

Fish and riparian ecotones – a hypothesis*

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Abstract

Authors present the hypothesis that freshwater fish diversity, recruitment and production depend greatly on riparian ecotones. These boundary environments are usually the most diverse elements of aquatic systems. Riparian ecotones moderate the transfer of energy and materials from the land, provide a high load of organic matter including invertebrate food, and moderate competition and predation among animals living in them. Riparian ecotones provide feeding places and shelter for fish, and are particularly important for their reproduction and earliest life-history stages. The complexity and biological importance of riparian ecotones depend on the extent to which the system is self-regulating, which depends in turn on geology, physiography, climate, vegetation, human activity and the age of the system. By changing riparian ecotone character, fish density can be regulated through controlling reproduction and recruitment, and energy flow through the food chain can be controlled for management of water quality.

Key words:

**The above paper was opening the first symposium of UNESCO MAB FLIWE held in Kraków – Mogilany in March 1991. The Editors decided to publish this paper considering that readers of this special issue might be interested to follow the pattern of FLIWE development and evolution, during five years, in sense of concept, hypothesis and ways of experimental testing. Besides, one may consider such exemplification as an unconventional tool to be used for anticipation of future trends in ecology and environmental sciences.*

Ecotones of riverine ecosystems: Rôle and typology, spatio-temporal dynamics, and river regulation

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Abstract

Natural riverine ecosystems are characterized by a high level of heterogeneity manifest across a range of spatio-temporal scales. Ecotonal habitats are both the result of and contributors to the spatio-temporal dynamics of riverine ecosystems. Natural disturbances play an important rôle in maintaining a diversity of ecotonal habitats. A typology of riverine ecotones is developed that provides an expansive perspective scaled along four dimensions (longitudinal, lateral, vertical, and temporal) and that encompasses environmental gradients and boundaries as well as distinct transition zones between adjacent patches. From this broad perspective it is apparent that riverine ecotones play important rôles relating to speciation, evolutionary invasion of fresh waters, biodiversity, bioproduction, and ecological connectivity. River regulation disrupts the natural disturbance regime downstream, thereby reducing the diversity of ecotonal habitats and their connectivity with the main river channel. The altered rôle of ecotonal habitats induced by regulation is especially pronounced in alluvial floodplaining rivers, which are characterized by a mosaic of habitat patches that collectively occupy a wide range of successional stages. Downstream hydrologic changes, such as truncated sediment transport and reductions in the frequency and intensity of flooding, typically lead to altered successional trajectories, desiccated floodplain waterbodies, severed migration pathways, and reduced exchange rates of nutrients and organic detritus across ecotone boundaries. Effective management of regulated rivers should focus on maintaining or restoring the important rôles of ecotones by re-establishing interactive pathways and by reconstituting a disturbance regime that leads to a diversity of habitat patches and successional stages.

Key words: riverine ecotones; river regulation; succession; connectivity; disturbance regime; scale; boundary flows; biodiversity

Conceptual framework for the analysis of riparian influences on fish and invertebrate assemblages

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Abstract

The paper questions the usefulness of the static concept of the habitat as a templet in analyses of the influence of the riparian environment on the dynamics of riverine fish assemblages. Studies on the effect of deforestation on the water quality and invertebrate assemblages in upland streams in mid-Wales found that changes in the nature of the riparian habitat caused by logging had relatively few unambiguous effects. A 22 years study of the population dynamics of a short-lived species, *Gasterosteus aculeatus*, inhabiting a backwater of a small river in west Wales, found that population characteristics were relatively stable although the study included periods of record drought and irregular episodes of flooding. The literature relating riparian characteristics to fish assemblages also illustrates the weakness of the static "habitat as templet" model. A more dynamic concept is required. Life histories can be viewed as sampling devices through which the habitats available can be explored and utilised by fish. Models should direct attention to the extent to which the biological characteristics of species based on the phenotypes of individuals in the species populations define the interactions between the riparian environment and the riverine invertebrate and fish assemblages. The emphasis needs to shift to quantitative effects of riparian influences on the movement, growth, mortality and reproduction of individuals in riverine populations.

Key words: habitat; templet; deforestation; population dynamics; stickleback.

Large rivers: the relevance of ecotonal structure and hydrological properties for the fish fauna

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Abstract

Fish diversity, population dynamics and production of fish depends to a large extent on the compound and often controversial effects of water level fluctuations. To balance their positive and negative effects the structural properties of the river-floodplain systems are important. Stochasticity of flood pulses control population size. Physical disturbances apparently are of higher significance in controlling fish community structure than biological interactions (River regulation and reduction of shoreline structure enhances the negative effects of flood pulses. Short spates during early summer are apparently most destructive, while strong year classes are linked to higher water levels in spring and lower water levels in summer. Apparently the gradual decline in the population size of characteristic rheophilic species in the larger European river systems is a long-term consequence of the major river regulation schemes in the late 19th century because the buffer capacity of richly structured inshore zones have been diminished.

Especially the 0+ stage of fish form excellent indicators for the diversity and function of riparian ecotones, which can be successfully applied in river engineering, nature conservation and landscape management.

Key words: floodplains, wetlands, river regulation, restoration, 0+ fish, bioenergetics

Riparian ecotones, invertebrates and fish: life cycle timing and trophic base.

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Abstract

Riparian ecotones are either within the bankfull lines (instream ecotones) or beyond (bank vegetation and floodplains). Instream ecotones (e.g. gravel bars) are most intimately and permanently interconnected with the stream system. The third order river Melk was channelized some decades ago with devastating effects on the fish fauna. The restoration of instream ecotones and of the riparian vegetation improved the fish population immediately. Instream ecotones are equally important for the fish community in high order streams. Data are given for the 9th order Danube. The duration of floodplain inundation is unpredictable but generally short in the temperate climatic zone. Fish do not migrate far into the inundated terrestrial vegetation but stay in or near to the enlarged backwaters. In backwaters separated from the main stream, a potamal fish population survives in an otherwise rhithral stream section. Floodplain inundation is predictable and lasts over long periods in the tropics. Fish and invertebrates are adapted to use the vast resources of habitats and food by active migration into the inundated forests.

Key words: ecotones, inshore structures, invertebrates, fish

Challenges to freshwater management

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Abstract

Water (including increasing use relative to availability, and deteriorating quality) may be one of the most severe stresses on the exponentially growing human population in the next century. Problems are becoming increasingly complex and diverse and require more and more specific knowledge from both a technical and non-technical perspective. These complexities create the need to understand and comprehend the more detailed technical components as well as broader managerial and societal issues. These non-complementary elements will increasingly demand the efficient integration of various disciplines, sectors, countries, and societies. The major challenges addressed are whether we are capable of and prepared to realize the needed integration and whether we can resolve the large amounts of existing gaps and barriers. The paper analyzes major past and desired future trends in fresh water management. There is an attempt to draw from the three main socio-economic regions: the developed world, Central and Eastern Europe (including countries of the former USSR) and the developing world. A number of issues are selected with regards to integrated freshwater management:

- Identification, occurrence, and perception of various problems (e.g. eutrophication, acidification, global warming, salinization, groundwater contamination, eco-system degradation, land cover changes, vulnerability);
- Current integration of methodologies; their strengths and weaknesses;
- Large scale projects; dams, irrigation schemes and water transfers;
- Global urbanization;
- Wastewater treatment and pollution control types (considering also consumption emissions);
- Modeling and monitoring;
- Planning and environmental impact assessment;
- Legislation and institutions;
- Education and public awareness;
- Sustainable development and time preference;
- The role of science and engineering.

The past two decades showed tremendous developments in the management of water as seen from many different perspectives. In spite of these advancements there is still room for

improvement. The focus of the present discussion lays mostly on the dissemination of lessons and questions which are crucial to likely future problems and desired improvements.

Key words: freshwater management, sustainability, global change, urbanization, integration, developing world

Economic aspects of agricultural areas management and land/water ecotones conservation

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Abstract

Today's management of agricultural areas is hardly in accordance with actual economic and ecological goals. In view of the future risks for the global system a revolutionary change within our current land use systems is essential. The paper gives an example of a workable strategy for agricultural policy based on the internalization of external burdens into a market price system as well as the expansion of property rights. Then it explains why sensible perspectives do exist, but are still not transformed into practical political measures or reforms

Key words: ecological economics, agricultural policy, eco-farming, land use concepts, energy production

Planning approaches to mitigate adverse human impacts on land-water ecotones

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Abstract

Land-inland water ecotones are environments of exceptional diversity, but are also highly vulnerable to impacts from human settlement. Settlement on floodplains and exacerbation of peak runoff from land-use changes have resulted in flood damage to human structures, leading in reaction to widespread efforts to control flooding through such measures as land drainage and construction of levees and artificial flood control channels. These measures increase flood hazard downstream and result in loss of valuable riparian and aquatic habitats. Similarly, human settlements along river banks may be threatened by natural channel migration, leading to ill-conceived bank stabilization projects, which eliminate riparian habitat. Environmental planning strategies to minimize these impacts include reducing stormwater runoff through use of permeable pavement, infiltration galleries, and detention basins; ordinances protecting urban streams and riparian corridors (from development, filling, etc.); prohibitions or restrictions on development on floodplains; retention of vegetative buffer strips along stream channels; maintenance of continuity of riparian corridors for wildlife and human use; use of alternatives to traditional flood control strategies; and release of flushing flows to mimic effects of natural floods below reservoirs.

Key words: stream restoration, riparian management zones, environmental planning

Aquatic habitat inventories using remote sensing

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Abstract

Increasing emphasis is being placed on managing aquatic resources on an integrated, basin-wide basis. Traditional ground inventory methods are time-consuming and expensive, and are not easy to integrate over large areas. Remote sensing, combined with Geographic Information Systems (GIS) and Geographic Positioning System (GPS) technology, offers a more flexible, cost-effective method for gathering and integrating information. Digital terrain models, spectral separations, and microwaves can be used to define physical and biological features. Habitat conditions in a basin can be defined by four basic elements: climate, geomorphology, vegetation and human activities. All of these can, to different degrees, be directly inventoried by remote sensing. When used with GPS and GIS systems, remote sensing information can be merged with field data and other sources of information to create an integrated summary of resource conditions. Information can be summarized on a range of scales, from local to region-wide, and can be compared over time as a monitoring and evaluation tool.

key words: remote sensing, aquatic habitat inventory

New environmental indices for assessing bank quality in the restoration and the sustainable management of a river: the method

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Abstract

Development culture, based on the dominance of man over nature and the built over the natural, continues to predominate. To take one example, the demands of an ever-increasing number of amateur fishermen are satisfied by financing the continuous re-stocking of rivers with juvenile or small-size fish while ignoring the extinction of native species, and the damage caused by the introduction of non-native species. This method of management, and the slow acceptance of the concept of environmentally sustainable planning, is partly due to the slow translation of the results of biological and ecological research into the standardised and integrated parameters of environmental analysis necessary for planning. The new Indices for assessing river-bank quality (developed for the River Adige but tested on other rivers) may well provide a useful step forward. These Indices, combined with others already in use or under development, may help to define a system of areas of differential tutelage along the course of a river and in the surrounding territory in which human activities and development will be compatible with conservation and rehabilitation of the river's self-purifying capacity, while at the same time allowing for effective flood defence and the reproduction of native fish species.

Key words: buffer strip index, wild state index, environmental landscape indices, sustainable management.

Hydrological processes in water and land ecotones

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Abstract

Water and land ecotones harbour complex interactions of hydrosphere, biosphere, atmosphere and lithosphere. Exchange processes at their interfaces involve multiple feedback mechanisms which to a large extent affect the overall conditions on earth.

Hydrological processes affect ecotones and *vice versa*. The paper outlines briefly some of the effects and gives examples of ecotones in arid and urban environments.

Key words: ecotones, hydrology, arid, urban

Populations of fish in relation to riparian ecotone development in the Narew river catchment

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Abstract

Number of species (S), density (N) and standing crop (B) were investigated in 331 sites in the catchment of the Narew River, the biggest tributary of the Vistula, against 4 categories of riparian ecotone intensity in various-width rivers. All populations were first analyzed together, then within the scope of three most abundant ecological spawning groups. The image obtained is to some extent blurred by anthropogenic alterations as well as human-created ecotones, yet it is evident that a total lack of bankside trees had a negative impact on the values of S, N and B of all investigated populations. Exceptions are only small streams of the Bialostocka Upland, where at a high percentage of submerged vegetation and occasionally stony bottom (washed away moraine bars), the lack of riparian trees did not cause any decrease in any of the three populational parameters. The uninterrupted compact forestation of the banks was positively correlated with S, N and B only in the lower Narew River, where the river bed was more than 100 m wide, hence where the access of light was not already limited. For lithophilous species a river's naturalness was a more important factor conditioning their abundance than the development of riparian ecotones. Indifferent species displayed a high, positive dependence on the development of ecotones, while phytophils (whose development is vegetation-dependent) formed the most qualitatively and quantitatively abundant populations at a weak, and in some rivers, even medium forestation of the banks.

Key words: Poland, anthropogenic alterations, fish diversity, fish density, standing crop, ecotone importance.

The role of the shoreline ecotonal zone in spawning success and early life history of dominant fish species in the lowland Sulejow Reservoir.

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Abstract

The roach preferred branches of spruce and juniper as artificial spawning substratum rather than pine and birch. Perch preferred birch over conifers. Thus altering the availability of spawning substrata in the littoral zone should be effective in controlling the density and structure of juvenile roach and perch communities in reservoirs. Density dependent processes affects the early life history of fishes. Surveys in the Sulejow Reservoir in 1994 and 1997 provide an example of how increased availability of prey fish in the littoral zone may influence a predator population. During early summer age-0 pikeperch formed two discrete groups, one in the littoral and the other in the pelagic zone. In the littoral pikeperch became piscivorous at c. 3 cm on the numerous juvenile cyprinids, and grew relatively fast (5.2->9 cm by mid-July 1994). Those in the pelagic where prey fish were scarcer fed chiefly on zooplankton and grew relatively slowly (4.2-6.6 cm by mid-July 1994). From the resulting bimodal length distribution the upper modal group (littoral) had a higher probability of surviving their first winter. These data suggest a critical role for the ecotonal habitats in the dynamics of the trophic cascade, and show possibilities for controlling symptoms of eutrophication.

Key words: spawning substratum preferences, roach, perch, pikeperch

The α and β diversities in the fish community of the Promissão reservoir (SP-Brazil): scales, complexities and ecotone heterogeneity.

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Abstract

This paper characterizes the fish community and its interaction with different ecotones within the reservoir. The transformation of a river basin into a cascade of reservoirs produces new ecotones which interact differentially with the spatial/temporal distribution of fish species, their diversity, trophic structures, etc. So the variations of the fish fauna are described to understand better the practices of conservation and management of these reservoirs. The concepts of α and β diversities are related to the concepts of scale, complexity and heterogeneity. Scale comprises the longitudinal, horizontal and vertical variation which are represented by the complexity and heterogeneity of the fish community in the reservoir. Complexity exhibits the variations in ecological data interpretation according to environmental variability or type of data. Heterogeneity describes the variations in species assemblages related to different ecotones. The sampled ecotones were: forest, agricultural land, beaches and mouths of tributaries, each with three replications. Cluster analysis of the environmental factors revealed two distinct ecotonal groups: i) forest, agricultural land and beach; and ii) the tributary mouths. The ANOVAS indicated two possible patterns of α diversity: 1- heterogeneity within the fish community represented by number of species, and differences between the ecotones; 2- homogeneity within the fish community described by the biomass of different species. The β diversities were congruent with environmental factors giving evidence of the horizontal scale within the reservoir. The forest ecotones revealed higher heterogeneity in the coexistence of fish species than did the with other ecotones. This fact is explained by the littoral areas close to the forest fragments with more refuge, increasing the environmental structural diversity. So it reinforces the importance of the forest as refuge enhancing fish dispersal. The fish assemblages related to agricultural land and beaches were more similar. Agricultural land and pasture were the dominant ecotone on the reservoir margins.

Key words: fish, community, diversity, reservoir, ecotones and heterogeneity

Buffering role of land/water ecotones in the structuring of the fish community of the Sorraia system

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Abstract

To test the role of riparian ecotones in fish community dynamics three different sites along the Sorraia system, were selected. Each station has been under distinct anthropogenic pressure, and characterized by a mosaic of habitat conditions. Fish were collected by electrofishing from October 1991 to October 1993 using two distinct sampling scales, (50 m and small sectors defined according to discontinuities in the dominant vegetation). The variation in species abundance and distribution was correlated with physical factors. The results showed the preference of barbel and nase for riparian vegetation and greater depth and of roach for zones with macrophytic vegetation and high current velocity. Fish community of the Sorraia system does not exhibit a consistent pattern of temporal variation, what is usually observed in Southern streams of the Iberian Peninsula. This fact is probably related to the landscape disturbance.

Key words: Iberian streams; fish community structure; riparian ecotones spatial and temporal variation; environmental variables; anthropogenic pressure; multivariate analysis.

**The role of river bank habitat in the early life of fish: the example of grayling,
*Thymallus thymallus***

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Abstract

In many rheophilic fish species, young stages with low swimming capacities are confined to lateral habitats protected from the main current. Among these lateral habitats, we defined „dead zones” as small bays with shallow water and slow water current caused by physical structures (obstacles or curves of the bank), but without a clear frontier with the main channel. Nevertheless, a study using two and three dimensional hydraulic models revealed the existence of a transition zone characterized by a strong velocity gradient between these dead zones and the adjacent channel.

Young stages of grayling constitute a good model for the study of the different aspects of the use of these lateral habitats. An approach based on direct observation in the field and on experimentations in an artificial channel allowed a precise description of young grayling size-dependent distribution patterns. The grayling undergoes an ontogenetic shift between larval and juvenile habitats. Larval stages are only found in dead zones: the smallest (15-20 mm) are found very close to the river bank and, with increasing age and size (20-40 mm), they begin to get closer to the transition zone. From a size of 40 mm, an increasing number of individuals is observed in the river channel, holding a benthic feeding station. A diel habitat shift also occurs between feeding habitats of larvae and juveniles and dead zones, where the fish are observed resting on the bottom in very shallow water at night. This points out the importance of lateral habitats as (1) exclusive nursery areas for larvae that use them both by day and by night and (2) resting habitats for juveniles at night.

Key words: Salmonidae, habitat use, habitat shift, ontogeny, dead zones

The importance of floodplains for the dynamics of fish communities of the upper river Paraná

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Abstract

The last free stretch of the River Paraná inside of Brazilian territory, about 230 km of the former 810 km, runs in a wide floodplain, which flood regime is controlled in part by upstream dams. Aim to evaluate the impacts of different levels of hydrological control on the regional fish diversity, nutritional condition, trophic categories proportion, reproduction and young abundance monthly sampling were carried, between 1986 and 1993, during three annual periods with different flood duration and intensity. Lagoons, secondary channels and river channel was sampled with gillnet of different mesh size and standardized effort. Diversity, evenness indexes and number of species increased with the occurrence of floods. The trophic category proportions varied among the periods considered, with a decrease in piscivores participation and an increase of iliophages, herbivores and insectivores (terrestrial) participation in big flood years. The tendencies for piscivores guild were not uniform to every species. The variations on the nutritional condition reveal that the absence of flooding has a negative effect on greater migratory species and positive on sedentary ones. The young abundance shows, however, that fail in the flooding has a strong negative impact on de recruitment of all the reproductive strategies. It's stressed the operational procedures in the upstream dams and the maintenance of the floodplain integrity is essential to preserve the regional biodiversity, fisheries and particularly the greater migratory fishes population.

Key words: floods, fish, biodiversity, neotropical

Effect of the trout farm on the lake-river ecosystem of the salmon river Lishma

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Abstract

The investigations were carried out in the lacustrine-fluvial system of the Lishma river (the Ladoga lake basin) in its natural condition (until 1993) and during the exploitation of its trout complex. The authors show the water bodies to increase their content of biogenic elements at the expense of the organic form. They mark some changes in the structure of algoflora. The abundance of alkophylic species of periphytome was found to increase, likewise the concentration of chlorophyll and the numbers of blue-green algae. The zooplankton community undergoes some restructurization in lakes; the role of predators in total biomass is growing. The biomass and numbers of zoobenthos have considerably enlarged. The structure and distribution pattern of invertebrates in the benthic community have changed in the pool part within the region of water discharge from the fishery farm. The ichthyofauna of the water bodies so far proves to remain stable.

Key words: chemical composition, algal communities, zooplankton, zoobenthos, fish community

**The role of land/inland water ecotones in fish ecology on the basis of Russian research -
A review**

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Abstract

This review summarises some results of investigation carried out by Russian scientists, concerning the influence of land/inland water ecotones on fish.

The main objectives and hypotheses developing in the framework UNESCO MAB working group "Fish and land/inland ecotones" in Russia are: comparison of fish population in salmonid rivers affected or non-affected by lake-rivers ecotones; small scale ecotone studies of model and restored microhabitat of salmonid rivers; comparison of the ecotone patterns and fish abundance in two rivers differing by historical origin of their ichthyofauna; the analysis of the effect of cattle ranching on fish assemblages distribution, dynamics and productivity along a river course in the steppe zone; and the influence of periodically drying up lakes and ecotones on the dynamics of fish populations in the connected river system.

Key words: salmon rivers, *Oreoleuciscus*, semi-desert waters

An instance of agreement between environmental and genetic diversity: chub, *Leuciscus cephalus*, populations in the Rhone catchment

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Abstract

According to heterozygosity, allele number, and Correspondence Analysis, the chub populations of the lentic Saone River were genetically homogeneous while those of the lotic Rhone River (including flowing sections and standing backwaters) were diverse. These two groups of populations were distant by 150 km.

Key words: heterozygosity, allele numbers, Correspondence Analysis, River Saone, River Rhone

Riparian ecotone as a key factor for stream restoration

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Abstract

The effect of riparian ecotone functional complexity and stream hydraulics on an upland river ecosystem has been analysed. The amount of nutrients retained by the bottom sediment was lowest on a sandy substrate and highest in wetland bays. A stream bed covered by *Berula erecta* had about three times higher nutrient retentive capacity than did a sandy substrate. The trophic potential of CPOM, measured as total protein, was significantly correlated with the amount of deposited CPOM and depended on stream order. Macroinvertebrate biomass was highest at an intermediate riparian ecotone complexity with an adequate supply of organic matter and incident light. Fish biomass followed the same trend, being lowest in heavily shaded areas and in open channels without riparian vegetation, but highest in ecotones of intermediate complexity. These results indicate that the riparian ecotone structure and the heterogeneity of the stream channel may regulate biodiversity, productivity and nutrient retention in the fluvial corridor.

Key-words: river restoration, stream hydraulics, retentive nutrient capacity, CPOM, total protein, calcium/carbonate system, macroinvertebrates; fish communities

Riparian vegetation of streams and the macroinvertebrate community structure

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Abstract

Riparian vegetation is a typical ecotone by its structural and functional position between the terrestrial part of the watershed and the stream (Naiman, Decamps 1990). In consequence, the riparian zone forming an integrated component of stream ecosystems significantly determines the aquatic community. Macroinvertebrates are affected by defined variability of environmental factors. In streams under canopy: light access is reduced; summer temperatures are lower; shed leaves form the main source of energy; insects falling from the vegetation into the water create another source of food; roots from trees form shelter and strongly influence hydraulic patterns. As a result, many (micro) habitats can exist and persist. The relationships between the covered percentage of the riparian zone, hydraulic processes, POM retention and macroinvertebrate functional organization was analyzed. Riparian vegetation forms a buffer zone in agricultural landscape and thus prevents inflow of nutrients, but also of fine sediments. Clearing of riparian vegetation changes all these conditions, resulting in a totally different and less varied biocommunity. Examples are given from Poland and The Netherlands.

Key words: ecotone, riparian vegetation, plant litter, debris dam, hydraulics, stream morphology, macroinvertebrates, feeding functional groups, canopy cover

Fish and land-inland water ecotones – overview and synthesis

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Abstract

The dramatic depletion of diversity and standing crop of freshwater fish has been due mostly to degradation of their habitats and water quality. To halt and reverse this negative trend, a new approach is needed urgently toward sustainability of fish resources. The UNESCO MAB programme on the role of land-water ecotones has opened a new perspective towards solving problems in landscape management and conservation. Land-water ecotones, if restored and managed in a sustainable way, can buffer and filter impacts on aquatic ecosystems due to catchment development, by moderating hydrological processes, improving water quality, and increasing spatial complexity of habitats. This way, fish resources can be safeguarded, restored and sustained. The programme of the 'Fish and Land-Inland Water Ecotones' (FLIWE) team has shown strong links between fish life histories and structures and processes in land-water ecotones. To be able to sustain freshwater fish populations a good understanding is needed of the biological linkages and pathways through land-water ecotones; of biogeochemistry; of modern techniques for habitat inventories; and of methods of habitat evaluation, planning and assessment of socio-economic feedback.

Key words: catchment, ecotones, fish