on highly windy, low

PHOTO
Ogasawara National Park, Japan
(Ministry of the Environment)



temperature, or highly humid lands that are difficult for woody plants to inhabit. They are wind-exposed grasslands, raised bogs and wet grasslands in high mountains, and aquiprata on the shores of rivers and lakes. Natural grasslands are established upon special environmental conditions, and therefore, they are difficult to restore once they are damaged. Wind-exposed grasslands in high mountains face the issue of increasing bare lands due to trampling on mountain paths.

On the other hand, secondary grasslands have been historically formed through traditional land use, such as grass collection and grazing, which has been continued from ancient times. Although natural grasslands do not presuppose human influence, secondary grasslands are maintained through continued human activity, and therefore when human management is somehow abandoned in a grassland, succession is accelerated, shifting it to forest. Grasslands are also often targets of development (Figure 14).

A characteristic of secondary grasslands is the grassland plants unique to secondary grasslands and the insects, birds and mammals that depend on them. In Japan many grassland butterfly species are said to have significantly decreased in number. *Fabriciana nerippe*, which is now listed as an endangered species in the Japanese Red List was common throughout Japan in the 1960s but became drastically reduced in number with the disappearance with of violets, which the larvae fed on.

2) Important notes for goal-setting

Natural grasslands are vulnerable in terms of their geographical settings, and therefore often cannot easily self-restore after being exposed to human impact. Once deterioration is triggered, it often develops into secondary damages, such as the outflow of topsoil and burial of vegetation due to sediment outflow. Taking this into consideration, restoration goals must be determined from the viewpoint of both the rehabilitation of damaged areas and the prevention of spreading damages to surrounding areas.

The deterioration of secondary grasslands proceeds when its management is abandoned and continued management is required into the future for their restoration. Where traditional management practices have been lost, in particular, it is important to set goals which embody the challenge of establishing a structure for permanent management in the local community.

3) Important notes for conducting surveys

When restoring a grassland ecosystem, surveys must be conducted to evaluate the current and historical status of the grassland, the causes of grassland deterioration, the factors hindering its resilience, and its potential for recovery. In semi-natural grasslands, in particular, it is important to gain understanding of historical land uses and management methods, and to study the social dimensions that have worked to maintain it.

Survey methods include analysis of past and present aerial photographs and satellite images, surveys on the structure and species composition of the current vegetation, surveys on buried seeds, habitat surveys (climate conditions, soil survey), literature survey (local history, local flora, etc.) and interviews to local residents.

(3) Satoyama

1) The characteristics of Satoyama from nature restoration dimensions

A *Satoyama* is a form secondary nature, maintained by continued human management. The *Satoyama* ecosystem has been formed in line with climate, agriculture, forestry and other aspects of people's lives. Many organisms inhabit a mosaic of various elements, such as rice paddies, scrub, irrigation ponds and water channels. A significant feature of a *Satoyama* is that it is home to endemic species and often endangered plant and animal species. (Figure 15).

Ecosystems change as succession occurs, but this process is controlled in a *Satoyama* ecosystem, which has been incessantly managed by humans.

Therefore, when alterations in the social environment cause human influence to change and disappear, the ecosystem, no longer capable of sustaining itself, will easily undergo change. Furthermore, the various changes of the ecosystem establish the biota. The vegetation mosaic is an important factor that characterizes the *Satoyama* ecosystem and requires the kind of management that will sustain such qualities.

With the aging of agricultural workers, paddy fields have inevitably been left fallow or abandoned. If these paddies continued to be abandoned for a long period of time, it will be extremely difficult to return them to their original state. There is a need to find some way to continue this management.

Phenomena in *Satoyama* that can be addressed in natural restoration include:

- Loss of cultivated land (terraced

Grassland in Aso Breeding cows and establishment of wet meadows
(Photo: Ministry of the Environment)

Japanese lawn grass / short grass grassland
(Mowing 4-5 times / year : May, June, July, August, September)

Japanese bloodgrass / medium-grass grassland
(Mowing about 3 times / year : May, July, September)

Japanese silver grass tall grass grassland
(Mowing 1-2 times / year : June, August)

Figure 14 Mowing frequency and grassland types in secondary grasslands
(Source: Asia Air Survey Co.,Ltd.)

paddy fields, paddy fields, fields, etc.)
- Reduction, fragmentation and isolation of important habitats of precious species
- Drying out of irrigation ponds and wetlands, and invasion of woody plants in grasslands and cultivated land due to succession
- Deterioration of forests due to abandoned management

2) Important notes for goal-setting

When a nature restoration project is implemented in *Satoyama*, phased goals should be considered from a long-term perspective in line with the scale and continuity of anthropogenic management. It is also important that local society, economy and culture are also considered.

Acknowledging that the *Satoyama* environment is an aggregate of paddy fields, scrub, irrigation ponds and water channels, an environmental management system must be established at the community level.

3) Important notes for conducting surveys

When deliberating restoration goals and implementation methods, surveys must be conducted to compare the state of the ecosystem and social system when the land was used as cultivated land with that after abandonment, to gain an understanding of the factors of ecosystem degradation, and to estimate its potential for recovery.

Studies on similar surrounding *Satoyama* areas, literature surveys (local history, local flora, etc.) and interviews to local residents are also useful methods.

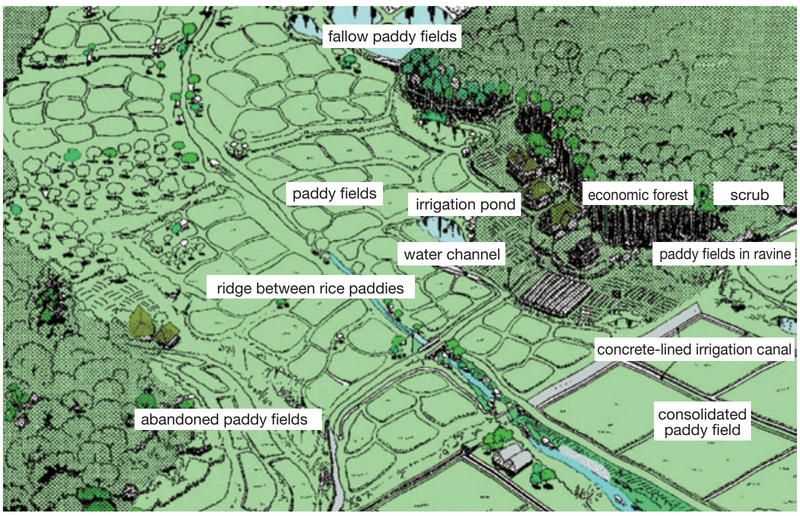


Figure 15 Diagram of a *Satoyama* ecosystem (Source: Shimizu Corporation)

2. Nature restoration in freshwater ecosystems

(1) Rivers

1) The characteristics of a river from nature restoration dimensions

A river embodies not only the riffles and pools in the river channel, but various environmental elements, such as the riverbeds, sand bars, backwaters (stagnant waters, wetlands, etc.), river banks, and riparian forests. A river ecosystem constantly changes due to repeated disturbances caused by droughts and floods.

Given its continuity over long distances from the headwaters to the river mouth, a river is interrelated with various surrounding environments, such as forests, lakes, farmland, urban areas and coastal areas, and bears the function of a corridor that connects diverse ecosystems into an ecological network. This means that impacts in surrounding ecosystems will affect the river ecosystem and impacts occurring in river ecosystems may greatly influence surrounding ecosystems, likewise. For example, logging in the headwaters will change the flow regime and increase sediment flow into the river. The construction of a dam in a river will generate a submerged area and cause changes in the water and sediment volume downstream, thereby fragmenting the ecosystem.

The abovementioned characteristics of river ecosystems should be noted when implementing a nature restoration project.

2) Important notes for goal-setting

A river ecosystem is a dynamic system. The key to implementing nature restoration projects in a river is to restore its dynamics and its accompanying functions. Nature restoration goals can be considered from two dimensions, namely, restoring the target river's function as a habitat for a diversity of organisms and its functions as the center of an ecological network encompassing surrounding areas as well.

Furthermore, in order to maintain the structure and functions of the riparian zones, relationships between upstream and downstream, forest and river, and surface runoff and groundwater should be noted. The basic environment that changes through time, as well as such spatial connections should also be acknowledged when establishing plan goals. Methods of post-implementation monitoring and evaluation must also be envisaged at the timing of goal-setting.

3) Important notes for conducting surveys

The basic elements that compose the river ecosystem should be understood when formulating restoration goals and implementation methods. These basic elements include the current status and historical evolution of the river basin and river, variations in social indicators such as the river basin population, records of floods and other disasters, records of forest improvement and flood control project, literature including aerial photographs and maps, measurement data of discharge and topographic surveys, water quality, etc., and land use in the river basin and horizontal and vertical alterations of the from the past to present. Organizing and analyzing these elements should be done not only from a river basin or river-wide perspective but also through understanding the mutual relationship between the entire river and its segments by compiling the river channel's features and its characteristics as a habitat for biota by segment.

For example, in the case of addressing a fish species with a decreasing population, the causes of deterioration are first derived from existing literature. Then, field surveys are conducted on the current population, the status quo and evolution of runs and spawning, and the evolution of the environmental conditions (the microtopography, bed material, sediment dynamics, pollution burden of the river). The findings are analyzed to observe interrelationships.

Simulations using numerical models are sometimes required.

(2) Lakes and ponds

1) The characteristics of lakes from nature restoration dimensions

A lake is generally deep and is not invaded by submerged plants whereas a pond or small lake can be inhabited by submerged plants in the entire area. A swamp is shallower and covered with emerged plants.

Lakes and ponds have several vegetation zones, distributed in the order of hygrophytes, emerged plants, plotophytes and submerged plants, from the shallowest waters near the shore out to the deeper parts. The development of vegetation zones is largely restricted by the amount of light that is transmitted in the water and varies according to the depth and visibility of the lake water. Many lakes are often influenced by the nutrients that are discharged from human activities in the water catchment area and risk being exposed to eutrophication. Ecosystems can be significantly altered by the influence of shallow waters (ecotones) disappearing as a result of land reclamation, among other bank protection works, and changes in the inflow and outflow of sediment, and water from flood control and water utilization efforts in the water catchment area. Lake ecosystems are composed of various biological communities, including hydrophytes, phytoplankton, zooplankton, fishes and benthic organisms. It has recently been discovered that these elements can be easily influenced by exterior factors and drastically change entire ecosystems.

On the other hand, an irrigation pond is a freshwater ecosystem maintained through agriculture. In times of traditional agriculture, the grass on the embankment or near the water was cut, and dirt and stones were removed to maintain the volume of pond water constantly every year; and therefore, a diversity of ecosystems were created on the shores and in the transitional zones as a result of such regular disturbances. However, against the backdrop of changing agricultural forms, or the mechanization and consolidation of agriculture and farm enlargement, the traditional agricultural practice of managing irrigation ponds is on the verge of disappearing. In some places, bank protection works in irrigation ponds have left them lined with concrete and with an extremely artificial environment; and the careless release of alien species such as the black bass and bluegill has substantially altered the ecosystem.

Lakes should also be carefully observed for "regime shifts," phenomena where lakes with high visibility and quality suddenly transforms into a polluted lake due to a massive outbreak of blue-green algae. This has been observed in the Takkobu Pond, located in the Kushiro Wetland National Park in Hokkaido. The eutrophication of the pond due to livestock wastewater, the outbreak of phytoplankton and the drastic decrease of waterweeds have been identified as causes for the phenomenon. It is known that once a regime shift occurs, it is will become even more difficult to return the ecosystem to its original state; and therefore, preliminary measures are called for.

2) Important notes for goal-setting

Lakes are varied in their size and form, from vary small lakes to those extended across a wide area, and from extremely shallow swamps to deep lakes. All lakes are cumulatively influenced by the catchment area. A lake nature restoration project should be implemented with consideration for not only the lake area but its relationship with land use in its catchment area.

3) Important notes for conducting surveys

An understanding of its current geographic features and the history of its development is required in order to grasp the status quo of a lake.

Useful references include current and historical topographical maps, geomorphological maps, and aerial photographs. Interviews to experts and local residents and the collection of old photographs are effective ways to learn of the historical evolution of a lake.

In order to gain technical understanding of the impact that erosion and sediment caused by waves have in coastal areas, observations

For the restoration of a rich coral reef: Transplanting and restoring coral in Bali, Indonesi

Bali Island in Indonesia is one of the world's largest beach resorts enjoying approximately two million foreign visitors annually. The coral reef surrounding the island has been intensively damaged by large coral mining projects and runway construction on coral reefs. Coral loss also accelerated coastline erosion, and the island was threatened with the loss of its white beaches, important tourism resources.

Therefore, an ODA project sponsored by Japan was implemented from 2000 through 2008 in the island's beaches and coral reefs.

Coral transplantation has been conducted by many countries but the same method is not necessarily applicable everywhere, as coral live under different environmental conditions in different regions. Therefore, after more than two years of field surveys and testing to establish ways for ameliorating the stress imposed on donor coral, site acclimation of fragmented coral pieces and secure settlement, the actual transplanting was conducted.

Limestone substrates were placed in the sea and pieces of coral broken off of donor coral were transplanted on the substrates. Twelve thousand substrates were placed per hectare in an effort to induce coral growth.

Sixteen months after transplantation, 95 percent of the transplanted *Acropora nobilis* had survived and grown several times larger in terms of width and height. Furthermore, it has become clear that coral taken from the same lagoon have higher survival rates and the luxuriant growth of algae and sediment coverage largely affect early growth.

Many coral reef fish have also been observed in increased coral reefs, thereby proving that the ecosystem is effectively recovering and that the local biodiversity is increasing.


Two weeks after coral transplantation


Status of coral restoration

Important Notes for Nature Restoration

from a coastal engineering perspective are also effective. Ecosystems are largely affected by artificial water level control for water utilization and flood control. Monitoring data on water level variations over the long term, and information on simultaneous changes in water quality and vegetation also need to be collected and organized.

(3) Wetlands

1) The characteristics of a wetland from nature restoration dimensions

A wetland is a plant community comprising mainly herbaceous plants and hydrophytes that are established in locations where the water level rises to the soil surface. In regions like Japan, located in the middle latitudes to the high latitudes, they are often established in locations where peat has accumulated. Wetlands are classified into three types, namely, fen, transitional mire, raised bog, according to the interrelationship between the location where peat develops and the groundwater level, as well as the vegetation (Figure 16). A wetland is constantly exposed to excessive moisture, but is nevertheless generally oligotrophic and contains little dissolved matter. Due to water quality conditions, such as high acidity, wetlands are home to very limited vegetation. Therefore, plant communities unique to wetlands develop. Wetland deterioration is accelerated by human influence and other disturbances, such as eutrophication and desiccation. Once a wetland is damaged, it is generally difficult for it to self-repair. The possibilities of restoration differ greatly depending on how much of the peat layer, which characterizes a wetland, is lost.

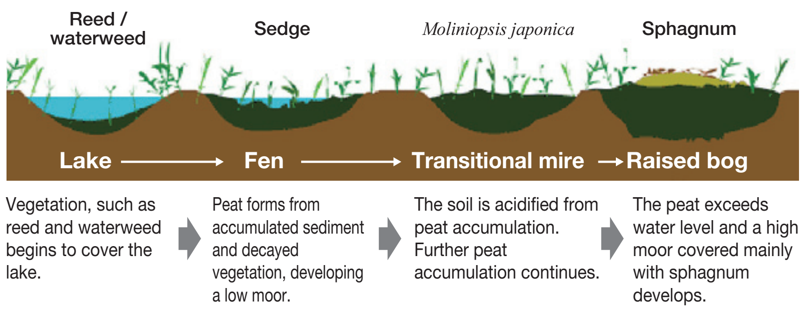


Figure 16 Types of wetlands (Source: Ministry of the Environment)

2) Important notes for goal-setting

Wetlands are varied in their size – from extremely small wetlands to those covering vast areas. All wetlands, regardless of their size, are cumulatively influenced by the catchment area. A nature restoration project in a wetland should be implemented with consideration for not only the wetland area but its relationship with land use in the catchment area.

Furthermore, it is often difficult to set concrete goals because of the ambiguity of the wetland conditions before it was exposed to human influence; and therefore, sustainable and feasible goals based on consensus among local actors is called for.

3) Important notes for conducting surveys

The deterioration of wetland ecosystems often owes to changes in the water cycle or material cycle. In order to understand the state of the environment it is important to compile as much information as possible regarding the hydrological environment. This, together with the knowledge of relationships and interactions among the organisms inhabiting the wetland, will provide an essential basis for understanding the wetland ecosystem. Hydrologic surveys include measurements of dissolved materials, electrical conductivity, oxidation-reduction potential, pH levels, water temperature, and water levels (average and fluctuation range). Biological surveys include those on flora (species, coverage) and those regarding fauna (fish species, aquatic insects).

Little data often exists on conditions before exposure to human influence but it is important to employ old aerial photographs and other historical material to gain an organized view of the process of environmental change to present.

3. Nature restoration in coastal ecosystems

(1) Tidal flats

1) The characteristics of a tidal flat from nature restoration dimensions

Tidal flats are classified into tidal flats which develop along the seacoast, tidal flats in estuaries and those in lagoons, according to their geographic features. Some tidal flats bear the characteristics of several different types and cannot be explicitly classified. Tidal flats often develop in inner bays and estuaries, close to urban areas. Therefore, they are natural environments with easy access, which in turn means that they are vulnerable to the influence of environmental factors and anthropogenic activities.

Major functions of a tidal flat include water purification, habitat, biological production, and water amenity functions. Because tidal flats stretch across areas in between the ocean and mainland, they are characterized by their diversity and encompass a rich variety of biological species. The structure and components of a tidal flat and its spatial and temporal changes should be understood in implementing nature restoration projects (Figure 17). The biological and social value of a tidal flat, such as its value as a habitat for rare species, its biological production functions as in fisheries production, and its water amenity functions represented by public use, should also be taken particular note of.

2) Important notes for goal-setting

Tidal flats have been utilized in many ways - clamming at low tide and fisheries drawing on the ebb and flow of the tide. Estuary tidal flats are also under the influence of the river basin area and require a basin-wide perspective. When setting goals for a nature restoration project in a tidal flat which has disappeared due to reclamation or has become functionally degraded, a decision must be made whether the project will aim to restore the tidal flat itself or to recover its lost functions. Historical records of the tidal flat's past state and other tidal

flats nearby which have maintained a healthy state should be referred to when setting goals for the restoration or conservation of a tidal flat.

Goals should be based on consensus among local people who are aware of the tidal flat's past condition and have utilized. The time required to restore a tidal flat depends largely on the goals established. An efficient method should be contrived so that feasible and concrete goals can be set for the immediate future and a step-by-step approach can be taken to achieve the ultimate goal in the long-term.

3) Important notes for conducting surveys

Restoration goals for a tidal flat ecosystem and plans for the implementation method must be determined based on surveys to gain understanding of its current and historical state, the causes of its deterioration and the factors hindering its resilience, as well as to assess its potential for recovery.

For the purpose, literature surveys or field surveys on physical conditions (topography, river inflow, interannual tidal changes, climate, sediment etc.), chemical conditions (water quality, salinity etc.), and biological conditions (fish, birds, benthos, saltwort communities, seaweed and sea grass) is required. The interview to a local people such as fishermen also offers useful information.

(2) Macroalgae beds

1) The characteristics of macroalgae beds from nature restoration dimensions

Macroalgae beds can be classified into rocky-shore macroalgae beds and sandy macroalgae beds according to where they have developed. Macroalgae beds can also be classified by their vegetation: sargassum beds inhabited mainly by sargasso algae; kelp beds inhabited mainly by kelp; submarine forest beds, with Lessoniaceae; zostera bed with zostera; and tropical sea grass beds. Rocky-shore macroalgae beds are composed of sargassum beds, kelpbeds and sea forests, and sandy macroalgae beds are covered with zostera beds.

The diverse functions of a macroalgae bed include basic production in biological production processes, the maintenance of the primary consumers in a food chain, providing spawning and nursery habitats, providing feeding and hiding grounds, stabilizing the sedimentary or sand/mud environment, and supplying drifting seaweed to as habitats for young fish. The distribution of macroalgae beds is determined by the geographic distribution of component species, physical environmental conditions, chemical conditions such as water quality and bottom sediment, and biological conditions such as the presence of organisms that cause feeding damage or competing species. Therefore, it is important that a nature restoration project secure the environmental conditions for required by macroalgae beds in order for them to be functional. The deterioration of macroalgae beds is attributable to its loss to reclamation, rocky shore denudation and environmental changes. Nature restoration projects can be implemented in ocean areas where macroalgae beds have become deteriorated.

2) Important notes for goal-setting

Some of the major functions of a macroalgae bed are basic production, water purification, habitat provision and contributions to the ecosystem, the stabilization of the environment and fishing grounds. In order to restore macroalgae beds, consensus must be sought among the local people and fishermen who use the area as their fishing grounds, based on considerations for the surrounding environment. Furthermore, due consideration is required regarding a nature restoration project's consistency with local development plans and other various coastal development measures.

Other macroalgae beds remaining in the surrounding area will provide good reference for goal-setting. Macroalgae beds may also be utilized for the introduction of organisms or to supply spores and seeds. Overall restoration goals can be determined based on the environmental conditions of the macroalgae restoration site, based on which the component species will be selected. However, phased goals should also be considered.

Kushiro Wetland (fen)
(Photo: Ministry of the Environment)

Sarobetsu Mire (raised bog)
(Photo: Ministry of the Environment)

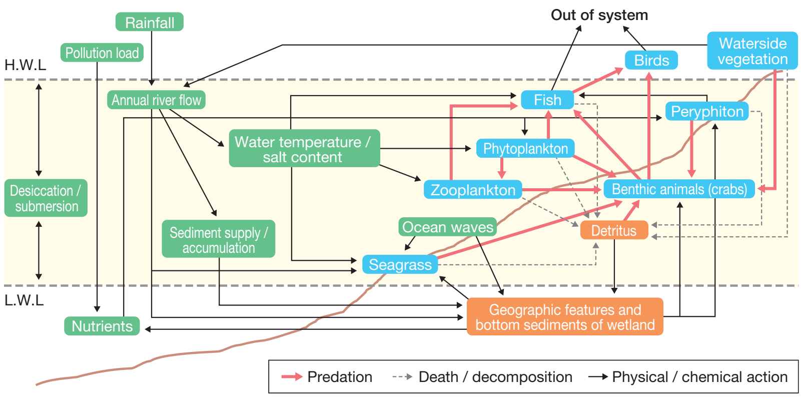


Figure 17 Interrelationship between biotic and abiotic elements of wetland
(Source: Idea Consultants, Inc.)

3) Important notes for conducting surveys

Restoration goals for a macroalgae ecosystem and the plans for the implementation method must be determined based on surveys to gain understanding of its current and historical state, the causes of its deterioration and the factors hindering its resilience, as well as to assess its potential for recovery.

For the purpose, literature surveys or field surveys on physical conditions (topography, river inflow, interannual tidal changes, climate, sediment etc.), chemical conditions (water quality, etc.), and biological conditions (fish, birds, benthos, seaweed, sea grass, and organisms that cause feeding damage or competing species, etc.) is required. The interview to a local people such as fishermen also offers useful information.

An adaptive approach is required in implementing a macroalgae bed restoration project. Appropriate monitoring surveys must be conducted to monitor the site until it develops and become capable of self-sustainment. The status of growth, physical and chemical conditions, the presence of organisms that cause feeding damage or competing species, and the macroalgae bed functions must be monitored comprehensively and regularly.

(3) Coral reefs

1) The characteristics of a coral reef from nature restoration dimensions

A coral reef is a geological formation that is mainly formed by organisms (hermatypic coral, etc. with calcareous skeletons. Coral reefs are categorized into fringing reefs which form along the coast, barrier reefs whose outer reefs are separated from the shore by lagoons, and atolls which comprise a circular outer reef and lagoon.

Inhabited by coral colonies, algae and sea grass, and many other organisms, a coral reef is rich in biodiversity. A coral reef bears important functions contributing to the regional environment in many dimensions: biological production, coexistence of organisms, environmental purification, landscape creation and water amenity, and disaster prevention.

The geographic distribution of coral reefs is restricted mainly by ocean temperature. Corals reefs are mostly found in warm waters in tropic regions. Environmental factors that affect the development of coral reefs include physical and chemical factors, geographical and geological factors, biological factors and anthropogenic activities. There have been recent reports of coral disappearing as a result of the inflow of topsoil (red soil) due to development, feeding damage by acanthaster and coral bleaching due to extraordinarily high ocean temperatures. Restoration projects need to be based on an understanding of the causes for such phenomena as well as the environmental conditions for the growth and formation of coral reefs.

Target waters for nature restoration projects may include:

- Waters where coral reefs have disappeared or have been affected due to development
- Waters with limited growth
- Waters with deteriorated environments

2) Important notes for goal-setting

A coral reef ecosystem has been built over a long period of time, layer by layer by nature and the organisms which inhabit it; and therefore, it is difficult to completely restore it once it is deteriorated. It is important that many local actors are invited to cooperate in setting goals for a restoration project and that consensus is sought through local deliberation. Goals should be based on a long-term perspective and phased goals should also be considered.

3) Important notes for conducting surveys

Restoration goals for a coral reef ecosystem and the plans for the implementation method must be determined based on surveys to gain an understanding of its current and historical state, the causes of its deterioration and the factors hindering its resilience, as well as to assess its potential for recovery.

Since the coral reef ecosystem often has a close relation with the human activities such as fisheries or sightseeing, social environment investigation of a surrounding area is important for restoration project in addition to physical environment, a chemical space, and biotic environment surveys.

In a coral reef restoration project, appropriate monitoring surveys must be conducted to monitor the site with an adaptive approach until the coral reef develops and become capable of self-sustainment. The restoration process and effectiveness of the project, as well as how much of the natural environment has been sustained must be monitored comprehensively and regularly.

4. Natural Environment in Urban Areas

1) The characteristics of urban environments from nature restoration dimensions

The ground covered with concrete, asphalt and other artificial material, a city is an artificial environment. Consequently, cities are faced with the emerging issues of deteriorating physical environments, including decreasing green coverage ratios, higher temperatures and dryer climate, and simplified ecosystems due to declining biological populations and extinction. Nature restoration in urban areas is believed to effectively resolve these challenges.

Prospective sites for urban nature restoration projects are rivers, tidal flats in estuaries, seashores and their adjoined zones. The pivot of a major city's water cycle, rivers are especially promising project sites that may contribute to nature restoration through re-naturalizing river banks, improving water quality and creating water amenity spaces. Nature restoration is an effort to recover the healthy ecosystem once lost, but in cities embodying extremely few natural elements, newly creating nature is as important as restoring it. From this perspective, reclaimed land along the water front and urban parks, rooftops and artificial grounds can also be site for creating nature (Figure 18).

2) Important notes for goal-setting

In an urban nature restoration project, a large question is to which point in history the environment should be restored. Cities have developed in phases and therefore careful deliberation is required on the stage to which the ecosystem should be restored and the stage to which the current ecosystem is potentially capable of restoring itself.

Target-setting for creating nature is also a large challenge. Targets must be determined with reference to the ecosystems of the nature creation site, its surroundings and river basins, and also with consideration for connecting with surrounding natural elements to establish ecological networks.

Although it is difficult to secure a vast project site in urban areas, there is a need to improve the quality of urban ecosystems by using the small pieces of natural elements (parks, green belts on hillsides, canals, rivers, etc.) remaining and linking them into an ecological network. Even small fragments of nature can be built into a more stable urban ecosystem by increasing biotopes and corridors.

Because diverse interests are entwined in cities, where nature and humans exist in neighboring or overlapping areas, it is important that the collective opinion of various actors is sought and agreed upon. Consensus should also be gained on a maintenance plan and rules on how to address negative impacts of nature restoration including bird damage and breakouts of pests which are likely to occur as nature restoration progresses.

3) Important notes for conducting surveys

There is little basic information available about urban ecosystems. Efforts must be made to conduct environmental surveys on the surrounding environment as well as the project site, and also literature surveys and interviews to local residents in order to understand the current status as accurately as possible. The changes in urban environments, drastically affected by anthropogenic activities should be taken note of in analyzing the survey results.

Once a nature restoration project has been implemented, it should be closely managed based on monitoring, with regard for changes in the surrounding environment and anthropogenic influence.

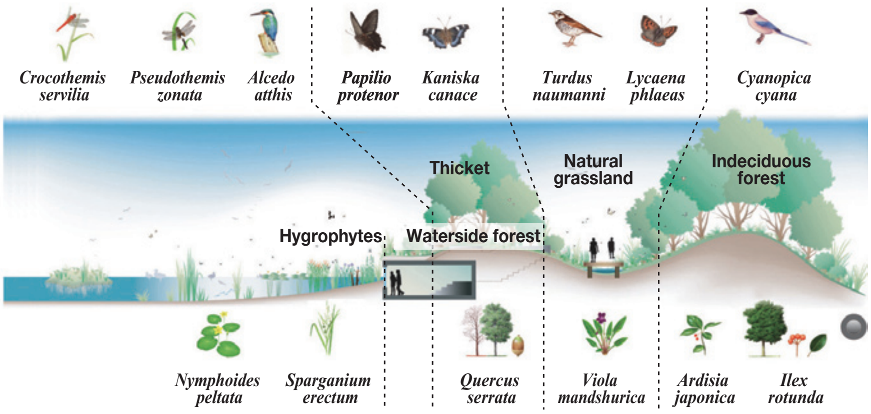


Figure 18 Biotope created in Ecchujima, Koto Ward (Source: Shimizu Corporation)

Urban biotope
(Photo: Shimizu Corporation)

Sekisei Lagoon: Using sexual reproduction dynamics in transplanting coral

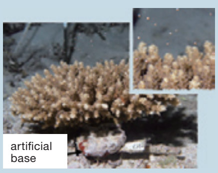
The Sekisei lagoon is located between Ishigaki Island and Iriomote Island south of the Ryukyu Islands. Stretched out approximately 15 km in the north-south direction, and around 20 km in the east-west direction, it is Japan's largest coral reef sea. Over 400 hermatypic coral species inhabit the area, making it highly diverse in species. The sea also importantly contributes to the regional economy by providing opportunities to use the rich coral reefs in tourism and fisheries.

However, coral reefs are have diminished due to terrestrial runoffs, coral bleaching as a consequence of high water temperatures, and feeding damage by the crown-of-thorns starfish (*Acnathaster planci*). Therefore, the Ministry of the Environment and other actors, including concerned government agencies and local groups, have joined hands in efforts to conserve and restore coral reefs. Among these efforts is a project run by the Ministry of the Environment to rehabilitate the environment by transplanting coral in sites where coral communities cannot recover due to insufficient juvenile recruitment.

Juveniles are reared on settlement devices (ceramic, with a diameter of 40mm and height of 40mm) and transplanted. Conventional coral transplantation techniques involved breaking off pieces of existing coral for transplanting, thereby damaging the host coral and creating a coral community with less genetic and species biodiversity. In the Sekisei lagoon, these problems have been resolved by using the in-situ sexual reproduction of coral to obtain juveniles for transplanting.

There are two methods to settle larvae on settlement devices. The first method is to place the devices on the sea floor and wait for the larvae to settle. The second method is to collect the fertilized eggs drifting on the sea surface after synchronous spawning and let them settle on devices set in an aquarium. In both methods, juveniles are reared on the devices for about 1.5 years prior to transplanting.

Transplanting activities have been implemented since 2005 and approximately 24,000 devices (10 devices/ m2) have been transplanted to date. The project has attained some progress: some of the transplanted coral have steadily developed and spawning has been observed for three consecutive years, from 2010 to 2012.



Spawning by adult coral

Map of Sekisei Lagoon

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