

# Conservation and monitoring of pond biodiversity

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### Abstracts

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## List of communications

Authors, title, type of presentation (Oral «O» or Poster «P») and page number

<b>Abdelhak Y.*</b> , Lena J-P.* , Quesada R.° & Joly P.* , *University of Lyon, F ; °Association Lo Parvi, F <i>Assessment of matrix connectivity in pond-breeding amphibians</i>	O	1
<b>Angélibert S.</b> , Marty P. & Giani N., University of Toulouse, F <i>Importance of pond network for faunal biodiversity: implications for pond conservation planning</i>	O	2
<b>Auderset Joye D.*</b> , Oertli B.°, Lehmann A.° Juge R.* & Lachavanne J-B.* , *University of Geneva, CH ; °University of Applied Sciences of Western Switzerland EIL, CH ; ° CSCF Neuchâtel, CH <i>Local and regional variables driving pond biodiversity</i>	O	3
<b>Bazzanti M.</b> & Della Bella V., University of Roma 1, I <i>Functional feeding groups and habits of macroinvertebrate communities of some astatic ponds in Central Italy</i>	P	4
<b>Beja P.*</b> , Ramalho C.°, Alcazar R.^ & Sousa J.°, *ERENA , P; °Technical University of Lisbon, P; ^Liga para a Protecção da Natureza, P <i>Breeding amphibians in Mediterranean temporary ponds: partitioning local and landscape effects on assemblage structure and dynamics</i>	O	5
<b>Biggs J.</b> , Bilton D., Williams P., Nicolet P. & Whitfield M., Ponds ConservationTrust, UK <i>Protecting temporary pond biodiversity in Eastern Poland</i>	P	6
<b>Biggs J.</b> , Williams P., Whitfield M., Nicolet P. & Weatherby A., Ponds Conservation Trust, UK <i>15 years of pond monitoring in Britain: results and lessons learned</i>	O	7
<b>Bilton D.</b> & Mc Abendroth L., Plymouth University, UK <i>Aquatic Coleoptera and the colonization of temporary ponds</i>	O	8
<b>Boix D.*</b> , Gascón S.* , Sala J.* , Martinoy M.°, Gifre J.° & Quintana X. D.* *Univ. of Girona, E; °Mosquito Control Service of Badia de Roses & Baix Ter, E <i>QAELS: an index to assess water quality in shallow lentic ecosystems based on invertebrates</i>	P	8
<b>Briers R. A.*</b> & Biggs J.°, *Napier Univ.; °Ponds ConservationTrust, UK <i>Spatial patterns in pond communities: separating environmental and distance effects</i>	O	9
<b>Briggs L.</b> , Amphiconsult, PL & DK <i>Does <i>Bombina bombina</i> indicate high quality pond landscapes in the North European Lowland</i>	O	9
<b>Carchini G.</b> , Solimini A. & Ruggiero A., University Roma 2, I <i>Habitat characteristics and Odonata diversity in Central Italy ponds</i>	P	10
<b>Céréghino R.</b> & Cayrou J., University of Toulouse, F <i>Seasonal dynamics of pond invertebrate populations: implications for biodiversity assessment and biomonitoring</i>	O	11
<b>Coronel J.</b> , Declerck S. & Brendonck L., University of Leuven, B <i>Patterns of zooplankton community structure and diversity in high altitude ponds of the Bolivian Andes</i>	P	11
<b>De Bie T.*</b> , Declerck S.* , Quartier J.* , Ercken D.°, De Meester L.* & Brendonck L.* , *Univ. of Leuven, B; °Royal Belgian Inst. Nat. Sciences, B <i>Patterns of diversity in zooplankton communities inhabiting farmland ponds</i>	P	12
<b>De Meester L.</b> & Louette G., University of Leuven, B <i>Dispersal capacity, priority effects and community and population build-up in small ponds</i>	O	13
<b>Declerck S.</b> , De Bie T., Ercken D., Hampel H., Vandergucht K., Vyverman W., Kestemont P., Losson B., Goddeeris B., Brendonck L., De Meester L. & Martens K., University of Leuven, B <i>Concordance of biodiversity patterns in pond communities: expectations based on results from shallow lakes</i>	P	14
<b>Della Bella V.</b> & Bazzanti, M., University of Roma 1, I <i>Species richness and distribution of macroinvertebrates and in Mediterranean temporary and permanent ponds: relationship with environmental factors and mesohabitat influence</i>	P	15

<b>Fleury Z.*</b> & Strehler Perrin C.°, *University of Applied Sciences of Western Switzerland, EIL, CH ; °Groupe d'étude et de gestion de la Grande Cariçaie, CH <i>Study and proposal for the management of temporary ponds in the Grande Cariçaie (southern shore of Lake Neuchâtel, VD, FR)</i>	P	16
<b>Forro L.</b> , Hungarian Natural History Museum, HU <i>Branchiopoda and Copepoda diversity of temporary pools in Hungary</i>	O	17
<b>Grillas P.</b> , Mouhssine R. & Yavercovski N., La Tour de Valat, F <i>Management and restoration of temporary pools: lessons from the LIFE project and future needs for research</i>	O	18
<b>Head S. M.</b> , Ponds Conservation Trust, UK <i>The Ponds Conservation Trust</i>	P	18
<b>Hinden H.*</b> , Oertli B.°, Auderset Joye D.*, Castella E.*, Juge R.* & Lachavanne J-B.*, *Univ. of Geneva, CH; °Univ. of Applied Sciences of Western Switzerland EIL, CH <i>Alpine ponds biodiversity: what are the driving variables?</i>	P	19
<b>Hull A.</b> , Liverpool John Moores University, UK <i>New directions for pond conservation in the 21st Century</i>	O	19
<b>Indermuehle N.*</b> , Oertli B.*, Perrottet N.° & Sager L.°, *University of Applied Sciences of Western Switzerland EIL, CH; °University of Geneva, CH <i>Pond biodiversity assessment: What is the state of the art?</i>	P	20
<b>Jeffries M.</b> , Northumbria University, UK <i>Small ponds and big landscapes; the challenge of macroinvertebrate spatial and temporal dynamics</i>	O	21
<b>Karaus U.</b> , Baur H., Alder L. & Tockner K., EAWAG, CH <i>Concave Islands: Ecology of parafluvial ponds along river corridors</i>	O	22
<b>Lachat B.</b> , BIOTEC Biologie appliquée SA, CH <i>Open-cast restoration of a hydrosystem and development of ponds and wetland in a agricultural surface by removal of drainage network and by soil modelling. Example of replacement of habitats to improve biodiversity</i>	P	23
<b>Lachavanne J-B.*</b> , Oertli B.°, Auderset Joye D.*, Hinden H.*, Juge R.*, Perrottet N*. & Sager L.*, *Univ. of Geneva, CH, °Univ. of Appl. Sciences of Western Switzerland EIL, CH <i>Altitude a major driving factor for biodiversity in small waterbodies (ponds, lakes) even at low elevations.</i>	P	24
<b>Louette G.</b> , Vander Elst M. & De Meester L., University of Leuven, B <i>Invasion success in juvenile zooplankton communities of small ponds: an experimental test</i>	P	25
<b>Marty P.</b> , Angelibert S. & Giani N., University of Toulouse, F <i>Relative scarceness of marbled newt in a pond network: competitive exclusion with palmed newts or specific habitat requirement ?</i>	P	26
<b>Miaud C.</b> , Université de Savoie, F <i>Landscape determinants of amphibian communities in alpine ponds</i>	O	27
<b>Nicolet P.</b> , Biggs J., Whitfield M. & Williams P., Ponds Conservation Trust, UK <i>A comparison between the conservation value and assemblages of temporary and permanent ponds</i>	P	27
<b>Nicolet P.</b> , Williams P. & Biggs J., Ponds Conservation Trust, UK <i>25 years of change in the plant community and the conservation value of some Cheshire ponds</i>	O	28
<b>Oertli B.*</b> , Auderset Joye D.°, Castella E.°, Juge R.°, Lehmann A <sup>x</sup> .& Lachavanne J-B.°, *University of Applied Sciences of Western Switzerland EIL, CH; °University of Geneva, CH; <sup>x</sup> CSCF Neuchâtel, CH <i>PLOCH: a standardised method for sampling and assessing the biodiversity in ponds</i>	O	29
<b>Perrottet N.*</b> , Sager L.*, Oertli B.° & Lachavanne J-B.*, *Univ. of Geneva, CH; °Univ. of Applied Sciences of Western Switzerland EIL, CH <i>Is a multimetric index suitable to assess the ecological status of ponds ? Part 2 Macroinvertebrates and Amphibians.</i>	P	30

<b>Quintana, X. D.</b> , Sala J., Gascón S. & Boix D., University of Girona, E <i>An evaluation proposal of the conservation state in shallow lentic ecosystems: the index ECELS</i>	P	31
<b>Reynolds J.*</b> & O'Connor A.°, *Trinity College in Dublin, EI; °National Parks and Wildlife Division, EI <i>Invertebrate biodiversity of atlantic temporary ponds (turloughs) and threats to their conservation</i>	O	31
<b>Ruggiero A.*</b> , Solimini A.° & Carchini G.*, *University Roma 2, I, ° EC Joint Research Center, Ispra, I <i>The ecology and conservation of mountain ponds in Central Apennines, Italy</i>	O	32
<b>Sager L.*</b> , Perrottet N.*, Oertli B.°, Auderset Joye, D.* & Lachavanne J-B.*, *Univ. of Geneva, CH; °Univ. of Applied Sciences of Western Switzerland EIL, CH <i>Is a multimetric index suitable to assess the ecological status of ponds ? Part 1 Macrophytes</i>	P	33
<b>Sajaloli B.*</b> , Dutilleul C.°, Thulie A.°, Pirot F.^ & Limoges O.*, *Pôle relais "Mares et mouillères de France", IEDD, F, °Centre de Biogéographie-Ecologie (CNRS-ENS LSH / ADREE), ^Maison des Sciences de l'Homme, F <i>The patrimonial typology of ponds, a tool to manage biodiversity and social value of small wetlands in the Parisian basin (France)</i>	O	34
<b>Scher, O.</b> & Thiéry A., University of Provence, F <i>An evaluation of road runoff impact on stormwater detention ponds invertebrates communities in South-eastern France</i>	P	35
<b>Schmidt B.</b> , Koordinationsstelle für Amphibien- und Reptilienschutz in der Schweiz (KARCH), CH <i>Monitoring the distribution of amphibians when species are not always detected</i>	O	35
<b>Solimini A.*</b> , Della Bella V.° & Bazzanti, M.°, *EC Joint Research Center, Ispra, I; °University of Roma 2, I <i>Macroinvertebrate biomass-size spectra of permanent and temporary ponds in Central Italy</i>	O	36
<b>Vandekerkhove J.</b> , Brendonck L., Declerck S. & De Meester L., Univ. Leuven, B <i>Monitoring and conservation of cladoceran diversity: the potentials of using dormant egg banks</i>	P	37

## Assessment of matrix connectivity in pond-breeding amphibians

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Ponds constitute breeding sites for many animals with complex life cycles such as insects or amphibians. In such species, population dynamics is assumed to depend on the connectivity of landscape matrix because of its influence on both yearly migrations and dispersal (metapopulation dynamics). We attempted at evaluating the impact of matrix connectivity by relating presence at a pond to *potential migration area*. Potential migration area is an integrating parameter of landscape connectivity computed from landscape configuration and habitat resistance coefficients that are drawn from our knowledge of habitat use by the focal species. This approach takes advantage of Generalised Linear Models for assessing the significance of the explanatory variables.

The focal species was the European treefrog (*Hyla arborea*) studied at Isle Cremieu, a limestone plateau where ponds and wetlands are widespread. Four sectors were defined according to pond density (high vs. low) and land use (pasture or forest vs. crop fields or urban areas). Within each sector, the presence of the treefrog was recorded at a sample of ponds. We first examined whether the occurrence of the treefrog within the sampled ponds varied significantly according to both the pond density and the land use of the studied sectors. We secondly established a friction map from the landscape mosaic drawn from satellite photographs by Arcview GIS. Around each pond, a migration area was computed from this friction map. The predictive power of such integrating parameter was then assessed by establishing its relationship with the current presence/absence of breeding choruses of the species at each studied pond.

The results are not in agreement with a strong impact of matrix connectivity suggesting that other factors have a stronger impact on treefrog distribution than land use, or that landscape connectivity has to be assessed at larger scale than that considered in the present study.

## **Importance of pond network for faunal biodiversity: implications for pond conservation planning**

**Angélibert S.\*<sup>1</sup>, Marty P.<sup>1</sup> & Giani N.<sup>1</sup>**

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Numerous ponds were bored by man into the calcareous rock of an arid limestone plateau ("Causses du Quercy", S.W. France), and these small permanent ponds are dispersed over a wide area (2156 km<sup>2</sup>) deprived of any stream system. Therefore, they can be considered as "islands" for freshwater life, forming a patchy aquatic habitat at the regional scale. However, they are now abandoned and, without human management, they are destined to disappear although they constitute the only available surface water resource in the area. The aim of this study was to demonstrate that the interest of these ecosystems lies in the entire pond network and not only in the pond itself. We demonstrated the importance of maintaining the heterogeneity of the pond succession stages for both fauna and flora. We also showed that, for active dispersers (Odonata and Amphibia), species distributions are influenced by environmental variables. For Odonata, large ponds are more likely to include all species (including rare species). For amphibia, forested ponds are more likely to include all species (including the rarest). For passive dispersers (Mollusca and Oligochaeta), our results indicated that the species distribution is a randomised distribution. Therefore, management plans must be thought at the regional scale to maintain an heterogeneity concerning area, surrounding and habitat diversity in ponds. Before dredging, it is also necessary to put systematic inventory policy in place to detect the faunistic interest of ponds in order to protect specific species or biota.

**Keywords:** pond network, invertebrate, vertebrate, species distribution, limestone plateau.

## Local and regional variables driving pond biodiversity.

Auderset Joye D.<sup>1</sup>, Oertli B.<sup>2</sup>, Lehmann A.<sup>3</sup>, Juge R.<sup>1</sup> & Lachavanne J-B.<sup>1</sup>

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1. Ponds are a valuable resource for the conservation of freshwater biodiversity. Pond biodiversity is influenced by many habitat characteristics (local variables) and by large-scale variables driving local habitat conditions (regional variables). For management and conservation purposes, it is of prime interest to identify and quantify the relevant environmental factors regulating pond biological diversity. About a hundred environmental variables were measured in situ or calculated
2. A standardized method was used to assess the diversity of 80 ponds and small lakes located in different biogeographic regions of Switzerland (altitude 200 to 2800 m). Five taxonomic groups were selected as complementary bio-indicators of pond quality: aquatic plants, Gastropoda, Coleoptera, adult Odonata and Amphibians.
3. Two biodiversity indices were tested: species richness and conservation value (where species are weighted by their vulnerability status according to national Red Lists). The two indices were highly correlated and the species richness only was considered further.
4. The relationships between these potential explanatory variables and species richness were tested with Linear Regressions (Ordinary Least Square, OLS) and Generalized Additive Models (GAMs).
5. Altitude (regional variable) was the key explanatory variable and had a negative effect on the species richness of the five taxonomic groups. A high connectivity index (regional variable) had a positive influence on aquatic plant and Odonata species richness. Among regional variables describing the catchment area (land use, geology) only the proportion of forested catchment had significant effect, namely on amphibian species richness.
6. At mesoscale, the proportion of different landscape components describing the 50m-surrounding of the ponds seemed to have no significant effect upon the species richness of the selected ponds.
7. At local scale, pond size was the main variable driving biodiversity and the most relevant morphometric variable. It was the second explanatory variable after altitude. A positive effect on the species richness of plants, dragonflies and gastropods was noted. A high sinuosity index of the shores was favourable to Coleoptera species richness and increasing depth caused a decrease of the aquatic plant species richness.
8. Physical and chemical variables (local variables) were also significant: nitrogen had a positive influence on plant species richness and conductivity on that of Coleoptera. High water transparency influenced positively Gastropoda species richness. Phosphorus had an indirect impact on biodiversity, via transparency. Among biological variables (local variables), a moderate shading by riparian trees (<25%) had a positive effect on aquatic plant and Odonata species richness. Increasing cover by floating-leaved vegetation was positively related to Gastropoda species richness and submerged vegetation influenced likewise Coleoptera species richness. The presence of fish decreased the aquatic beetles species richness. Pond age showed no direct effect on species richness.
9. Many variables, not significant in our final models, influence potentially the species richness of the selected groups. For instance, catchment area, 50m-surrounding, physico-chemical and biological variables were closely related to altitude. Pond area, the second most important variable in the explanation of biodiversity, was independent from altitude but correlated to morphometric and to biological variables.
10. A high number of variables, ranging from regional to the local scale, played a role in explaining pond species richness. The complex relationships between them and between these variables and the taxonomic groups are responsible for the maintenance of a high level of biodiversity of these ecosystems.

## **Functional feeding groups and habits of macroinvertebrate communities of some astatic ponds in central Italy**

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The organizations of functional feeding groups and habits of the invertebrate macrofauna in temporary and permanent ponds located in a natural reserve near Rome were studied in order to complete the knowledge of the most relevant ecological aspects of this community, recently analyzed also from a taxonomic point of view (Bazzanti et al. 2003). Collector-gatherers, predators, sprawlers+climbers and burrowers dominated in the studied ponds. The differences encountered in the taxonomic composition and structure of the macroinvertebrate community between temporary and permanent ponds were not evident in the functional feeding groups and habits. Only collector-filterers (bivalves and some chironomids) seemed to be negatively influenced by drought being more abundant in the permanent biotopes, which probably favour a better utilization of seston (algae) with respect to the shallower temporary pools. Scrapers appeared to be negatively influenced by tree cover and positively by conductivity and macrophyte number of species and growth, according to the increase of their potential food. The abundances of sprawlers and climbers were negatively influenced by tree cover and positively by macrophyte cover because of their dependence by aquatic vegetation as a suitable substrate for living, whereas swimmers and divers were conditioned by depth which increased the available space for moving. This paper suggests that macrophytes strongly influenced the functional aspects (feeding mechanisms and habits) of the macroinvertebrates in temporary and permanent ponds. Finally, the analysis on the life history categories of Wiggins et al. (1980) indicated a certain similarity to resist dessication for macroinvertebrates of both temporary and permanent pond communities, with the residents (Group 1) almost belonging to collector-gatherers and burrowers, and the active colonizers (Group 4) to predators and motile fauna (swimmers and divers, sprawlers and climbers).

**Keywords:** permanent and temporary ponds, macroinvertebrates, feeding mechanisms, habits, Wiggins’ groups

## **Breeding amphibians in Mediterranean temporary ponds: partitioning local and landscape effects on assemblage structure and dynamics**

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Pond biodiversity is likely influenced by both pond characteristics (e.g., area and hydroperiod) and landscape context (e.g., land cover composition and structure), though the relevant spatial scales and their relative importance are largely unknown. These issues were addressed in Mediterranean temporary ponds of Southwest Portugal, by examining local and landscape effects on the structure and dynamics of breeding amphibian assemblages. Amphibians and habitat attributes were sampled in 1997 and 2001, at ponds located in a predominantly farmland landscape. An image object-based classification approach using a multi-resolution algorithm was firstly applied to orthophoto images to produce land cover cartography of the study area. Landscape composition and diversity was then estimated at eight spatial scales (radius 150-3000 m). The relationship between assemblage (richness and abundance) and pond and landscape descriptors was analyzed by stepwise multiple regression and variation partitioning methods. Preliminary analysis of the data showed that 1) pond area and hydroperiod were critical factors affecting the assemblage diversity, composition and dynamics; 2) amphibians were strongly related to farmland habitats, being positively influenced at small to medium scales by the proportional cover of fallows, pastures and extensive dry cereals, and negatively so at medium to large scales by the cultivation of irrigated vegetables and cereals; 3) amphibian abundances were mainly explained by landscape variables while species richness was equally explained by local and landscape factors. The study highlights the need to account for landscape context when designing pond conservation strategies

## **Protecting temporary pond biodiversity in Eastern Poland**

**Biggs J., Bilton D., Williams P., Nicolet P. & Whitfield M.**

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The landscape of eastern Poland is notable for its low intensity agriculture and its exceptional biodiversity. Limited land drainage means that seasonal ponds are widespread in this landscape and are comparatively little impacted by agriculture compared to western Europe. As a result, ponds in this region support an exceptional variety of rare and protected amphibians and invertebrates.

Despite their ecological value, seasonal ponds in eastern Poland now face a variety of threats resulting from changes in agriculture associated with accession to the EU. Threats are most severe in the agricultural landscape where land drainage, increased use of agricultural chemicals, deepening for fish culture and abandonment of grazing has the potential to completely eliminate temporary water habitats. Within protected area, such as the floodplain of the Biebrza river and the Białowieża Forest, seasonal ponds are also threatened by agricultural abandonment, and diffuse pollution arising from agriculture in the catchment.

Here we evaluate the importance of seasonal ponds within and outside of existing protected areas in Eastern Poland. Make a preliminary analysis of the threats faced by temporary ponds in these areas and propose potential solutions.

## **15 years of pond monitoring in Britain: results and lessons learned**

**Biggs J., Williams P., Whitfield M., Nicolet P. & Weatherby A.**

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Over the last 15 years the Ponds Conservation Trust, and its predecessor Pond Action, have undertaken a number of projects monitoring ponds in Britain. These studies have focussed on five main areas: describing the characteristics of minimally impaired ponds, tracking changes in pond numbers, assessing the effects of anthropogenic impacts on pond quality, describing the value of new ponds and, most recently, assessing the relative importance of ponds, compared to other freshwater habitats, for aquatic biodiversity. The datasets generated during this work have also proved valuable in refining approaches to the practical management of ponds, developing strategies for their conservation and the development of policies for their protection.

We are now attempting to build on the foundations established by this work. Three main areas need to be addressed:

- Establishment of regular national and Europe-wide monitoring of small waterbodies, particularly within the frame of the WFD and the Habitats Directive;
- The implementation of policies to protect and improve small waterbodies at the catchment scale; ironically ponds are the easiest of waterbodies to protect, but minimal effort is spent on this activity.
- Refining knowledge of the function of ponds, particularly the effects of management on ponds, the function of pond networks and the ecology of endangered species associated with ponds.

Institutionally there is a need to strengthen the European network of biologists working on ponds, capitalising particularly on the high level of public awareness of the habitat.

## **Aquatic Coleoptera and the colonization of temporary ponds**

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Despite the fact that they support many scarce animal and plant taxa, the density of temporary water bodies is declining across Europe, emphasising the need for successful habitat creation. In this study, fourteen small replicate ponds were created on grassland and heathland plots on the Lizard Peninsula (Cornwall, UK), and monitored over a three year period for colonization by aquatic beetles.

The Coleoptera assemblages developing in grassland and heathland ponds were not significantly different from those found in small natural ponds in the region. Experimental sites were colonised by a high number of taxa typical of small natural sites (e.g. *Helophorus* spp and *Graptodytes flavipes*), but were also sporadically colonised by a number species usually characteristic of more permanent waters (e.g. *Enochrus fuscipennis* and *Haliphus ruficollis*). This study suggests that small ponds can be successfully created, potentially increasing habitat availability for taxa of conservation concern.

## **QAELS: an index to assess water quality in shallow lentic ecosystems based on invertebrates**

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According to the Water Framework Directive (2000/60/CE) tools to evaluate the ecological quality in wetlands are required. In this context, a biological index to evaluate the water quality (QAELS) has been obtained for wetlands and ponds in Catalunya (NE Iberian peninsula). The study has been carried out in two phases: in the first one the index QAELS was elaborated by a data set of monthly samples of 20 wetlands; in the second one the index QAELS was validated by means of the information obtained in a biannual sampling of 40 additional wetlands. In each sampling point we measured water parameters (Temperature, conductivity, pH, dissolved oxygen, Chlorophyll-a, dissolved nutrients and total nutrients) and the invertebrate species composition (captures by dip net of 250 µm mesh size). A previous typification of wetlands in that area has been required to obtain QAELS.

The index QAELS is obtained by: (1) the relative abundance of each microcrustacean taxon (cladocera, copepoda and ostracoda) weighted by a quality coefficient, which is obtained for each taxon by means of partial canonical correspondence analysis; and (2) the taxonomic richness of crustaceans and aquatic insects. The taxonomic resolution required has been determined comparing the results obtained in several scenarios (each one with a different taxonomic resolution) with the results obtained with the identifications at species level.

## **Spatial patterns in pond communities: separating environmental and distance effects**

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Ponds are a valuable but threatened resource for conserving freshwater biodiversity. Due to the importance of between site dispersal for the persistence of many pond dwelling organisms, it is important to take into account spatial aspects of pond ecology in effective conservation strategies. Previous studies, over relatively small spatial scales, have emphasised the unpredictability of pond communities, with low community similarity between neighbouring sites, even in the absence of differences in environmental conditions. Patterns of community similarity over greater spatial distances have not been documented. Here data on macroinvertebrate communities and physico-chemical conditions for 102 ponds over a 60x60km area of Oxfordshire, UK, were used to examine effects of environment and spatial distance on community similarity. Environmental similarity, derived from PCA scores, had a significant effect on community similarity. When environmental effects were accounted for, there was still significant spatial autocorrelation of community composition over inter-site distances of up to 13km. These results emphasise the need to consider spatial issues in pond conservation planning.

## **Does *Bombina bombina* indicate high quality pond landscapes in the North European lowland**

**Briggs, L.**

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The historical range of *bombina bombina* in North Europe covers all lowland in Lithuania, Poland, former East Germany and large areas of Ukraine, Belarus and Russia. Edges distributions are to be found in Latvia, South Sweden, East Denmark and North Germany (Schleswig Holstein moraine landscape and Elbe floodplain).

The distribution often occurred in areas of various agricultural interest from intensive crop production use in East Germany and West Poland to extensive grassland use in floodplains of east Poland and moraine landscapes of Lithuania.

The presentation covers

1. Impact on Pesticide use and buffer zone with on breeding ponds of *Bombina bombina*.
2. Impact of land use on the the populations dynamics and survival of adult *Bombina bombina*.
3. Decline rates of *Bombina bombina* in North west Europe.
4. Are pond and landscape improvement effective (Experience from LIFE project)
5. Conservation status in North East Poland.
6. Possible relation between *Bombina bombina* and other amphibians and invertebrates of conservation interest.

## Habitat characteristics and Odonata diversity in Central Italy ponds

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In Mediterranean Italy natural lakes are not abundant because of the high permeability of the rocks (mainly limestone) and to the drainage of wetlands made in the last two centuries for agricultural purposes. Therefore ponds represent an important habitat type for the conservation of the odonate fauna. Ponds have often been preserved, and in some cases newly created, for watering of game or herds, particularly in mountain areas. However, this use may conflict with the conservation of a diversified odonate fauna. The aim of this study is to report on habitat requirements of Odonata of mountain ponds of Central Italy and to compare these results with those of a similar work on flatland ponds.

Thirty-one ponds, ranging from 1014 to 2004 m a.s.l., were qualitatively sampled for odonate larvae twice during 1998 summer, and a total of 14 species were collected, ranging from 0 to six species for pond. Several physical, chemical and biotic habitat variables were measured for each pond. A multiple regression analysis showed that the species number was affected positively by the amount of pond hydrophytae coverage and negatively by the amount of NH<sub>4</sub> concentration. The remaining variables did not enter the regression model, but some showed significant correlations with the selected ones. Particularly, hydrophytae coverage was negatively correlated with Chl-a concentration and positively with helophytae and frog presence; ammonium concentration was positively correlated with altitude, Chl-a, frog presence and the origin of the pond (higher NH<sub>4</sub> values in artificial ponds). A Canonical Correspondence Analysis gave a more detailed insight into the relations between Odonata (assessed as species presence/absence) and habitat variables. The lack of Odonata in several ponds was related to increasing values of NH<sub>4</sub>, Chl-a and altitude. Among the remaining habitat variables two main groups were identified: the first included helophytae, newt and hydrophytae and corresponded to seven odonate species, the outermost with preference for astatic ponds: *Lestes dryas* and *Sympetrum flaveolum*. The second included depth, frog and fish, and corresponded to *Cercion lindeni*, *Ischnura elegans* and *Enallagma cyathigerum*, all Coenagrionidae of permanent water. Combining these results with others obtained by studying a set of ponds in a flatland game reserve, we noted: 1) the mountain ponds showed less odonate species, 2) the abundance of vegetation, inside and around the pond, increased the number of species while the eutrophication decreased it, 3) the presence of fish, newt or frog did not reduce the odonate diversity strongly, 4) the intensive use of ponds for game or herd watering could damage vegetation and shift the equilibrium of the pond toward a condition of high turbidity (= high Chl-a), causing a reduction of the odonate diversity.

Keyword: Dragonfly, lentic species, conservation, vegetation, landscape.

## **Seasonal dynamics of pond invertebrate populations : implications for biodiversity assessment and biomonitoring**

**Céréghino R. & Cayrou J.**

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Many bioassessment tools use measures of community biodiversity to evaluate the ecological health of aquatic ecosystems. Because communities consist in many populations which coexist in space and time, biodiversity measures depend on “where” and “when” one looks within a given ecosystem. We studied the life history patterns of 28 dominant invertebrate species in permanent ponds of the “Causses du Quercy” limestone plateau (SW France). Six species were clearly bivoltine with a slow winter and one or two short spring generations. One species also had two generations per year, but with a short spring and a short summer generation. Twelve species exhibited univoltine fast seasonal cycles with a short growth period, and adult in spring, summer, or autumn respectively. Nine species showed univoltine slow seasonal cycles, their growth occurring over a long period before spring or summer adults. By overlapping the various life history plots, we emphasized the temporal segregation of many species. Finally, a classification of invertebrate samples showed that seasons tended to have a greater influence on the delineation of clusters than substrates. The design of tools for the bioassessment of ponds remains an ongoing task. In small ponds such as in our study area, the question “when” should be balanced with the question “where”, if we wish to accurately measure invertebrate diversity.

Keywords : Ponds, invertebrates, biodiversity, life history, biomonitoring

## **Patterns of zooplankton community structure and diversity in high altitude ponds of the Bolivian Andes.**

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The Andes of the Cochabamba region (Bolivia) contain numerous peat bog pools that are spatially organised in clusters (the so called ‘bofedales’). The pools are small, shallow systems that are exposed to high UV-radiation and harsh climatologic conditions. A substantial part of the pools dries out yearly. There is almost no information on the ecological characteristics and biodiversity of these pools. A survey has been made of the zooplankton communities of 60 pools above an altitude of 4000m. Patterns of zooplankton community composition and diversity will be discussed in relation to crucial environmental variables (nutrient levels, food concentration, macrophyte abundance and altitude) and the distance matrix.

## **Patterns of diversity in zooplankton communities inhabiting farmland ponds**

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Small lentic freshwater bodies contribute substantially to the biodiversity of agricultural landscapes. As part of the project 'Integrated management tools for water bodies in agricultural landscapes' (MANSCAPE; funded by the Belgian Science Policy), the structure and diversity of zooplankton communities in pools and small ponds will be studied in a large scale survey (126 water bodies). The design of the study is such that most of the Belgian territory is represented and that land use effects can independently be evaluated from regional dependency. In addition, zooplankton community characteristics will be studied in relation to a wide array of other variables, such as abiotic and morphometric variables (e.g. surface area, depth), general foodweb structure (composition and diversity of organism groups at other trophic levels; structural diversity), variables associated with the landscape context (total number and surface of ponds and ditches in the surroundings, distance to neighboring ponds), and variables that are expected to be related to land use and farm practice (e.g. nutrient and pesticide levels, cattle density). In the study, analyses of samples taken from the active communities during spring and summer will be complemented with analyses of zooplankton resting egg banks. The application of the two different methods will allow evaluating the use of resting egg bank analyses as a cost-efficient method for biodiversity assessment in small water bodies.

**Keywords:** biodiversity, zooplankton, pool, pond, landuse

## **Dispersal capacity, priority effects and community and population build-up in small ponds**

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The relative contribution of regional and local factors to community structure is an important question in ecology. Ponds are suitable model systems to investigate this issue, because they are small and nicely delimited in the landscape. If dispersal is not limiting, one expects a strong impact of local factors to community build-up. This is, however, not the case if high dispersal capacity is accompanied by important priority effects.

Ponds contribute significantly to regional diversity. Even though their communities are often relatively simple, community structure is often very different from pond to pond. Because of their importance to the conservation of biodiversity, nature development plans often involve the creation of new pond habitats. We monitored the colonization of newly created ponds by zooplankton, using this group as a model taxon to explore the impact of regional and local factors in determining community structure. There are several lines of evidence that dispersal capacity of zooplankton is high, and this is corroborated by our data: most of the investigated ponds were colonized rapidly by several species of zooplankton. There was a positive correlation between colonization rate and regional species diversity in zooplankton, suggesting that regional characteristics do impact colonization rates. We carried out experiments exploring the impact of the resident community on establishment success of invading species from the regional species pool. Two main conclusions can be derived from the results of these experiments: first, local biotic interactions are important to establishment success, and second, species sorting is strikingly rapid. These observations corroborate results from earlier experiments in which we observed very efficient species sorting in response to biotic gradients in a transplant experiment involving zooplankton communities from two neighbouring ponds. Efficient species sorting suggests that priority effects are not very important. To further explore this issue, the importance of priority effects is currently being experimentally tested.

Data on the population genetic structure of *Daphnia* species inhabiting small ponds suggest low levels of gene flow. Given the high colonization ability and the evidence for high dispersal capacity, these low levels of gene flow are difficult to explain. We have hypothesized (so-called Monopolization Hypothesis) that strong priority effects at the genotype level result in strong priority effects (founder effects), thus explaining high levels of genetic differentiation between zooplankton populations inhabiting nearby ponds. In the lecture, we will also discuss the parallels and differences in the mechanisms determining the relative contribution of local and regional factors to community and population genetic structure in zooplankton. On the one hand, one expects the mechanisms to be similar. On the other hand, current evidence suggests that priority effects may be more important at the population than at the community level. We will also stress the importance of taking the resting egg bank into consideration when explaining the community and population genetic structure of aquatic organisms inhabiting ponds.

**Keywords:** dispersal, colonisation, community structure, zooplankton, genetic diversity

## **Concordance of biodiversity patterns in pond communities: expectations based on results from shallow lakes.**

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A good knowledge of the extant patterns of biodiversity in natural ecosystems is essential for the formulation of relevant hypotheses on the drivers and ecosystem consequences of richness, and the development of efficient monitoring methods and conservation practices. The Belgian project 'Integrated Management Tools for Water Bodies in Agricultural Landscapes' (MANSCAPE) aims at revealing the major patterns of multi-group biodiversity in pools within the context of agricultural landscapes. For this project, biodiversity of several organism groups at different trophic levels of the food web (zooplankton, zoobenthos, phytobenthos, coleoptera, heteroptera, odonata, molluscs, macrophytes) is assessed in a set of 126 Belgian pools. One of the major objectives of MANSCAPE is the assessment of the degree of concordance in the biodiversity of those organism groups. The design of the MANSCAPE project will be presented and expectations on concordance patterns will be discussed in the light of results that have recently been obtained on shallow lakes within the framework of the EU-research project 'Biodiversity and Human Impact in Shallow Lakes (BIOMAN).

# **Species richness and distribution of macroinvertebrates in Mediterranean temporary and permanent ponds: relationships with environmental factors and mesohabitat influence**

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In Italy the small water bodies, especially those of a temporary character, are still neglected and their conservation value as biodiversity resource is often overlooked although Mediterranean temporary waters are listed as European conservation priorities after the Habitats Directive (92/43/EEC). We have designed a monitoring programme to elucidate which factors influence the species richness and to analyse within and among ponds macroinvertebrate community variations. In a series of 13 temporary and 8 permanent ponds located in Central Italy, three main contrasting mesohabitats (macrophyte, littoral and central sediments) were selected and invertebrate macrofauna was collected in March, May and June 2002. The results suggest that the number of species positively correlated with the hydroperiod length, pond depth and surface, water transparency, macrophyte species richness and coverage. In contrast, total P and N in the water were the most important factors negatively affecting species richness. Permanent biotopes showed a higher taxonomic richness than temporary ones. Moreover, the number of species of the total fauna, and particularly of Coleoptera, Odonata, Hemiptera and Gastropoda was higher in the macrophyte mesohabitat than both littoral and central sediments. The multivariate analysis showed that the overall variation of the assemblages was greater between temporary and permanent ponds rather than among mesohabitats, suggesting that some environmental variables, and in particular the hydroperiod, have a stronger effect on macroinvertebrate communities than substrata. On the basis of results concerning species richness and rarity a provisional picture of conservation of the studied pond was discussed. This study suggests that different types of the ponds and mesohabitats should be considered to obtain a correct conservation value of ponds because of the presence of interesting species for ecological and/or geographical point of view.

**Keywords:** macroinvertebrate species richness, mesohabitats, temporary and permanent ponds, hydroperiod, conservation value

## **Study and proposal for the management of temporary ponds in the Grande Cariçaie (southern shore of Lake Neuchâtel, VD, FR)**

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The Grande Cariçaie, situated on the southern shore of Lake Neuchâtel, is the largest lacustrine marsh in Switzerland. As a result of work undertaken to regulate the flow of water from the Jura mountains, direct flooding of paludal environments became less frequent and the future of temporary ponds uncertain. To preserve a range of pioneer animal and plant species, artificial ponds were created in the Grande Cariçaie between 1995 and 1998.

The aim of the present study was to conduct a first assessment of the effectiveness of the measures taken, in particular by comparing the results with those observed in other temporary pools formed simply by the passage of maintenance vehicles (ruts). Improvements were suggested on the basis of the characteristics of the environments which proved most favourable for pioneer species. To preserve these species, the ponds must be recently formed and have gently sloping sides so as to increase the drawdown zone. Plant cover should be no more than 20%, and zones of open water should be maintained. The presence of 5 to 10 cm of weathered mineral horizon accelerates colonization by vegetation.

Although not planned as such, ruts regularly renewed by the passage of heavy vehicles offer an environment that is more favourable to pioneer species than artificially created ponds. To preserve the pioneer nature of the latter, maintenance work must be carried out at intervals ranging from 5 to 15 years, depending on the quality of the substrate, the type of vegetation in the immediate surroundings (presence of particularly successful colonizing species), and the period during which the pond has been flooded.

## Branchiopoda and Copepoda diversity of temporary pools in Hungary

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About 80% of the territory of Hungary is below 200 m level and a large part of the area was endorheic or was exposed to inundations. Large scale river regulations were started about 150 years ago which greatly reduced the flooded area. In the 20th century human impacts, e. g. intensification of agriculture, canalization, urbanization, resulted in further decline of the number and area of temporary waters.

Crustaceans are important components of the invertebrate fauna of temporary waters, among them large branchiopods are the most prominent group, since their occurrence is confined to these habitats. Up to now nineteen species of anostracans, notostracans and conchostracans were recorded in the territory of Hungary, all but one were found during the last years, *Branchipus schaefferi* and *Triops cancriformis* were common. Characteristic species of temporary waters can also be found in microcrustaceans, such as species of the cladoceran genera *Daphnia* and *Moina*, while of the copepods some species of *Mixodiaptomus*, *Cyclops* and *Metacyclops*.

During the last years several temporary pools in the Hungarian Plain were studied: some abiotic parameters were measured and the crustacean fauna sampled. Allozymes in the populations of dominant *Daphnia* and *Moina* species were investigated using cellulose acetate electrophoresis. Altogether 45 species were recorded, based on chemical features and the species composition two groups could be separated in the plain. The number of species found varied between 2 and 13, it showed positive correlation with the size (area) of water bodies and negative correlation with salinity. The allozyme studies indicated the presence of cryptic species in *Daphnia* and *Moina*, four loci were investigated and in most populations high genetic diversity was detected.

It seems that the still abundant temporary pools in Hungary have relatively high diversity, particularly if compared with Western European data. These data and the findings of cryptic species stress the importance of temporary pools in biodiversity.

Crustaceans are usually not listed among protected species, with the exception of freshwater crayfish, this is the practice in Hungary, as well. Large branchiopods, particularly the tadpole shrimp (*Triops cancriformis*) could be used as “flagship species” to raise public awareness for the values of temporary pools.

Keywords: Branchiopoda, Copepoda, species composition, genetic diversity

## **Management and restoration of temporary pools: lessons from the LIFE project and future needs for research**

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In the European Mediterranean region, temporary pools are identified as important habitats for conservation. Their biological richness tends to decline in several sites being affected by ecological changes such as shrub or perennial herbaceous vegetation encroachment, alteration of the hydroperiod, sediment in-filling, etc. These ecological changes are often resulting from mismanagement in the surrounding areas of the pool or decrease of the disturbance rate of perennial vegetation by extensive grazing activity. In the context of a LIFE project several experiments for management and restoration of the temporary marshes were implemented aiming at testing management methods, identifying the processes involved and indicators of success.

Several experiments of removal of the dominant perennial vegetation, by grazing or using mechanical means, resulted in significant increase in the number and abundance of the annual species which are characteristic of oligotrophic temporary pools. Removal of litter enhanced this positive result while mechanical removal of root mat did not show a positive effect after 2 years. On the long term, the development of these annual communities requires the implementation of a disturbance regime in order to control perennial vegetation. Grazing seems an appropriate tool for the management of the perennial vegetation in temporary marshes.

In temporary aquatic habitats the seeds and spores constitute a key compartment for the restoration of the populations of annual plant species. When seed-banks are depleted, the re-introduction of species preferably as seeds should be considered. Future work should aim at further testing of management practices and at improving our understanding of the ecology of seed banks, including the dispersal, dormancy and survival of seeds.

## **The Ponds Conservation Trust**

**Head S.**

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The Ponds Conservation Trust is an environmental charity working to promote the understanding and conservation management of freshwater habitats. It has a strong and successful research background in ponds, rivers, ditches and canals, and catchment level conservation. We would be very interested in participation in joint European research projects. In the last few years, we have developed very effective programmes of community based practical conservation promoting understanding of freshwater biodiversity by the public. The poster will describe the scope of the Trust's work in the UK and in Europe, and set out some of our research and conservation policy objectives for the future.

## **Alpine ponds biodiversity: what are the driving variables ?**

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Alpine ponds are particularly sensitive to environmental impacts and changes. The aim of this study is to determine the driving variables of biodiversity in alpine ponds in order to establish the threats, better understand the biodiversity changes and have an idea of the conservation measures to undertake in these ecosystems.

20 alpine ponds in Switzerland were used to examine the relationship between their biodiversity and 8 environmental variables: mean depth, area, altitude, occurrence of fishes, occurrence of aquatic vegetation, trophy, conductivity and pH. Six metrics were used as indicators of biodiversity: species richness in Macrophytes, Odonates, Amphibians, Sphaeriidae, Coleoptera and families richness in macroinvertebrate.

The results show for instance (i) the importance of pH and conductivity on the richness of several species groups (Sphaeriidae, Macrophytes, Odonates and Amphibians), (ii) the negative impact of fish presence on Coleopteran richness and (iii) the lack of significant relationship with pond area, depth and trophic state. These results highlight that driving variables operate on biodiversity in a different way in alpine ponds than in lowland ponds. Therefore, there is a need to establish specific biodiversity evaluation tools for alpine ponds that differ from those already used in lowland ponds.

Keywords : alpine ponds, biodiversity, environmental variables.

## **New Directions for Pond Conservation in the 21<sup>st</sup> Century**

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Concern for pond conservation in the United Kingdom has had a relatively short and undistinguished history. Apart from individual initiatives largely from the wildlife community, the first organised scientific meeting did not take place until 1989. Activities following this meeting resulted in the development of widely adopted pond management practices and pond creation techniques and a number of other influential conferences and community-based projects. Despite these significant advances, pond conservation has and continues to remain low on the environmental agenda. This position has meant that these small water bodies have received little support from successive governments and their statutory agencies. As we enter the 21<sup>st</sup> century this position is unlikely to change and therefore a new methodology is required. This paper argues that a new multi-faceted landscape approach to pond conservation needs to be developed. This approach requires, firstly, a greater awareness of the requirements of the EU Habitats Directive and in Article 10, its prescription for the wider countryside; secondly, to liaise closely with amphibian groups many of whom clearly understand metapopulation dynamics and for whom Article 10 is a mission statement; thirdly, pond conservation should be prepared to respond to the Implementation Plan at the Johannesburg Summit (2002) committing the UK Government to the delivery of ecological networks; and finally, as a result of the first three points, there is a pressing need to work intimately with the agricultural community, and to participate fully in agri-environmental planning.

Keywords: ponds; conservation; landscape; ecological networks; planning

## **Pond biodiversity assessment: what is the state of the art ?**

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A considerable number of biological assessment methods for streams and rivers has been set up during the last two decades but lentic freshwater habitats have been rather neglected. Ponds, in particular, have been widely ignored in spite of their significant contribution to regional biodiversity. Even in the recent Water Framework Directive (WFD 2000/60/EC), ponds are not explicitly mentioned.

We present a review of existing biodiversity assessment methods suitable to ponds in order to summarize information for future research. A keyword literature survey was performed using ISI Web of Science and additional papers were obtained by examining cited references and browsing the web for relevant reports by environment agencies and research institutes (*gray literature*). A table shows the summary of assessment methods specific to ponds, as well as a certain number of wetland assessments. The literature review reflects also the efforts accorded to different freshwater assessment objectives. It appears that biodiversity is far behind water quality and functional integrity and that the assessment objectives are generally vague and articulated in confusing terms (integrity, health, function, status etc). Moreover, a quantitative analysis was carried out to evaluate the number of papers accorded to biodiversity assessment of different waterbody types. The results emphasize that pond-specific methods are clearly underrepresented compared to running water and wetland assessments.

## **Small ponds and big landscapes; the challenge of macroinvertebrate spatial and temporal dynamics.**

**Jeffries M.**

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Our understanding of the ecology and conservation of European ponds is built on two traditions; firstly extensive surveys of many ponds, often based on one visit, testing relationships between species assemblages and the pond's environment or, secondly, intensive experiments usually restricted to one site, over longer time periods. Neither approach adequately captures the long-term spatial and temporal dynamics of pond invertebrates across the landscape. Over the last decade the significance of landscape, land use and species turnover between ponds has been highlighted both for the conservation of pond wildlife and as a key factor in the ecology of many macroinvertebrates. These larger scale spatial patterns and the resulting heterogeneity of ponds and their wildlife are not effectively addressed by the tradition of intensive, single-site studies. Longer term data bases, often sufficient to allow analysis of species turnover in relation to climate, show considerable annual temporal variation in species distributions, a phenomenon not adequately addressed using the approach of extensive, single year surveys. I will use data from a decade long study of biodiversity of small, temporary ponds in Northumberland to explore longer term temporal variation, species turnover and the development of spatial variation between ponds. A diversity of invertebrates, from small ostracods to large snails and highly mobile beetles to, allegedly, sedentary molluscs will be used to show species-specific turnover on scales from individual intra-pond habitat to decadal regional climate. In particular the distribution of the macroinvertebrates shows variations between the years tracking climate and successional change to pond habitat. The full value and natural function of individual ponds relies on the opportunity for change being conserved at these larger temporal and spatial scales. Then I will draw out key lessons from this study of small ponds at just one site for the conservation and ecological security of pond systems in the wider landscape.

**Keywords;** Macroinvertebrates, turnover, heterogeneity, metacommunities, landscape.

## **Concave Islands: Ecology of parafluvial ponds along river corridors**

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Parafluvial ponds are distinct aquatic “islands” within the floodplain habitat mosaic. They are sensitive landscape elements that disappear first from river regulation, wood removal, and flow control. We systematically investigated pond heterogeneity and invertebrate diversity along the entire length of three Alpine river corridors arranged along a human impact gradient (Tagliamento>Thur>Rhône River). The number of parafluvial ponds peaked in bar- and island-braided floodplain reaches, averaging a maximum of 29 ponds per river-km. Ponds were absent in regulated and naturally-constrained sections along each corridor. Within one natural flood plain, the number of ponds containing water ranged between 18 and 39 over time, depending on the water level in the main channel. Thermal characteristics and water level fluctuations were the most important variables determining pond heterogeneity. Ponds were foci of biodiversity. Although covering a small proportion of the total aquatic area (<3%), ponds contributed >50% to invertebrate diversity. A high proportion of pond taxa were classified as “rare”, with limited spatial distributions. The loss of parafluvial ponds, therefore, can lead to a major decrease in aquatic invertebrate diversity.

**Keywords:** reference river, braided, restoration, rare taxa, Tagliamento

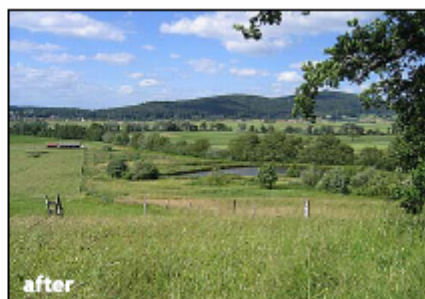
## **Open-cast restoration of a hydrosystem and development of ponds and wetland in a agricultural surface by removal of drainage network and by soil modelling. Example of replacement of habitats to improve biodiversity**

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Within the framework of measurements of habitats replacement related to the negative impacts due to the construction of the motorway (A16) in the Swiss Jura, it was planned to create a large wetland with ponds on an slightly inclined pasture. The implementation of a reparcelation facilitated the possession of the ground by the promoters of the road and allowed to elaborate so a complete and complex project of revitalization. Indeed, a drainage network was destroyed upstream of the land. Then, one forced the water to be flowed in surface so as to moisten at most soils. A preferential flow in natural open channel was created along which basins and pools were dug for creating morphology and habitats diversification. Two ponds, of which one with a strong depth, were carried out in succession. Water leaving by two weirs the principal pond continues to feed rivulets along which numerous pools were dug. The nature of the soils as well as the variable degrees of hydromorphy made possible to constitute, naturally, a whole of various vegetation and water surfaces in complex mosaics. Other measurements, like the plantation of very old fruit varieties in orchard high-stems or the grazing ground of some zones contribute to favor a greater diversity of this sector. A scientific monitoring on some target groups of the flora and fauna allowed making obvious types of rare butterflies and dragonflies for the region. The presence of these species allows equally to orient the management of the site to long term.

Thus, from a simple revitalization of a drain upstream, it was recreated by surface run-off a complexe wetland very rich in mosaics and ecotones. The old agricultural zone of 5 hectares now presents a high environmental value and a remarkable ecological functioning for the region.



## **Altitude, a major driving factor for biodiversity in small waterbodies (ponds, lakes) even at low elevations**

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1. It is well known since Théophraste (III<sup>rd</sup>-IV<sup>th</sup> BC) that in terrestrial ecosystems of alpine regions the main factor governing species richness is likely to be the altitude. However, this factor is rarely taken into account in the assessment of the biodiversity in small waterbodies (ponds or lakes).
2. As several methods for the assessment of ecological quality are currently being elaborated, it is important to examine the influence of altitude upon biodiversity.
3. Our objectives are: (i) to describe and model the relationship *altitude-species richness* for various pond-dwelling taxonomic groups, (ii) to identify the key factors associated with altitude, (iii) to assess the consequences of the observed relationships for biodiversity evaluation.
4. 109 ponds located in different biogeographic regions of Switzerland were chosen along an altitudinal gradient from 210 m.a.s.l. to 2757 m.a.s.l.
5. The species richness of five taxonomic groups (aquatic plants, aquatic Gastropoda, aquatic Coleoptera, Odonata and Amphibia) was assessed through standardised methods.
6. More than one hundred local and regional variables measured in situ or calculated were taken into account. Compared to other local and regional variables, altitude appeared to be the most important parameter driving biodiversity. Altitude was not only correlated with climatic parameters, but also with pond age, shading, catchment characteristics (land use, geology) and physico-chemical variables (Nitrogen, Phosphorus, Conductibility, pH, water transparency).
7. The relationships altitude-species richness, for the five taxonomic groups, differed in magnitude, this being partly related to the respective sizes of the regional species pools.
8. Differences were also recorded in the shape of the relationship: at lower altitudes, the curves decrease more for fauna than for vegetation.
9. The results emphasised the importance of altitude in biodiversity assessments. What is new in this research is that altitude is already an important parameter at lower elevations, especially for fauna.
10. A weighting system should be included in the analysis of observed species richness. This could be achieved through the use of taxon-specific richness-altitude models.

## **Invasion success in juvenile zooplankton communities of small ponds: an experimental test**

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The species composition of a local community is determined by regional and local factors. During community build-up, the relative importance of both factors changes, with regional factors expected to be more important during early colonization history and the effects of local factors increasing when the community matures. We tested the relative importance of both factors during the early stages of colonization of new aquatic habitats by zooplankton in an enclosure experiment. Invasion success of immigrant species was assessed in juvenile zooplankton communities in the first and second year of existence in a set of five newly dug pools. Each year, three experimental treatments, representing a gradient of strength in biotic interactions with the resident communities, were created to explore the impact of competition with the resident communities on establishment success of immigrant species. In both years, species diversity of the communities in the experimental units increased when immigrant species were added, suggesting dispersal limitation in the pools. However, establishment success was reduced in the second compared to the first year, indicating an increase of the importance of local effects during the course of community build-up. The first year, no difference could be detected in invasion success between the experimental treatments. The second year, when resident communities had developed further, immigrant species were significantly more present in the treatment without resident species than in the treatments with resident species. Overall, our results point to biotic interactions, mainly competition among zooplankton species and predation by *Chaoborus*, as being most important in determining zooplankton community build-up.

Keywords: juvenile community; invasion success; colonization; new habitat; local versus regional factors

## **Relative scarceness of marbled newt in a pond network: competitive exclusion with palmed newts or specific habitat requirement?**

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The Regional Park of the « Causses du Quercy » is a 1757 km<sup>2</sup> karstic region in SouthWestern France. In this arid area, about 400 ponds were bored by man into the calcareous rock. These ponds are the only surface water resource available for wildlife, and they are also the only available breeding sites for amphibians. Our preliminary studies showed that 66% of the monitored ponds (40 ponds) were spawning sites for palmed newt (*Triturus helveticus*), whereas only 30% were convenient for the marbled newt (*T. marmoratus*) which is a vulnerable species (Appendix III of the Bern Convention and Appendix II of the European Directive on Habitats). The occurrence of marbled newt populations among ponds was always associated with the presence of palmed newts.. The aim of our study was to establish whether the relative scarceness of marbled populations was due to competitive exclusion between both newts species at the breeding site, or if marbled newts exhibited stronger environmental requirements than palmed newts. Concerning a potential interspecific competition, we studied all critical life stages, i.e., eggs, larval stages, and reproductive adults (no immature were found in aquatic phase). We first demonstrated a temporal partitioning of the egg deposition, with only of short overlapping period, reducing competition for the spawning substrate during the egg laying phase. Moreover, during the growth periods, predatory larval stages were spatially segregated, thus reducing interspecific predation. furthermore, the analyses of adult stomach contents did not show a preferential predation on the eggs or larvae of the other species and, the adults did not select the same type of preys. Therefore, there was also a partition of food resources. Concerning environmental requirements, vegetation at the vicinity of the breeding site generated an attractive effect during pre- and post-breeding migrations of adults. Contrary to palmed newts, marbled newts arrived from forested area and returned to this habitat after the egg deposition. Palmed newts seemed to more ubiquitous, finding more easily safe habitats during their terrestrial phase. The relative scarceness of marbled newt populations was directly linked to a specific terrestrial area, rather than to interspecific competitive exclusion. The results of nestedness analyses confirmed the above assumption, by showing a highest amphibian biodiversity in ponds located close to a forested area (especially due to the occurrence of marbled newts and fire salamanders). These results highlight the need to protect the pond surroundings in wetland conservation and management plans.

**Keywords:** newt, competition, pond, conservation, habitat requirement.

## Landscape determinants of amphibian communities in alpine ponds

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Amphibians that migrate from land to water for reproduction are suitable candidates for an analysis of the matrix habitat quality on species occurrence and abundance. In the Alps, the newt *Triturus alpestris* and the frog *Rana temporaria* can be found in numerous aquatic sites. Our goal was to evaluate the influence of the surrounding matrix terrestrial habitat structure on the occurrence of these two species. We selected 74 aquatic sites (from alpine lakes to bog ponds) varying in surrounding landscape structure. For each sites, we collected information on intrinsic variables (i.e. breeding site) and landscape (i.e. terrestrial habitat structure within a circular 800 m radius area centered on the breeding site). The number of spawn deposited was used to estimate Frog abundance. Only occurrence of newts was used in the analysis.

We used a GAM to relate occurrence and abundance of each species to the environmental characteristics of the pond and the surrounding habitats.

Results reveal that the most favorable structure of terrestrial habitats differ for the common frog and the alpine newt in mountainous environment. We also show that the way the terrestrial structure is described (proportion of each habitat type, spatial position of each habitat type, etc...) can change the overall predictive power of the models but also the response curves (for the common frog) in relation to the environmental variables. These results are also compared with previous works on amphibian habitat determinants in other environments.

Keywords: matrix habitats, metapopulation, montane, *Rana temporaria*, *Triturus alpestris*

## A comparison between the conservation value and assemblages of temporary and permanent ponds.

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Worldwide, temporary ponds are a neglected habitat, and there are many gaps in our understanding of their conservation value and ecology. This study investigated the effect of drying out on the conservation value and community characteristics of ponds in semi-natural areas by comparing national datasets of temporary (n=71) and permanent ponds (n=132) for (i) wetland plants, (ii) macroinvertebrates and (iii) a range of physico-chemical parameters. The results showed that temporary ponds supported fewer aquatic species than permanent ponds, but that they were as important as a habitat for uncommon and rare species. Thus, one in four temporary ponds supported at least one Red Data Book species. Canonical Correspondence Analyses (CCA) revealed that temporary ponds generally supported distinct assemblages compared to permanent ponds. However, there was some overlap between temporary and permanent pond communities. This was linked to the presence in temporary ponds of species which lack adaptations to survive the dry period, and which are generally thought to be typical of permanent waters. These findings suggested that temporary ponds may play an important role as a stepping stone between aquatic habitats. Overall, the study highlights the importance of temporary ponds as a biodiversity resource in the UK.

Keywords: macroinvertebrates, macrophytes, temporary ponds, permanent ponds, conservation value

## **25 years of change in the plant community and the conservation value of some Cheshire ponds**

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The importance of ponds for biodiversity and amenity has, in recent years, increasingly been recognised. However, although studies of changes in pond numbers are common, far less is known about changes in the ecological quality of ponds. In the present study we repeated a survey of ponds on the parish of Christleton, in Cheshire, which was originally carried out in 1973 by a team of botanists. We believe it is the first time that a survey of a group of ponds has been repeated after 25 years. The aims of the present study were to: (i) identify the changes in the conservation value and plant communities of the Christleton ponds over 25 years, and (ii) assess whether any changes identified were due to natural or anthropogenic causes.

A total of 88 ponds were surveyed in 1998 for their wetland plants, using the methods of the National Pond Survey (NPS). The results of the study showed that about one quarter of the ponds surveyed had been lost. Comparison between the plant species composition of ponds in 1973 and 1998 showed that similarity was relatively low for most of the ponds surveyed. However, species composition at the landscape level was relatively high (88%). The conservation value of ponds decreased from 1973 to 1998, with the loss of some species sensitive to nutrient enrichment. Overall, changes in landuse, and in particular, the conversion of grazing land to arable, seem to have been the main reason for the changes identified. The study highlighted the importance of monitoring biodiversity in ponds and other small waterbodies on a long-term basis.

**Keywords:** wetland plants, macrophytes, ecological monitoring, conservation value

## **PLOCH: a standardised method for sampling and assessing the biodiversity in ponds**

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1. As ponds are now recognised as freshwater habitats clearly distinct from lakes and running waters, there is a need of standardised tools for assessing their degree of integrity and defining their ecological status, as required by the EC Water Framework Directive (WFD).
2. We developed a standardised method for assessing the biodiversity in ponds of Switzerland, in term of species richness.
3. Five taxonomic groups were chosen because of their good representativeness as ponds inhabitants and as keystone, umbrella or flagship groups: aquatic plants, aquatic Gastropoda, aquatic Coleoptera, adult Odonata and Amphibians. National red lists exist in several European states for these taxa, indicating a relatively good knowledge of their geographic distribution.
4. Data gathered in the study of 80 Swiss ponds, together with experiences accumulated in previous studies, formed the basis of the proposed standardised sampling method.
5. For the aquatic flora, quadrats are located along transects perpendicular to the longest axis of the pond. To decide the number of quadrats necessary to record more than 70% of the pond species richness, a relation with the pond area has been proposed. A non-parametric estimator (Jackknife-1) is used to estimate the real species richness (100%).
6. Aquatic invertebrates (Gastropoda, Coleoptera) are collected with a hand-net (rectangular frame 14x10 cm, mesh size 0.5 mm). Sampling is stratified within the dominant habitats. The number of samples necessary to collect more than 70% of Coleoptera and Gastropoda species is calculated from a relationship with pond size. The Jackknife-1 estimator is used to estimate the real species richness (100%).
7. The diversity of adult Odonata is assessed using a standardised field survey method combining observations from early and late summer. The species richness is corrected with an abundance-based estimator (Chao1).
8. The species richness of Amphibia is calculated from an exhaustive inventory.
9. For the assessment of biodiversity (species richness), observed values are compared to predicted values for an expected "good ecological status" (following WFD). Generalized Additive Models are used to predict species richness from environmental predictors characterizing the pond. Comparison of observed and predicted richness through a ratio allows the allocation of an ecological status to each pond (five classes of ecological status, as recommended in the EC Water Framework Directive).
10. The application of this method to nature conservation is discussed and illustrated with tests conducted in Switzerland.

## Is a multimetric index suitable to assess the ecological status of ponds ? Part 2 Macroinvertebrates and Amphibians.

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The biological assessment of water quality belongs to the current focus upon the monitoring of surface waters resources<sup>1</sup>. Standardised methods exist concerning running waters and lakes but they do not apply in the specific context of small standing water bodies like ponds. They are based upon the indications given by taxa such as diatoms, macrophytes, fishes, invertebrates, identified at various taxonomic levels and used individually (lake indices "Oligochaetes" or "Chironomidae"), or in combination (stream biotic indices, metrics like EPT taxa<sup>2</sup>).

Recent biological approaches use "multi-metric" indices (cf Karr & Chu, 1999) and offer new monitoring prospects particularly for the comparisons between investigated and reference sites. This approach was chosen by Pond Action (2000) in Great Britain for the development of an original method for the assessment of small standing water bodies; however this method remains restricted to Great Britain.

A recent work carried out in Switzerland (Oertli *et al.*, 2000, Perrottet *et al.*, in press) provided a database of a hundred small standing water bodies used : (i) to test metrics selected from the literature for their potential to indicate water quality, (ii) to identify new metrics indicator of water quality. Such metrics included specific composition of aquatic macroinvertebrates assemblages (such as for example species and families richness), diversity indices (such as Margalef) or biological and ecological traits (Usseglio-Polatera *et al.* 2000).

The relations between eighty metrics and the level of water eutrophication of the ponds were computed, and highlighted the metrics suitable for the development of a method to assess pond water quality.

Total species richness (Coleoptera + Gasteropoda + Odonata + Amphibian), total number of macroinvertebrate families, Coleoptera and Odonata species richness, total number of EPT families and total number of MO families (Megaloptera + Odonata) decreased with increasing eutrophication. This was particularly noticeable between the mesotrophic and hypertrophic stages. A selection of biological and ecological traits reacts positively or negatively, too. These results show that the selected metrics (and combinaison in a multimetric index) are well suited for incorporation into a water quality assessment method for ponds. They stress the importance of taking macroinvertebrates metrics into account within routine monitoring frameworks, such as those carried out by cantonal administrations in Switzerland.

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<sup>1</sup> See for example the European directive ([http://europa.eu.int/eur-lex/fr/lif/dat/2000/fr\\_300L0060.html](http://europa.eu.int/eur-lex/fr/lif/dat/2000/fr_300L0060.html)), or the documents concerning the modular concept for river assessment in Switzerland II

<sup>2</sup> Ephemeroptera + Plecoptera + Trichoptera

## **An evaluation proposal of the conservation state in shallow lentic ecosystems: the index ECELS**

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The implementation of the Water Framework Directive (2000/60/CE) requires the existence of easy tools for the assessment of the ecological quality of wetlands and other shallow lentic ecosystems. Several proposals are developed for the assessment of water quality and trophic state in these and other ecosystems. However, the water quality assessment does not show the conservation state of the whole ecosystem. Human activity has changed wetland morphology, surface and ecological processes, but these alterations not always have effect on water quality. We propose an index (index ECELS) which has been used to evaluate the conservation state for the shallow lentic ecosystems of Catalunya (NE Iberian peninsula) to evaluate its conservation state. The ECELS index is based on five subjects: (1) basin littoral morphology, (2) human activity, (3) water characteristics, (4) helophytic and/or halophytic vegetation, and (5) hydrophytic vegetation.

## **Invertebrate biodiversity of atlantic temporary ponds (turloughs) and threats to their conservation**

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Turloughs (a gaelic term meaning 'dry lake') are ponds lying on karstic limestone in the western third of Ireland. They are not vernal, but governed by local climatic events and they fill and empty with groundwater associated with underground drainage systems. Their biota shows adaptations such as short life span, parthenogenesis and resting stages, but as predation is mild they are also refugia for some arctic or alpine branchiopod crustaceans. Characteristic turlough groups include branchiopods, copepods, ephemeropterans and turbellarians. While these ecotonal ponds are priority habitats under the Habitats Directive, their rapid and unpredictable flooding had caused hardship and may lead to demands for flood relief.

Keywords: turlough, temporary pond, crustacean, branchiopod, conservation

## **The ecology and conservation of mountain ponds in Central Apennines, Italy**

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Ponds contribute significantly to the biological diversity of Central Apennines. In particular, they play a key role in sustaining the aquatic life over 1000 a.s.l.. A relevant research effort has enlarged the scientific knowledge of these lentic systems during last decades. Researchers have mainly focused their interest on the communities living in. On the other hand no intense research programs have been performed to increase the knowledge about the limnological properties of these mountain freshwater habitats. In this study we report the results of a large research program (1996-2000) on mountain ponds in Central Apennines. We merge original data with the ones already published (i) to give a comprehensive picture of the limnological properties of these systems and (ii) to address the ecological mechanisms potentially significant from a conservation standpoint. Our data indicate that ponds are extremely vulnerable to degradation in Central Apennines. In particular a huge amount of nitrogen and phosphorus, coming from dejections of the livestock grazing in mountain pasturelands (during snow free periods) makes them to shift towards turbid conditions. We observed algal blooms and large fish kills which are events proper to lowland eutrophic systems. We also found ponds showing good environmental quality (i.e. low phytoplankton biomass and high water transparency) despite the nutrient enrichment. The alternative equilibria hypothesis states that shallow freshwater systems can show a clear state also with high nutrient availability thanks to ecological mechanisms related to the macrophyte presence. We then discuss if, with reference to this hypothesis, new theoretic and practical tools for the conservation of mountain ponds in Central Apennines may be developed.

## **Is a multimetric index suitable to assess the ecological status of ponds? Part 1 Macrophytes.**

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The biological assessment of water quality belongs to the current focus upon the ecological monitoring of surface water resources. Standardised methods exist concerning running waters and lakes, but do not apply to the specific context of small standing water bodies such as ponds. There is a long history in the use of aquatic vegetation to assess aquatic ecosystems as it is known for its sensitivity to environmental conditions, including variations. Because of its wide ranging bio-indication properties, this group has a considerable potential to detect various kinds of impairments in heterogeneous ecosystems such as ponds.

Recent biological multi-metric approaches offer new assessment and monitoring prospects and allow comparisons between investigated and reference sites. A biological metric is a measure based upon the indications given by taxa, at different taxonomic level or merged by ecological traits. With the final objective of developing a method to assess pond ecological quality, we explored the relationships between several vegetation metrics and indicators of impairment. The tested indicators of potential impairment were water eutrophication, land-use in the watershed and coverage for each type of plant association in a buffer zone of 50 metres around the pond. The tested vegetation metrics were species richness in macrophytes, diversity indexes, mean and relative species richness for morphological and biological types, the proportion of pond colonised by growth forms and biological types, the relative rate of covering between different growth forms, the maximum depth of colonisation by rooted macrophytes and the total and mean conservation value per pond (based on the degree of threat for each species according to data from the national red list). To test the sensitivity of the selected metrics to impairment, we used data collected from a hundred ponds located in the four altitudinal vegetation belts of Switzerland (colinean, mountain, sub-alpine and alpine).

The results indicate that the three categories of potential impairments are each detected by at least three of the tested vegetation metrics. Furthermore, there is a complementarity of the metrics, each metric being not sensitive to the same kind of impairment. This observed complementarity is an important property for the selection of non-redundant metrics to incorporate in a multimetric index. Depending on the altitudinal belt considered, differences in the sensitivity of the metrics to an impairment were also noticed. For example, at the colinean and alpine belt, the proportion of the pond area colonised by submerged macrophytes decreases significantly with an increase in eutrophication whereas this relation is hump shaped at the mountain belt and positively correlated at the sub-alpine belt. The main results for the colinean belt show that species richness, mean and relative rate of covering by submerged species and mean conservation value significantly decrease with an increase in the eutrophication of water and when there is farming in the watershed. When the proportion of forest increase in the watershed, the total species richness, the mean conservation value and the relative rate of covering by submerged species also increase. These results indicate that aquatic vegetation is a suitable biological group to detect, identify and measure impairments of the ecological integrity of ponds. They also highlight the importance of biological monitoring in taking into account the presence and abundance of macrophytes identified at the species level.

## The patrimonial typology of ponds, a tool to manage biodiversity and social value of small wetlands in the Parisian basin (France)

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The preservation of the 600.000 French ponds is no longer established because they are not well-known and because of the specific difficulties to insure their protection due to their small size and dispersion. This situation induces the drastic disparition of these biotopes, as well as a strong ecological uniformization and a prejudiciable artificialization of their valorization modes. The wetland patrimony is so altered in his most discret expression while the environmental functions of these elementary hydrosystems, most of the time at the head of the watersheds, are essential to the conservation of the landscape and the ecology of these territories. On the other side, the land managers express a certain unmightiness in front of the object "pond" and can hardly define how they contribute to the land sustainable development. The matter is to precise the ecological and social contributions of the ponds and to precise the links between their uses and the biological content in order to build a social strategy of preservation of the dispersed ponds. This proposition is inserted in the frame of The Programme National de Recherches sur les Zones Humides (PNRZH) « Les mares, des potentialités environnementales à valoriser », managed by B. Sajaloli for the Centre de Biogéographie-Ecologie (FRE 2545 CNRS-ENS LSH).

At a biological point of view, a lot of contributions have already shown the very important participation of the ponds to the spatial biodiversity (Sajaloli & al, 2000)<sup>3</sup>. At a social point of view, they are spots out of value due to the loss of their traditional utilities or, at the opposite, the very precise functions they fill (decantation basins, stormy rain pools,...). However, the ponds have still a great variety of uses and fonctions suitable to be associated to types of locations and therefore to specific kinds of managers (Sajaloli & Dutilleul, 2001)<sup>4</sup>.

The confrontation of the two approaches leads to elaborate a patrimonial typology, on a geographical basis, which put for each pond a biological value and a type of thread. It is today possible to correlate spot, biology and uses of the pond : so we appears the basis of a scientific strategy of intervention of the whole ponds wich is purchased by the « Pôle relais Mares et mouillères de France » (Limoges O, 2004)<sup>5</sup>. This contribution has been built from a data bank of more than 500 ponds (located in 12 representative areas of the Parisian basin) and presents 500 qualitative variables that come in 1016 modes including morphological and environmental factors and about 400 vegetal species.

<sup>3</sup> Sajaloli B., Limoges O., Dutilleul C., Thulie A. (2000) *Contribution des mares à la qualité écologique et sociale des territoires*, pp. 215-234, in Wicherek S. (éditeur scientifique) *L'eau, de la cellule au paysage*, ELSEVIER, 424 p.

<sup>4</sup> Sajaloli B. & Dutilleul C. (2001) *Les mares des potentialités environnementales à revaloriser*, rapport final du Programme national de Recherches sur les Zones Humides, Centre de Biogéographie-Ecologie FRE 2545 CNRS ENS LSH, 104 p.

<sup>5</sup> Limoges O. (2004) site internet : [www.polerelaismares.org](http://www.polerelaismares.org)

## **An evaluation of road runoff impact on stormwater detention ponds invertebrates communities in South-eastern France**

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Protection of water resource is one of the main priority for future. During the last decades, highway companies have dug stormwater detention ponds in order to mainly prevent water resource from accidental or chronic pollution (runoff). These detention ponds have shown to be highly attractive for aquatic invertebrates.

Five of these “ponds”, localized in the Mediterranean region were sampled during one year ( march 2002 – march 2003) for their chemical and biological characteristics. These parameters were correlated with their invertebrates composition.

The main results were the low levels of road contaminants (such as trace metals and hydrocarbons) detected in water column and the marked contamination of top sediment layer by zinc and copper in pools with an artificial substrate (Poly Ethylene High Density membrane).

Data were analysed using multivariate approaches. Great differences between detention ponds were observed not clearly linked to the main road runoff pollution.

Nevertheless, these constructed biotopes show a high potential as models for pollution experiments that could be used in restoration ecology.

## **Monitoring the distribution of amphibians when species are not always detected.**

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The goal of a monitoring program is to collect reliable data on the distribution and abundance of the species under study. When researchers estimate the species richness of a pond or determine the regional distribution of a species, they usually assume that all species or populations are detected or that non-detections are such that they don't matter. Thus, inference from most monitoring programs depend on the assumption that all species are detected with certainty or that detection probabilities are at least constant. Such assumptions, however, are rarely true. If sites are visited multiple times, then it is possible to estimate detection probabilities and to adjust estimates of species richness or estimates of the distribution of species. Using data on the distribution of newts (genus *Triturus*) that were collected for the update of the swiss amphibian red list, I present an example of an analysis of the distribution of species that takes detection probabilities into account. I also show how covariates can be incorporated into such an analysis.

**Keywords:** amphibian, detection probability, distribution

## **Macroinvertebrate biomass-size spectra of permanent and temporary ponds in Central Italy**

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Size spectra is a simple two dimensional representation which may be useful to describe, compare and make prediction about different communities. However, the application of this approach to freshwater benthic community is only on the early stage of development and there are no data from small water bodies. In particular, it is not clear how physicochemical variables and community structural characteristics as species diversity may influence the shape of the spectrum. We compared the biomass size spectra of the macroinvertebrate community sampled in 21 temporary and permanent ponds. Several habitat characteristics were also recorded. More than 18000 invertebrates belonging to 202 taxa were collected and size of each individual measured. Biomass-size spectra covered 6 orders of magnitude in size with the small size classes (0.0625 µg) occupied mainly by early instars of Insect taxa and Oligochaeta, and the larger size classes (up to 0.5 mg) by Odonata and Decapoda. Peaks of biomass were recorded in different classes depending on the specific biotope and the substrate type. The log<sub>2</sub>-normalized size spectra was little different between substrates, while the differences among temporary and permanent ponds were more evident. Permanent ponds showed more biomass per size class than temporary ponds. The results are used to discuss the influence of habitat characteristics on the shape of the spectra.

**Keywords:** temporary and permanent ponds, macroinvertebrates, size spectra

## **Monitoring and conservation of cladoceran diversity: the potentials of using dormant egg banks**

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Traditionally, cladoceran species richness is monitored through analysis of active community samples. Given the often high spatial and temporal heterogeneity of active communities, the resulting measure is strongly dependent on the location and on the timing of sampling. To have a better estimate of the overall diversity, labour-intensive multiple sampling in space and in time is usually needed. We developed an alternative integrative method to monitor cladoceran diversity, based on the identification of individuals emerging after incubation of single-date egg bank samples. Dormant egg banks are indeed believed to integrate to some extent the variability encountered in active communities as a result of sediment focussing and resuspension. This egg bank based method was compared to the traditional one in terms of species yield and cost-efficiency using samples collected in 95 shallow European lakes. On average, hatching the egg bank samples under suitable conditions allowed detection of 35 % more species than the traditional approach, whereas the associated effort was lower in nearly all cases. We next applied our method to monitor the egg bank build-up in 24 newly created ponds in Flanders (Belgium). One year after creation, only a single pond remained without a detectable cladoceran egg bank. In other ponds, dormant egg densities ranged from 59 to 10,041 eggs m<sup>-2</sup>. However, less than half of the species in the active community samples also hatched from the corresponding egg bank samples. This suggests that the method may fail in young habitats with poorly developed egg banks. Further research is required to test the applicability of our method in mature ponds and whether or not it also allows the rapid detection of other aquatic organisms that produce dormant propagules, like bacteria, protists, plants and other invertebrates.

## Index of Authors

Abdelhak .....	1	Lachavanne .....	3, 19, 24, 29, 30, 33
Alcazar .....	5	Lehmann .....	3, 29
Alder .....	22	Lena .....	1
Angélibert .....	2, 26	Limoges .....	34
Auderset Joye .....	3, 19, 24, 29, 33	Losson .....	14
Baur .....	22	Louette .....	13, 25
Bazzanti .....	4, 15, 36	Martens .....	14
Beja .....	5	Martinoy .....	8
Biggs .....	6, 7, 9, 27, 28	Marty .....	2, 26
Bilton .....	6, 8	McAbendroth .....	8
Boix .....	8, 31	Miaud .....	27
Brendonck .....	11, 12, 14, 37	Mouhssine .....	18
Briers .....	9	Nicolet .....	6, 7, 27, 28
Briggs .....	9	O Connor .....	31
Carchini .....	10, 32	Oertli .....	3, 19, 20, 24, 29, 30, 33
Castella .....	19, 29	Perrottet .....	20, 24, 30, 33
Cayrou .....	11	Pirot .....	34
Céréghino .....	11	Quartier .....	12
Coronel .....	11	Quesada .....	1
De Bie .....	12, 14	Quintana .....	8, 31
De Meester .....	12, 13, 14, 25, 37	Ramalho .....	5
Declerck .....	11, 12, 14, 37	Reynolds .....	31
Della Bella .....	4, 15, 36	Ruggiero .....	10, 32
Dutilleul .....	34	Sager .....	20, 24, 30, 33
Ercken .....	12, 14	Sajaloli .....	34
Fleury .....	16	Sala .....	8, 31
Forró .....	17	Scher .....	35
Gascón .....	8, 31	Schmidt .....	35
Giani .....	2, 26	Solimini .....	10, 32, 36
Gifre .....	8	Sousa .....	5
Goddeeris .....	14	Strehler Perrin .....	16
Grillas .....	18	Thièry .....	35
Hampel .....	14	Thulie .....	34
Head .....	18	Tockner .....	22
Hinden .....	19, 24	Vandekerkhove .....	37
Hull .....	19	Vander Elst .....	25
Indermuehle .....	20	Vandergucht .....	14
Jeffries .....	21	Vyverman .....	14
Joly .....	1	Weatherby .....	7
Juge .....	3, 19, 24, 29	Whitfield .....	6, 7, 27
Karaus .....	22	Williams .....	6, 7, 27, 28
Kestemont .....	14	Yavercovski .....	18
Lachat .....	23		

