WATERSHED ECOLOGY RESEARCH SEMINAR

A public seminar has been held once a year since 1998 on the day of the Conference to present results of Watershed Ecology Research from the Committees and further facilitate their research through discussions with members of the public. Some 300 participants including ecologists, engineers, riparian managers and practitioners participate the seminar each year.

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PERSPECTIVES OF WATERSHED ECOLOGY RESEARCH

～ Natural Surroundings of the Reservoir ～

Watershed Ecology Research Conference

ESTABLISHMENT AND OBJECTIVES

Today, environmental conservation is an important issue, not just for any specific region but everywhere in the world. Widespread also in Japan is the realisation that consideration for the environment and ecosystems is indispensable for the maintenance of human life and socio-economic activities. In 1997, the Environmental Impact Assessment Law was promulgated and the River Law was revised to expand the policy of attaching great importance to the environment. The River Law aims at maintaining and conserving the environment as well as flood control and water use in river management.

The river occupies an open space with a continuous directional flow of water from its source in the forested watershed through upper streams to the lower river. For the conservation of river ecosystems it is necessary to understand scientifically the entire system from the headwaters to the river mouth. In watersheds large dams have been constructed for the purpose of flood mitigation and water supply to support human life and to develop socio-economic activities. This has slowed down water flow and produced a new body of water in the reservoir in the upper reaches of the river. However, it is not clearly understood, even today, how the construction of dam walls, emergence of a water reservoir, associated riparian works and the maintenance and operation of the dam affect the neighbouring ecosystems. Also, reduction in the amount of sediments in the lower reaches of the river due to reduced water flow from the dam and the change in the quality of water due to storage of water have become concerns in recent years. The Watershed Ecology Research Conference was established in 1998 as an on-going conference of research teams to investigate these effects scientifically and to arrive at a desirable state of watershed ecology for the conservation of beautiful and biologically diverse rivers in Japan. Its Secretariat is located within the Water Resources Environment Technology Center (Foundation) in Tokyo.

ORGANISATION

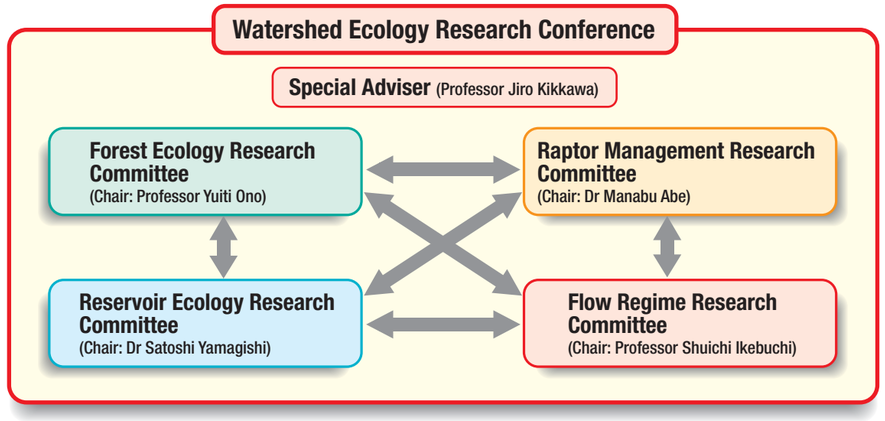
For assessing the effects of dam construction on the natural surroundings in relation to regional characteristics, we may divide the water system of the basin containing the dam into (1) the headwaters above the dam, (2) the artificial lake created by the dam and (3) the river below the dam. Accordingly, the Conference formed the following Research Committees

- 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.
- Raptor Management Research Committee: to pay special attention to the raptors that occupy the top positions of food-chains in watersheds, and study their ecology and develop conservation measures.
- Reservoir Ecology Research Committee: to evaluate the ecological roles of the reservoir, such as material transfer, and aims at proposing operational plans for the dam which take into consideration the health of the basin ecosystem.
- Flow Regime Research Committee: to study downstream ecosystems, particularly the influence of dam operation on the habitat of diverse biota and methods to mitigate its adverse effects.

Each Research Committee has a core of university researchers and research is conducted in respective fields including dam sites.

The Watershed Ecology Research Conference for all 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 Special Adviser has been appointed to give advice for the management of the Conference as a whole.



FOREST ECOLOGY RESEARCH COMMITTEE

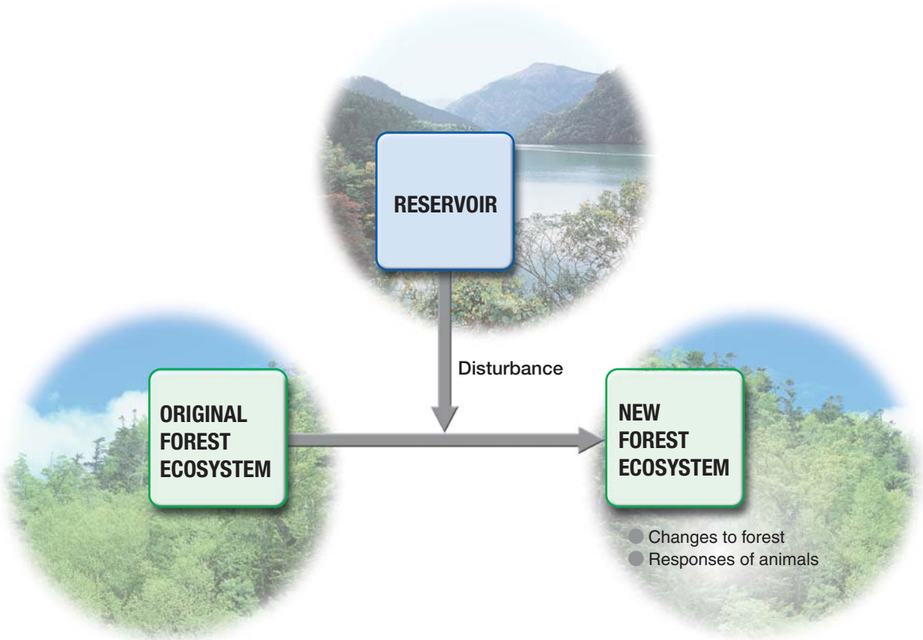
【Aims】

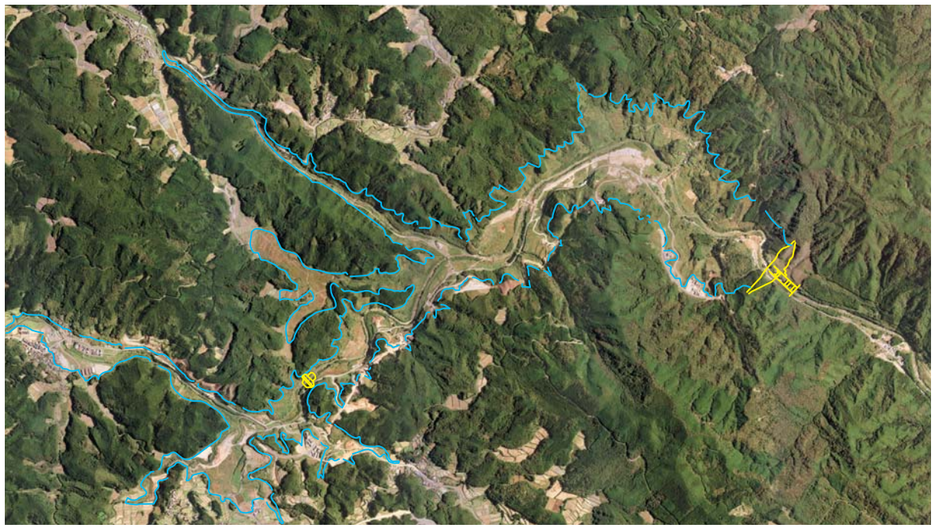
Formation of a reservoir following dam construction reduces a considerable amount of forest vegetation in the region and transforms the 'ecotone' between the aquatic and terrestrial environments. How the forest of the basin is maintained, and if it is healthy or not, are important topics of study as they affect the state of the ecosystems including reservoirs. The Forest Ecology Research Committee views the forest and the river as an integrated system, and aims to understand the structure and function of the forest ecosystem and its ecological interactions with the associated aquatic environment and 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 a habitat of middle-sized mammals using the marten as a representative species, a study of aquatic communities, mainly of fish, as influenced by the presence of riparian forests, 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 utilising existing data on 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.





(above): The Kase River dam site, Saga Prefecture. At this common field-site of the Forest Ecology Research Committee the effects of modifications to the land-water interface on biodiversity and ecosystems are being studied continually since prior to the impoundment of the dam. In the picture yellow lines indicate the dam wall and the blue lines the expected boundaries of the reservoir.

(left): A Japanese marten, *Martes melampus melampus*, carrying a radio-transmitter. The feeding habits and behaviour of the Japanese marten as a representative animal of the riparian forest are studied for elucidating the effects of changes to the shoreline zone on the animals.

Research Findings of the Forest Ecology Research Committee

In the study of martens as a representative animal it was found that feeding activities and movements of the marten are confined to the riparian forests. In the study of gaps in the beech forest a method to quantify forest vegetation in three dimensions has been developed and influences of the gap as mosaic structures on biotic communities have been demonstrated. In the study of lower-reach riparian forests the relationship between the life history of trees growing in them and disturbances caused by flooding has been elucidated, and predictions have been made of the effects of flow control through dam operation on the regeneration dynamics of riparian forests using the models developed from this study.

Main publications

1) Arai, S., Adachi, T., Kuwahara, Y. and Yoshida, K. (2003) Food habits of the Japanese marten (*Martes melampus*) at Kuju Highland in Kyushu, Japan. *Honyurui Kagaku* (*Mammalian Science*) 43, 19-28. (in Japanese)

2) Hotta, M. and Ezaki, Y. (2001) Intra- and interspecific relationships for cavities among cavity-nesting birds, particularly on studies with natural cavities. *Jpn. J. Ornithol.* 50, 145-157. (in Japanese)

3) Ida, H., Hotta, M. and Ezaki, Y, (2004) Predispersal predation by rodents to beechnuts (*Fagus crenata* Blume). *Ecol. Res.* 19, 503-509.

4) Nakamura, F. (1999) Influences of dam structure on dynamics of riparian forests. *Ecol. Civil Eng.* 2, 125-139. (in Japanese)

5) Nakamura, F. (1999) Conservation of riparian environments and roles of landscape ecology. *Kagaku* (*Science*, Iwanami) 69, 1029-1035. (in Japanese)

Plus 9 other reports.

RAPTOR MANAGEMENT RESEARCH COMMITTEE

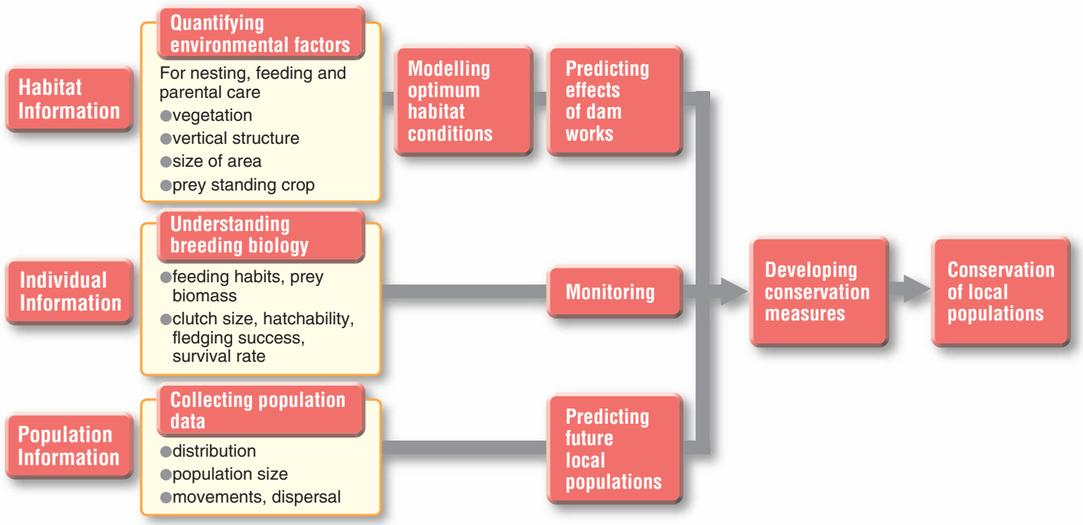
【Aims】

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 (*Spizaetus nipalensis*). Thus it is an important task 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. The Raptor Management Research Committee intends to accumulate basic ecological data on the 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】

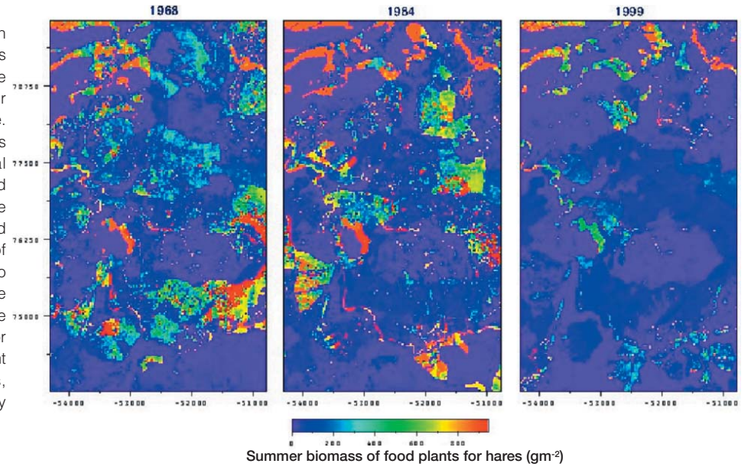
Not just raptors but all animals are supported by their habitats, and the quality of the habitat governs their success or decline as a species. In other words, food availability, nesting sites, prey production, feeding areas, spatial relations with other individuals, etc. determine the survival of raptors. The Raptor Management Research Committee has been collecting data using a CCD video camera at the nest of the goshawk (*Accipiter gentiles*), honey buzzard (*Pernis apivorus*), osprey (*Pandion haliaetus*) and Hodgson's hawk-eagle. Also, special attention has been paid to the large raptors and their prey, especially the hare (*Lepus brachyurus*). Vegetation as their habitat has been analysed from aerial photographs and the standing crop of their prey (hare) estimated. The hare population available as prey to raptors has also been studied. As for the copper pheasant (*Syrmaticus soemmerringii*), another important prey animal of large raptors, there is no established method to estimate the population size, and efforts are being made to devise an effective census method.

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



(right): A picture taken by a CCD camera placed at a hawk-eagle's nest. CCD video cameras have been placed at the nests of rare raptors, such as Hodgson's hawk-eagle, to investigate their breeding ecology with continuous recording of activities at the nests.

(right): Spatial distribution of food plants for hares and its historical change in the Kurihara River basin of Gunma Prefecture. Vegetation height was calculated from aerial photographs, and the food plant density over large areas was estimated from the correlation of vegetation height to biomass obtained from the study in the field. The biomass of food plants for hares, which are important prey of large raptors, decreased dramatically over 30 years.



Research Findings of the Raptor Management Research Committee

From the analysis of images obtained by the video camera at the nest it was found that Hodgson's hawk-eagle preyed on a variety of animals besides hares, copper pheasants and snakes, which had been considered as its main prey. For estimating the density of copper pheasants as a prey species, a method of line transect census specifically modified for the copper pheasant has been proposed. In addition, vegetation height calculated from aerial photographs and the correlation of vegetation height to biomass obtained from the field study gave estimates of hare's food-plant biomass from a large area over many years. The results revealed a decline of the food-plant biomass of hares, an important prey, in recent years.

Main publications

1) Abe, M. (ed.) (2001) *Present Status of Raptors in Japan and Advanced Research Techniques*. Technology Information Institute, Tokyo. (in Japanese)

2) Abe, M. (2001) *Sylviculture for Conserving Biodiversity and Raptors*. Japan Forestry Technology Association, Tokyo. (in Japanese)

3) Kawaji, N., Yamaguchi, Y. and Yano, Y. (2002) The fate of captive-bred copper pheasants *Syrmaticus soemmerringii* released in Tochigi Prefecture, eastern Japan. *J. Yamashina Inst. Ornithol.* 34, 80-88.

4) Kawaji, N. (2002) The current status of the copper pheasant and its conservation problems – towards effective population management of game birds. *Sanrin* (*Forests*) 1415, 54-59. (in Japanese)

5) Nakashizuka, T. (2001) Application of canopy dynamics in landscape research. *Bull. Intern. Assoc. Landscape Ecol. – Japan* 6, 5-8.

6) Yamaguchi, Y. and Kawaji, N. (2003) Habitat use of the copper pheasant *Syrmaticus soemmerringii* in central Japan. *Bull. Forestry and Forest Products Res. Inst.* 2, 193-198.

Plus 14 other reports.

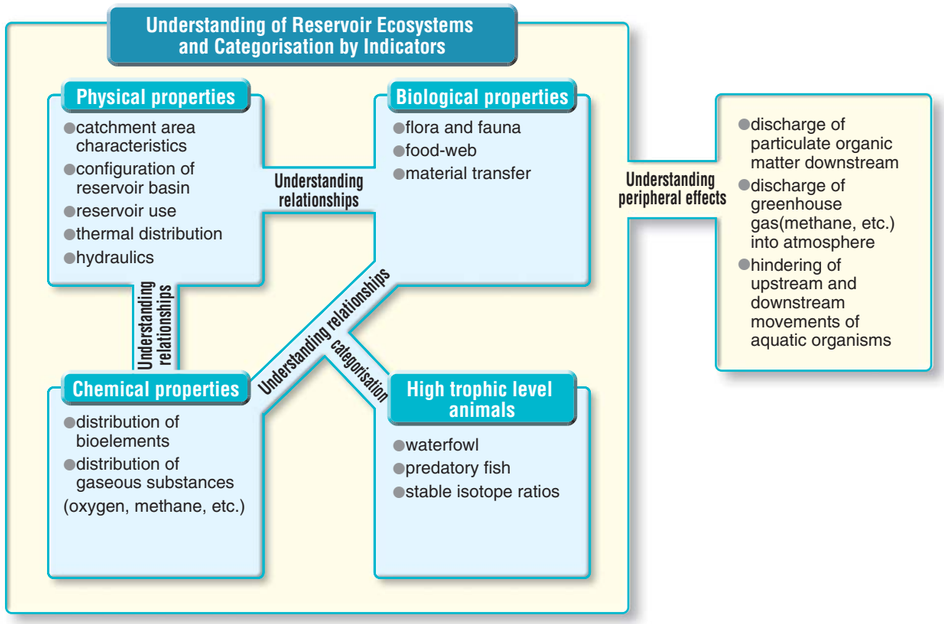
RESERVOIR ECOLOGY RESEARCH COMMITTEE

【Aims】

The backwaters of a dam form an artificial lake, where a new ecosystem is created. This reservoir exerts a variety of influences over the surrounding ecosystems, for example, interrupting movements of animals, 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. The 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 methods of dam management, which minimise dam's adverse effects on the basin ecosystems.

【Activities】

In the initial phase of the study, instead of investigating physico-chemical properties of the reservoir or detailed biology of the ecosystem, 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. Later, focusing on the aquatic biota and material transfer within the river basin and reservoir, and also considering the effects on the atmosphere and the basin ecosystem below the dam, the Committee has been carrying out diagnosis of the reservoir ecosystem using the stable isotope ratios and gaseous substances as indictors, model building for material transfer incorporating functional groups of the ecosystem and analysis of limnological and other characteristics of the reservoir ecosystem in comparison with natural lakes.



(left): Backwaters of a dam in watersheds. Compared to natural lakes, the reservoir as an artificial lake generally changes its water level greatly in a complex manner as it is managed for water resource utilisation and flood control. It is also characterised by steep slopes along the shorelines and poorly developed littoral zones. What sorts of ecological characteristics these features produce is a question being studied in comparison with natural lakes.

(right): A pochard (*Aythya ferina*). In many reservoirs in Japan the diving ducks, such as the pochard, characteristically appear only where shallow waters exist. In Japan dams are often constructed in mountainous regions, lacking shallow waters in the reservoir. This fact is reflected in the fauna as seen in ducks.

Research Findings of the Reservoir Ecology Research Committee

An optimum method of management for reservoir ecosystems is being examined on the basis of balance in material transfer. The water quality that maintains the healthy river ecosystem below the dam is defined for the water discharged from the dam. Estimates based on the river ecosystem model showed the upper limits of TN = 1 ppm and TP = 0.25 ppm and the lower limit of TN = 0.1 ppm, the limiting concentration for attached algal growth. It was found that indicators based on the analysis of stable isotopes would reveal eutrophication and enable evaluation of its process in the reservoir ecosystem. The indicator shown to be effective was the ratio of nitrogen isotope in piscivorous fishes. Discharge of methane, a greenhouse gas produced in the anaerobic environment, was found to be greater from excessively eutrophicated reservoirs than that from natural lakes. It is now expected that the amount of methane discharged would indicate the health of the reservoir ecosystem. The optimum quality of reservoir water is being calculated from the reservoir ecosystem model. From the relationship of TP - Chl a obtained from 100 dams in Japan the optimum water quality was estimated to be TP = .025 ppm (Chl a = 10 μg/L).

Main publications

1) Mahaulpatha, D., Mahaulpatha, T., Nakane, K. and Fujii, T. (2000) Factors affecting the distribution of waterfowl wintering in the inland water of the Saijo Basin in western Japan. *Jpn. J. Ornithol.* 49, 167-173.

2) Mori, Y., Kawanishi, S., Sodhi, N.S. and Yamagishi, S. (2000) An evaluation of waterfowl sampling methods for the national census on river and dam lake environments. *Ecol. Civil Eng.* 3, 93-102.

3) Mori, Y., Kawanishi, S., Sodhi, N.S. and Yamagishi, S. (2000) The relationship between waterfowl assemblage and environmental properties in dam lakes in central Japan: implications for dam management practices. *Ecol. Civil Eng.* 3, 103-112.

4) Mori, Y., Kawanishi, S., Sodhi, N.S. and Yamagishi, S. (2001) The effect of human disturbance and flock composition on the flight distances of waterfowl species. *J. Ethol.* 19, 102-106.

5) Nakamura, M. and Atsumi, T. (2000) Adaptive significance of wintering pair bond in male pintail, *Anas acuta*. *J. Ethol.* 18, 127-131.

6) Shimizu, Y. and Nakamura, M. (2000) Mutual and parasitic mixed-feeding association in waterfowl: a food-addition experiment. *Jpn. J. Ornithol.* 49, 17-30.

7) Yamada, Y. and Nakashima, S. (2003) Availability of the stable isotope ratios as the standard indicator in basin research. *Jpn. J. Limnol.* 64, 197-202. (in Japanese)

FLOW REGIME RESEARCH COMMITTEE

【Aims】

Rivers maintain diverse habitats for organisms by receiving certain disturbances, such as moderate flooding, erosion and sedimentation on 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. The Flow Regime Research Committee analyses and categorises the actual effects of such changes on 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 the Kinki District. 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 dam construction, such as its 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 operation of the dam, which causes changes to water volume, silt, water temperature, water quality and particulate organic matter through physico-chemical and biological processes within the reservoir. 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 work 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.

Understanding of environmental changes caused by the dam that affect the downstream ecosystem

- dam-origin (location, purpose of dam, reservoir capacity, number of years since construction, etc.)
- flow regime (time-scale to be used, degree of smoothing over the time interval)
- water temperature
- water quality
- silt and silt trapping
- particulate organic matter (quantity and quality)

Understanding ofthe downstream ecosystem

- flow distance from dam
- river channel configuration
- channel hydraulics
- riverbed modification (incl. 'armour-coating')
- riverbed surface, interstitial microenvironment, substrate environmentl
- benthic community (life-forms, guilds)
- food-chains

↓

- factor analysis and correlation analysis of flow regime and environmental Modifications caused by the reservoir and responses of the downstream ecosystem
- degrees of dam influences and their range in time and space

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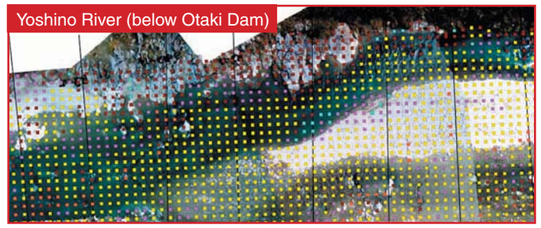
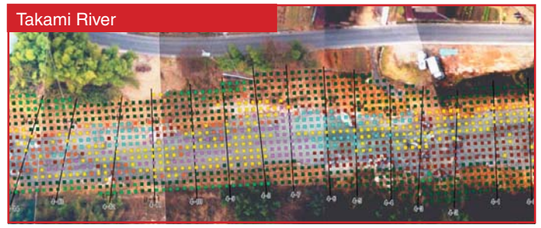
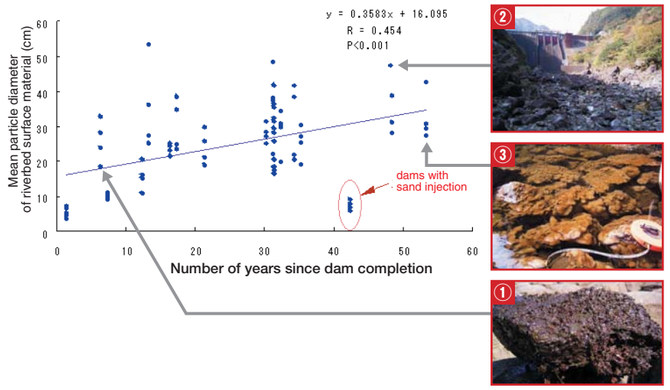
- proposals for mitigation and environmental improvement measures such as experimental flooding from the dam and return of sediments downstream





(left): Distribution of riverbed materials as seen in low-level aerial photographs of the river channels of the Yoshino River below Otaki Dam and its tributary, the Takami River. Investigation of the riverbed materials is being made downstream from Osako Dam completed over 30 years ago and newly constructed Otaki Dam in the Yoshino River, and in the Takami River where there is no dam. The pictures show major riverbed materials in different colours painted over low-level aerial photographs.



(right): Increase in particle size and development of biofilm below the dam. As years pass since dam construction the riverbed materials become coarse.

1) Downstream from Hiyoshi Dam, 6 years since completion in 1998. No biofilm develops on the riverbed surface but hydropsychid caddis fly cases appear in high density below the newly constructed dam.
2) Downstream from Miyakawa Dam, 48 years since completion in 1956. Increase in particle size of the substrate is conspicuous.
3) Downstream from Yasukawa Dam, 63 years since completion in 1951. Below the old dam sediments become coarse and biofilm develops on the surface.

Research Findings of the Flow Regime Research Committee

Monitoring of rivers in early stages of dam impoundment clarified the changes of river channel configuration, gravelling of riverbed materials and initial changes to the benthic fauna at the downstream sites. The composition of benthic communities seems to reflect the effects of hydraulic changes in the past as well as environmental conditions at the time of study. At several established dams 'armour-coating' below the dam brought about biofilm on the conglomerate of organic matter and silt, affecting the benthic fauna.

Main publications

1) Hatano, K., Takemon, Y. and Ikebuchi, S. (2003) Evaluation of the impact of water-storage dam on lower river ecosystems – response of the substrate structure and benthos communities –. *Ann. Disaster Prevention Res. Inst., Kyoto* University 46B, 851-866. (in Japanese)
2) Osugi, T., Fukuda, K. and Izumida, T. (2003) Influence of flow regime modification during the first filling water on benthic communities in downstream of a dam. *Adv. in River Eng.* 6, 179-184. (in Japanese)
3) Tanida, K. and Takemon, Y. (1999) Effects of dams on benthic animals in streams and rivers. *Ecol. Civil Eng.* 2, 153-164. (in Japanese)
4) Tanida, K. (2003) Evaluation of dam projects and conservation of ecosystems. *Kasen* (*River*) 2003 (6), 7-12. (in Japanese)
5) Tsujimoto, T. (1999) Effects of dams on physical environment of rivers – from the aspects of river engineering and hydraulics – . *Ecol. Civil Eng.* 2, 103-112. (in Japanese)

Plus 17 other reports.