ECOLOGICAL RESEARCH FOR THE RESTORATION AND MANAGEMENT OF RIVERS AND RESERVOIRS IN JAPAN

Tomonori OSUGI

Senior Researcher, Environment Research Division,

Water Resources Environment Technology Center (WEC)

Kojimachi NK Bldg., 2-14-2 Koji-machi, Chiyoda-ku, Tokyo 102-0083, Japan

Phone: +81-3-3263-9952 Fax: +81-3-3263-9922

E-mail: t-osugi@wec.or.jp

http://www.wec.or.jp/

and

Shinichiro TATE

Researcher, Research Division 4

Foundation for Riverfront Improvement and Restoration (RFC)

Ichibancho FS Bldg. 3rd Flr., 8 Ichiban-cho, Chiyoda-ku, Tokyo 102-0082, Japan

Phone: +81-3-3265-7121 Fax: +81-3-3265-7456

E-mail: tate@rfc.or.jp

http://www.rfc.or.jp/

1 Introduction

Our country, Japan, is situated in the Far East of East Asia and occupies an area of 377,837 sq km, which is less than one twentieth of the size of the Commonwealth of Australia or slightly larger than Federal Republic of Germany. The lowlands occupy only about 20 % of land surface, and the rest of the country is mountainous and almost entirely covered with forest. The Japanese Archipelago falls within the Asian Monsoon climate zone, one of the few high rainfall regions of the world, blessed with a mean annual precipitation of c.1710 mm, about twice the world average of c.970 mm[1)]. However, because of high population density, per capita precipitation in Japan is about one quarter of the world average and cannot be considered water-rich. Moreover, precipitation fluctuates greatly between seasons, concentrating in the rainy season (June – July) and the typhoon season (August – October). The dividing range runs along the archipelago, producing rugged topography and steep gradients in many rivers. Therefore, floodwaters from heavy rain run off rapidly, increasing the flow rate of rivers enormously at the peak of flooding[2)].

Japan has a population of about 130 million and its GDP exceeds US$42 million, but 51 % of the population and 75 % of the assets are concentrated in the flood-prone regions, about 10 % of the total land area of Japan[3)]. Placed under such severe physical conditions Japan suffered periodic

floods and much damage to the properties during its history. Also, Japan's agricultural system is centred on rice growing and dams have been built for water supply to paddies and waterways since ancient times, the oldest record of dam construction going as far back as 616 AD.

Under such natural and social conditions, Japan has had to manage its rivers since the old days, constructing levees and dams, changing waterways and excavating riverbeds to prevent floods and secure water supply. As a result, the safety of flood control and the stability of water supply have been achieved, enabling economic advancement and safe and rich life style that people of Japan enjoy today. However, straightening of waterways and protection of banks with concrete produced monotony in the riparian landscape, and water quality has deteriorated with the intake of drainage water. Dam construction caused the intake of drainage water. Dam construction caused interruption of migratory routes of anadromous and catadromous fishes and fragmentation of habitats for land animals besides the loss of the stream environment in watershed areas. It also changed the river environment downstream with reduction and stabilization of flow rate as well as reduction in sediment supply. These are beginning to be recognised as environmental impacts today[4)].

Many environmental scientists and ecologists voiced their view that we should recognise the importance of conserving the natural environment and biodiversity. As exemplified by global warming, we now need to address the environmental issues globally. The government of Japan responded seriously to the cry for the environmental conservation within the country and such trends in the world, and began to examine river management, among other efforts, with a view to preserving the natural environment. In January 1994, the Ministry of Construction (now the Ministry of Land, Infrastructure and Transport), which then administered river management in Japan, produced an outline of the environmental policy and adopted the policy of actively introducing nature conservation into river administration. Further, the River Council submitted a report in September 1995, urging the government to positively support "securing of diverse habitats for wildlife", "securing of healthy water circulation", and other measures for protecting the environment.

The River Law was revised in 1997 in response to the social outcry, clearly recognising the "improvement and conservation of the riparian environment" as an objective of river management, in addition to the conventional roles of "flood control" and "water use". Also, in 1997 the "Environmental Impact Assessment Law" was promulgated, stipulating "the execution of environmental impact assessment during the various stages of construction work". Further enactments in 2002 of the Law for the Promotion of Nature Restoration to promote restoration

work and in 2004 of the Invasive Alien Species Act to control exotic species of plants and animals and prevent their damaging impacts on the ecosystems, urged the administration to conserve and restore species-rich indigenous ecosystems. Thus environmental management has gained much importance in river management in recent years and further promotion of environment-friendly management of rivers and dams is being encouraged. If we are to achieve such management goals, it is imperative that we obtain and understand ecological information on the river and watershed environments containing dams. Unfortunately, we cannot say that we fully understand the functions of the ecosystems involved.

In an effort to overcome these difficulties and promote environmental conservation in river management, researchers and administrators in Japan combined their efforts to establish the River Ecology Research Group in 1995 to conduct integrated research into river ecology, and the Watershed Ecology Research Group in 1998 to assess the effects of dams scientifically and search for the ideal state of watershed ecosystems and landscapes. These two groups have been making integrated studies of the river and watershed environments of Japan, respectively.

This paper presents the current status of these two Research Groups and reports on the research effort being made towards the conservation of the river environment in Japan.

2 River Ecology Research Group

The purpose of establishing this Research Group was to introduce the ecological viewpoint into the future management of rivers (Figure 1). To achieve this, we needed to appreciate that the rivers changed their shape, every time a disturbance such as flooding occurred, which in turn altered the flora and fauna and their habitats. This cycle of dynamic relationships is the essential nature of the rivers. We further need to clarify how the biomass of plants and animals changes and what sorts of ecosystems organisms form and how they affect the river environment in general as they respond to the changes of flow rate, water quality and sediment supply, and to the alterations of physical elements such as riffles and pools. It is the intention of this research group to conduct surveys and research on this principle and examine the methods of river management[5)].

To introduce the ecological viewpoint into river management it was necessary for river engineers and ecologists to hold frequent discussions at the same table. They realised that it was important to understand the fundamental nature of rivers, while clarifying the contributions of organisms and ecosystems to the river environment under the fluctuating conditions of rivers. Thus they joined forces in the “River Ecology Research Group” to conduct integrated research into river ecology with an aim of making new contributions to river management in Japan.

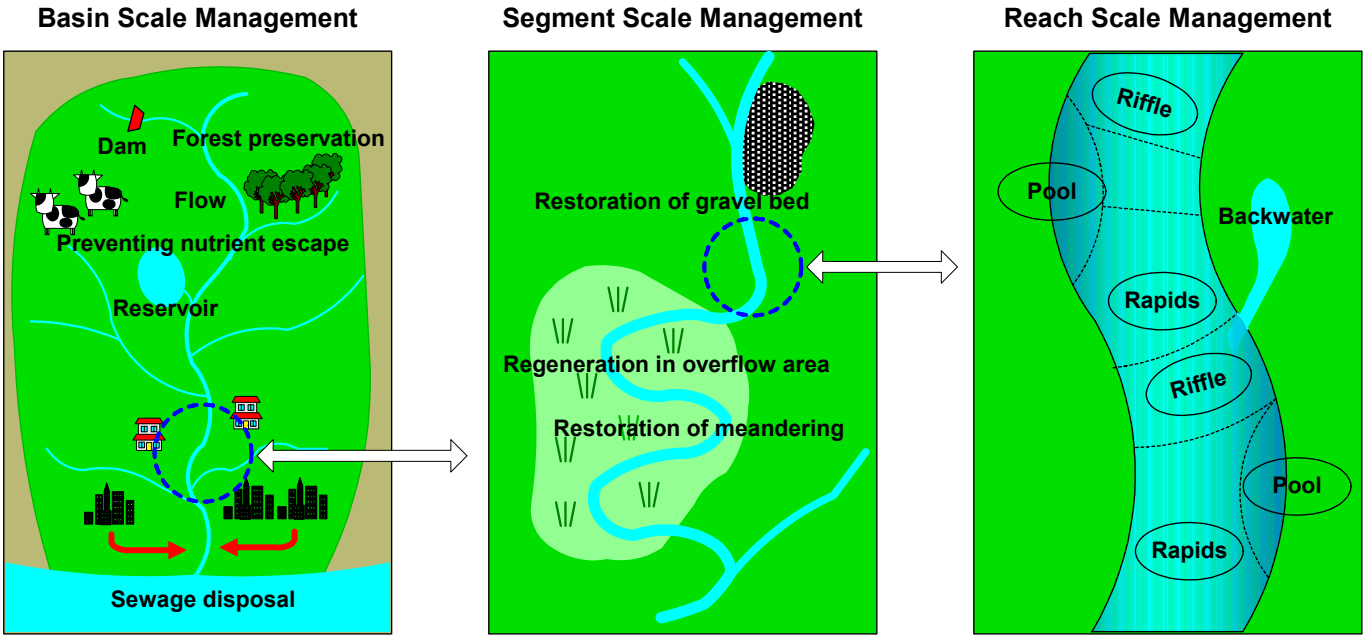

Figure 1. River management from ecological perspective

2.1 Study Rivers

The rivers being studied at present (Figure 2) are: the Tama (in Kanto), the Chikuma (in Hokuriku), the Kizu (in Kinki), the Kita (in Kyushu), the Shibetsu (in Hokkaido) and the Iwaki (in Tohoku). Table 1 summarises the characteristics of the region in which each study area has been selected.

1) The Tama River (Kanto)

The Tama River, situated in Kanto, is a Class A River (controlled by Central Government), flowing 138 km from Yamanashi Prefecture through Tokyo Metropolis and Kanagawa Prefecture into Tokyo Bay. It is one of the few metropolitan rivers in Japan, with a population of 4.25 million in its drainage basin of 1,240 km^2. The middle reaches of the Tama have gravel beds and support an endangered endemic composite species, the riverbed aster (*Aster kantoensis*). In recent years spreading of exotic trees, such as black acacia, is conspicuous. The Tama is the first river to be studied by the group in 1996 and two study areas have been selected. One is in Nagata District (1.6 km), where water flow is constant being controlled by the dam, and the other is in Tama-Ohashi District (2.2 km), where human impact is strong with input of treated sewage water. In the middle reaches a new project to restore the gravel riverbed was launched and the flood plains were excavated, removing the black acacia and the topsoil, and the exposed gravel bed was sown for the riverbed aster. The outcome is now seen in a dramatic increase of aster

stands and the return of the endemic Japanese grasshopper (*Eusphingonotus japonica*), the large-billed plover (*Charadrius placidus*) and other floodplain species.

2) The Chikuma River (Hokuriku)

The Chikuma River, situated in Hokuriku, is surrounded by high mountains. Flowing through Nagano Prefecture it changes its name to “the Shinano River” where it enters Niigata Prefecture. The Shinano River is the longest river in Japan, with the total length of 367 km, of which 210 km belongs to the Chikuma and 150 km the Shinano proper. The drainage basin of the Chikuma has 7,163 km^2, supporting 1.5 million people. The Chikuma flows through the fossa magna zone and its lower reaches have complicated landforms and fragile geological strata. Like the Tama River, the study was initiated in 1996. The two Districts selected for study are Nezumibashi District (2.0 km) of Sakaki-machi in Nagano Prefecture, considered to be typical of the middle reaches of the Chikuma from its water quality and topographic features, and Awasa Disrict (1.0 km), where experimental excavation of waterways was executed. A major flood occurred during the study, providing an opportunity to examine the effect of flooding on the ecosystem. In Nezumibashi District the bare ground increased from less than 1 % to 22 % of the area after the flood, and 22 % of the area lost vegetation cover. New sandbars and cliff faces produced by flooding became nesting grounds of some birds, revealing a cycle of avifaunal changes with increase of grassland and forest birds in conjunction with the recovery of vegetation.

3) The Kizu River (Kinki)

The Kizu River, situated in Kansai, is a Class A River, flowing through Mie and Kyoto Prefectures and merging with the Uji and the Katsura Rivers to form the Yodo River. Its total length is 147 km and basin area 1,596 km^2. The Kizu is a sandy river due to the wind-eroded granite in the basin and is characterized by the development of alternating sand bars in the riverbed. The study was initiated in 1998 in Kyotanabe District (2.5 km) with an aim of understanding the ecosystem of a violently fluctuating sandy river. Comparison of water quality between the upstream and the downstream revealed a decrease in the concentration of nitrogen and phosphorus in the subsurface flow of downstream, indicating the possible water purifying role of sandbars.

4) The Kita River (Kyushu)

The Kita River, situated in Kyushu, is a primary tributary of the Gokase River flowing through the northern part of Miyazaki Prefecture. Its length is 50.9 km, basin area 587 km^2 and basin population 18,000. It is rich in natural features, with many continuous riparian forests, well-developed riffles and pools, and wetlands in lower reaches. A disaster struck in September

1997 when the typhoon No. 19 caused extensive flooding, inundating 1894 homes above the floor level. In response to this disaster the study was initiated along the section (16 km) from Kumata District to the mouth of the river to follow up the effect of restoration work on the ecosystem. In the restoration work, excavation of lower channels to gain the cross-sectional area was avoided, but instead a minimum number of trees were felled and the floodplains excavated for biodiversity conservation. The effect of such river restoration work on the biota was studied and a prediction was made that the creeping reed (*Phragmites japonica*) and willow trees would become dominant in 20 years. Recovery of plants and animals was accelerated after the construction work if refuge areas and feeding stations were provided for small mammals during the construction.

5) The Shibetsu River (Hokkaido)

The Shibetsu River flows in the eastern part of Hokkaido and enters the Sea of Okhotsk. It is a Class B River (controlled by Prefectural Government), basin area 671 km^2 and basin population 25,000. Prior to the 1940s the Shibetsu was a highly meandering river with rich wetlands, but waterways have been straightened to prevent flooding in the 1960s. As a result, *Hucho perryi*, a rare primitive species of salmon, has disappeared and willows have become dominant, replacing tall trees of Japanese elm (*Ulmus davidana*) and Japanese ash (*Fraxinus mandshurica*) in wetland forests. However, in the river restoration work started in 2000, meandering was restored experimentally in Kyosei District. There is no other example of large-scale restoration to recover meandering in Japan. After three years since the restoration we can see the formation of more riffles and pools than the straightened river and diversification of water depths and flow rates. Where the bank is eroded in meandering, cliffs are formed providing a nesting ground for the sand martin (*Riparia riparia*). In the fish habitat created with logs large salmonid fishes returned, which were absent in the straightened river.

6) The Iwaki River (Tohoku)

The Iwaki River is situated in the western part of Aomori Prefecture and forms headwaters in World Heritage Shirakami Mountains. It is a Class A River flowing through Tsugaru Plains and entering the Sea of Japan via the brackish lake (Lake Jusan) at the mouth. Its length is 102 km and basin area 2,540 km^2. Brackish Lake Jusan is well known for its freshwater clam *Corbicula japonica*. An extensive reed formation has developed along 10 km of the river from Lake Jusan providing excellent avian habitats, particularly for great reed warblers (*Acrocephalus arundinaceus*) and endangered Japanese marsh warblers (*Megalurus pryeri*). Participation of the Research Group in this project was prompted in 2006 for the purpose of investigating the formation of the ecosystems of the brackish lake and the extensive reedbed.

7) Synthesis Team

The Synthesis Team was established in 2005 to integrate and evaluate the outcome of research for all rivers. It aims to synthesis the river ecology research by comparing the study methods and physical and ecosystem characteristics of respective study rivers, and deriving similarities and differences from this exercise.

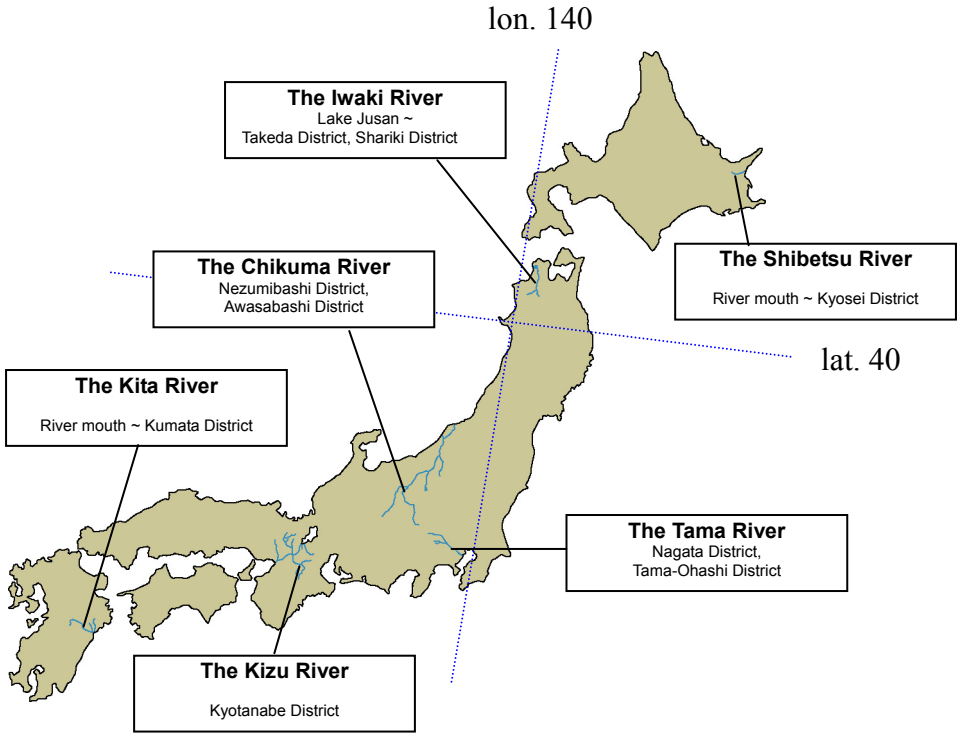

Figure 2. The rivers under study

Table 1. Characteristics of study areas

STUDY RIVER	STUDY DISTRICT	CHARACTERISTICS
Tama R.	Nagata	Constant flow-rate maintained by dam
	Tama-Ohashi	Impact with input of treated sewage
Chikuma R.	Nezumibashi	Gravel beds with riffles and pools typical of middle reaches of the Chikuma
	Awasabashi	Experimental excavation of waterways
Kizu R.	Kyotanabe	Alternating sandbars, typical of the Kizu
Kita R.	River mouth - Kumata	Prompt restoration work after flooding
Shibetsu R.	River mouth - Kyosei	Restoration of meandering as gov't work
Iwaki R.	Lake Jusan - Takeda & Shariki	Estuary with brackish lake and extensive reedbeds

2.2 Research Framework

The Research Group conducts research cooperatively among research scientists of universities (river engineers, biologists), National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure and Transport (mainly river engineers) and Public Works Research Institute of Independent Administrative Foundation (mainly river

engineers). Its office is run by the administrative river controllers of the study rivers and Technology Research Center for Riverfront Development. The officers are responsible for the management of conferences and synthesis of research outcomes as well as conducting publicity work and various activities of coordination for the River Ecology Research Group.

1) Researchers of universities, etc.

University researchers form a core of the Research Group and represent many different fields. Among the ecologists there are specialists on birds, fishes, benthic organisms, plants, insects, mammals and algae, whereas specialties of engineers include river engineering, civil engineering, erosion control, hydraulics and matter circulation. They usually belong to the universities close to the study river as it is an advantage to have an easy access to the field site. Graduate students in Masters and Doctors courses and other young researchers also take part in the projects, as this system of the Research Group contributes much to the training of research scientists.

2) Research organisations of the government

Members of National Institute for Land and Infrastructure Management and Public Works Research Institute also belong to the Research Group. The Ministry of Land, Infrastructure and Transport is responsible for managing the social capital for the use, development and conservation of land and for the promotion of transport policy, whereas National Institute for Land and Infrastructure Management within it is a research organisation concerned with the development of surveys and research planned by the Ministry. The Public Works Research Institute is another research organisation concerned with research and development of civil engineering technology. Both research institutes have teams pursuing surveys and research on rivers, and researchers mainly in the field of river engineering belong to the River Ecology Research Group.

3) River managers (Administration)

The staff of the Ministry of Land, Infrastructure and Transport manages the rivers under study. On the ground they are responsible for the management of river infrastructure for flood control and water use, and conduct measurement of water levels and discharge, maintenance and inspection of rivers, and various other tasks concerned with the management of rivers. They also collect and collate water level and discharge data and aerial photographs, and provide general support to researchers, together with Technology Research Center for Riverfront Development, as an agent for River Ecology Research Group. They distribute a variety of information to the researchers, organize conferences, procure research funds, help with

collation of research results and engage in publicity work for the Research Group.

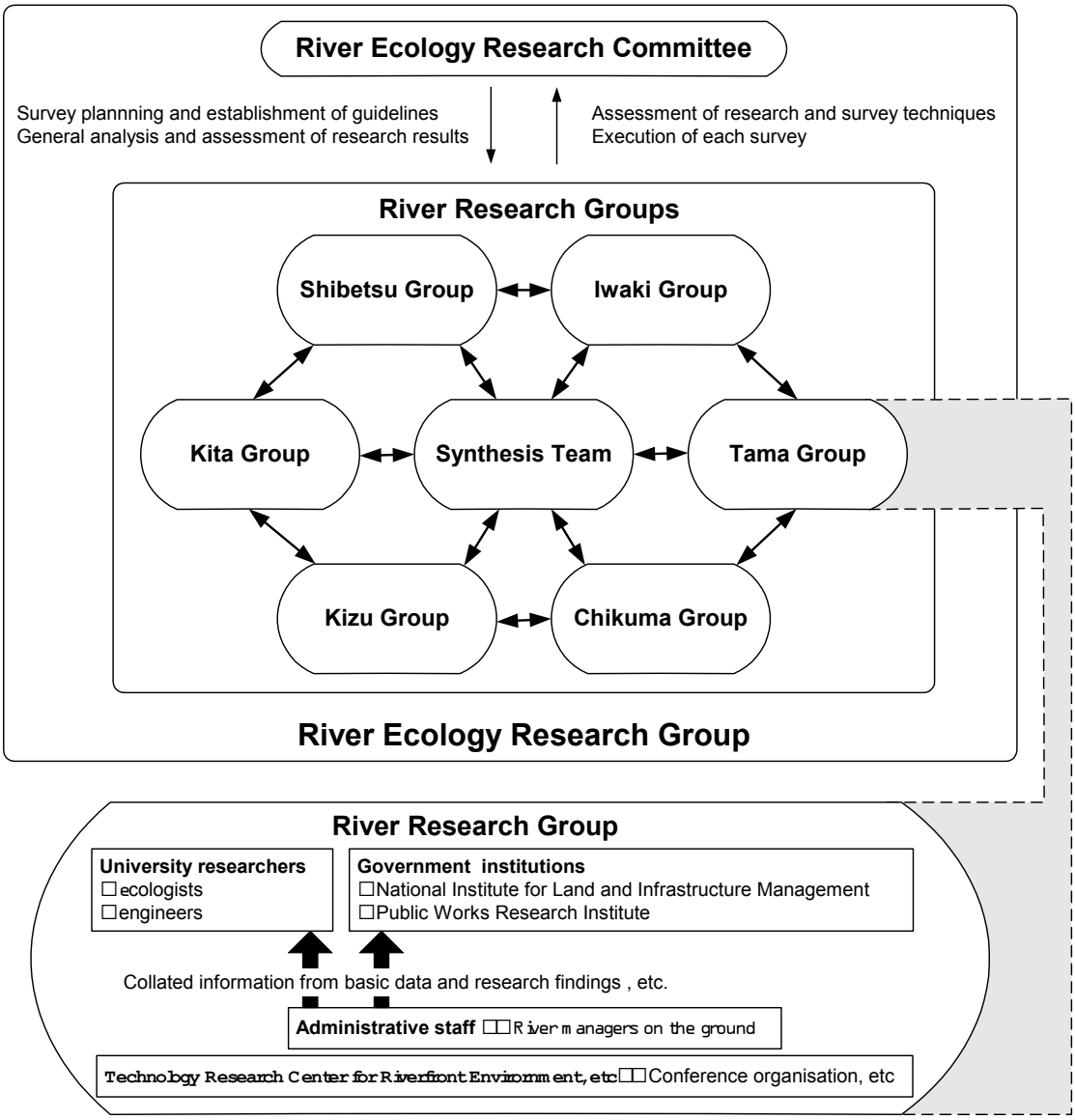

Figure 3. Research organisation chart

2.3 Operation of the Research Groups

As shown in the previous section, a research group is formed for each study river, consisting of researchers from universities and government research institutions. Each research group meets three to four times a year to discuss its operations and report on its findings. At the meeting researchers discuss what to focus their efforts on, how to form a study team, how frequently they should survey, and so on, and they proceed accordingly to conduct surveys and research. The study period is about 4 to 5 years to reach its conclusion.

In addition, the representatives of respective river study groups meet twice a year, in spring and autumn, to report on the research methods and findings to their parent committee. At the spring meeting the committee inspects the study area and collects information regarding the status of

nature restoration and river management. Many government officials attend the meetings of the parent committee and collect useful information for administration and receive advice directly from the researchers at the meeting.

Researchers working on different rivers can also glean information on research results from other members at a meeting held in December each year in Tokyo, where a large hall with a capacity of several hundreds is hired for the presentation to be given to the combined conference of research groups. This combined research conference is having its 9th meeting this year. The participants have opportunities to compare their own studies with those of other rivers and take part in active discussion.

2.4 Future Perspective

The Tama River Research Group is trying to restore the gravel riverbed where the flood plains are forested today as a result of large-scale gravel mining and sediment reduction due to upstream infrastructure for flood control and water supply. The Chikuma River Research Group is searching for the ecosystem-friendly way to excavate waterways by examining the restoration process following the experimental excavation carried out by the government for the purpose of improving the flow rate. However, there are still very few examples of making or trying the transfer of research results to actual river management as being attempted in the Tama and the Chikuma Rivers. From the executive point of view we must promote further discussion and cooperation between the researchers and administrators to achieve this in the future.

As stated earlier, a total of 5 rivers have been surveyed and studied for 10 years, during which time much ecological information has been accumulated on each river. It will be necessary in future to compare and evaluate the enormous amount of data accumulated for different rivers. In fact, the Synthesis Team was established in 2005 and started to compare the individual results across different rivers. The Synthesis Team is planning to analyse the basic data, such as climatic conditions of individual rivers, in relation to the increased local precipitation in recent years accompanying global warming. In so doing, we hope to clarify the issues relating to the survey and research that have escaped attention in the previous discussions on each river, and to improve methods and hence further expand the work of the River Ecology Research Group.

3 Watershed Ecology Research Group

In Japan, of all structures built across the river those that have the embankment height of 15 m or more are called the dams. Then there are about 3,000 dams in Japan, most of which are multi-purpose dams serving combinations of irrigation, flood control, power generation, etc. Of the

3,000, roughly 62 % are built for irrigation, 26 % for flood control and 20 % for power generation. Japanese dams are relatively small, the largest being Okutadami Dam with a reservoir capacity of 600 million tons or Uryu No. 1 Dam with a reservoir surface area of 237 ha. There are 109 Class A Rivers managed by the government, but fewer than 10 of these are without a dam. That is to say that most Japanese rivers have dams.

However, the effects of dam construction, operation and management on the neighbouring ecosystems are not always clear even today. In fact, we have not enough information to permit the construction and management of dams that are friendly to the environment. Thus it was decided that river engineers and ecologists combined their effort to establish the Watershed Ecology Research Group and conduct integrated cooperative research on reservoirs and watershed areas with an aim to investigate these effects scientifically and to search for an ideal state of the watershed areas for the conservation of beautiful and biologically diverse rivers in Japan[6].

3.1 Organisation

For the assessment of the environmental impacts of dam construction in terms of regional characteristics, we divided the river system of the basin containing the dam into (1) the headwaters above the dam, (2) the artificial lake (reservoir) created by the dam, and (3) the river below the dam. Accordingly, the research group formed the following research committees.

λ Forest Ecology Research Committee: to evaluate the forest ecosystem of the catchment area, particularly its responses to natural fluctuations of conditions and human impacts on it, and to develop new research methods for the understanding of interactions between forests and the water system.

λ Raptor Management Research Committee: to study the ecology of raptors and develop their conservation measures, with special attention to the species that occupy the top positions of food chains in the watershed areas.

λ Reservoir Ecology Research Committee: to evaluate the ecological roles of the reservoir, such as nutrient transfer, and to propose operational plans for the dam, which take into consideration the health of the basin ecosystem.

λ Flow Regime Research Committee: to study downstream ecosystems, particularly the influence of dam operations on the habitat of diverse biota and methods to mitigate their adverse effects.

Each Research Committee has a core of university researchers and research is conducted in respective fields including the dam sites. As in the River Ecology Research Group, participating researchers come from both fields of ecology (specialties in birds, fishes, bethos, etc.) and

engineering (specialties in river engineering, civil engineering, matter circulation, etc.). Also, some researchers of Public Works Research Institute, an Independent Administrative Foundation associated with Ministry of Land, Infrastructure and Transport, are participating in research as members of the Watershed Ecology Research Group.

Each Research Committee meets once to three times a year to discuss its research findings and future operations. At the meeting, they discuss significance of the findings and future operations in relation to the purpose of the Committee, and explore methods of application of research to dam operations.

In addition, the Watershed Ecology Research Conference for all four Committees is held once a year to facilitate exchange of views and links of activities among the Committees. General discussions are held towards proposing new plans for the management of rivers and dams, considering ecological interactions of ecosystems above the dam, in the reservoir and below the dam. A public seminar, open to the general public, is held at the same time to disseminate the outcome of watershed ecology research to a wider audience of some 300. In order to steer research directions, a special adviser has been appointed to give advice on the management of the Group as a whole and to help with occasional meetings with the chairmen of the Committees for the coordination and smooth operation of multidisciplinary research. The Water Resources Environment Technology Center (Foundation) acts as Secretariat for the Watershed Ecology Research Group and also procures research funds for the operation of the Committees. The Center takes responsibility in organising various meetings, seminars and conferences, collating their reports, database transfer on dams and watershed information to researchers, advice on field site selection, liaison with dam offices, administration and local authorities.

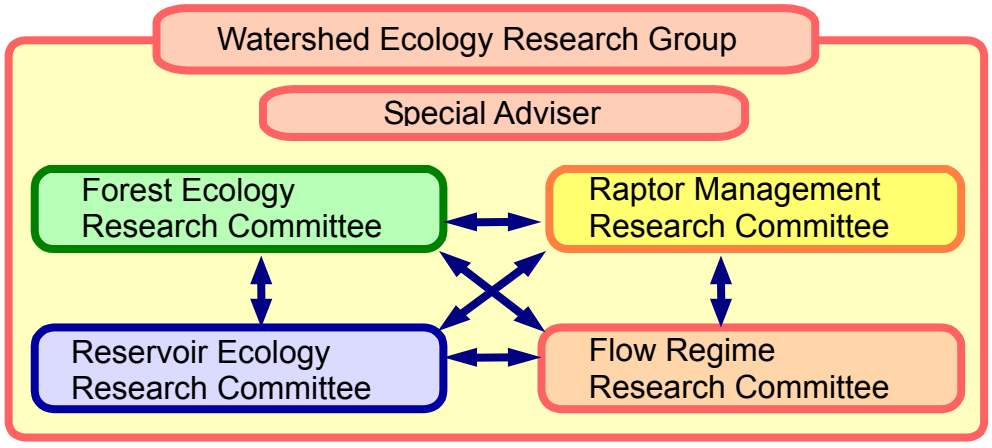

Figure 4. Organisation of the Watershed Ecology Research Group

3.2 Research Committees

1) Forest Ecology Research Committee

[Aims] How the forest of the basin is maintained, and if it is healthy or not, are important topics of study as they affect the state of the ecosystem including reservoirs. Forest Ecology Research Committee views the forest and the river as an integrated system. Its objective is to understand the structure and function of the forest ecosystem and its ecological interactions with the associated aquatic environment. It also aims to establish methods of evaluating these interactions and the responses of the forest to fluctuations of natural conditions and human impacts on them.

[Activities] In the early stages several independent projects were carried out: a study of the function of riparian forests as habitat of middle-sized mammals using the marten as a representative species; a study of the function of gaps in the beech forest; and a study of methods to assess the impacts of artificial structures on the riparian forest below the dam.

Since 2004 a new project has been conducted to assess the effects of impoundment of the dam on biodiversity and ecosystems through the modification of the land-water interface, using as targets, plants, mammals and insects around the site of the dam under construction on the Kase River of Saga Prefecture. In addition, collateral effects of impoundment on forest ecosystems are studied, using birds as indicators and utilisng existing data over 110 dams throughout the country. Also, a study has been initiated to elucidate the relations of topography and hydrology of the catchment area to drift wood and other objects entering the reservoir using existing data collected from about 200 dams throughout the country.

The results of the study in the riparian forest so far indicate a strong attachment of martens to the riparian forest, both for feeding and movements, and a possibility that the control of flow regime at the dam site influences the regeneration dynamics of the forest.

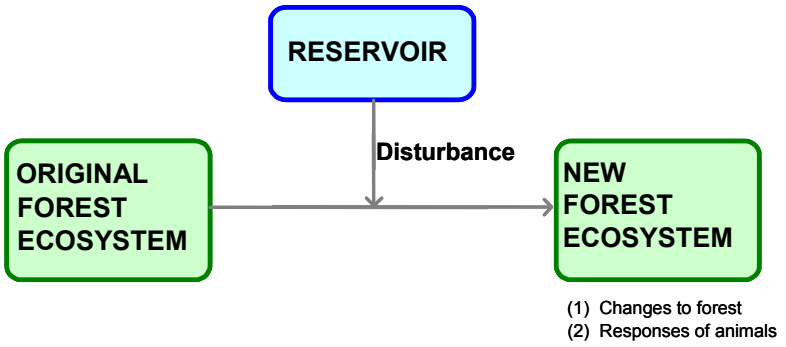

Figure 5. Study scheme of Forest Ecology Research Committee

2) Raptor Management Research Committee

[Aims] The site selected for dam construction often coincides with a territory of rare raptor species such as the golden eagle (*Aquila chrysaetos*) and Hodgson's hawk-eagle (*Spizetus nipalensis*). Thus it is important to conserve these species, if present, while proceeding with dam construction. These raptors occupy the pinnacle of food chains and are regarded as indicators of a healthy ecosystem. Raptor Management Research Committee studies the ecology of raptors and, through the understanding of their ecology, aims to establish methods of impact assessment of dam construction and effective conservation measures towards their coexistence with people.

[Activities] Raptor Management Research Committee aims to understand basic ecology of raptors and, in particular, the quality and quantity of their food items. They use CCD video cameras at selected nests of raptors to record prey animals brought to the nests and aerial photographs to analyse vegetation and the standing crop of food plants of hares, a major prey animal.

The future topic of study is to establish a method of evaluating influences of dam construction and operation on the hawk-eagles and construct their models. Towards this end, it is planned to work out the home range of hawk-eagles in their feeding and nesting habitats, to estimate the amount of food brought to the young and to follow the change of activities of young as they grow, including the process of their movements, dispersal and settlement.

Examples of research findings so far include clarification of prey animals fed to the hawk-eagle young in the nest as revealed by the CCD video camera and development of a new device to estimate the density of copper pheasants (*Syrmaticus soemmerringii*), an important prey species.

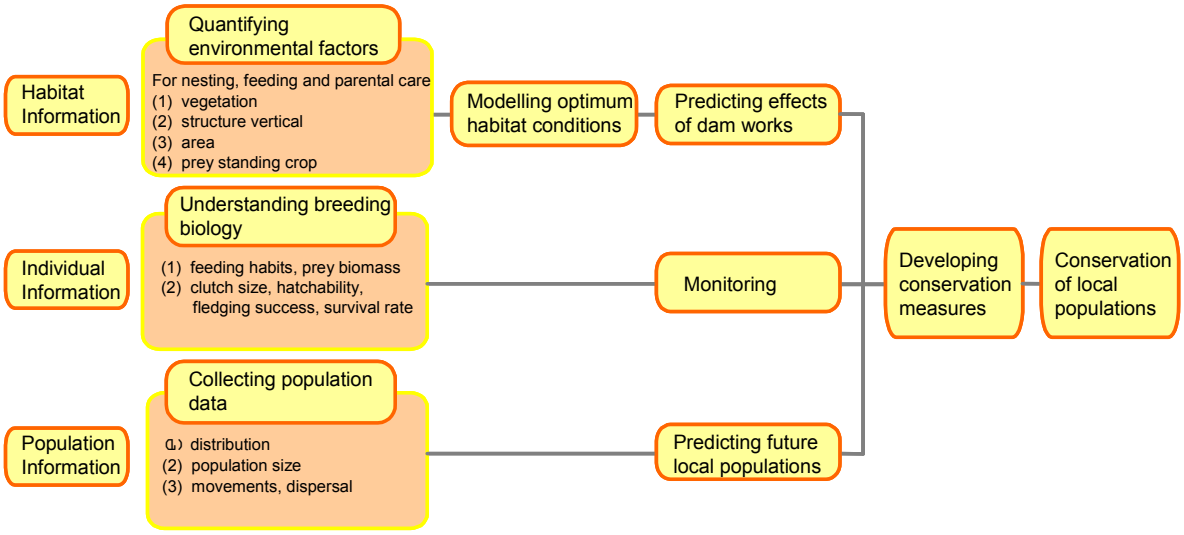

Figure 6. Study scheme of Raptor Management Research Committee

3) Reservoir Ecology Research Committee

[Aims] The reservoir created by the dam is a new ecosystem. It exerts a variety of influences over the surrounding ecosystems, for example, interrupting movements of animals, fragmenting their habitats, changing water quality of rivers above and below the reservoir and producing changes to the local atmosphere and weather. How best to manage the reservoir for organisms and the basin ecosystems as well as for people has become an important issue in recent years, and how to keep a balance among the different demands has become a subject of study. Reservoir Ecology Research Committee, supporting the notion of managing the reservoir with the method most appropriate for each specific river basin, aims to establish methods of studying the reservoir ecosystem and its dynamics and to arrive at operational plans for dam management that will minimise dam's adverse effects on the basin ecosystems.

[Activities] In the initial phase of the study, instead of investigating the physico-chemical properties of the reservoir or detailed biology of the ecosystem biota, the Research Committee examined the possible use of ducks and other water birds as indicators for evaluating the reservoir ecosystem, by looking at their species composition and reservoir utilisation patterns.

More recently, focusing on the aquatic biota and nutrient transfer within the river basin and the reservoir, and also considering the effects on the atmosphere and the basin ecosystem below the dam, the Committee has been carrying out diagnostic work of the reservoir ecosystem using stable isotope ratios and gaseous substances as indicators. Other important tasks of the Committee involve model building for nutrient cycle, incorporating functional groups of the ecosystem, and analysis of limnological and other characteristics of the reservoir ecosystem in comparison with natural lakes.

It is now possible to evaluate eutrophication of the reservoir and its process through the ecosystem using stable isotope ratios as indicators. Research results indicate a relationship between eutrophication and methane, a greenhouse gas, produced in the anaerobic environment, and a possibility of using methane discharge as an indicator of the health of the reservoir ecosystem.

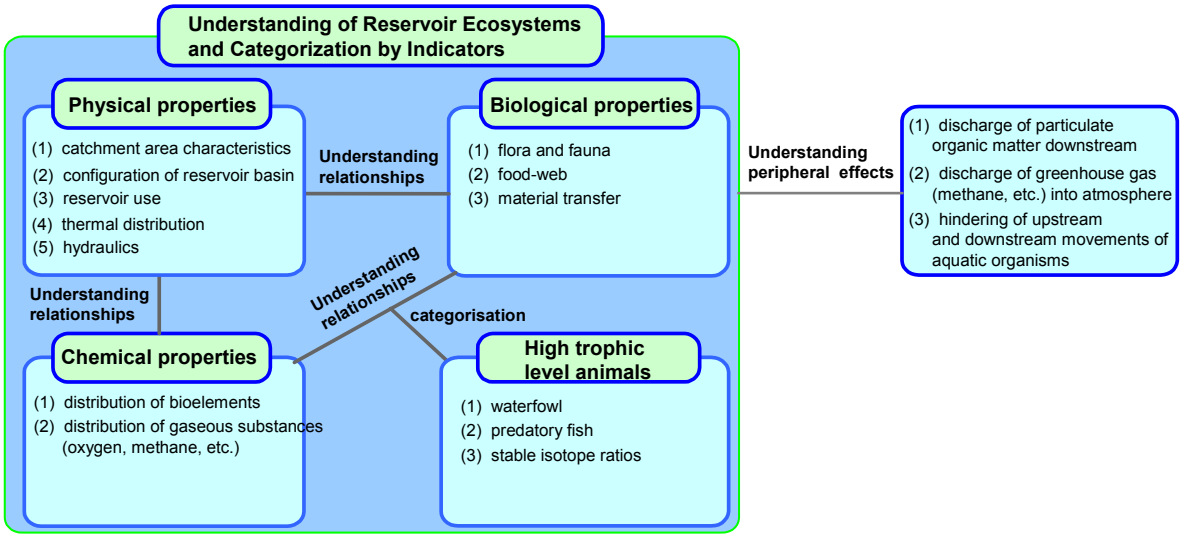

Figure 7. Study scheme of Reservoir Ecology Research Committee

4) Flow Regime Research Committee

[Aims] Rivers maintain diverse habitats for organisms as a result of certain disturbances, such as moderate flooding, erosion and sedimentation on the riverbed. Depending on the location within the basin, the presence of a dam exerts influences on the downstream ecosystem, not only by changing the flow regime of the river but also by changing the dynamics of its sand load, particulate organic matter, water temperature and quality. Flow Regime Research Committee analyses and categorises the actual effects of such changes to the downstream ecosystem. The Committee is investigating the rivers above and below the dam and the factors involved, including their magnitude, in several rivers that originate from dams with different situations in Kinki. The Committee aims to find suitable indicators with which to measure the magnitude of such effects and develop methods of mitigating adverse influences, and to present a framework of evaluating the effects of mitigation measures to be taken.

[Activities] Dam's influences on the river below the dam vary according to the degree to which the physical environment is modified by the infrastructure impact, such as dam's location in the river basin, the catchment area, reservoir capacity and the purpose of the dam. The effect

also varies depending on the degree to which the discharged water is modified by the operational impact, which causes changes to water volume, silt, water temperature, water quality and particulate organic matter. Moreover, the degree of influences on the downstream ecosystem is expected to vary according to the flow distance and the number of years since dam construction. In other words, changes at the dam source bring about changes to the downstream responses and self-restoration functions of the ecosystem. The range and degree of influences are further modified by the entry of tributaries and other factors. It is necessary to recognise the presence of these complex factors when measuring the effects of dam operation on the downstream ecosystem and predicting these changes. It is also desirable to approach this problem by identifying and analysing these factors as far as possible, including the degrees of their influences. In reality, the research is proceeding according to the flow chart shown below.

The results so far show that the 'armouring' process of the riverbed below the dam cause gravelling of substrate and produce biofilm with organic matter affecting the benthic fauna.

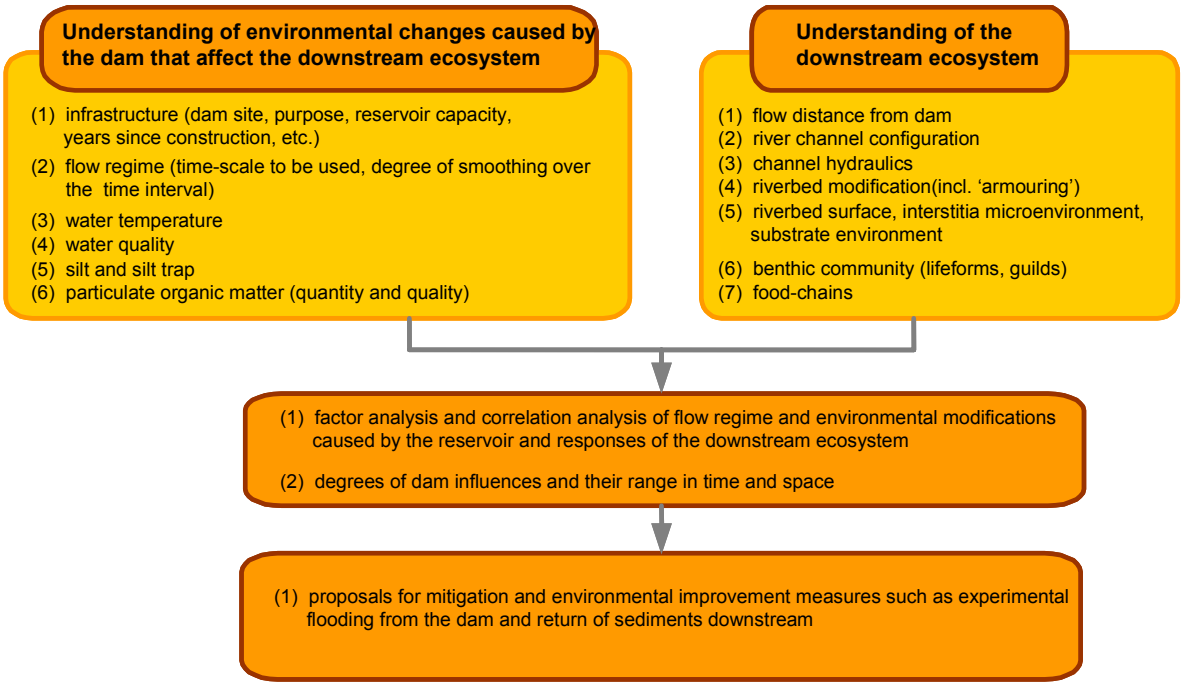

Figure 8. Study scheme of the Flow Regime Research Committee

3.3 Future Perspective

Individual Research Committees have conducted research successfully over 8 years and have accumulated a great deal of ecological and engineering data, but in reality there is still very few examples of any research outcome having been transferred or being transferred in the management of dams for the conservation of the natural environment. We, in the office of the

Secretariat, need to address this issue in the future by providing opportunities for further discussion and cooperation among the researchers and administrators.

The Watershed Ecology Research Group must also take up as its task for the future the comparison and evaluation of the enormous amount of survey and research results accumulated across the different Committees. New problems, not realised in the discussions within the Committee, will emerge from such exercises and will be overcome in the course of improvement and advancement of surveys and research. We may then expect further development of the Watershed Ecology Research Group and improvement of dam management for the conservation of the natural environment.

4 Concluding Remarks

There are interesting statistics on the water resources of Japan. Figure 9 shows a trend and fluctuations of annual precipitation over 100 years till the year 2004. There is a trend of gradual reduction in the amount of precipitation accompanied by an increase in the amplitude of variation in the amount. Climate change in recent years is considered responsible for these changes.

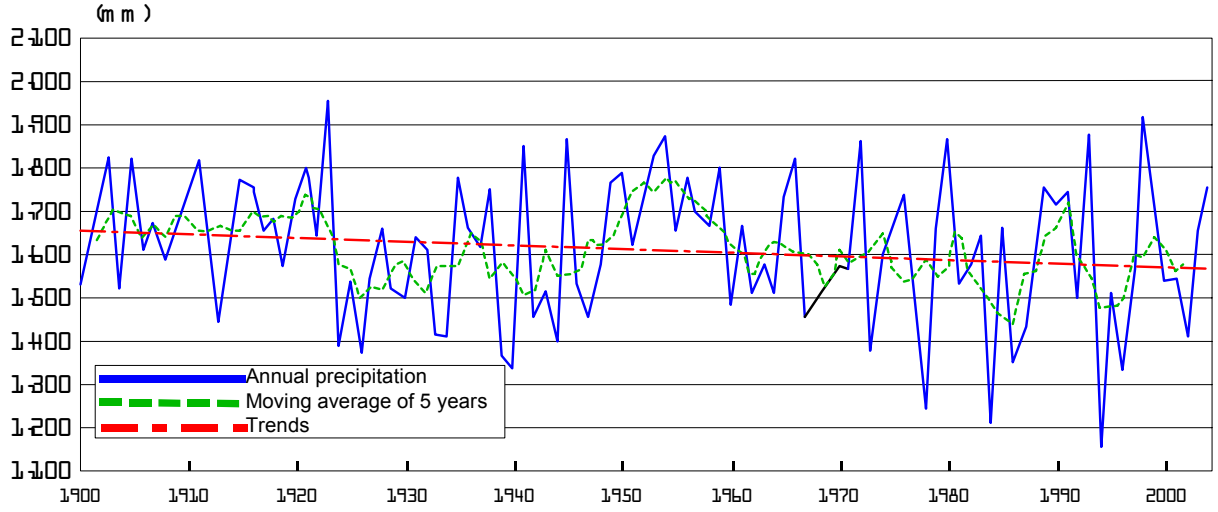

Figure 9. Fluctuations of annual precipitation in Japan

Arresting global warming is a most urgent global issue to be addressed by the entire world today. The Japanese Government is considering the construction of more reservoirs to respond to floods and draughts, which are expected to become more frequent as a result of global warming[8]. Accordingly, the importance of surveys and research on dams, watershed areas and river systems will increase in the future.

The two research groups outlined in this paper and introduced to this River Symposium are also addressing the question of energy flow through the river basin by investigating the mechanisms of

dynamics involving both the physical and living environments of rivers as a subject of study. Consequently, we consider that the role of the two research groups becomes important in addressing the climate change predicted in future. Our approach is not only for the benefit of the administration of river management, but also more importantly and hopefully for the legacy of the common asset of humankind and is an attempt to conserve the natural environment by combining the natural workings and human wisdom in a concerted effort of scientists and administrators springing from the watershed areas and rivers.

5 Acknowledgements

We wish to thank the Organising Committee of the 9th International River Symposium for the opportunity to present our paper and report on the river management and watershed conservation research in Japan. We also wish to thank Professor Jiro Kikkawa of Queensland University, acting as Special Adviser to the Watershed Ecology Research Group, for his encouragement and assistance in preparing the paper. We are indebted to the River Ecology Research Group and Watershed Ecology Research Group for their permission to present this paper from the offices of the Secretariat, and the members of the Groups and Committees and respective administrative offices for their support. We are particularly grateful to Dr Koji Omori of Ehime University and Dr Satoshi Yamagishi of Yamashina Institute for Ornithology for their comments on earlier drafts of the paper, and Hitomi Godo (RFC), Dr Hidetaka Ichiyanagi (WEC), Munehiro Igarashi(WEC), Iemasa Oomoto (WEC) and Professor Kazumi Tanida (Osaka Prefecture University) for their help with the preparation of the manuscript.

References

1 Japanese Ministry of Land, Infrastructure and Transport, “Water Resources of Japan” , Printing Bureau, Ministry of Finance, 2004.

2 National Land Agency, “Water Resources of Japan” , Printing Bureau, Ministry of Finance, 1994.

3 Ministry of Land, Infrastructure, and Transport, 2003 White Paper on Land, Infrastructure, and Transport in Japan, Gyosei, 2003.

4 Ministry of Land, Infrastructure and Transport, “FY 2001-2002 Program Evaluation: Dam Projects - Verification of the Various Regional Effects and Impacts”, March 2003.

5 Understanding the Natural Environment of Rivers. River Ecology Research Group of Japan, 2002.

6 Perspectives of Watershed Ecology Research, Watershed Ecology Research Conference, 2005.

7 Water Resource in Japan, 2005 edition, ~The Influence which Climatic Variation Gives to the

Water Resource~, Homepage of Ministry of Land, Infrastructure and Transport – River Bureau, Japan, 2005.
(http://www.mlit.go.jp/tochimizushigen/mizsei/hakusyo/H17/index.html)
8 “Stop the Warming” the Brochure, Homepage of Ministry of the Environment, 2006. (http://www.env.go.jp/earth/ondanka/stop2005/index.html)