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MANAGEMENT of Natura 2000 habitats
Alluvial meadows of river valleys of the *Cnidion dubii*
6440

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The European Commission (DG ENV B2) commissioned this Management model for habitats in Natura 2000 sites. 6440 Alluvial meadows of river valleys of the *Cnidion dubii*

This document was completed in February 2008 by Ján Šeffer, Milan Janák and Viera Šefferová Stanová, Daphne-Institute of Applied Ecology, Slovakia

Comments, data or general information were generously provided by:

Erika Schneider, WWF Floodplain Institute, Germany
Werner Lazowski, Techn. Büro für Ökologie, Austria
Dušan Valachovic, State Nature Conservancy – PLA Záhorie, Slovakia
Mats O.G. Eriksson, MK-Konsult, Sweden
Guy Beaufoy, EFNCP - European Forum on Nature Conservation and Pastoralism, UK
Gwyn Jones, EFNCP - European Forum on Nature Conservation and Pastoralism, UK

Coordination: Concha Olmeda, ATECMA & Daniela Zaghi, Comunita Ambiente

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Alluvial meadows of Morava River floodplains. Photo: Viera Šefferova Stanova

64 - Semi-natural tall-herb humid meadows

EUNIS classification:

E3.43- Subcontinental riverine meadows

Summary

Alluvial meadows with natural flooding regime occur in large lowland river floodplains, which are regularly flooded, but dry out in summer due to a continental climate. The species composition of these communities is influenced by ecological factors, mainly the frequency, duration and time of flooding, which is the main source of nutrients. Floodplains have a long tradition of high-quality hay production. Meadows are usually mowed once or twice a year, depending on weather and floods, with the hay being used for the feeding of livestock.

Mowing is usually recommended for the conservation of wet meadows, in particular the prevention of land degradation and scrub encroachment. When mowing is abandoned litter accumulates and a decrease in species vitality is observed. This is then followed by self-fertilization, which leads to a progressive change in the botanical composition of the meadow and, later on, to scrub encroachment. Finally, mowing can also reduce the competitiveness of some invasive species.

Early mowing improves the floristical composition and prospects for an integration of management and biomass in existing farming systems. Moreover, early management often conflicts with zoological interests, in particular because ground nesting birds and many invertebrates depend on late mowing and a tall vegetation structure in early summer.

The keys to sustainable grazing of the floodplains are control of access, duration and intensity of grazing. The floodplains should not be grazed in the late wet/early dry season and should be lightly grazed early in the wet season. Duration of grazing is important. It is critical to keep the stock off the floodplains, particularly low lying areas until they dry out. The effects of grazing on floodplains tend to be less positive with mixed effects on species richness, and major impacts on both below- and above-ground biomass at high stocking rates.

If manipulation of the flood regime is possible, flooding should be over by the end of April and the area should not be flooded for more than 10 days (except for depressions).

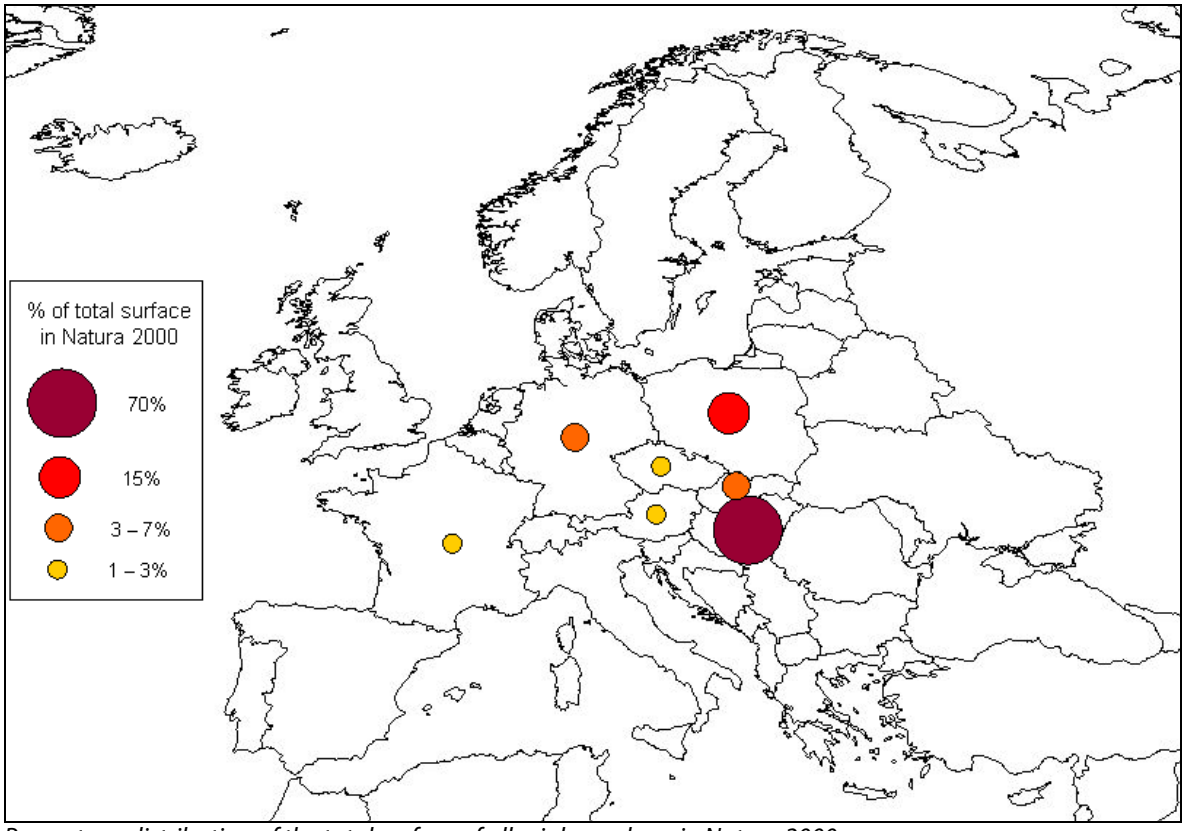
Due to their high value for biodiversity preservation, flood mitigation and nutrient retention, the re-creation of flood-meadows is presently one of the main targets of restoration projects along large Central European lowland rivers. Like other semi-natural grasslands, flood meadows depend on adequate agricultural management to fulfil these important ecological functions. To achieve this in an ecologically and economically sensible way, the prospects for incorporating management and biomass utilization in farming systems appears to be a key issue.

1. Description of habitat and related species

The habitat encompasses alluvial meadows with a natural flooding regime belonging to the *Cnidion dubii* alliance, which occur under continental to sub-continental climatic conditions. The habitat includes meadows on large lowland river floodplains, which are regularly flooded but dry out in summer due to the dry continental climate.

Distribution

The *Cnidion* community includes all floodplain meadows where continental species occur (Balátová-Tuláčková 1969). They are distributed from S Russia, through the Ukraine, Poland and E Germany, and into the Pannonian basin and the Rhine valley of SW Germany and France.



Percentage distribution of the total surface of alluvial meadows in Natura 2000

Alluvial meadows of river valleys of the *Cnidion dubii* in Natura 2000 sites

The following data have been extracted from the Natura 2000 Network database, elaborated by the European Commission with data updated on December 2006. The surface was estimated on the basis of the habitat cover indicated for each protected site and should be considered only as indicative of the habitat surface included in Natura 2000.

Biogeographical region	Nº of sites	Estimated surface in Natura 2000 (ha)	% of total surface in Natura 2000
Panonic	115	43.994	74,93
Continental	115	14.712	25,05
Atlantic	3	14	0,02
Countries	**Nº of sites**	**Estimated surface in Natura 2000 (ha)**	**% of total surface in Natura 200**
Hungary	100	41.628	70,9
Poland	4	8.573	14,6
Germany	105	3.732	6,3
Slovakia	12	1.743	3,0
France	7	1.522	2,6
Austria	2	808	1,4
Czech Republic	8	724	1,2
TOTAL	**233**	**58.720**	**100**

According to Romanian and Bulgarian interpretation manuals, this habitat type also occurs in these two countries. Erika Schneider (pers. comm.) recorded samples in Lower Danube in Romania.

Main habitat features, ecology and variability

There is little consensus over the classification of lowland wet meadows. They occur across a broader geographic gradient from the sub-oceanic to sub-continental areas within Central and Western Europe. The sub-continental lowland wet meadows are mainly assigned to several vegetation alliances, but the conceptual basis of these alliances varies between countries and authors (Botta-Dukát *et al.* 2005).

The largest difference occurs between the sub-oceanic areas (e.g. Germany and western part of Czech Republic), and sub-continental areas of Central Europe, (e.g. Hungary). These meadows are of great conservation interest as they harbour a number of rare plant species. They are also increasingly endangered due to changes in land use (Joyce & Wade 1999, Šeffer & Stanová 1999).

The habitat includes meadows in large lowland river floodplains that are regularly flooded but, unlike the *Calthion* meadows, they dry out in summer due to the dry continental climate. They also differ from the *Molinion* meadows in that they develop on mineral soils with a good supply of nutrients.

Wet *Cnidion* meadows

The wet *Cnidion* meadows are dominated by different species, most frequently *Alopecurus pratensis*, but in places also *Deschampsia cespitosa, Agrostis stolonifera, Poa palustris* or *Carex vulpina*. Diagnostic species indicate that the soil is wetter than for the sub-oceanic type. Species of tall sedge beds indicate a high ground-water table, even in summer. Such situations can develop on low terraces of river floodplains and in depressions. These meadows occur in the SE Czech Republic, S Slovakia and in Hungary.

Characteristic species: *Poa palustris, Galium palustre* agg., *Iris pseudacorus, Gratiola officinalis, Carex vulpina, Mentha pulegium, Eleocharis palustris agg.*

Summer-dry, continental *Cnidion* meadows

These are meadows where *Alopecurus pratensis, Poa pratensis, Carex praecox* and *Serratula tinctoria* have greater coverage in places. This type is strongly differentiated from all others by several species typical of continental distribution such as *Cnidium dubium, Carex praecox, Viola pumila, Veronica longifolia, Inula salicina* and *Carex melanostachya*. These meadows are regularly flooded for a few weeks every spring but in summer the water table can often drop to approximately 1 m below ground level or even deeper due to the dry continental climate (Balátová-Tuláčková 1968). They are usually mown once or twice a year but never grazed (Šeffer & Stanová 1999).

This vegetation occurs mostly in large river floodplains in SE Moravia, E Austria and W and S Slovakia (Vicherek 1962, Balátová-Tuláčková 1966, 1969, Balátová-Tuláčková & Hübl 1974, Šeffer & Stanová 1999, Vicherek *et al.* 2000). There are indications that this type also occurs in Hungary.

Characteristic species: *Cnidium dubium, Viola pumila, Carex praecox, Inula salicina, Veronica arvensis, Serratula tinctoria, Carex melanostachya, Clematis integrifolia, Valerianella locusta, Veronica longifolia, Agropyron repens, Glechoma hederacea, Scutellaria hastifolia, Lythrum virgatum, Vicia tetrasperma, Myosotis ramosissima, Allium angulosum, Potentilla reptans, Euphorbia esula, Calamagrostis epigejos, Rumex thyrsiflorus, Vicia angustifolia, Iris sibirica, Festuca rupicola, Cirsium arvense, Symphytum officinale agg*.

Sub-oceanic *Cnidion* meadows

These meadows may be dominated by different species, mostly by *Alopecurus pratensis,* less frequently by *Holcus lanatus, Poa pratensis, Festuca pratensis, Sanguisorba officinalis* and *Cirsium canum*. Species of mesophytic meadows (*Arrhenatherion*) are frequent in drier stands, based on floodplain topography. The absence of species characteristic of tall-sedge beds (*Magnocaricion*) indicates that these meadows are less influenced by flooding than the previous two types.

Sub-oceanic *Cnidion* meadows are only flooded for a short time or not at all. In this respect, they are similar to the mesophytic continental Cnidion meadows (described below). However, the presence of drought-sensitive species (e.g. *Lysimachia nummularia, Chaerophyllum aromaticum, Polygonum bistorta*) that are absent in next type indicates that the soils of these meadows do not dry out even in summer. This difference can be caused by the macroclimatic gradient: these communities are scattered across the Czech Republic and Slovakia but are absent from all except the west of Hungary, while the next type is widespread in Hungary.

Characteristic species: *Geranium pratense, Trisetum flavescens, Cerastium holosteoides, Dactylis glomerata, Campanula patula, Veronica chamaedrys agg., Galium mollugo agg., Pimpinella major, Anthriscus sylvestris, Poa pratensis agg., Vicia sepium*.

Mesophytic, continental *Cnidion* meadows

These meadows which are distributed in higher location in floodplains, are mainly dominated by *Festuca pratensis,* though in some places this is replaced by other grasses (e.g. *Alopecurus pratensis, Deschampsia cespit*osa and *Poa pratensis*). The number of typical species is extremely low; they include several species of mesic[1] hay meadows (*Arrhenatherion* alliance, e.g. *Daucus carota, Trifolium pratense, Pastinaca sativa*).

On the other hand, common wet-meadow species that are absent in the *Arrhenatherion* stands occur frequently here. This points to the transitional position of these meadows between wet alluvial meadows and mesic meadows (*Arrhenatherion*); they are slightly drier than the former and slightly wetter than the latter. They often occur on mesic soils above the floodplains. If they are found on the floodplains they are confined to elevated ground which is only slightly affected by floods.

These meadows are usually cut once a year and not fertilized (Ružičková 1971). They are widespread across Hungary and S Slovakia, but become rare towards the north-west, where they are gradually replaced by the sub-oceanic type. However, the occurrence of this type of meadow in the Czech Republic may have been under-estimated.

Characteristic species: *Medicago lupulina, Bromus commutatus, Daucus carota*.

Species that depend on the habitat

Alluvial meadows represent important breeding, nesting and wintering habitat for birds. During the breeding season the habitat provides nesting space for many waders such as *Philomachus pugnax* (ruff), *Tringa totanus* (common redshank), *Numenius arquata* (curlew), *Limosa limosa* (black-tailed godwit), *Gallinago gallinago* (common snipe) (Benstead *et al.*1997, Tomovčík *et al.* 1999). Also number of passerines such as *Motacilla alba* and *Motacilla flava* (white and the yellow wagtail), *Anthus pratensis* and

[1] *Mesophytic* or *mesic* means "moderate loving" and refers to plants that prefer moderate levels of soil moisture and temperate climate.

Anthus trivialis (meadow and tree pipit), *Saxicola rubetra* (whinchat) and *Saxicola torquata* (stonechat) nest on the ground. Other important birds nesting on alluvial meadows include *Crex crex* (corncrake), *Asio flammeus* (short-eared owl), *Circus pygargus* (montagu's harrier) and *Circus aeruginosus* (marsh harrier) (Tomovčík *et al.* 1999).

In Morava Floodplains, Slovakia, *Crex crex* (corncrake) originally inhabited alluvial meadows with scattered woody vegetation. Wet meadows with mosaics of mesophilous grassland communities and high vegetation with scattered woody vegetation is strongly preferred by this species. Agricultural intensification is clearly responsible for its present-day decrease in nearly the whole range of its distribution (Tomovčík *et al.* 1999). Though recent surveys in Eastern Europe and new population estimates for Asiatic Russia have shown this species to be considerably more numerous than was thought in the early 1990s, further declines are predicted due to further intensification of agriculture. For this reason the species is listed as Near Threatened in the IUCN Red list (BirdLife International 2006).

Asio flammeus (short-eared owl) is a species bound in Central Europe almost exclusively to wet meadow habitats and it is strongly conservative when selecting its breeding habitat. A reduction in the area of wet meadows as well as the inappropriate timing of mowing (before 30th June) has resulted in the loss of some of its breeding habitats (Tomovčík *et al.* 1999). However the species can be still present on such places during winter time, depending on the abundance of its main prey *Microtus arvalis* (common vole).
Cnidion venosi alluvial meadows represent an important habitat for a number of endangered plant species. Out of many, *Angelica palustris* can be mentioned as a prime example.

Floristically-rich alluvial *Cnidion venosi* meadows are also rich in invertebrates such as butterflies. The undisturbed water regime and mosaic of mown and unmown plots is favourable for *Maculinea nausithous* (dusky large blue) and *Maculinea teleius* (scarce large blue). Both species are connected to their exclusive host plant, *Sanguisorba officinalis* (great burnet) and their life cycle largely depends on colonies *of Myrmica rubra* and *M. scabrinodis* ants respectively. These specific habitat requirements and complicated life cycle mean that these butterfly species have a limited ability to survive in changing environmental conditions.

Related habitats

6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)
They are usually dominated by *Molinia arundinacea* or *M. caerulea* and are found on nutrient-poor and acidic soils, often containing a high proportion of organic matter. An important habitat feature is moisture in spring (may be temporarily flooded) followed by drying out in summer. They are typical of lowlands and may occur in mosaic with *Cnidion* meadows.

Tall sedges (*Magnocaricion*) and reed beds (*Phragmition*) are occurring in mosaic with *Cnidion* in floodplain areas. They are located in shallow meadow depressions and at margins of river arms. Management of tall sedge communities may be the same as of *Cnidion* meadows, depending on moisture conditions.

6450 Northern Boreal alluvial meadows. The habitat type refers to meadows located along large rivers with placid river sections which are frozen every winter and affected by flooding in spring. The habitat is almost entirely exclusive for the Boreal region and there is no overlap in distribution with *Cnidion* meadows, but ecological requirements and management needs are similar. Traditionally, they have been managed as hay meadows; this management usually has ceased but the habitat persists on sites which are not yet severely overgrown with bushes and trees.

6510 Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*). They are species-rich, occurring on lightly to moderately fertilised soils of the plain to submontane levels. They may occur on elevated parts of river floodplains, having the same management requirements as Cnidion meadows.

Calthion meadows. These are dominated by large herbs, while grasses and sedges are of secondary importance in many stands. They are found on the alluvia of small streams, near springs and in seepage areas where the soil is moist throughout the year and usually well supplied with nutrients. The centre of their distribution is in sub-montane and montane areas. They are only rarely present in the lowlands. In

Central Europe they tend to have a sub-atlantic distribution, being rather common in Germany and the Czech Republic but rare in Hungary.

Ecological services and benefits of the habitat

Temperate wetlands are ecosystems with a high biomass yield. The productivity of these meadow habitats varies from 10-30 tonnes per ha (dependent upon moisture); thus they belong to the most productive ecosystems in the world.

In intensively managed agricultural landscapes, meadows represent a unique landscape element that secures both agricultural yield and ecological benefits. Alluvial meadows enable man to exploit floodplains economically. The energy subsidy required is less and the efficiency higher than for any other crop.

Their nutrient sink capacity, especially for nitrogen, is one of the most important ecosystem services of wetlands (Vymazal 1995). Vegetation uptake of the nitrate present within a floodplain is variable in space and time, depending on the temperature and light conditions. During the growing season, vegetation uptake will be at a maximum in late spring and summer, when temperature and light intensity are at a maximum. The uptake of nitrate by vegetation is only a storage process and hay-making will act to remove this nitrate from the ecosystem.

Regularly mown meadows are unique in that they act as huge nutrient sinks. Nutrients from the water are removed by growing vegetation and, if the vegetation is removed, the net result is a reduction of nutrients.

Nitrogen losses by microbial denitrification require the presence of nitrate, a suitable carbon substrate and the absence of oxygen. Since all conditions are fulfilled in these floodplain habitats, a high denitrification rate is expected. This system process constitutes a system of removal, since nitrogen is lost from the ecosystem, being transformed in most cases, into non-polluting gaseous nitrogen. The moisture regime must be variable, that is, there must be a wetting and drying cycle of the soil, which will enhance the microbial activity and affect the rate of denitrification (Haycock *et al.* 1993).

The meadows provide important sources of food and habitats for a wide range of birds, including many rare and endangered species.

Trends

During the last 100 years intensive agriculture, river regulation, drainage and other destructive activities have become commonplace. There has been a massive loss of native plants and animals as well as a heavy invasion of non-native species. In addition, an increase in soil erosion coupled with an increase in pollution has led to a decrease in species richness.

River regulation has been the principal immediate cause of wetland loss. During the last century, the majority of river courses have been regulated. This has involved dike construction, canalisation, and the elimination of all major meanders, which has, in turn resulted in the shrinkage of the naturally inundating floodplains and a deepening of the channel beds. Rivers can now transport more water than before but the resulting loss of extensive floodplain meadows and forests as well as oxbows, riverbank habitats and shallow water areas within the river itself has had a very negative effect on the overall biodiversity value of these areas.

Another major cause of wetland loss is the conversion of floodplain meadows to arable land through ploughing. Fertilisers and herbicides are then regularly used on the arable land. Not only is there a direct loss of floodplain grassland, but the intensive use of chemicals causes an increase in input of nutrients to the whole downstream river system and a wider decrease in species richness. Some fields are still active, but most fields have since been abandoned and are now being invaded by weeds and alien species (eg. in some sections of Morava River floodplain).

Threats

The most important factors impacting upon habitat diversity in the river floodplains have been found to be:

River regulation
This has resulted in a significant decrease in floodplain area;

Intensification of grassland management
This includes the use of fertilisers, improved grass varieties, the making of silage instead of traditional hay, the improved drainage of fields and an increase in control over winter flooding.

Surface water pollution
The accumulation of high amount of nutrients has altered the habitat and its species composition and encouraged the growth of less valuable reeds and/or tall-sedge or grass communities;

Conversion of floodplain meadows
Conversion to arable land in dyked areas leads to many environmental problems, including soil erosion, water pollution etc.

Reduction or absence of mowing
The abandonment of traditional agriculture within floodplain meadows occurs particularly in eastern European countries and is considered a major threat. In a longer term, abandoned areas will (if left unmanaged) be subject to vegetation succession and will become overgrown with scrub and trees.

Invasive alien species
Floodplain habitats in central Europe are frequently invaded by exotic species of American or Asian origin (*Aster novi-belgii, Reynutria japonica* etc.). Their very dense root systems and high above-ground biomass can quickly dominate original meadow species.

Climate change effects

Due to the fact that more extreme floods are expected, rivers and floodplains should be given more space to enable them to absorb the excess floodwater. This could contribute significantly to future flood alleviation schemes. Large-scale restoration projects in central Europe have demonstrated that the restoration potential of this habitat type is good.

Cnidion meadows can easily survive also during extensive dry periods. Such dry periods are expected to increase as a result of climate change; the meadows are dependent upon a drop in the water table and a drying out of the upper soil layer in summer.

2 Conservation management

General recommendations

Floodplain grassland habitats in lowland river valleys are the result of an extensive flooding regime and sustainable land use. Semi-natural meadows of the *Cnidion venosi* alliance belong to the most extensive grassland habitats of the river alluvia. They are the dominant and most species-rich vegetation type in these areas.

The species composition of these communities is influenced by a series of ecological factors, mainly related to the frequency, duration and timing of the flooding which is the main source of nutrients. The maintenance and management of species-rich floodplain meadows is a major concern because the decline in meadow areas results in the demise of naturally functioning ecosystems, which, in turn, leads to the loss of numerous plant and animal species.

The river floodplain has a long tradition of high quality hay production. Usually meadows are mown once and some types twice a year, depending on weather and floods, and the hay is used for feeding livestock.

Active management

Mowing

Mowing is usually recommended for the conservation of wet meadows, in particular the prevention of land degradation and scrub encroachment. When mowing is abandoned litter accumulates and a decrease in species vitality is observed. This is then followed by self-fertilization, which leads to a progressive change in the botanical composition of the meadow and, later on, to scrub encroachment. Finally, mowing can also reduce the competitiveness of some invasive species. In natural stands the application of high doses of fertiliser is also associated with a gradual deterioration in the floristic composition of the plant community (Hrabě & Halva 1993).

Determining the appropriate levels of fertilisers is vital because different levels can positively or negatively influence the biodiversity value of the meadows. In the past, meadows in the floodplain areas were irregularly fertilized and often only fertilised by floods. Květ *et al*. (1996) found that fertiliser doses higher than 90 kg of nitrogen coupled with corresponding doses of phosphorus and potassium strongly reduced the number of species in the alluvial meadow community: the strongest reduction was recorded when using 400 kg of nitrogen per hectare. This led to a 40% loss in species diversity.

Three years of management experiments in the Morava river floodplains in Slovakia (Šeffer & Stanova 1999) have shown that mesophytic *Cnidion* meadows depend on two significant factors: the duration of spring floods and bi-annual mowing. Flood is a dominant factor and many species react either negatively or positively to floods. Prolonged floods can paradoxically support species, such as *Festuca arundinacea* and *Festuca rupicola*, from the gradient's drier end.

In the case of the moist *Cnidion* meadow community, the results also showed a strong impact on species composition depending on the duration and timing of floods. It is clear that the moist *Cnidion* community is more successful in adapting to long-term floods than the mesophytic *Cnidion* community. The number of hygrophillous species present in the community (*Eleocharis uniglumis, Carex vulpina, Ranunculus polyanthemos* etc.) positively correlates with the longevity of the floods.

The more dynamic the meadow in terms of ecological conditions, the more it reacts to management factors. Various treatments were conducted, but only the moist *Cnidion* community reacted quickly to a no-mowing regime – succession was very fast compared to the mesophytic type.

Management requirements for this habitat type (Háková 2003) consist of the following:

TYPE OF MANAGEMENT	Mowing with removal of fresh biomass, mowing with removal of dry biomass, (flooding, mowing and burning of biomass).
SUITABLE INTERVAL	1-2x/year
MIN. INTERVAL	1x/year
EQUIPMENT	
1. SUITABLE	Light mowing equipment
2. POSSIBLE	Heavy mowing equipment
3. UNSUITABLE	Other equipment, fertilisation, grazing

Additional management prescriptions:

- Cutting and chopping with a flail or rotary mower, leaving the cuttings spread on the ground[2].
- The duration and method of mowing should be adapted according to the biological requirements of threatened species (*Cardamine parviflora, Lathyrus palustris, Viola elatior, V. pumila*).
- River regulation should be prevented as it alters the flooding regime.

If it is possible to manipulate the flooding regime, then the spring floods should only be allowed until the end of April and the area should not be flooded for longer than 10 days (except in depressions).

Findings in the Upper Rhine valley suggest mowing in June at more nutrient-rich sites (alliance *Cnidion*). For target species within flood-meadows (e.g. *Silaum silaus, Inula salicina, Allium angulosum*) an early first cut also proves to be advantageous (Joyce 1998; Hölzel *et al.* 2002). All these species exhibit an ability to regenerate vegetatively, to flower and set seed during the second growth in late summer and may benefit from competitive release after mowing. This suggests that only species lacking both the ability to produce seeds after a first cut in June and the ability to propagate through cloning depend on a late first cut to reproduce successfully.

Early mowing also strongly improves the prospects for integrating the management of alluvial meadows in existing farming systems. As shown by Donath *et al.* (2004) the relatively high yields and good quality of hay derived from flood-meadows means that it can be readily incorporated as basic fodder in feeding-systems of cattle and horses. On the other hand restrictive management guidelines that insist on a late first cut leads to a subsequent loss in forage quality. Thus, generally more flexible management schemes should be employed and evaluated.

Nevertheless it should also be borne in mind that early management can often conflict with zoological interests, in particular ground nesting birds and many invertebrates that depend on a tall vegetation structure in early summer. In these cases late mowing may be more appropriate.

In France (Gaudillat & Haury 2002), delayed mowing to allow the flowering of certain species, which are indicators of this habitat, is recommended. Currently, this type of management is applied in the Alsace in the first half of September because the soil is dry and suitable for collecting dry biomass. The use of heavy machinery, mulching and the input of nutrients is however prohibited.

Management prescriptions in Poland focus on the date of mowing: this is restricted to the interval between mid May and the end of June, after the floods. The height of mowing should be 5 – 10 cm above the ground. In the case of possible manipulation of the water regime (in polders), the maximum duration of flooding should be two weeks (http://natura2000.mos.gov.pl/natura2000/pl/poradnik.php#1).

In Hungary there are few references in the literature regarding the management regimes applied to *Cnidion dubii* alluvial meadows. They tend to be dealt with under the more general group of temporarily flooded, summer-dry-out meadows. The area of these meadows has decreased dramatically in Hungary during last century as a result of land reclamation and watercourse engineering works. The dried out

[2] This practice is referred to in some countries as "mulching".

areas are nowadays used mainly for grazing, which leads to a further degradation of the plant community and the soil. For these summer-drying-out meadows a late summer mowing is considered to be an appropriate management if approximately 10% of the area is left unmown. Grazing, further drainage and fertilisation with manure, is not considered appropriate (Zsigrai 2006).

The management plan for the 125,51 ha site of Daru-rét, a proposed Natura 2000 site in Hungary, recommends that alluvial *Cnidion dubii* meadows, which represent 25% of the area, are mowed and grazed and that encroaching shrubs and trees are removed (Sándor *et al*. 2005). On nature conservation areas one of 3 different mowing regimes may be applied:

(1) Mowing at least twice a year to combat weeds. However more frequent mowing should be applied on areas infested with invasive plant species.
(2) Nature-conservation oriented mosaic machine mowing (rotation of mown and unmown plots). The mowing is carried out 1-2 times a year, during the period between 15th-30th of June or after 30th of September.
(3) Nature-conservation oriented mosaic hand mowing on the most fragile areas. This management regime is applied to the habitats of fragile species with management requirements that are different from those of the habitat itself, such as *Angelica palustris*, for which mowing after 30th of September is recommended.

On all areas maintained by mowing (except those with weed/invasive plant infestations) a mosaic mowing regime should be applied. This can be done in two ways: 1) leaving approximately 20% of the managed area every year without mowing and rotating these mown and unmown plots around annually, 2) rotating plots according to different mowing periods so that some plots are mown earlier, some are mown later in the same year.

During mowing it is also necessary to leave stubble at least an 8 cm high. Whether baled or not, the hay should be removed from the meadow within 3 weeks as so that there are no negative side effects for the soil and the ground cover.

As for many other semi-natural grasslands of high nature conservation value, securing an adequate management regime for this habitat type is a major challenge. The interests of farmers and conservationists are often divergent, particularly when it comes to raising productivity through fertiliser use or setting the date and frequency of mowing. The willingness of farmers to accept non-intensive management schemes largely depends on the quantity and quality of biomass yield. Both aspects are of crucial importance for the marketability and utilization of the harvest as livestock fodder.

However, the divergence between the interests of farmers and conservationists remains the most serious problem. Farmers are interested in high yields of high quality whereas conservationists demand management regimes that support floristic and faunistic diversity. Although often regarded as sensitive towards early mowing (Briemle & Ellenberg 1994) the majority of the target plant species have been shown to tolerate a first cut in June. For instance meadows that have undergone such management for decades remain abundant in such plant species (Hölzel 1999; Leyer 2002).

Most of these species have an aptitude for successful vegetative regeneration or flowering and seed production during the second growth in late summer. In terms of plant species diversity there is often no real need for a delayed first cut that considerably diminishes forage quality. Kirkham and Tallowin (1995) also found that the cutting date inflicted only small changes in species diversity in meadows on the Somerset Levels because vegetative regeneration predominates in the habitat. This suggests that only species lacking both a vegetative regeneration strategy and the ability to produce seeds after a first cut depend from time to time on a late first cut to reproduce successfully from seeds. However, since restrictive management guidelines with a late first cut inflict a considerable loss in forage quality (Tallowin & Jefferson 1999) more flexible management schemes should generally be employed and evaluated.

Grazing

As above-mentioned, inappropriate grazing could lead to degradation of the plant community and the soil. The key to sustainable grazing of floodplains is dependent on the control of access, the duration and

the intensity of grazing. The floodplains, whether the better areas on the plain or the less fertile and less productive areas further inland, should be fenced off from the surrounding upland area so that access can be controlled. The floodplains should not be grazed in the late wet or early dry season and should only be lightly grazed early on in the wet season otherwise the grasses may drown during rapid inundation or flooding. The duration of grazing is important. It is critical to keep livestock off the floodplains, particularly in low-lying areas, until they dry out. The low-lying areas generally have a water table or moisture close to the surface.

The effect of livestock grazing on species composition has been found to affect the structure and function of floodplain grassland vegetation. Middleton (2002) found that sedge meadows that were recovering from cattle grazing changed structurally into dense carr, while sedge meadows that had never been grazed had a different species composition to that of grazed meadows. It appears that the consumption of biomass and the trampling of sedges open up the habitat, allowing the shrub to invade. Cattle grazing also facilitates a short-term proliferation of subordinate species that prevented sedges from expanding as result of the introduction of seeds and propagules and the creation of bare patches.

The effects of grazing on floodplains tends to have mixed effects on species richness, and, at high stocking levels, has a major impact on the amount of biomass produced both above and below ground. High stocking rates have much worse effects on soil quality, water quality and the overall condition of the floodplain than low stocking rates. Disturbance and alteration of vegetation structure also appears to affect bird species richness and abundance even at low grazing intensities.

Recovery management

The following restoration scheme has been proposed (Šeffer & Stanová 1999) and applied for arable land, initial succession stages and for those localities with a heavy infestation of alien species in Morava river floodplain:

1st phase

In spring and summer

- the selection of source plots for seed collection from suitable ecological conditions in the floodplain.
- The harvesting of ripe seeds in two periods according to the phenological phases of the target species. The first focused on grass and sedge species and the later on herbs. The exact dates are specified after phenological monitoring of source meadows.
- The processing of the seed mixture – drying, cleaning and preparation for transport.

2nd phase

In autumn or spring

- Seed-bed preparation – ploughing and harrowing.
- Distribution of collected seed mixture together with a nurse crop on the surface and rolling (oat is used to establish vegetation cover quickly and to block the invasion of weeds).
- Creation of "islands of high diversity" by the transfer of sections of turf from good quality meadows. The turves, 0.5 m wide, several metres long and 0.1 m thick, were stripped from species rich meadows. They were placed on small open trailers and cut into small pieces, 10 by 10 cm. The island was then planted with a 4 by 2 metre plot of chopped turf. The turfs were spread out over eight times the area of ground they had previously occupied and approximately one island was created per hectare.

3rd phase

In spring or in summer (according to time of sowing) the biomass is removed.

- The frequency of mowing depends on the extent of weed invasion.
- In the case of low effectiveness of seed germination the additional restricted input of meadow seeds follows.
- Monitoring plots are established and the restored area is monitored regularly.

4th phase

The area is mowed and biomass is removed at least twice a year. In exceptional cases, for instance in the case of heavy weed invasion, it is necessary to re-seed some plots.

A special mowing scheme is proposed for areas where native grassland species are present and where there is no strong infestation of alien species. The frequency of mowing depends on the extent of weed invasion. Mown vegetation should be removed after mowing. In exceptional cases sowing some plots is realised. The entire restored area is regularly monitored.

Collection of seed material

Since the restoration method uses original seeds from floodplain meadows, large-scale restoration requires an efficient method of seed collection. Identifying resource meadows on the Morava River floodplain and determining the methodology for collecting and storing seeds was achieved thanks to consultations with, and advice from, local farmers.

The collection of herb seeds is complicated because the size of seeds, the height of herbs and the fact that their ripening time is more variable than for grass species. The following method is more effective:

1. The meadow is mowed when the desired herb species are ripening.
2. The hay is dried out and chopped.
3. The hay is distributed by machine on prepared arable land and rolled into the land.

The advantages of seed collection using this method include low financial costs, the lack of special requirements for machinery, the presence of the original gene pool and the use of natural resources without making new fields for planting grass or herb species.

In the Austrian part of Morava-Dyje floodplain, a regional seed mixture was prepared on special propagation fields in order to produce sufficient seed for the restoration of 74 ha of meadows (Wurzer 1999). The first questions raised for this meadow re-creation project were the appropriate seed mixture to use, the seed rate and local sources of seed. A local seed source was found and the mixture of mostly grasses was sown at a rate of 25 kg per hectare. Lower rates led to competition from undesirable species. Various seed collection methods were tried. Collecting by hand was was found to be the best way of producing enough seeds for restoration projects (Neuhauser 2001). The arable land was transformed and is now managed as grassland.

Physical restoration of arable soil

The soil quality is a significant factor in determining the restoration potential of arable land within an alluvial floodplain area. It is also important to be aware of the area's history.

Floodplains are dynamic ecosystems and restoration plans require careful preparation within a suitable timeframe. After reviewing flood frequency, weather conditions and seasonal agricultural works, it was determined that transformation work should start in early October. Both spring and autumn sowing can be successful, but an autumn sowing must be carried out early enough to allow adequate preparation of the seedbed and good seedling growth before the winter.

In Slovak side of Morava River floodplain was restored 140 ha of arable land, starting in 1999. The mixture was distributed on arable land and rolled into the soil twice, and then the "islands of biodiversity" were established using the turves from the nearest species-rich meadows. In the same year the area was mowed twice and the biomass consisting of the nurse crop (oat) was used as fodder for cattle (Šeffer & Stanová 1999).

The monitoring results of the restoration work in Slovak side of Morava River floodplain after six years show that the prospects for wetter, more flooded sites are very good - their species composition is approaching that of the original *Cnidion* and *Magnocaricion* meadows after six years. The prospects for less flooded site is also good, but development is not as quick. One monitored site was restored only by more frequent mowing (twice a year), but its development was still very slow.

The existence of viable remnant populations of target species in the vicinity of restoration sites proved to be of major importance for species-enrichment at the target sites (Donath *et al.* 2003). However, even under favourable conditions, dispersal and establishment of target species seems to be an uncertain and

time-consuming process. Management of remnant populations and target areas, active enhancement of seed dispersal and timing of activities are the main ways to maximise the chance of restoration success in terms of species enrichment.

The restoration measures also apply to the northern Upper Rhine where, after the opening of dykes, about 300 ha of former arable land have been converted into alluvial grassland during the past two decades (Dister *et al.* 1992). The former arable land was mostly either left to revert or sown with species-poor seed mixtures of common grasses. These meadows and remnant stands of old flood meadows, partly degraded by intense use (i.e. application of fertiliser, two to three cuts per year) were protected to improve their floristic quality by non-intensive (i.e. no application of fertiliser, mowing restricted to the time after mid-June) agricultural use as hay meadows. Today the meadows are mown once a year, mostly for hay-production, and a second harvest is only taken in years with exceptionally high precipitation.

The large-scale restoration attempts in the northern Upper Rhine aiming at the recreation of species-rich alluvial meadows from arable fields were evaluated by Bissels *et al.* (2004). They analysed floristic composition, soil nutrient status and biomass production of old and newly established meadows with respect to their position in both the recently re-created functional floodplain and the fossil floodplain area which is still protected from flooding by a dyke. It is hypothesised that restoration will be more successful in terms of species-enrichment on the functional floodplain, due to the input of propagules in the course of flooding events. After 15-20 years of restoration management, the floristic structure of new meadows was still dominated by sown grasses and a high proportion of ruderal and arable species, whereas the target species of flood-meadows had largely failed to establish in either compartment. Their results strongly suggest that dispersal limitation of target species is unlikely to be overcome merely by the restoration of more natural flooding conditions.

Techniques such as rewetting, topsoil removal, diaspore transfer or combinations of these are increasingly applied in fen meadow and flood meadow restoration in Western Europe. Restoration success was partly determined by the starting situation. Top soil removal and diaspore transfer were found to contribute most to restoration success. A combination of top soil removal and diaspore transfer and a combination of all three techniques appeared to be the most effective measure. Rewetting alone had no measurable effect on restoration success (Klimkowska *et al.* 2007).

Grazing by Galloway cattle was used as a restoration measure for degraded floodplain meadows close to Marchegg in the Morava river floodplain (Neuhauser 2000). Galloway are relatively light animals, which is very important for wet pastures, and do not need fodder of high quality. However, some supplementary feeding is required. In summer, they need additional food in the form of hay. In winter they need hay and dry roughage. During the grazing period, there were about 50 head of cattle on 50 ha of grasslands. The number of plant species has increased from 35 in 1995 to 66 in 1997. There are 25 constant species; 10 have disappeared and 41 are new.

The following changes have been observed and have been attributed to the effects of grazing:

- development into seasonal flooded grasslands with species indicating disturbance
- increase in typical grasses
- increase in the number of species
- increase in the biodiversity of habitats

Other relevant measures

Due to their high value for biodiversity preservation, flood mitigation and nutrient retention, the re-creation of flood-meadows is presently one of the main objectives of restoration projects along large Central European lowland rivers. Like other semi-natural grasslands, flooded meadows depend on adequate agricultural management to fulfil these important ecological functions. To achieve this in an ecologically and economically sensible way, the prospects for incorporating management and biomass utilization into farming systems appears to be a key issue.

For management or restoration plans to be successfully implemented, it is necessary to co-operate with stakeholders, particularly, farmers and local authorities. It is important to remember that local people are physically and emotionally connected with nature and their comments, recommendations and needs

have to be taken into account when developing restoration plans. By emphasising farmers' involvement in restoration, there is a shift away from the "top down" activity that is so often imposed on local people. To create a working environment that will yield success, it is critical to learn to communicate in a style and language that will be effective with local people. Through personal meetings and workshops, a platform can be provided for discussion and the exchange of experiences on ecological agriculture and agri-environmental topics.

Farmers should be regularly consulted, their recommendations considered and their concerns regarding issues like the area proposed for transformation, the management or restoration methods used and financial conditions should be addressed.

Indicators

The best indicator is a characteristic species composition of different subtypes of *Cnidion* meadows.

Wet *Cnidion* meadows:

Poa palustris, Galium palustre agg., Iris pseudacorus, Gratiola officinalis, Carex vulpina, Mentha pulegium, Eleocharis palustris agg.

Summer-dry, continental *Cnidion* meadows:
Cnidium dubium, Viola pumila, Carex praecox, Inula salicina, Veronica arvensis, Serratula tinctoria, Carex melanostachya, Clematis integrifolia, Valerianella locusta, Veronica longifolia, Agropyron repens, Glechoma hederacea, Scutellaria hastifolia, Lythrum virgatum, Vicia tetrasperma, Myosotis ramosissima, Allium angulosum, Potentilla reptans, Euphorbia esula, Calamagrostis epigejos, Rumex thyrsiflorus, Vicia angustifolia, Iris sibirica, Festuca rupicola, Cirsium arvense, Symphytum officinale agg.

Sub-oceanic *Cnidion* meadows:
Geranium pratense, Trisetum flavescens, Cerastium holosteoides, Dactylis glomerata, Campanula patula, Veronica chamaedrys agg., Galium mollugo agg., Pimpinella major, Anthriscus sylvestris, Poa pratensis agg., Vicia sepium.

Mesophytic, continental *Cnidion* meadows:
Festuca pratensis, Alopecurus pratensis, Deschampsia cespitosa, Poa pratensis, Medicago lupulina, Bromus commutatus, Daucus carota

Special requirements driven by relevant species

In Hungary the mowing regime on alluvial *Cnidion dubii* meadows is postponed on localities of *Angelica palustris* in order to preserve and strengthen its population. The special regime consists of machine or hand mowing parcels once in a year, in the period between 15th-30th of June (depending on the water table) or after 30th of September, while leaving yearly 20% of the managed area without intervention in a rotating manner (except areas with invasive plants infestation) (Sándor *et al*. 2005).

In order to preserve animal life, especially ground nesting birds, on the alluvial grasslands, a special mowing technique is applied which allows animals to escape from the mown plots. These involve either mowing from the middle of the plot towards the margins in concentric circles or mowing in one direction, ensuring that there are set-aside plots (not mown) next to the mown plots (Sándor *et al*. 2005).

Research on *Crex crex* (corncrake) breeding populations in several European countries have shown that a simple change in direction of mowing reduces the loss of hatched chicks from 90% to 18% (Tomovčík *et al.* 1999). The same ratio can be expected for other altricial bird species breeding on the ground - such as *Coturnix coturnix* (common quail) and *Perdix perdix* (partridge). The first mowing must not be carried out before 30th of June. The combination of late annual mowing after 30th of June with late grazing carried out in large rotating blocks (larger than 50 hectares) is considered to be an ideal way to cultivate alluvial meadows from the point of view of ground nesting birds.

The grazed blocks should be located in the central parts of vast homogenous meadow vegetation to avoid forming small unmown islands of high water plants and woody plant groups where families of

breeding altricial birds concentrate after mowing. Such small islands strongly attract predators and thus can lead to further loss of young individuals in particular (Tomovčík *et al*. 1999).

In some cases (e.g. in Hungary in the Aggtelek National Park area) the first moving is delayed until after 31st of July on wet meadows used for breeding by *Crex crex* (corncrake).

Though delayed mowing carried out after the 30th of June should be sufficient for the majority of ground nesting birds including passerines such as *Motacilla alba* and *Motacilla flava* (white and yellow wagtails), *Anthus pratensis* and *Anthus trivialis* (meadow and tree pipits), *Saxicola rubetra* (whinchat) and *Saxicola torquata* (stonechat) and waders such as *Tringa totanus* (common redshank), *Numenius arquata* (curlew), *Limosa limosa* (black-tailed godwit), *Gallinago gallinago* (common snipe).

In the case of harriers the absolute exclusion of mowing on their nesting sites during the breeding season is thought to be necessary. For instance, in Hungary nests of harriers are being located before the first mowing and a 50 m diameter circle protective zone is set up around the nest on which the mowing is excluded until 31st of July. This applies mainly to *Circus pygargus* (montagu's harrier) but can be similarly applied in the case of breeding *Circus aeruginosus* (marsh harrier) as well. Creating a mosaic of mown and unmown plots will also provide shelter for wintering *Circus cyaneus* (northern harrier) (Tomovčík *et al.* 1999).

Successful breeding by waders depends not only on an appropriate mowing regime but also on an appropriate undisturbed water regime. Thus the ground should be covered by shallow water during spring, the water table should not drop more than 15 cm below the surface during the summer and terrain depressions with shallow water should be present at all times (Tomovčík *et al.* 1999).

For preservation of the butterflies *Maculinea nausithous* (dusky large blue) and *Maculinea teleius* (scarce large blue), it is important that the meadows are regularly mown before the emergence of the adults, that is, before the 10th of June. The area should be mown by hand or by machine in a mosaic (stripes or squares) of mown and unmown plots.

The areas, where *Maculinea teleius* (scarce large blue) appears, should be mown only by hand, as the species is tightly connected to the host ant *Myrmica scabrinodis*, which cannot survive on permanently inundated depressions or on the flat surface of machine-mown meadows. On mown plots, sufficient stubble should be left. Unmown plots should be mown in the next calendar year. On twice -mown meadows the second mowing should not be carried out before the 10th of September, again leaving some parts of the area unmown (http://www.lepidoptera.cz/index.php?id=194).

Cost estimates and potential sources of EU financing

Cost estimates

The cost usually depends on whether:

1. The farming management is done by farmers, albeit using conservation-orientated methods
2. The conservation management is done by parks, reserves or NGOs where best practices are implemented for ecological purposes but where there is no economic logic or imperative.

In the first case, agri-environmental schemes can be used that pay for additional costs incurred or income foregone resulting from the scheme. The Polish payment (Ministry of Agriculture and Rural Development of Poland 2007) is €307,49 /ha and the calculation was tailored for Molinion and Cnidion litter meadows. The Slovak RDP payment (Ministry of Agriculture of Slovakia 2007) is €53 /ha. In addition, agri-environmental payments can be combined with LFA payments and direct payments, so the real payment per hectare for Alluvial *Cnidion* meadows may be about €150-170 /ha depending on the location of the site within LFAs.

In the case of converting of arable land back to meadow habitat, the cost of seeds and of more frequent mowing to prevent weed invasion needs to be taken into consideration. In the case of delayed mowing, the loss in quality of the fodder.

In the second case, land managers can consider using article 39.2 of EARDF ("Where duly justified to achieve environmental objectives, agri-environment payments may be granted to other land managers."). In the case of mowing their costs will consist of:

- Manual or machine mowing (price per staff per day/hours)
- Conditioning the grass (price per staff per day/hours)
- Removal of the grass from the area (cost per kilometre)
- Cost of expert advice if needed.

A rate of depreciation for capital items (such as farming machinery) and overheads may need to be included. Staff costs may have to be justified in order to demonstrate that no profit is made. The main question for these eligible land managers is to know if the full cost may be considered as additional.
Recovery costs consist of the cost of 1) seed mixture, 2) seeding and reseeding in second season, 3) mowing twice/year during three years of restoration.

The cost of floodplain grassland restoration on Austrian side of Morava-Dyje floodplain project was almost €7000 per hectare (Neuhauser 2001). The cost of returning 140 ha of arable land to meadows with natural species composition was €75,017 at 1999 prices on Slovak side of the river. It is €536 per hectare (Šeffer & Stanová 1999).

Potential sources of EU funding

EU funds for Natura 2000 in the period 2007-2013 should come from different existing Community financial instruments aiming to enhance rural, regional, and marine development in the EU. The integrated use of these resources will allow the financing of various management actions for areas with habitats listed in the Habitats Directive and included in the Natura 2000 network.

Each Member State has identified the issues that are of most concern locally and has prioritized EU funds in order to address these issues. National and regional programs, which have been prepared by Member States on the basis of the EU Regulations, determine the concrete funding possibilities for Natura 2000. The funds to be taken into consideration are:

- The Structural Funds: (European Social Fund (ESF) and European Regional Development Fund (ERDF).
- The Cohesion Fund (CF).
- The European Agricultural Fund for Rural Development (EAFRD).
- The Financial Instrument for the Environment (LIFE+).
- The 7th Research Framework Program (FP7).

Among the diversity of sources for EU funding, the following funds might primarily be of interest for the management of the alluvial meadows of river valleys of the *Cnidion dubii*.

- The European Fund for Rural Development (EARDF): This program has a potential to cover several management activities that might be relevant, although the measures have to be covered in the National Strategy and related Rural Development plans (RDPs) in order to be eligible on a national basis. Furthermore Leader+ projects have to be studied on a national basis.

- The European Regional Development Fund (ERDF), The Cohesion Fund and Interreg: These funds might be relevant in single cases although activities related to Natura 2000 sites mostly need to be integrated in a broader development context. However, the Interreg approach is more flexible but requires a European objective and partnership. Different geographical levels were defined and all of them have their specific rules, eligibility criteria and objectives.

- The Financial Instrument for the Environment (LIFE+): The 'Nature' component of LIFE+ supports best practice and demonstration projects contributing to the implementation of the Birds and Habitats Directives but only exceptionally outside Natura 2000 sites. The 'Biodiversity' component is for demonstration and innovation projects contributing to the objectives of the Commission Communication 'Halting the loss of biodiversity by 2010 – and beyond'. Both the 'Nature' and

'Biodiversity' components emphasise on concrete non-recurring management actions (at least 25 % of the budget). Recurring management is not eligible under LIFE+.

Concerning potential sources of EU financing, the European Commision has published a Guidance Handbook that presents the EU funding options for Natura 2000 sites in the period 2007-2013, which are, in principle, available at the national and regional level (Torkler 2007). Furthermore an IT-tool is available on the EC web site (http://ec.europa.eu/environment/nature/natura2000/financing/index_en.htm).

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